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สถาบันวิทยบริการ
จุฬาลงกรณ์มหาวิทยาลัย

ภาคผนวก ก

การคำนวณ Sensitivity

สำหรับค่า Sensitivity คือความไวต่อการเปลี่ยนแปลงตัวแปรซึ่งเทอมของ Sensitivity ที่ใช้ในวิทยานิพนธ์เล่มนี้เป็นแบบ normalized differential sensitivity , S_{nnn} ซึ่งอยู่ในรูปของสมการไร้หน่วย สามารถแสดงได้ดังต่อไปนี้

$$S_{nnn} = \frac{\Delta F / F_0}{\Delta x / x_0}\Big|_{\Delta x \to 0} \qquad (1)\ [29]$$

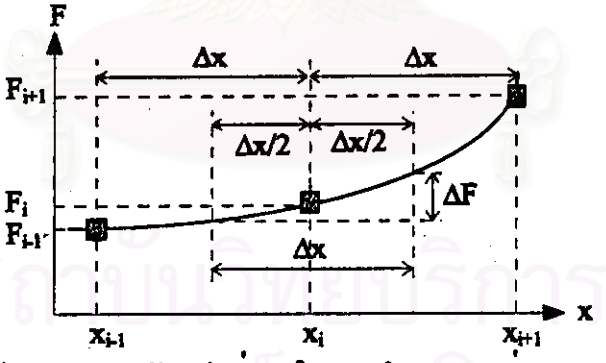
โดยเทอมของ

F_0 คือ function ของกำลังงานสูญเสียหรือ Net indicated power ที่ตัวแปร $x = x_0$

x_0 คือ ตัวแปรการออกแบบจาก baseline engine data

ΔF คือ ผลต่าง function ของกำลังงานสูญเสีย หรือ Net indicated power ในช่วงตัวแปร Δx

Δx คือ ช่วงตัวแปรที่เข้าใกล้ 0 ซึ่งในวิทยานิพนธ์เล่มนี้จะประมาณเป็นช่วงที่ครอบคลุมจุดที่พิจารณา โดยจะแสดงได้ดังรูปต่อไปนี้



รูป ก.1 แสดงตัวแปรต่างๆในการคำนวณหาค่า sensitivity

F_i คือ function ของกำลังงานสูญเสียหรือ Net indicated power ที่ตัวแปร $x = x_i$ ซึ่งเป็นตัวแปรที่พิจารณา

F_{i-1} คือ function ของกำลังงานสูญเสียหรือ Net indicated power ที่ตัวแปร $x = x_{i-1}$

F_{i+1} คือ function ของกำลังงานสูญเสียหรือ Net indicated power ที่ตัวแปร $x = x_{i+1}$

ซึ่ง ค่า sensitivity เป็นบวก หมายถึงเมื่อเปลี่ยนแปลงตัวแปร x จะทำให้ค่า F มากขึ้น

ค่า sensitivity เป็นลบ หมายถึงเมื่อเปลี่ยนแปลงตัวแปร x จะทำให้ค่า F ลดลง

สำหรับผลในการคำนวณค่า Sensitivity ของตัวแปรต่างๆสามารถแสดงได้ดังตาราง ก1

ตาราง ก.1 แสดงผลการคำนวณค่า Sensitivity ของตัวแปรต่างๆที่ความเร็ว 2600 รอบต่อนาที

ตัวแปรที่เกี่ยวข้องกับองค์ประกอบทางเทอร์โมไดนามิกส์						
ตัวแปรการออกแบบ	Sensitivity					
- Spark advance	-30	-28	-26	-24	-22	-20
(degree crank angle)	0.832	0.891	0.953	0.901	0.965	0.871
- Combustion duration	36	37.6	39.2	40.2	42.4	44
(degree crank angle)	-1.297	-1.373	-1.411	-1.429	-1.42	-1.401
- Compression ratio	8.5	8.9	9.3	9.7	10.1	10.5
	1.259	1.259	1.25	1.241	1.232	1.232
- Connecting rod length	0.12	0.128	0.136	0.144	0.152	0.16
(m)	0.072	0.066	0.059	0.053	0.046	0.053
ตัวแปรที่เกี่ยวข้องกับองค์ประกอบในส่วนของเครื่องยนต์						
ก) Connecting rod bearing						
- Radius bearing at big-end	0.021	0.022	0.023	0.024	0.025	0.026
(m)	2.281	2.523	2.736	2.979	3.232	3.497
- Radius clearance at big-end	0.0315	0.0329	0.0343	0.0357	0.0371	0.0385
(mm)	-1.225	-1.129	-1.034	-0.954	-0.884	-0.821
- Bearing width at big-end	0.02	0.0208	0.0216	0.0224	0.0232	0.024
(m)	0.992	0.992	0.992	0.992	0.992	0.992
- Radius bearing at small-end	0.01	0.0104	0.0108	0.0112	0.0116	0.012
(m)	0.0171	0.0184	0.0199	0.214	0.0231	0.0246
- Radius clearance at small-end	0.0162	0.017	0.0177	0.0185	0.0192	0.02
(mm)	-0.0081	-0.0077	-0.0071	-0.0065	-0.006	-0.0055
- Bearing width at small-end	0.02	0.0208	0.0216	0.0224	0.0232	0.024
(m)	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068
ข) Crankshaft bearing						
- Radius of bearing	0.021	0.022	0.023	0.024	0.025	0.026
(m)	2.297	2.521	2.755	3.001	3.255	3.521
- Bearing width	0.02	0.0208	0.0216	0.0224	0.0232	0.024
(m)	1	1	1	1	1	1
- Radius clearance	0.022	0.023	0.024	0.025	0.026	0.027
(mm)	-1.191	-1.089	-1.001	-0.922	-0.852	-0.791
ค) Piston ring and skirt						
- Piston clearance	0.06	0.064	0.068	0.072	0.076	0.08
(mm)	-1.358	-1.193	-1.007	-0.992	-0.846	-0.763
- Skirt length	0.036	0.0376	0.0392	0.0408	0.0424	0.044
(m)	1.001	1.001	1.001	1.001	1.001	1.001
- Pressure ring depth	3	3.17	3.34	3.51	3.68	3.85
(mm)	0.873	0.874	0.875	0.876	0.878	0.881
- Oil ring depth	1	1.042	1.084	1.126	1.168	1.21
(mm)	0.1099	0.1035	0.103	0.1031	0.1031	0.1032

ตาราง ก.1 ต่อ แสดงผลการคำนวณค่า Sensitivity ของตัวแปรต่างๆที่ความเร็ว 2600 รอบต่อนาที

ตัวแปรการออกแบบ	Sensitivity					
ตัวแปรที่เกี่ยวข้องกับองค์ประกอบในส่วนของเครื่องยนต์						
ง) Cam system						
- Valve follower mass (kg)	**0.09**	**0.102**	**0.114**	**0.126**	**0.138**	**0.15**
	-0.031	-0.031	-0.031	-0.031	-0.031	-0.031
- Spring stiffness (N/m)	**21600**	**22560**	**23520**	**24480**	**25440**	**26400**
	0.521	0.521	0.521	0.521	0.521	0.521
- Valve preloading (N)	**140**	**146**	**152**	**158**	**164**	**170**
	0.51	0.51	0.51	0.51	0.51	0.51
- Base radius (mm)	**14**	**14.7**	**15.4**	**16.1**	**16.8**	**17.5**
	0.291	0.484	0.54	0.304	0.592	0.606
- Tip radius (mm)	**2.2**	**2.31**	**2.42**	**2.53**	**2.64**	**2.75**
	0.104	0.109	-0.157	0.117	0.119	-0.171
- Valve lift (mm)	**9**	**9.4**	**9.8**	**10.2**	**10.6**	**11**
	0.9917	1.035	0.786	1.089	1.153	0.662
จ) Accessories load						
- Cooling load (W)	**2300**	**2380**	**2460**	**2540**	**2620**	**2700**
	1	1	1	1	1	1
- Rotor diameter in alternator (m)	**0.1**	**0.105**	**0.11**	**0.115**	**0.12**	**0.125**
	0.649	0.734	0.824	0.921	1.024	1.135
- Rotor length in alternator (m)	**0.09**	**0.094**	**0.098**	**0.102**	**0.106**	**0.11**
	0.138	0.135	0.132	0.13	0.127	0.125
ฉ) Pumping losses						
- Inlet valve diameter (m)	**0.027**	**0.0282**	**0.0294**	**0.0306**	**0.0318**	**0.033**
	-0.686	-0.587	-0.506	-0.439	-0.383	-0.335
ตัวแปรร่วมอื่นๆ						
- Absolute viscosity (Pa.s)	**0.012**	**0.0126**	**0.0132**	**0.0138**	**0.0144**	**0.015**
	3.998	3.998	3.998	3.998	3.998	3.998
- Piston bore (m)	**0.07**	**0.074**	**0.078**	**0.082**	**0.086**	**0.09**
	1.979	1.979	1.979	1.979	1.979	1.979
- Crank arm (m)	**0.0346**	**0.0361**	**0.0376**	**0.039**	**0.0405**	**0.042**
	3.519	3.679	3.829	3.976	4.131	4.231
ตัวแปรที่เกี่ยวข้องกับองค์ประกอบในส่วนของยานยนต์						
- Drag coefficient	**0.3**	**0.312**	**0.324**	**0.336**	**0.348**	**0.36**
	1	1	1	1	1	1
- Frontal area (m^2)	**1.75**	**1.8**	**1.85**	**1.9**	**1.95**	**2**
	1	1	1	1	1	1
- Rolling coefficient	**0.0145**	**0.0149**	**0.0154**	**0.0158**	**0.0163**	**0.0168**
	0.999	0.999	0.999	0.999	0.999	0.999
- Vehicle mass (kg)	**1000**	**1040**	**1080**	**1120**	**1160**	**1200**
	0.999	0.999	0.999	0.999	0.999	0.999

ภาคผนวก ข

ข้อมูลตัวแปรการออกแบบจาก baseline engine data

สำหรับข้อมูลจาก baseline engine data ที่ใช้ในการคำนวณในโปรแกรม Indicate , Engine และ Optimum สามารถแสดงได้ดังตาราง ข.1

ตาราง ข.1 แสดงข้อมูล baseline engine data

ตัวแปรต่างๆใน baseline engine data	ค่าตัวแปร
ก) ตัวแปรในทางเทอร์โมไดนามิกส์	
- θ_s (spark advance) , degree crank angle	-26
- θ_b (combustion duration) , degree crank angle	40
- l (connecting rod length) , m	0.14
- R_c (compression ratio)	9.5
ข) ตัวแปรในส่วนของเครื่องยนต์	
- V_d (displacement volume) , m^3	0.001587
- B (piston bore) , m	0.081
- n_c (number cylinder) , cylinder	4
- a (crank arm) , m	0.0385
- r (connecting rod length to crank arm ratio , l/a)	3.636
- b'_{press} (pressure ring width) , mm	3.5
- b'_{oil} (oil ring width) , mm	1.1
- n_{press} (number pressure ring)	2
- n_{oil} (number oil ring)	1
- h'_2 (oil minimum thickness) , μm	5
- L_{skirt} (skirt length) , m	0.04
- C_p (piston clearance) , mm	0.07
- μ (absolute viscosity) , Pa.s	0.0136
- C_{big} (radius clearance at big-end side) , m	3.5×10^{-5}
- R_{big} (radius bearing at big-end side) , m	0.024
- L_{big} (bearing width at big-end side) , m	0.022
- ε_{big} (eccenticity ratio at big-end side)	0.9
- C_{small} (radius clearance at small-end side) , m	1.8×10^{-5}
- R_{small} (radius bearing at small-end side) , m	0.011
- L_{small} (bearing width at small-end side) , m	0.022
- ε_{small} (eccenticity ratio at small-end side)	0.9
- C_{crank} (radius clearance in crankshaft bearing) , m	2.4×10^{-5}
- R_{crank} (radius bearing in crankshaft bearing) , m	0.024
- L_{crank} (bearing width in crankshaft bearing) , m	0.022
- ε_{crank} (eccentricity ratio)	0.9
- n_b (number bearing in crankshaft)	5
- m (valve follower mass) , kg	0.1
- K (spring stiffness) , N/m	24000

ตาราง ข.1 (ต่อ) แสดงข้อมูล baseline engine data

ตัวแปรต่างๆใน baseline engine data	ค่าตัวแปร
ข) ตัวแปรในส่วนของเครื่องยนต์	
- r (tip radius) , mm	2.5
- R (base radius) , mm	15.9
- ϕ (starting angle) , degree	31
- μ_f (friction coefficient on cam surface)	0.11
- L_{lift} (valve follower lift) , mm	10
- N_{valve} (number valve follower per cylinder) , valve/cylinder	4
- n_{iv} (number inlet valve per cylinder) , valve/cylinder	2
- D_{iv} (inlet vale diameter) , m	0.03
- P'_e (exhaust pressure at full load) , In.Hg	10
- P_a (ambient pressure) , kPa	101.325
- k (isentropic of R12)	1.136
- e_v (compression efficiency)	0.7
- e_m (mechanical efficiency in compressor)	0.8
- P_2 (condenser pressure) , Pa	1.53×10^6
- P_1 (evaporator pressure) , Pa	0.255×10^6
- B_{com} (piston bore in compressor) , m	0.048
- Cooling load , W	2500
- L_{com} (stroke length in compressor) , m	0.04
- D_a (rotor diameter in alternator) , m	0.115
- L_a (rotor length in alternator) , m	0.1
- ρ_{Hg} (mercury density) , kg/m^3	13550
ค) ตัวแปรในส่วนของยานยนต์	
- G_1 (gear ratio # 1)	3.166
- G_2 (gear ratio # 2)	1.904
- G_3 (gear ratio # 3)	1.31
- G_4 (gear ratio # 4)	0.969
- G_5 (gear ratio # 5)	0.815
- G_D (differential ratio)	4.058
- C_d (drag coefficient)	0.33
- A_f (frontal area) , m^2	1.94
- f (rolling coefficient)	0.01536
- m_v (vehicle mass) , kg	1110
- R_w (wheel radius) , m	0.281
- ρ_{air} (air density) , kg/m^3	1.17

ภาคผนวก ค
แฟ้มข้อมูลป้อนค่าตัวแปรการออกแบบ

ในการคำนวณจากโปรแกรม Engine และ Optimum จะมีแฟ้มข้อมูลที่ใช้เป็นฐานข้อมูลเบื้องต้นในการคำนวณ โดยแฟ้มข้อมูลคือ base.dat ซึ่งประกอบด้วยข้อมูล 2 กลุ่ม ประกอบด้วยดังต่อไปนี้

1) กลุ่มที่หนึ่ง เป็นกลุ่มของข้อมูลตัวแปรการออกแบบและตัวแปรค่าคงที่

2) กลุ่มที่สอง เป็นกลุ่มข้อมูลของช่วงของตัวแปรการออกแบบที่พิจารณา โดยช่วงตัวแปรการออกแบบนั้น จะพิจารณาจากการเพิ่มลดค่าจาก baseline engine data ประมาณร้อยละ 10 หรือมีความเป็นไปได้ในทางปฏิบัติ เป็นช่วงตัวแปรการออกแบบที่พิจารณา

สำหรับสัญลักษณะตัวแปรๆของแฟ้มข้อมูลป้อนค่าตัวแปรการออกแบบ base.dat สามารถแสดงได้ดังนี้

ข้อมูลกลุ่มที่หนึ่ง ประกอบด้วยดังนี้

```
VISB,RCRANKB,CRANKLB,CCRANKB,BN,QB
RKB,EMB,ECB,CONDP,EVAPP,BCOMB,SCOMB
BPRESSB,BOILB,NPRESSB,NOILB
BRCONB,BCCONB,BLCONB
SRCONB,SCCONB,SLCONB
NCB,BOREB,ARMB,CONLB
NVCB,SDEGB,TRB,VLB
FMB,SCB,PLB,BRB
RDALTB,RLALTB
DVB,RCB,NVB
PCB,PISLB
G1,G2,G3,G4,G5,GD
CDB,AREAB,FRB,MGB,WR
```

ข้อมูลกลุ่มที่สอง ประกอบด้วยดังนี้

```
RCRANKL,RCRANKH
CRANKLL,CRANKLH
CCRANKL,CCRANKH
BRCONL,BRCONH
BCCONL,BCCONH
BLCONL,BLCONH
SRCONL,SRCONH
SCCONL,SCCONH
SLCONL,SLCONH
BPRESSL,BPRESSH
BOILL,BOILH
BOREL,BOREH
```

VISL,VISH
ARML,ARMH
RDALTL,RDALTH
RLALTL,RLALTH
CONLL,CONLH
PISLL,PISLH
DVL,DVH
RCL,RCH
PCL,PCH
FML,FMH
SCL,SCH
PLL,PLH
BRL,BRH
TRL,TRH
VLL,VLH
QL,QH
CDL,CDH
AFL,AFH
FRL,FRH
MGL,MGH

สำหรับคำอธิบายสัญลักษณะของตัวแปรการออกแบบและช่วงตัวแปรการออกแบบแสดงได้ดังต่อไปนี้

VIS	= ABSOLUTE VISCOSITY	:	(Pa.s)
RCRANK	= RADIUS OF CRANK-SHAFT BEARING	:	(m)
CRANKL	= CRANK-SHAFT BEARING WIDTH	:	(m)
CCRANK	= RADIUS CLEARANCE IN CRANK-SHAFT BEARING	:	(m)
BN	= AMOUNT OF BEARING SUPPORT		
RKB	= REFRIGERANT ISENTROPIC INDEX		
EMB	= MECHANICAL EFFICIENCY		
ECB	= COMPRESSION EFFICIENCY		
CONDP	= CONDENSER PRESSURE	:	(Pa)
EVAPP	= EVAPORATOR PRESSURE	:	(Pa)
BCOMB	= PISTON BORE AT COMPRESSOR	:	(m)
SCOMB	COMPRESSOR STROKE LENGTH	:	(m)
BPRESS	= PRESSURE RING SURFACE DEPTH	:	(mm)
BOIL	= OIL RING SURFACE DEPTH	:	(mm)
NPRESS	= AMOUNT OF PRESSURE RING		
NOIL	= AMOUNT OF OIL RING		
BRCON	= RADIUS OF CONNECTING ROD BEARING AT BIG-END	:	(m)
BCCON	= RADIUS CLEARANCE IN CONNECTING ROD BIG-END	:	(m)
BLCON	= CONNECTING ROD BEARING WIDTH AT BIG-END	:	(m)
SRCON	= RADIUS OF CONNECTING ROD BEARING AT SMALL-END	:	(m)
SCCON	= RADIUS CLEARANCE IN CONNECTING ROD SMALL-END	:	(m)
SLCON	= CONNECTING ROD BEARING WIDTH AT SMALL-END	:	(m)
NCB	= NUMBER OF CYLINDER		
BORE	= PISTON BORE	:	(m)
ARM	= CRANK ARM	:	(m)
CONL	= CONNECTING ROD LENGTH	:	(m)
NVCB	= NUMBER VALVE PER CYLINDER		
SDEGB	= STARTING ANGLE	:	(deg.)
TR	= TIP RADIUS OF CAM	:	(mm)
BR	= BASE RADIUS OF CAM	:	(mm)
VL	= VALVE FOLLOWER LIFT	:	(mm)
FM	= VALVE FOLLOWER MASS	:	(mm)
SC	= SPRING STIFFNSS	:	(N/m)
PL	= VALVE PRELOAD	:	(N)
RDALTB	= ROTOR DIAMETER OF ALTERATOR	:	(m)

```
RLALTB = ROTOR LENGTH OF ALTERATOR                          : (m)
DV     = INLET VALVE DIAMETER                               : (m)
RC     = COMPRESSION RATIO
NVB    = NUMBER OF INLET VALVE PER CYLINDER
PC     = PISTON CLEARANCE                                   : (m)
PISL   = PISTON SKIRT LENGTH                                : (m)
G      = GEAR RATIO IN 1-5 AND DIFFERENT
CD     = DRAG COEFFICIENT
AREA   = FRONTAL AREA                                       : (m^3)
FR     = ROLLING COFFICIENT
MG     = VEHICLE MASS                                       : (kg)
WR     = WHEEL RADIUS                                       : (m)
```

สำหรับสัญลักษณะตัวแปรที่มีอักษรต่อท้ายดังต่อไปนี้

อักษร B ต่อท้ายจะหมายถึง ข้อมูลตัวแปรการออกแบบจาก baseline engine data

อักษร L ต่อท้ายจะหมายถึง ข้อมูลที่เป็นช่วงตัวแปร ที่ช่วงต่ำสุด(lower limit)

อักษร H ต่อท้ายจะหมายถึง ข้อมูลที่เป็นช่วงตัวแปร ที่ช่วงสูงสุด(upper limit)

ยกตัวอย่างเช่น ตัวแปร MG เมื่อมีอักษร B, L และ H ต่อท้ายจะหมายถึง

MGB จะเป็นตัวแปรออกแบบจาก baseline engine data

MGL จะเป็นข้อมูลช่วงตัวแปร ที่ช่วงต่ำสุด(lower limit)

MGH จะเป็นข้อมูลช่วงตัวแปร ที่ช่วงสูงสุด(upper limit)

คำอธิบายกลุ่มข้อมูลตัวแปรคงที่แสดงได้ดังนี้

```
CONDP  = CONDENSER PRESSURE                                 : (Pa)
EVAPP  = EVAPORATOR PRESSURE                                : (Pa)
RKB    = REFRIGERANT ISENTROPIC INDEX
EMB    = MECHANICAL EFFICIENCY
ECB    = COMPRESSION EFFICIENCY
NCB    = NUMBER OF CYLINDER
BN     = AMOUNT OF BEARING SUPPORT
NPRESS = AMOUNT OF PRESSURE RING
NOIL   = AMOUNT OF OIL RING
NVCB   = NUMBER VALVE PER CYLINDER
SDEGB  = STARTING ANGLE                                     : (deg.)
NVB    = NUMBER OF INLET VALVE PER CYLINDER
G      = GEAR RATIO IN 1-5 AND DIFFERENT
WR     = WHEEL RADIUS                                       : (m)
```

สำหรับข้อมูลป้อนค่าตัวแปรการออกแบบจากแฟ้มข้อมูล base.dat สามารถแสดงได้ดังนี้

```
0.0136 0.024 0.022 2.4E-5 5. 2500.
1.136 0.8 0.7 1530E+3 255E+3 0.047 0.047
3.5 1.1 2 1
0.024 3.5E-5 0.022
0.011 1.8E-5 0.022
4 0.081 0.0385 0.14
4 31 2.5 10
0.1 24000 155 15.9
0.115 0.1
```

```
0.03 9.5 2
0.00007 0.04
3.166 1.904 1.31 0.969 0.815 4.058
0.33 1.94 0.01536 1110 0.281
0.021 0.026
0.02 0.024
2.2E-5 2.7E-5
0.021 0.026
3.15E-5 3.85E-5
0.02 0.024
0.01 0.012
1.62E-5 2E-5
0.02 0.024
3. 3.85
1. 1.21
0.07 0.09
0.012 0.015
0.0346 0.042
0.1 0.125
0.09 0.11
0.12 0.16
0.036 0.044
0.027 0.033
8.5 10.5
0.00006 0.00008
0.09 0.15
21600. 26400.
140. 170.
14. 17.5
2.2 2.75
9. 11.
2300. 2700.
0.3 0.36
1.75 2.
0.0145 0.0168
1000 1200
```

สถาบันวิทยบริการ
จุฬาลงกรณ์มหาวิทยาลัย

ภาคผนวก ง

รายละเอียดโปรแกรม INDICATE

โปรแกรม indicate สามารถแสดงรายละเอียดดังต่อไปนี้

```
C*****-------------------------********-------------------------******C
C             PROGRAM FOR DETERMINATION NET INDICATED POWER            C
C*****-------------------------********-------------------------******C
      PROGRAM INDICATE
      DATA DEG1/-180./,DEG2/180./,GRAM/1.3/,RC/9.5/,NC/4./,DENHG/13550./
     $,B/0.081/,A/0.0385/,CL/0.14/,C/4/,RCL/8.5/,RCH/10.5/,CLL/0.12/,
     $CLH/0.16/,DEGS1L/-30./,DEGS1H/-20./,DEGBL/36./,DEGBH/44./,NVB/2./,
     $DV/0.03/
       DHE = 10.
        PE = 9.81*DENHG*DHE*0.0254/1000.
        PI = 2.*ASIN(1.)
        PA = 101.325
C*****-------------------------********-------------------------******C
C                    CONSTANT VALUE FOR CALCULATION                    C
C   DENHG  =  MERCURY DENSITY                          : (kg/m^3)      C
C    DEG1  =  CRANK ANGLE AT BDC IN COMPRESSION STROKE : (degree)      C
C    DEG2  =  CRANK ANGLE AT BDC IN EXPANSION STROKE   : (degree)      C
C      PA  =  AMBIENT PRESSURE                         : (kPa)         C
C      PE  =  EXHAUST PRESSURE AT FULL LOAD            : (kPa)         C
C      CL  =  CONNECTING ROD LENGTH                    : (m)           C
C       A  =  CRANK ARM                                : (m)           C
C       B  =  PISTON BORE                              : (m)           C
C     QIN  =  HEAT ADDITION                  : (J/cycle/cylinder)      C
C       C  =  INDEX OF FRACTION OF THE HEAT RELEASE                    C
C      NC  =  NUMBER OF CYLINDER                                       C
C      RC  =  COMPRESSION RATIO                                        C
C      NV  =  AMOUNT OF INLET VALVE                                    C
C    GRAM  =  SPECIFIC HEAT RATIO                                      C
C*****-------------------------********-------------------------******C
      WRITE(6,*) ' PLEASE ENTER DATA TO CALCULATE INDICATED POWER '
      WRITE(6,*) ' ENTER HEAT ADDITION             : (J/cycle/cylinder)'
        READ(*,*) QIN
      WRITE(6,*) ' ENTER ENGINE SPEED TO CALCULATION      : (RPM)'
        READ(*,*) RPM
      WRITE(6,*) ' ENTER AMOUNT OF INTERVAL OF PARAMETERS : (TIMES)'
        READ(*,*) M
        DDEGS1 = (DEGS1H-DEGS1L)/M
         DDEGB = (DEGBH-DEGBL)/M
C.....CALCULATION AT BASELINE DATA
      OPEN(UNIT=1,FILE='RESULT1.OUT',STATUS='OLD')
      WRITE(1,*) ' INDICATED POWER BASELINE DATA '
      WRITE(6,*) ' INDICATED POWER BASELINE DATA '
      WRITE(1,*) '  '
      WRITE(6,*) '  '
      IF (RPM.LE.1300.) THEN
         DH = 9.9
      ELSE
       IF (RPM.LE.1700.) THEN
          DH = 10.2
       ELSE
        IF (RPM.LE.2000.) THEN
           DH = 11.
        ELSE
         IF (RPM.LE.2400.) THEN
            DH = 12.
         ELSE
          IF (RPM.LE.2700.) THEN
```

```
            DH = 13.
          ELSE
           IF (RPM.LE.3000.) THEN
              DH = 13.7
           ELSE
            IF (RPM.LE.3400.) THEN
               DH = 14.9
            ELSE
             IF (RPM.LE.3700.) THEN
                DH = 15.9
             ELSE
              IF (RPM.LE.4000.) THEN
                 DH = 16.5
              ELSE
                 WRITE(*,*) ' OVER ENGINE SPEED '
              ENDIF
             ENDIF
            ENDIF
           ENDIF
          ENDIF
         ENDIF
        ENDIF
       ENDIF
          DEGS1 = -26.
           DEGB = 40.
         DEGS1B = -26.
          DEGBB = 40.
          DEGS2 = DEGS1+DEGB
              R = CL/A
             VD = 2.*A*PI*(B**2.)/4.
             VC = VD/(RC-1.)
             V1 = VC + A*PI*(B**2.)*( R + 1. - COS(PI*DEG1/180.)
     $            -SQRT(R**2.-SIN(PI*DEG1/180.)**2.) )/4.
             V2 = VC + A*PI*(B**2.)*( R + 1. - COS(PI*DEGS1/180.)
     $            -SQRT(R**2.-SIN(PI*DEGS1/180.)**2.) )/4.
             V3 = VC + A*PI*(B**2.)*( R + 1. - COS(PI*DEGS2/180.)
     $            -SQRT(R**2.-SIN(PI*DEGS2/180.)**2.) )/4.
             V4 = VC + A*PI*(B**2.)*( R + 1. - COS(PI*DEG2/180.)
     $            -SQRT(R**2.-SIN(PI*DEG2/180.)**2.) )/4.
             P1 = 9.81*DENHG*DH*0.0254
C.....THIS PART CALCULATE P-V DIAGRAM IN COMPRESSION STROKE
              N = 200
           SUM1 = 0.
          DDEG1 = (DEG1-DEGS1)/N
       DO  90 I = 0,N
          DEGX1 = DEG1-I*DDEG1
            VX1 = VC + A*PI*((B**2.)/4.)*( R + 1. - COS(DEGX1*PI/180.)
     $            -SQRT(R**2.-SIN(DEGX1*PI/180.)**2.) )
            PX1 = P1*(V1/VX1)**GRAM
            DV1 = A*PI*((B**2.)/4.)*( SIN(PI*DEGX1/180.) +
     $            0.5*SIN(2.*DEGX1*PI/180.) /
     $            SQRT(R**2.-SIN(DEGX1*PI/180.)**2.) )*(PI/180.)
            WX1 = PX1*DV1
           SUM1 = SUM1 + WX1
   90 CONTINUE
           WX01 = P1*A*PI*(B**2.)*( SIN(DEG1*PI/180.) +
     $            0.5*SIN(2.*DEG1*PI/180.) /
     $            SQRT(R**2.-SIN(DEG1*PI/180.)**2.) )/4.
           WXN1 = (P1*(V1/V2)**GRAM)*A*PI*(B**2.)*( SIN(PI*DEGS1/180.) +
     $            0.5*SIN(2.*DEGS1*PI/180.) /
     $            SQRT(R**2.-SIN(DEGS1*PI/180.)**2.) )/4.
         POWER1 = (-WX01-WXN1 + 2.*SUM1)*(-DDEG1)/2.
C.....THIS PART CALCULATE P-V DIAGRAM DURING COMBUSTION PERIOD
              N = 200
           SUM2 = 0.
          DDEG2 = DEGB/N
           PRE0 = PX1
```

```
          DEG0 = DEGS1
       DO 190 I = 0,N
          DEGX2 = DEGS1+I*DDEG2
            VX2 = VC + A*PI*(B**2.)*( R + 1. - COS(DEGX2*PI/180.)
     $            -SQRT(R**2.-SIN(DEGX2*PI/180.)**2.) )/4.
            DV2 = A*PI*((B**2.)/4.)*( SIN(DEGX2*PI/180.) +
     $            0.5*SIN(2.*DEGX2*PI/180.) /
     $            SQRT(R**2.-SIN(DEGX2*PI/180.)**2.) )*(PI/180.)
            WX2 = PRE0*DV2
           SUM2 = SUM2 + WX2
          SLOPE = (GRAM-1)/VX2*QIN*C/DEGB*(((DEGX2-DEGS1)/DEGB)**(C-1))*
     $            EXP( -((DEGX2-DEGS1)/DEGB)**C ) - GRAM*PRE0/VX2*A*(PI*
     $            (B**2)/4.)*(PI/180.)*( SIN(DEGX2*PI/180.) +
     $            0.5*SIN(2.*DEGX2*PI/180.)/
     $            SQRT(R**2.-SIN(DEGX2*PI/180.)**2) )
           PRE1 = PRE0 + SLOPE*DDEG2
           PRE0 = PRE1
  190 CONTINUE
           WX20 = (P1*(V1/V2)**GRAM)*A*PI*(B**2.)*( SIN(DEGS1*PI/180.) +
     $            0.5*SIN(2.*DEGS1*PI/180) /
     $            SQRT(R**2.-SIN(DEGS1*PI/180.)**2.) )/4.
           WX2N = WX2
         POWER2 = (-WX20-WX2N+2.*SUM2)*(DDEG2)/2.
C.....THIS PART CALCULATE P-V DIAGRAM IN EXPANSION STROKE
             P3 = PRE0
              N = 200
           SUM3 = 0.
          DDEG3 = (DEG2-DEGS2)/N
       DO 290 I = 0,N
          DEGX3 = DEGS2+I*DDEG3
            VX3 = VC + A*PI*(B**2.)*( R + 1. - COS(PI*DEGX3/180.)
     $            -SQRT(R**2.-SIN(PI*DEGX3/180.)**2.) )/4.
            PX3 = P3*(V3/VX3)**GRAM
            DV3 = A*PI*((B**2.)/4.)*( SIN(PI*DEGX3/180.) +
     $            0.5*SIN(2.*DEGX3*PI/180) /
     $            SQRT(R**2.-SIN(DEGX3*PI/180.)**2.) )*(PI/180.)
            WX3 = P3*DV3
           SUM3 = SUM3 + WX3
  290 CONTINUE
           WX03 = P3*A*PI*(B**2.)*( SIN(DEGS2*PI/180.) +
     $            0.5*SIN(2.*DEGS2*PI/180.) /
     $            SQRT(R**2.-SIN(DEGS2*PI/180.)**2.) )/4.
           WXN3 = (P3*(V3/V1)**GRAM)*A*PI*(B**2.)*( SIN(PI*DEG2/180.) +
     $            0.5*SIN(2.*DEG2*PI/180.) /
     $            SQRT(R**2.-SIN(DEG2*PI/180.)**2.) )/4.
         POWER3 = (-WX03-WXN3+2.*SUM3)*(DDEG3)/2.
C......SHOW RESULTS FROM CALCULATION
          POWER = POWER1+POWER2+POWER3
       CALL PUMPING(RPM,DH,NC,B,A,DV,RC,NVB,DENHG,PE,PA,PPUMP,PI)
          WNTB = (POWER/1000.)*NC*RPM/(2.*60.)-PPUMP/1000
C*****-------------------------*********-------------------------------******C
       PMAX1 = 0.
       DO 1000 J1 = 0,M
       OPEN(UNIT=1,FILE='RESULT1.OUT',STATUS='OLD')
            DRC = (RCH-RCL)/M
             RC = RCL+J1*DRC
        WRITE(1,*) RC
        WRITE(6,*) RC
        WRITE(1,*) ' '
       DO 2000 J2 = 0,M
            DCL = (CLH-CLL)/M
             CL = CLL+J2*DCL
              R = CL/A
        WRITE(1,*) CL
        WRITE(6,*) CL
        WRITE(1,*) ' '
       DO 3000 J3 = 0,M
            DEGB = DEGBL+J3*DDEGB
```

```
      OPEN(UNIT=1,FILE='RESULT1.OUT',STATUS='OLD')
       WRITE(1,1001) DEGB
       WRITE(6,1001) DEGB
       WRITE(1,*) ' '
 1001 FORMAT(2X,'COMBUSTION DURATION(degree) : ',F8.2)
       DO 4000 J4 = 0,M
             DEGS1 = DEGS1L+J4*DDEGS1
      OPEN(UNIT=1,FILE='RESULT1.OUT',STATUS='OLD')
         DEGS2 = DEGS1+DEGB
             R = CL/A
            VD = 2.*A*PI*(B**2.)/4.
            VC = VD/(RC-1)
            V1 = VC + A*PI*(B**2.)*( R + 1. - COS(PI*DEG1/180.)
     $           -SQRT(R**2.-SIN(PI*DEG1/180.)**2.) )/4.
            V2 = VC + A*PI*(B**2.)*( R + 1. - COS(PI*DEGS1/180.)
     $           -SQRT(R**2.-SIN(PI*DEGS1/180.)**2.) )/4.
            V3 = VC + A*PI*(B**2.)*( R + 1. - COS(PI*DEGS2/180.)
     $           -SQRT(R**2.-SIN(PI*DEGS2/180.)**2.) )/4.
            V4 = VC + A*PI*(B**2.)*( R + 1. - COS(PI*DEG2/180.)
     $           -SQRT(R**2.-SIN(PI*DEG2/180.)**2.) )/4.
            P1 = 9.81*DENHG*DH*0.0254
C.....THIS PART CALCULATE P-V DIAGRAM IN COMPRESSION STROKE
             N = 200
          SUM1 = 0.
         DDEG1 = (DEG1-DEGS1)/N
       DO 100 I = 0,N
         DEGX1 = DEG1-I*DDEG1
           VX1 = VC + A*PI*((B**2.)/4.)*( R + 1. - COS(DEGX1*PI/180.)
     $           -SQRT(R**2.-SIN(DEGX1*PI/180.)**2.) )
           PX1 = P1*(V1/VX1)**GRAM
           DV1 = A*PI*((B**2.)/4.)*( SIN(PI*DEGX1/180.) +
     $           0.5*SIN(2.*DEGX1*PI/180.) /
     $           SQRT(R**2.-SIN(DEGX1*PI/180.)**2.) )*(PI/180.)
           WX1 = PX1*DV1
          SUM1 = SUM1 + WX1
  100 CONTINUE
          WX01 = P1*A*PI*(B**2.)*( SIN(DEG1*PI/180.) +
     $           0.5*SIN(2.*DEG1*PI/180.) /
     $           SQRT(R**2.-SIN(DEG1*PI/180.)**2.) )/4.
          WXN1 = (P1*(V1/V2)**GRAM)*A*PI*(B**2.)*( SIN(PI*DEGS1/180.) +
     $           0.5*SIN(2.*DEGS1*PI/180.) /
     $           SQRT(R**2.-SIN(DEGS1*PI/180.)**2.) )/4.
        POWER1 = (-WX01-WXN1 + 2.*SUM1)*(-DDEG1)/2.
C.....THIS PART CALCULATE P-V DIAGRAM DURING COMBUSTION PERIOD
             N = 200
          SUM2 = 0.
         DDEG2 = DEGB/N
          PRE0 = PX1
          DEG0 = DEGS1
       DO 200 I = 0,N
         DEGX2 = DEGS1+I*DDEG2
           VX2 = VC + A*PI*(B**2.)*( R + 1. - COS(DEGX2*PI/180.)
     $           -SQRT(R**2.-SIN(DEGX2*PI/180.)**2.) )/4.
           DV2 = A*PI*((B**2.)/4.)*( SIN(DEGX2*PI/180.) +
     $           0.5*SIN(2.*DEGX2*PI/180.) /
     $           SQRT(R**2.-SIN(DEGX2*PI/180.)**2.) )*(PI/180.)
           WX2 = PRE0*DV2
          SUM2 = SUM2 + WX2
         SLOPE = (GRAM-1)/VX2*QIN*C/DEGB*(((DEGX2-DEGS1)/DEGB)**(C-1))*
     $           EXP( -((DEGX2-DEGS1)/DEGB)**C ) - GRAM*PRE0/VX2*A*(PI*
     $           (B**2)/4.)*(PI/180.)*( SIN(DEGX2*PI/180.) +
     $           0.5*SIN(2.*DEGX2*PI/180.)/
     $           SQRT(R**2.-SIN(DEGX2*PI/180.)**2) )
          PRE1 = PRE0 + SLOPE*DDEG2
          PRE0 = PRE1
  200 CONTINUE
          WX20 = (P1*(V1/V2)**GRAM)*A*PI*(B**2.)*( SIN(DEGS1*PI/180.) +
     $           0.5*SIN(2.*DEGS1*PI/180) /
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     $           SQRT(R**2.-SIN(DEGS1*PI/180.)**2.) )/4.
         WX2N = WX2
        POWER2 = (-WX20-WX2N+2.*SUM2)*(DDEG2)/2.
C.....THIS PART CALCULATE P-V DIAGRAM IN EXPANSION STROKE
           P3 = PRE0
            N = 200
         SUM3 = 0.
        DDEG3 = (DEG2-DEGS2)/N
      DO 300 I = 0,N
        DEGX3 = DEGS2+I*DDEG3
          VX3 = VC + A*PI*(B**2.)*( R + 1. - COS(PI*DEGX3/180.)
     $           -SQRT(R**2.-SIN(PI*DEGX3/180.)**2.) )/4.
          PX3 = P3*(V3/VX3)**GRAM
          DV3 = A*PI*((B**2.)/4.)*( SIN(PI*DEGX3/180.) +
     $           0.5*SIN(2.*DEGX3*PI/180) /
     $           SQRT(R**2.-SIN(DEGX3*PI/180.)**2.) )*(PI/180.)
          WX3 = P3*DV3
         SUM3 = SUM3 + WX3
  300 CONTINUE
         WX03 = P3*A*PI*(B**2.)*( SIN(DEGS2*PI/180.) +
     $           0.5*SIN(2.*DEGS2*PI/180.) /
     $           SQRT(R**2.-SIN(DEGS2*PI/180.)**2.) )/4.
         WXN3 = (P3*(V3/V1)**GRAM)*A*PI*(B**2.)*( SIN(PI*DEG2/180.) +
     $           0.5*SIN(2.*DEG2*PI/180.) /
     $           SQRT(R**2.-SIN(DEG2*PI/180.)**2.) )/4.
        POWER3 = (-WX03-WXN3+2.*SUM3)*(DDEG3)/2.
C.....SHOW RESULTS FROM CALCULATION
         POWER = POWER1+POWER2+POWER3
      CALL PUMPING(RPM,DH,NC,B,A,DV,RC,NVB,DENHG,PE,PA,PPUMP,PI)
           WNT = (POWER/1000.)*NC*RPM/(2.*60.)-PPUMP/1000
      WRITE(1,400) DEGS1,WNT
      WRITE(6,400) DEGS1,WNT
C......       DETERMINATION INDICATED POWER MAXIMUN
C......              FROM SPARK ADVANCE & COMBUSTION DURATION
      IF(PMAX1.LT.WNT) THEN
         PMAX1 = WNT
        XMAX11 = DEGS1
        XMAX12 = DEGB
         XMAX2 = CL
         XMAX3 = RC
      ENDIF
  400 FORMAT(2X,F8.2,T20,F8.2)
 4000 CONTINUE
 3000 CONTINUE
 2000 CONTINUE
 1000 CONTINUE
      WRITE(1,*) '  '
      WRITE(1,*) ' OPTIMUM PARAMETERS OF INDICATED POWER '
      WRITE(6,*) '  '
      WRITE(6,*) ' OPTIMUM PARAMETERS OF INDICATED POWER '
      WRITE(1,500) RPM,DH
      WRITE(1,501) XMAX11
      WRITE(1,502) XMAX12
      WRITE(1,*) ' '
      WRITE(1,503) DEGS1B,DEGBB
      WRITE(1,504) XMAX2
      WRITE(1,505) XMAX3
      WRITE(6,500) RPM,DH
      WRITE(6,501) XMAX11
      WRITE(6,502) XMAX12
      WRITE(6,*) ' '
      WRITE(6,503) DEGS1B,DEGBB
      WRITE(6,504) XMAX2
      WRITE(6,505) XMAX3
  500 FORMAT(2X,' AT ',2X,F7.2,' (RPM) :  ',2X,F5.2,'  (INCH)')
  501 FORMAT(2X,'SPARK ADVANCE AT    ',T30,F7.2,' : (degree) ')
  502 FORMAT(2X,'COMBUSTION DURATION   ',T30,F7.2,' : (degree) ')
  503 FORMAT(2X,'SPARK ADV. AT  ',F7.2,2X,' DURATION AT ',F7.2)
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  504 FORMAT(2X,'CONNECTING ROD LENGTH  ',T30,F7.2,' : (m) ')
  505 FORMAT(2X,'COMPRESSION RATIO   ',T30,F7.2)
C*****------------------------********----------------------------******C
      WRITE(1,*) ' INDICATED POWER OPTIMUM DATA '
      WRITE(6,*) ' INDICATED POWER OPTIMUM DATA '
      WRITE(1,*) '  '
      WRITE(6,*) '  '
      OPEN(UNIT=1,FILE='RESULT1.OUT',STATUS='OLD')
           RC = XMAX3
         DEGB = XMAX12
        DEGS1 = XMAX11
        DEGS2 = DEGS1+DEGB
           CL = XMAX2
            R = CL/A
           VD = 2.*A*PI*(B**2.)/4.
           VC = VD/(RC-1)
           V1 = VC + A*PI*(B**2.)*( R + 1. - COS(PI*DEG1/180.)
     $          -SQRT(R**2.-SIN(PI*DEG1/180.)**2.) )/4.
           V2 = VC + A*PI*(B**2.)*( R + 1. - COS(PI*DEGS1/180.)
     $          -SQRT(R**2.-SIN(PI*DEGS1/180.)**2.) )/4.
           V3 = VC + A*PI*(B**2.)*( R + 1. - COS(PI*DEGS2/180.)
     $          -SQRT(R**2.-SIN(PI*DEGS2/180.)**2.) )/4.
           V4 = VC + A*PI*(B**2.)*( R + 1. - COS(PI*DEG2/180.)
     $          -SQRT(R**2.-SIN(PI*DEG2/180.)**2.) )/4.
           P1 = 9.81*DENHG*DH*0.0254
C.....THIS PART CALCULATE P-V DIAGRAM IN COMPRESSION STROKE
            N = 200
         SUM1 = 0.
        DDEG1 = (DEG1-DEGS1)/N
     DO 130 I = 0,N
        DEGX1 = DEG1-I*DDEG1
          VX1 = VC + A*PI*((B**2.)/4.)*( R + 1. - COS(DEGX1*PI/180.)
     $          -SQRT(R**2.-SIN(DEGX1*PI/180.)**2.) )
          PX1 = P1*(V1/VX1)**GRAM
          DV1 = A*PI*((B**2.)/4.)*( SIN(PI*DEGX1/180.) +
     $          0.5*SIN(2.*DEGX1*PI/180.) /
     $          SQRT(R**2.-SIN(DEGX1*PI/180.)**2.) )*(PI/180.)
          WX1 = PX1*DV1
         SUM1 = SUM1 + WX1
  130 CONTINUE
         WX01 = P1*A*PI*(B**2.)*( SIN(DEG1*PI/180.) +
     $          0.5*SIN(2.*DEG1*PI/180.) /
     $          SQRT(R**2.-SIN(DEG1*PI/180.)**2.) )/4.
         WXN1 = (P1*(V1/V2)**GRAM)*A*PI*(B**2.)*( SIN(PI*DEGS1/180.) +
     $          0.5*SIN(2.*DEGS1*PI/180.) /
     $          SQRT(R**2.-SIN(DEGS1*PI/180.)**2.) )/4.
       POWER1 = (-WX01-WXN1 + 2.*SUM1)*(-DDEG1)/2.
C.....THIS PART CALCULATE P-V DIAGRAM DURING COMBUSTION PERIOD
            N = 200
         SUM2 = 0.
        DDEG2 = DEGB/N
         PRE0 = PX1
         DEG0 = DEGS1
     DO 230 I = 0,N
        DEGX2 = DEGS1+I*DDEG2
          VX2 = VC + A*PI*(B**2.)*( R + 1. - COS(DEGX2*PI/180.)
     $          -SQRT(R**2.-SIN(DEGX2*PI/180.)**2.) )/4.
          DV2 = A*PI*((B**2.)/4.)*( SIN(DEGX2*PI/180.) +
     $          0.5*SIN(2.*DEGX2*PI/180.) /
     $          SQRT(R**2.-SIN(DEGX2*PI/180.)**2.) )*(PI/180.)
          WX2 = PRE0*DV2
         SUM2 = SUM2 + WX2
        SLOPE = (GRAM-1)/VX2*QIN*C/DEGB*(((DEGX2-DEGS1)/DEGB)**(C-1))*
     $          EXP( -((DEGX2-DEGS1)/DEGB)**C ) - GRAM*PRE0/VX2*A*(PI*
     $          (B**2)/4.)*(PI/180.)*( SIN(DEGX2*PI/180.) +
     $          0.5*SIN(2.*DEGX2*PI/180.)/
     $          SQRT(R**2.-SIN(DEGX2*PI/180.)**2) )
         PRE1 = PRE0 + SLOPE*DDEG2
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          PRE0 = PRE1
  230 CONTINUE
          WX20 = (P1*(V1/V2)**GRAM)*A*PI*(B**2.)*( SIN(DEGS1*PI/180.) +
     $            0.5*SIN(2.*DEGS1*PI/180) /
     $            SQRT(R**2.-SIN(DEGS1*PI/180.)**2.) )/4.
          WX2N = WX2
         POWER2 = (-WX20-WX2N+2.*SUM2)*(DDEG2)/2.
C.....THIS PART CALCULATE P-V DIAGRAM IN EXPANSION STROKE
            P3 = PRE0
             N = 200
          SUM3 = 0.
         DDEG3 = (DEG2-DEGS2)/N
       DO 330 I = 0,N
         DEGX3 = DEGS2+I*DDEG3
           VX3 = VC + A*PI*(B**2.)*( R + 1. - COS(PI*DEGX3/180.)
     $            -SQRT(R**2.-SIN(PI*DEGX3/180.)**2.) )/4.
           PX3 = P3*(V3/VX3)**GRAM
           DV3 = A*PI*((B**2.)/4.)*( SIN(PI*DEGX3/180.) +
     $            0.5*SIN(2.*DEGX3*PI/180) /
     $            SQRT(R**2.-SIN(DEGX3*PI/180.)**2.) )*(PI/180.)
           WX3 = P3*DV3
          SUM3 = SUM3 + WX3
  330 CONTINUE
          WX03 = P3*A*PI*(B**2.)*( SIN(DEGS2*PI/180.) +
     $            0.5*SIN(2.*DEGS2*PI/180.) /
     $            SQRT(R**2.-SIN(DEGS2*PI/180.)**2.) )/4.
          WXN3 = (P3*(V3/V1)**GRAM)*A*PI*(B**2.)*( SIN(PI*DEG2/180.) +
     $            0.5*SIN(2.*DEG2*PI/180.) /
     $            SQRT(R**2.-SIN(DEG2*PI/180.)**2.) )/4.
        POWER3 = (-WX03-WXN3+2.*SUM3)*(DDEG3)/2.
C......SHOW RESULTS FROM CALCULATION
         POWER = POWER1+POWER2+POWER3
       CALL PUMPING(RPM,DH,NC,B,A,DV,RC,NVB,DENHG,PE,PA,PPUMP,PI)
          WNTO = (POWER/1000.)*NC*RPM/(2.*60.)-PPUMP/1000
          DWNT = (WNTO-WNTB)/WNTB*100
       WRITE(1,*) ' COMPARATIVE BASELINE WITH OPTIMUM DATA '
       WRITE(1,*) ' BASELINE DATA : OPTIMUM DATA : IMPROVEMENT '
       WRITE(6,*) ' COMPARATIVE BASELINE WITH OPTIMUM DATA '
       WRITE(6,*) ' BASELINE DATA : OPTIMUM DATA : IMPROVEMENT '
       WRITE(1,333) WNTB,WNTO,DWNT
       WRITE(6,333) WNTB,WNTO,DWNT
  333 FORMAT(2X,F7.2,2X,F7.2,2X,F7.2)
       STOP
       END
C*****-----------------------********-----------------------------******C
C                SUBROUTINE FOR PUMPING LOSSES                          C
C*****-----------------------********-----------------------------******C
       SUBROUTINE PUMPING(RPM,DH,NC,B,A,DV,RC,NVB,DENHG,PE,PA,PPUMP,PI)
              PIA = 9.81*DENHG*DH*0.0254/1000
            CIMEP = 12.87*PA*((PIA/PA)-0.1)
              PIG = PA-(CIMEP/12.8)-10.14
                F = (NVB*NC*(DV**2))/(2*A*PI*NC*(B**2)/4)
       PPUMP = (PA-(CIMEP/12.8)-10.14+PE*(((CIMEP*RPM)/(3904000))**2) +
     $          8.9667*(SQRT(CIMEP/1124.3))*((RPM/1000)**1.7)
     $          *((2.984/F)**1.28) + (SQRT((PA-PIG)/97.94))
     $          *(11.86*(RC**0.4)-(3.38+0.103*RC)*((RPM/1000)**1.185)))
     $          *1000*(2*A*PI*NC*(B**2)/4)*(RPM/120)
       RETURN
       END
```

ภาคผนวก จ

รายละเอียดโปรแกรม ENGINE

โปรแกรม engine สามารถแสดงรายละเอียดดังต่อไปนี้

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C*****-----------------------********-------------------------------******C
C              PROGRAM FOR CALULATION ENGINE POWER REQUIRED                C
C                              WRITEN BY                                   C
C                       MR. PAIRAT LERTARAYAPONG                           C
C*****-----------------------********-------------------------------******C
      PROGRAM ENGINE
C-----------READ DATA FROM BASELINE AND LIMIT DATA FILE----------------C
       AIRDEN = 1.17
        DENHG = 13550.
         FCOE = 0.11
        CORRK = 0.06
         RALT = 2.
         PCLE = 4.5
         RCOM = 1.18
         NCOM = 1.
          DHE = 10.
           RP = 0.5
           RO = 1.
           PI = 2.*ASIN(1.)
           PA = 101.325
          ESM = 0.9
           EC = 0.9
            E = 0.9
            H = 0.005
           PE = 9.81*DENHG*DHE*0.0254/1000.
           H1 = 185.*1000.
           H2 = 95.7*1000.
           V1 = 0.0666252
         FRAC = 25.
C*****-----------------------********-------------------------------******C
C                     CONSTANT VALUE FOR CALCULATION                       C
C  AIRDEN  =  AIR DENSITY                                : (kg/m^3)  C
C   DENHG  =  MERCURY DENSITY                            : (kg/m^3)  C
C    FCOE  =  FRICTION COEFFICIENT IN CAM SURFACE                      C
C     RCOM =  PULLEY RATIO AT COMPRESSOR                               C
C     NCOM =  NUMBER OF CYLINDER AT COMPRESSOR                         C
C     PCLE =  PERCENT CLEARANCE AT COMPRESSOR          : (%)           C
C     FRAC =  PERCENT BETWEEN MECH. LOSS WITH TOTAL LOSS : (%)         C
C    CORRK =  CORRECTION FACTOR OF ALTERNATOR                          C
C     RALT =  PULLEY RATIO AT ALTERNATOR                               C
C      RP  =  PRESSURE RING CONSTANT                                   C
C      RO  =  OIL RING CONSTANT                                        C
C      PA  =  AMBIENT PRESSURE                          : (kPa)        C
C     DHE  =  EXHAUST MANIFOLD PRESSURE AT FULL LOAD    : (INCH)       C
C       H  =  OIL MINIMUM THICKNESS                     : (mm)         C
C      PE  =  EXHAUST MANIFOLD PRESSURE AT FULL LOAD    : (kPa)        C
C      EC  =  ECCENTRICITY RATIO IN CRANK-SHAFT BEARING                C
C       E  =  ECCENTRICITY RATIO IN CONNECTION ROD BIG-END             C
C     ESM  =  ECCENTRICITY RATIO IN CONNECTION ROD SMALL-END           C
C       H1 =  ENTHALPY AT SATURATED VAPOUR              : (kJ/kg)      C
C       H2 =  ENTHALPY AT SATURATED LIQUID              : (kJ/kg)      C
C       V1 =  SPECIFICE VOLUME OF REFRIGERANT           : (m^3/kg)     C
C*****-----------------------********-------------------------------******C
       OPEN(UNIT=7,FILE='BASE.DAT',STATUS='OLD')
       READ(7,*) VISB,RCRANKB,CRANKLB,CCRANKB,BN,QB
       READ(7,*) RKB,EMB,ECB,CONDP,EVAPP,BCOMB,SCOMB
       READ(7,*) BPRESSB,BOILB,NPRESSB,NOILB
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      READ(7,*) BRCONB,BCCONB,BLCONB
      READ(7,*) SRCONB,SCCONB,SLCONB
      READ(7,*) NCB,BOREB,ARMB,CONLB
      READ(7,*) NVCB,SDEGB,TRB,VLB
      READ(7,*) FMB,SCB,PLB,BRB
      READ(7,*) RDALTB,RLALTB
      READ(7,*) DVB,RCB,NVB
      READ(7,*) PCB,PISLB
      READ(7,*) G1,G2,G3,G4,G5,GD
      READ(7,*) CDB,AREAB,FRB,MGB,WR
C-----------------------DATA LIMIT FOR CALCULATION--------------------C
      READ(7,*) RCRANKL,RCRANKH
      READ(7,*) CRANKLL,CRANKLH
      READ(7,*) CCRANKL,CCRANKH
      READ(7,*) BRCONL,BRCONH
      READ(7,*) BCCONL,BCCONH
      READ(7,*) BLCONL,BLCONH
      READ(7,*) SRCONL,SRCONH
      READ(7,*) SCCONL,SCCONH
      READ(7,*) SLCONL,SLCONH
      READ(7,*) BPRESSL,BPRESSH
      READ(7,*) BOILL,BOILH
      READ(7,*) BOREL,BOREH
      READ(7,*) VISL,VISH
      READ(7,*) ARML,ARMH
      READ(7,*) RDALTL,RDALTH
      READ(7,*) RLALTL,RLALTH
      READ(7,*) CONLL,CONLH
      READ(7,*) PISLL,PISLH
      READ(7,*) DVL,DVH
      READ(7,*) RCL,RCH
      READ(7,*) PCL,PCH
      READ(7,*) FML,FMH
      READ(7,*) SCL,SCH
      READ(7,*) PLL,PLH
      READ(7,*) BRL,BRH
      READ(7,*) TRL,TRH
      READ(7,*) VLL,VLH
      READ(7,*) QL,QH
      READ(7,*) CDL,CDH
      READ(7,*) AFL,AFH
      READ(7,*) FRL,FRH
      READ(7,*) MGL,MGH
C******-------------------------********---------------------------******C
C                          ENGINE PARAMETERS                           C
C  VIS    = ABSOLUTE VISCOSITY                          : (Pa.s)      C
C  RCRANK = RADIUS OF CRANK-SHAFT BEARING               : (m)         C
C  CRANKL = CRANK-SHAFT BEARING WIDTH                   : (m)         C
C  CCRANK = RADIUS CLEARANCE IN CRANK-SHAFT BEARING     : (m)         C
C  BN     = AMOUNT OF BEARING SUPPORT                                 C
C  RKB    = REFRIGERANT ISENTROPIC INDEX                              C
C  EMB    = MECHANICAL EFFICIENCY                                     C
C  ECB    = COMPRESSION EFFICIENCY                                    C
C  CONDP  = CONDENSOR PRESSURE                          : (Pa)        C
C  EVAPP  = EVAPOURATOR PRESSURE                        : (Pa)        C
C  BCOMB  = PISTON BORE AT COMPRESSOR                   : (m)         C
C  SCOMB    COMPRESSOR STROKE LENGTH                    : (m)         C
C  BPRESS = PRESSURE RING SURFACE DEPTH                 : (mm)        C
C  BOIL   = OIL RING SURFACE DEPTH                      : (mm)        C
C  NPRESS = AMOUNT OF PRESSURE RING                                   C
C  NOIL   = AMOUNT OF OIL RING                                        C
C  BRCON  = RADIUS OF CONNECTING ROD BEARING AT BIG-END : (m)         C
C  BCCON  = RADIUS CLEARANCE IN CONNECTING ROD BIG-END  : (m)         C
C  BLCON  = CONNECTING ROD BEARING WIDTH AT BIG-END     : (m)         C
C  SRCON  = RADIUS OF CONNECTING ROD BEARING AT SMALL-END : (m)       C
C  SCCON  = RADIUS CLEARANCE IN CONNECTING ROD SMALL-END  : (m)       C
C  SLCON  = CONNECTING ROD BEARING WIDTH AT SMALL-END   : (m)         C
C  NCB    = NUMBER OF CYLINDER                                        C
C  BORE   = PISTON BORE                                 : (m)         C
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C  ARM     = CRANK ARM                                          : (m)       C
C  CONL    = CONNECTING ROD LENGTH                              : (m)       C
C  NVCB    = NUMBER VALVE PER CYLINDER                                      C
C  SDEGB   = STARTING ANGLE                                    : (deg.)    C
C  TR      = TIP RADIUS OF CAM                                  : (mm)      C
C  BR      = BASE RADIUS OF CAM                                 : (mm)      C
C  VL      = VALVE FOLLOWER LIFT                                : (mm)      C
C  FM      = VALVE FOLLOWER MASS                                : (mm)      C
C  SC      = SPRING STIFFNSS                                    : (N/m)     C
C  PL      = VALVE PRELOAD                                      : (N)       C
C  RDALTB  = ROTOR DIAMETER OF ALTERATOR                        : (m)       C
C  RLALTB  = ROTOR LENGTH OF ALTERATOR                          : (m)       C
C  DV      = INLET VALVE DIAMETER                               : (m)       C
C  RC      = COMPRESSION RATIO                                              C
C  NVB     = NUMBER OF INLET VALVE PER CYLINDER                             C
C  PC      = PISTON CLEARANCE                                   : (m)       C
C  PISL    = PISTON SKIRT LENGTH                                : (m)       C
C  G       = GEAR RATIO IN 1-5 AND DIFFERENT                                C
C  CD      = DRAG COEFFICIENT                                               C
C  AREA    = FRONTAL AREA                                       : (m^3)     C
C  FR      = ROLLING COFFICIENT                                             C
C  MG      = VEHICLE MASS                                       : (kg)      C
C  WR      = WHEEL RADIUS                                       : (m)       C
C*****-------------------------********-------------------------******C
C*****-------------------------********-------------------------******C
C           MAIN PROGRAM FOR CALCULATION POWER LOSS                       C
C*****-------------------------********-------------------------******C
      WRITE(6,*) ' ENTER AMOUNT OF INTERVAL OF PARAMETERS      : (TIMES)'
        READ(*,*)  N
      WRITE(6,*) ' ENTER ENGINE UPPER LIMIT SPEED              : (RPM)'
        READ(*,*)  RPMH
      WRITE(6,*) ' ENTER ENGINE LOWER LIMIT SPEED              : (RPM)'
        READ(*,*)  RPML
      WRITE(6,*) ' ENTER AMOUNT OF INTERVAL OF ENGINE SPEED    : (TIMES)'
        READ(*,*)  RPMN
      WRITE(6,*) ' ENTER AMBIENT PRESSURE            : (APPROX 30 INCH)'
        READ(*,*)  DHH
      WRITE(6,*) ' ENTER LOWER MANIFOLD PRESSURE LIMIT         : (INCH)'
        READ(*,*)  DHL
      WRITE(6,*) ' ENTER AMOUNT OF INTERVAL OF MANI-PRESSURE   : (TIMES)'
        READ(*,*)  M
      RPMMAX = RPMH
       POINT = 1
      CALL P1(N,RPMH,RPML,RPMN,VISL,VISH,ARML,ARMH,CONLL,CONLH,
     $   BRCONL,BRCONH,BCCONL,BCCONH,BLCONL,BLCONH,SRCONL,SRCONH,
     $   SCCONL,SCCONH,SLCONL,SLCONH,VISB,NCB,CONLB,ARMB,BRCONB,
     $   BCCONB,BLCONB,SRCONB,SCCONB,SLCONB,PVIS,PCONL,PARM,PBRCON,
     $   PBCCON,PBLCON,PSRCON,PSCCON,PRCON,PSLCON,E,ESM,PI,POINT,
     $   RPMMAX)
        POINT = 2
      CALL P2(N,RPMH,RPML,RPMN,VISB,RCRANKB,CRANKLB,CCRANKB,BN,
     $   VISL,VISH,RCRANKL,RCRANKH,CRANKLL,CRANKLH,CCRANKL,CCRANKH,
     $   PVIS,PRCRANK,PLCRANK,PCCRANK,EC,PI,POINT,RPMMAX)
        POINT = 3
      CALL P3(N,RPMH,RPML,RPMN,VISL,VISH,PCL,PCH,PISLL,PISLH,NCB,
     $ARMH,ARML,BOREH,BOREL,BOREB,ARMB,VISB,PCB,PISLB,PVPIS,PCPPIS,
     $PLPIS,PAPIS,PBPIS,PI,POINT,RPMMAX)
        POINT = 4
      CALL P4(N,RPMH,RPML,RPMN,VISL,VISH,BPRESSL,BPRESSH,
     $   BOILL,BOILH,BOREL,BOREH,ARML,ARMH,NCB,BOREB,ARMB,VISB,BPRESSB,
     $   BOILB,NPRESSB,NOILB,H,PVRING,PBPRING,PBORING,PBRING,PARING,
     $   PI,RP,RO,POINT,RPMMAX)
        POINT = 5
      CALL P5(N,RPMH,RPML,RPMN,FML,FMH,SCL,SCH,PLL,PLH,BRL,BRH,
     $   TRL,TRH,VLL,VLH,NVCB,NCB,FMB,SCB,PLB,BRB,TRB,VLB,SDEGB,
     $   PFCAM,PSCAM,PPCAM,PBCAM,PTCAM,PVCAM,PI,FCOE,POINT,RPMMAX)
        POINT = 6
      CALL P6(N,RPMH,RPML,RPMN,BCOMB,SCOMB,NCB,BOREB,ARMB,RKB,EMB,ECB,
     $RDALTB,RLALTB,QH,QL,H1,H2,V1,RDALTL,RDALTH,RLALTL,RLALTH,RCOM,
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     $NCOM,PCLE,EVAPP,CONDP,CORRK,RALT,PWP,PAIRQ,PALTD,PALTL,PI,POINT,
     $FRAC,RPMMAX)
       POINT = 7
      CALL P7(N,RPMH,RPML,RPMN,DHH,DHL,M,DVL,DVH,RCL,RCH,NCB,
     $    BOREB,ARMB,DVB,RCB,NVB,DENHG,PE,PA,PDPUMP,PRPUMP,PI,POINT,
     $    RPMMAX)
       POINT = 8
      CALL P8(N,CDB,AREAB,FRB,MGB,WR,RPMH,RPML,RPMN,CDL,CDH,AFL,AFH,
     $    FRL,FRH,MGL,MGH,G1,G2,G3,G4,G5,GD,PI,AIRDEN,PAIRC,
     $    PAIRA,PROLLF,PROLLM,POINT,RPMMAX)
      STOP
      END
C*****-----------------------********-----------------------------******C
C                      END OF THE MAIN PROGRAM                          C
C*****-----------------------********-----------------------------******C
C*****-----------------------********-----------------------------******C
C                 (P1) SUBROUTINE FOR CONNECTING ROD                    C
C*****-----------------------********-----------------------------******C
      SUBROUTINE P1(N,RPMH,RPML,RPMN,VISL,VISH,ARML,ARMH,CONLL,CONLH,
     $    BRCONL,BRCONH,BCCONL,BCCONH,BLCONL,BLCONH,SRCONL,SRCONH,
     $    SCCONL,SCCONH,SLCONL,SLCONH,VISB,NCB,CONLB,ARMB,BRCONB,
     $    BCCONB,BLCONB,SRCONB,SCCONB,SLCONB,PVIS,PCONL,PARM,PBRCON,
     $    PBCCON,PBLCON,PSRCON,PSCCON,PSLCON,PRCON,E,ESM,PI,POINT,
     $    RPMMAX)
       IF (POINT.EQ.1) THEN
           RPMH = RPMMAX
          RPMMAX = RPMMAX
       ENDIF
       DRPM = (RPMH-RPML)/RPMN
      OPEN(UNIT=9,FILE='RESULT2.OUT',STATUS='OLD')
       WRITE(9,*) 'POWER LOSS FROM CONNECTING ROD'
       WRITE(9,*) ' * POWER LOSS VARY WITH ABSOLUTE VISCOSITY '
       WRITE(9,*) '   ABSOLUTE VISCOSITY (Pa.s) & POWER LOSS (W) '
      DO 11 I = 0,RPMN,1
       DO 12 J = 0,N,1
          DVIS = (VISH-VISL)/N
           RPM = RPML + I*DRPM
           VIS = VISL + J*DVIS
C.........SUBPROGRAM MAEN 1 FOR CALCULATION MEAN ANGULAR VELOCITY
       CALL MEAN1(CONLB,ARMB,VBMEAN1,VSMEAN1)
       PVIS = VIS*(BRCONB**3)*BLCONB*((2*PI)/(BCCONB*SQRT(1-E**2)))
     $        *((2*PI*(RPM/60))**2)*NCB*VBMEAN1 +
     $        VIS*(SRCONB**3)*SLCONB*((2*PI)/(SCCONB*SQRT(1-ESM**2)))
     $        *((2*PI*(RPM/60))**2)*NCB*VSMEAN1
       WRITE(9,100) RPM,VIS,PVIS
       WRITE(6,100) RPM,VIS,PVIS
   12 CONTINUE
       WRITE(9,*) ' '
   11 CONTINUE
  100 FORMAT(1X,F7.2,3X,F10.6,3X,F7.2)
C*****-----------------------********-----------------------------******C
       WRITE(9,*) ' * POWER LOSS VARY WITH CRANK ARM '
       WRITE(9,*) '   CRANK ARM (m) & POWER LOSS (W) '
      DO 21 I = 0,RPMN,1
       DO 22 J = 0,N,1
          DARM = (ARMH-ARML)/N
           RPM = RPML + I*DRPM
           ARM = ARML + J*DARM
C.........SUBPROGRAM MAEN 2 FOR CALCULATION MEAN ANGULAR VELOCITY
       CALL MEAN2(CONLB,ARM,VBMEAN2,VSMEAN2)
       PARM = VISB*(BRCONB**3)*BLCONB*((2*PI)/(BCCONB*SQRT(1-E**2)))
     $        *((2*PI*(RPM/60))**2)*NCB*VBMEAN2 +
     $        VISB*(SRCONB**3)*SLCONB*((2*PI)/(SCCONB*SQRT(1-ESM**2)))
     $        *((2*PI*(RPM/60))**2)*NCB*VSMEAN2
       WRITE(9,200) RPM,ARM,PARM
       WRITE(6,200) RPM,ARM,PARM
   22 CONTINUE
       WRITE(9,*) ' '
   21 CONTINUE
```

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  200 FORMAT(1X,F7.2,3X,F7.5,3X,F7.2)
C*****-------------------------********-------------------------******C
      WRITE(9,*) ' * POWER LOSS VARY WITH CONNECTING ROD '
      WRITE(9,*) '   CONNECTING ROG LENGTH (m) & POWER LOSS (W) '
      DO 31 I = 0,RPMN,1
       DO 32 J = 0,N,1
         DCONL = (CONLH-CONLL)/N
           RPM = RPML + I*DRPM
         CONL = CONLL + J*DCONL
C.......SUBPROGRAM MAEN 3 FOR CALCULATION MEAN ANGULAR VELOCITY
      CALL MEAN3(CONL,ARMB,VBMEAN3,VSMEAN3)
      PCONL = VISB*(BRCONB**3)*BLCONB*((2*PI)/(BCCONB*SQRT(1-E**2)))
     $        *((2*PI*(RPM/60))**2)*NCB*VBMEAN3 +
     $        VISB*(SRCONB**3)*SLCONB*((2*PI)/(SCCONB*SQRT(1-ESM**2)))
     $        *((2*PI*(RPM/60))**2)*NCB*VSMEAN3
         WRITE(9,300) RPM,CONL,PCONL
         WRITE(6,300) RPM,CONL,PCONL
   32 CONTINUE
      WRITE(9,*) '  '
   31 CONTINUE
  300 FORMAT(1X,F7.2,3X,F9.6,3X,F7.2)
C*****-------------------------********-------------------------******C
      WRITE(9,*) ' * POWER LOSS VARY WITH REDIUS BEARING BIG-END '
      WRITE(9,*) '    REDIUS BEARING BIG-END (m) & POWER LOSS (W) '
      DO 41 I = 0,RPMN,1
       DO 42 J = 0,N,1
        DBRCON = (BRCONH-BRCONL)/N
           RPM = RPML + I*DRPM
         BRCON = BRCONL + J*DBRCON
        PBRCON = VISB*(BRCON**3)*BLCONB*((2*PI)/(BCCONB*SQRT(1-E**2)))
     $           *((2*PI*(RPM/60))**2)*NCB*VBMEAN1 +
     $           VISB*(SRCONB**3)*SLCONB*((2*PI)/(SCCONB*SQRT(1-ESM**2)))
     $           *((2*PI*(RPM/60))**2)*NCB*VSMEAN1
        WRITE(9,400) RPM,BRCON,PBRCON
        WRITE(6,400) RPM,BRCON,PBRCON
   42 CONTINUE
      WRITE(9,*) '  '
   41 CONTINUE
  400 FORMAT(1X,F7.2,3X,F9.5,3X,F7.2)
C*****-------------------------********-------------------------******C
      WRITE(9,*) ' * POWER LOSS VARY WITH REDIUS CLEARANCE BIG-END '
      WRITE(9,*) '   REDIUS CLEARANCE BIG-END (m) & POWER LOSS (W) '
      DO 51 I = 0,RPMN,1
       DO 52 J = 0,N,1
        DBCCON = (BCCONH-BCCONL)/N
           RPM = RPML + I*DRPM
         BCCON = BCCONL + J*DBCCON
       PBCCON = VISB*(BRCONB**3)*BLCONB*((2*PI)/(BCCON*SQRT(1-E**2)))
     $          *((2*PI*(RPM/60))**2)*NCB*VBMEAN1 +
     $          VISB*(SRCONB**3)*SLCONB*((2*PI)/(SCCONB*SQRT(1-ESM**2)))
     $          *((2*PI*(RPM/60))**2)*NCB*VSMEAN1
        WRITE(9,500) RPM,BCCON,PBCCON
        WRITE(6,500) RPM,BCCON,PBCCON
   52 CONTINUE
      WRITE(9,*) '  '
   51 CONTINUE
  500 FORMAT(1X,F7.2,3X,F9.7,3X,F7.2)
C*****-------------------------********-------------------------******C
      WRITE(9,*) ' * POWER LOSS VARY WITH BEARING WIDTH BIG-END '
      WRITE(9,*) '   BEARING WIDTH BIG-END (m) & POWER LOSS (W) '
      DO 61 I = 0,RPMN,1
       DO 62 J = 0,N,1
        DBLCON = (BLCONH-BLCONL)/N
           RPM = RPML + I*DRPM
         BLCON = BLCONL + J*DBLCON
C.......SUBPROGRAM MAEN 1 FOR CALCULATION MEAN ANGULAR VELOCITY
      CALL MEAN1(CONLB,ARMB,VBMEAN1,VSMEAN1)
      PBLCON = VISB*(BRCONB**3)*BLCON*((2*PI)/(BCCONB*SQRT(1-E**2)))
     $         *((2*PI*(RPM/60))**2)*NCB*VBMEAN1 +
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     $          VISB*(SRCONB**3)*SLCONB*((2*PI)/(SCCONB*SQRT(1-ESM**2)))
     $          *((2*PI*(RPM/60))**2)*NCB*VSMEAN1
       WRITE(9,600) RPM,BLCON,PBLCON
       WRITE(6,600) RPM,BLCON,PBLCON
    62 CONTINUE
       WRITE(9,*) '  '
    61 CONTINUE
   600 FORMAT(1X,F7.2,3X,F9.5,3X,F7.2)
C*****-------------------------********-------------------------******C
       WRITE(9,*) ' * POWER LOSS VARY WITH REDIUS BEARING SMALL-END '
       WRITE(9,*) '   REDIUD BEARING SMALL-END (m) & POWER LOSS (W) '
      DO 71 I = 0,RPMN,1
       DO 72 J = 0,N,1
        DSRCON = (SRCONH-SRCONL)/N
           RPM = RPML + I*DRPM
         SRCON = SRCONL + J*DSRCON
C.......SUBPROGRAM MAEN 1 FOR CALCULATION MEAN ANGULAR VELOCITY
       CALL MEAN1(CONLB,ARMB,VBMEAN1,VSMEAN1)
       PSRCON = VISB*(BRCONB**3)*BLCONB*((2*PI)/(BCCONB*SQRT(1-E**2)))
     $          *((2*PI*(RPM/60))**2)*NCB*VBMEAN1 +
     $          VISB*(SRCON**3)*SLCONB*((2*PI)/(SCCONB*SQRT(1-ESM**2)))
     $          *((2*PI*(RPM/60))**2)*NCB*VSMEAN1
       WRITE(9,700) RPM,SRCON,PSRCON
       WRITE(6,700) RPM,SRCON,PSRCON
    72 CONTINUE
       WRITE(9,*) '  '
    71 CONTINUE
   700 FORMAT(1X,F7.2,3X,F9.6,3X,F7.2)
C*****-------------------------********-------------------------******C
       WRITE(9,*) ' * POWER LOSS VARY WITH REDIUS CLEARANCE SMALL-END '
       WRITE(9,*) '   REDIUS CLEARANCE SAMLL-END (m) & POWER LOSS (W) '
      DO 81 I = 0,RPMN,1
       DO 82 J = 0,N,1
        DSCCON = (SCCONH-SCCONL)/N
           RPM = RPML + I*DRPM
         SCCON = SCCONL + J*DSCCON
       PSCCON = VISB*(BRCONB**3)*BLCONB*((2*PI)/(BCCONB*SQRT(1-E**2)))
     $          *((2*PI*(RPM/60))**2)*NCB*VBMEAN1 +
     $          VISB*(SRCONB**3)*SLCONB*((2*PI)/(SCCON*SQRT(1-ESM**2)))
     $          *((2*PI*(RPM/60))**2)*NCB*VSMEAN1
       WRITE(9,800) RPM,SCCON,PSCCON
       WRITE(6,800) RPM,SCCON,PSCCON
    82 CONTINUE
       WRITE(9,*) '  '
    81 CONTINUE
   800 FORMAT(1X,F7.2,3X,F9.7,3X,F7.2)
C*****-------------------------********-------------------------******C
       WRITE(9,*) ' * POWER LOSS VARY WITH BEARING WIDTH SMALL-END '
       WRITE(9,*) '   BEARING WIDTH SMALL-END (m) & POWER LOSS (W) '
      DO 91 I = 0,RPMN,1
       DO 92 J = 0,N,1
        DSLCON = (SLCONH-SLCONL)/N
           RPM = RPML + I*DRPM
         SLCON = SLCONL + J*DSLCON
       PSLCON = VISB*(BRCONB**3)*BLCONB*((2*PI)/(BCCONB*SQRT(1-E**2)))
     $          *((2*PI*(RPM/60))**2)*NCB*VBMEAN1 +
     $          VISB*(SRCONB**3)*SLCON*((2*PI)/(SCCONB*SQRT(1-ESM**2)))
     $          *((2*PI*(RPM/60))**2)*NCB*VSMEAN1
       WRITE(9,900) RPM,SLCON,PSLCON
       WRITE(6,900) RPM,SLCON,PSLCON
    92 CONTINUE
       WRITE(9,*) '  '
    91 CONTINUE
   900 FORMAT(1X,F7.2,3X,F9.5,3X,F7.2)
C*****-------------------------********-------------------------******C
       WRITE(9,*) ' * POWER LOSS VARY WITH CON-ROD TO CRANK RATIO '
       WRITE(9,*) '   CON-ROD TO CRANK RATIO & POWER LOSS (W) '
       RH = CONLH/ARML
       RL = CONLL/ARMH
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      DO 93 I = 0,RPMN,1
      DO 94 J = 0,N,1
            DR = (RH-RL)/N
          RPM = RPML + I*DRPM
            R = RL + J*DR
      CALL MEAN4(R,VBMEAN4,VSMEAN4)
         PRCON = VISB*(BRCONB**3)*BLCONB*((2*PI)/(BCCONB*SQRT(1-E**2)))
     $           *((2*PI*(RPM/60))**2)*NCB*VBMEAN4 +
     $           VISB*(SRCONB**3)*SLCONB*((2*PI)/(SCCONB*SQRT(1-ESM**2)))
     $           *((2*PI*(RPM/60))**2)*NCB*VSMEAN4
       WRITE(9,901) RPM,R,PRCON
       WRITE(6,901) RPM,R,PRCON
   94 CONTINUE
      WRITE(9,*) '  '
   93 CONTINUE
  901 FORMAT(1X,F7.2,3X,F9.5,3X,F7.2)
      RETURN
      END
C*****-------------------------********-------------------------******C
C             (P2) SUBROUTINE FOR CRANK-SHAFT BEARING                  C
C*****-------------------------********-------------------------******C
      SUBROUTINE P2(N,RPMH,RPML,RPMN,VISB,RCRANKB,CRANKLB,CCRANKB,BN,
     $ VISL,VISH,RCRANKL,RCRANKH,CRANKLL,CRANKLH,CCRANKL,CCRANKH,
     $ PVIS,PRCRANK,PLCRANK,PCCRANK,EC,PI,POINT,RPMMAX)
       IF (POINT.EQ.2) THEN
            RPMH = RPMMAX
         RPMMAX = RPMMAX
       ENDIF
       DRPM = (RPMH-RPML)/RPMN
       OPEN(UNIT=9,FILE='RESULT2.OUT',STATUS='OLD')
       WRITE(9,*) 'POWER LOSS FROM CRANK-SHAFT BEARING '
       WRITE(9,*) ' * POWER LOSS VARY WITH ABSOLUTE VISCOSITY '
       WRITE(9,*) '   ABSOLUTE VISCOSITY (Pa.s) $ POWER LOSS (W) '
      DO 11 I = 0,RPMN,1
        DO 12 J = 0,N,1
           DRPM = (RPMH-RPML)/RPMN
           DVIS = (VISH-VISL)/N
            RPM = RPML + I*DRPM
            VIS = VISL + J*DVIS
           PVIS = VIS*(RCRANKB**3)*CRANKLB*((2*PI)/
     $              (CCRANKB*SQRT(1-EC**2)))*((2*PI*(RPM/60))**2)*BN
        WRITE(9,100) RPM,VIS,PVIS
        WRITE(6,100) RPM,VIS,PVIS
   12 CONTINUE
      WRITE(9,*) '  '
   11 CONTINUE
  100 FORMAT(1X,F7.2,3X,F9.6,3X,F7.2)
C*****-------------------------********-------------------------******C
      WRITE(9,*) ' * POWER LOSS VARY WITH REDIUS BEARING '
      WRITE(9,*) '   REDIUS BEARING (m) & POWER LOSS (W)'
      DO 21 I = 0,RPMN,1
       DO 22 J = 0,N,1
       DRCRANK = (RCRANKH-RCRANKL)/N
           RPM = RPML + I*DRPM
        RCRANK = RCRANKL + J*DRCRANK
       PRCRANK = VISB*(RCRANK**3)*CRANKLB*((2*PI)
     $             /(CCRANKB*SQRT(1-EC**2)))*((2*PI*(RPM/60))**2)*BN
       WRITE(9,200) RPM,RCRANK,PRCRANK
       WRITE(6,200) RPM,RCRANK,PRCRANK
   22 CONTINUE
      WRITE(9,*) '  '
   21 CONTINUE
  200 FORMAT(1X,F7.2,3X,F9.6,3X,F8.2)
C*****-------------------------********-------------------------******C
      WRITE(9,*) ' * POWER LOSS VARY WITH BEARING WIDTH '
      WRITE(9,*) '   BEARING WIDTH (m) & POWER LOSS (W) '
      DO 31 I = 0,RPMN,1
       DO 32 J = 0,N,1
       DLCRANK = (CRANKLH-CRANKLL)/N
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          RPM = RPML + I*DRPM
       CRANKL = CRANKLL + J*DLCRANK
      PLCRANK = VISB*(RCRANKB**3)*CRANKL*((2*PI)
     $             /(CCRANKB*SQRT(1-EC**2)))*((2*PI*(RPM/60))**2)*BN
       WRITE(9,300) RPM,CRANKL,PLCRANK
       WRITE(6,300) RPM,CRANKL,PLCRANK
    32 CONTINUE
       WRITE(9,*) '  '
    31 CONTINUE
   300 FORMAT(1X,F7.2,3X,F9.6,3X,F7.2)
C*****-------------------------********-------------------------******C
       WRITE(9,*) ' * POWER LOSS VARY WITH REDIUS CLEARANCE '
       WRITE(9,*) '   REDIUS CLEARANCE (m) & POWER LOSS (W) '
      DO 41 I = 0,RPMN,1
       DO 42 J = 0,N,1
       DCCRANK = (CCRANKH-CCRANKL)/N
          RPM = RPML + I*DRPM
       CCRANK = CCRANKL + J*DCCRANK
      PCCRANK = VISB*(RCRANKB**3)*CRANKLB*((2*PI)
     $             /(CCRANK*SQRT(1-EC**2)))*((2*PI*(RPM/60))**2)*BN
       WRITE(9,400) RPM,CCRANK,PCCRANK
       WRITE(6,400) RPM,CCRANK,PCCRANK
    42 CONTINUE
       WRITE(9,*) '  '
    41 CONTINUE
   400 FORMAT(1X,F7.2,3X,F9.7,3X,F7.2)
       RETURN
       END
C*****-------------------------********-------------------------******C
C                (P3) SUBROUTINE FOR PISTON SKIRT                      C
C*****-------------------------********-------------------------******C
       SUBROUTINE P3(N,RPMH,RPML,RPMN,VISL,VISH,PCL,PCH,PISLL,PISLH,NCB,
      $ARMH,ARML,BOREH,BOREL,BOREB,ARMB,VISB,PCB,PISLB,PVPIS,PCPPIS,
      $PLPIS,PAPIS,PBPIS,PI,POINT,RPMMAX)
       IF (POINT.EQ.3) THEN
            RPMH = RPMMAX
         RPMMAX = RPMMAX
       ENDIF
       DRPM = (RPMH-RPML)/RPMN
      OPEN(UNIT=9,FILE='RESULT2.OUT',STATUS='OLD')
       WRITE(9,*) 'POWER LOSS FROM PISTON SKIRT  '
       WRITE(9,*) ' * POWER LOSS VARY WITH ABSOLUTE VISCOSITY '
       WRITE(9,*) '   ABSOLUTE VISCOSITY (Pa.s) & POWER LOSS (W)'
      DO 11 I = 0,RPMN,1
       DO 12 J = 0,N,1
          DVIS = (VISH-VISL)/N
           RPM = RPML + I*DRPM
           VIS = VISL + J*DVIS
         PVPIS = (VIS*PI*BOREB*PISLB/PCB)*((ARMB*(RPM/15))**2)*NCB
        WRITE(9,100) RPM,VIS,PVPIS
        WRITE(6,100) RPM,VIS,PVPIS
    12 CONTINUE
       WRITE(9,*) '  '
    11 CONTINUE
   100 FORMAT(1X,F7.2,3X,F9.7,3X,F7.2)
C*****-------------------------********-------------------------******C
       WRITE(9,*) ' * POWER LOSS VARY WITH PISTON CLEARANCE '
       WRITE(9,*) '   PISTON CLEARANCE (mm) & POWER LOSS (W) '
      DO 21  I = 0,RPMN,1
       DO 22 J = 0,N,1
           DPC = (PCH-PCL)/N
           RPM = RPML + I*DRPM
            PC = PCL + J*DPC
        PCPPIS = (VISB*PI*BOREB*PISLB/PC)*((ARMB*(RPM/15))**2)*NCB
         WRITE(9,200) RPM,PC,PCPPIS
         WRITE(6,200) RPM,PC,PCPPIS
    22 CONTINUE
       WRITE(9,*) '  '
    21 CONTINUE
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  200 FORMAT(1X,F7.2,3X,F9.7,3X,F7.2)
C*****-------------------------********-------------------------******C
      WRITE(9,*) '  * POWER LOSS VARY WITH SKIRT LENGTH '
      WRITE(9,*) '    SKIRT LENGTH (m) & POWER LOSS (W) '
     DO 31 I = 0,RPMN,1
      DO 32 J = 0,N,1
        DPISL = (PISLH-PISLL)/N
          RPM = RPML + I*DRPM
         PISL = PISLL + J*DPISL
        PLPIS = (VISB*PI*BOREB*PISL/PCB)*((ARMB*(RPM/15))**2)*NCB
        WRITE(9,300) RPM,PISL,PLPIS
        WRITE(6,300) RPM,PISL,PLPIS
   32 CONTINUE
      WRITE(9,*) '  '
   31 CONTINUE
  300 FORMAT(1X,F7.2,3X,F8.5,3X,F7.2)
C*****-------------------------********-------------------------******C
      WRITE(9,*) '  * POWER LOSS VARY WITH CRANK ARM '
      WRITE(9,*) '    CRANK ARM (m) & POWER LOSS (W) '
     DO 41 I = 0,RPMN,1
      DO 42 J = 0,N,1
         DARM = (ARMH-ARML)/N
          RPM = RPML + I*DRPM
          ARM = ARML + J*DARM
        PAPIS = (VISB*PI*BOREB*PISLB/PCB)*((ARM*(RPM/15))**2)*NCB
        WRITE(9,400) RPM,ARM,PAPIS
        WRITE(6,400) RPM,ARM,PAPIS
   42 CONTINUE
      WRITE(9,*) '  '
   41 CONTINUE
  400 FORMAT(1X,F7.2,3X,F7.4,3X,F7.2)
C*****-------------------------********-------------------------******C
      WRITE(9,*) '  * POWER LOSS VARY WITH PISTON BORE '
      WRITE(9,*) '    PISTON BORE (m) & POWER LOSS (W) '
     DO 51 I = 0,RPMN,1
      DO 52 J = 0,N,1
        DBORE = (BOREH-BOREL)/N
          RPM = RPML + I*DRPM
         BORE = BOREL + J*DBORE
        PBPIS = (VISB*PI*BORE*PISLB/PCB)*((ARMB*(RPM/15))**2)*NCB
        WRITE(9,500) RPM,BORE,PBPIS
        WRITE(6,500) RPM,BORE,PBPIS
   52 CONTINUE
      WRITE(9,*) '  '
   51 CONTINUE
  500 FORMAT(1X,F7.2,3X,F7.4,3X,F7.2)
      RETURN
      END
C*****-------------------------********-------------------------******C
C                (P4) SUBROUTINE FOR PISTON RING                      C
C*****-------------------------********-------------------------******C
      SUBROUTINE P4(N,RPMH,RPML,RPMN,VISL,VISH,BPRESSL,BPRESSH,
     $ BOILL,BOILH,BOREL,BOREH,ARML,ARMH,NCB,BOREB,ARMB,VISB,BPRESSB,
     $ BOILB,NPRESSB,NOILB,H,PVRING,PBPRING,PBORING,PBRING,PARING,
     $ PI,RP,RO,POINT,RPMMAX)
      IF (POINT.EQ.4) THEN
          RPMH = RPMMAX
         RPMMAX = RPMMAX
      ENDIF
      DRPM = (RPMH-RPML)/RPMN
      OPEN(UNIT=9,FILE='RESULT2.OUT',STATUS='OLD')
C*****-------------------------********-------------------------******C
      WRITE(9,*) 'POWER LOSS PISTON RING  '
      WRITE(9,*) ' * POWER LOSS VARY WITH ABSOLUTE VISCOSITY '
      WRITE(9,*) '   ABSOLUTE VISCOSITY (Pa.s) & POWER LOSS (W)'
     DO 11 I = 0,RPMN,1
      DO 12 J = 0,N,1
         DVIS = (VISH-VISL)/N
          RPM = RPML + I*DRPM
```

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          VIS = VISL + J*DVIS
C.........SUBPROGRAM FOR INTERATION NUM 1
       CALL NUM1(BPRESSB,BOILB,RP,RO,H,HP1,HO1,HP2,HO2,HP3,HO3)
       PVRING = VIS*ARMB*2*PI*(RPM/60)*(4*HO1-3*(HO2**2)/HO3+BOILB
      $          *(1-RO)/(1+RO))*4*ARMB*PI*BOREB*(RPM/60)*NOILB*NCB +
      $          VIS*ARMB*2*PI*(RPM/60)*(4*HP1-3*(HP2**2)/HP3+(BPRESSB
      $          *(1-RP)/(1+RP))/H)*4*ARMB*PI*BOREB*(RPM/60)*NPRESSB*NCB
        WRITE(9,100)  RPM,VIS,PVRING
        WRITE(6,100)  RPM,VIS,PVRING
    12 CONTINUE
        WRITE(9,*) '  '
    11 CONTINUE
   100 FORMAT(1X,F7.2,3X,F8.6,3X,F7.2)
C*****-------------------------********-------------------------******C
        WRITE(9,*) ' * POWER LOSS VARY WITH PRESSURE RING WIDTH '
        WRITE(9,*) '   PRESSURE RING WIDTH (mm) & POWER LOSS (W).'
       DO 21 I = 0,RPMN,1
        DO 22 J = 0,N,1
        DBPRESS = (BPRESSH-BPRESSL)/N
            RPM = RPML + I*DRPM
         BPRESS = BPRESSL + J*DBPRESS
C........SUBPROGRAM FOR INTERATION NUM 2
       CALL NUM2(BPRESS,BOILB,RP,RO,H,HP4,HO4,HP5,HO5,HP6,HO6)
       PBPRING = VISB*ARMB*2*PI*(RPM/60)*(4*HO4-3*(HO5**2)/HO6+BOILB
      $           *(1-RO)/(1+RO))*4*ARMB*PI*BOREB*(RPM/60)*NOILB*NCB +
      $           VISB*ARMB*2*PI*(RPM/60)*(4*HP4-3*(HP5**2)/HP6+(BPRESS
      $           *(1-RP)/(1+RP))/H)*4*ARMB*PI*BOREB*(RPM/60)*NPRESSB*NCB
        WRITE(9,200)  RPM,BPRESS,PBPRING
        WRITE(6,200)  RPM,BPRESS,PBPRING
    22 CONTINUE
        WRITE(9,*) '  '
    21 CONTINUE
   200 FORMAT(1X,F7.2,3X,F6.3,3X,F7.2)
C*****-------------------------********-------------------------******C
        WRITE(9,*) ' * POWER LOSS VARY WITH OIL RING WIDTH '
        WRITE(9,*) '   OIL RING WIDTH (mm) & POWER LOSS (W) '
       DO 31 I = 0,RPMN,1
        DO 32 J = 0,N,1
          DBOIL = (BOILH-BOILL)/N
            RPM = RPML + I*DRPM
           BOIL = BOILL + J*DBOIL
C........SUBPROGRAM FOR INTERATION NUM 3
         CALL NUM3(BPRESSB,BOIL,RP,RO,H,HP7,HO7,HP8,HO8,HP9,HO9)
         PBORING = VISB*ARMB*2*PI*(RPM/60)*(4*HO7-3*(HO8**2)/HO9+BOIL
      $            *(1-RO)/(1+RO))*4*ARMB*PI*BOREB*(RPM/60)*NOILB*NCB +
      $            VISB*ARMB*2*PI*(RPM/60)*(4*HP7-3*(HP8**2)/HP9+(BPRESSB
      $            *(1-RP)/(1+RP))/H)*4*ARMB*PI*BOREB*(RPM/60)*NPRESSB*NCB
        WRITE(9,300)  RPM,BOIL,PBORING
        WRITE(6,300)  RPM,BOIL,PBORING
    32 CONTINUE
        WRITE(9,*) '  '
    31 CONTINUE
   300 FORMAT(1X,F7.2,3X,F6.3,3X,F7.2)
C*****-------------------------********-------------------------******C
        WRITE(9,*) ' * POWER LOSS VARY WITH PISTON BORE '
        WRITE(9,*) '   PISTON BORE (m)  & POWER LOSS (W) '
       DO 41 I = 0,RPMN,1
        DO 42 J = 0,N,1
           DBORE = (BOREH-BOREL)/N
             RPM = RPML + I*DRPM
            BORE = BOREL + J*DBORE
            ARMV = ARMB*((BOREB/BORE)**2)
       CALL NUM1(BPRESSB,BOILB,RP,RO,H,HP1,HO1,HP2,HO2,HP3,HO3)
       PBRING = VISB*ARMV*2*PI*(RPM/60)*(4*HO1-3*(HO2**2)/HO3+BOILB
      $          *(1-RO)/(1+RO))*4*ARMV*PI*BORE*(RPM/60)*NOILB*NCB +
      $          VIS*ARMV*2*PI*(RPM/60)*(4*HP1-3*(HP2**2)/HP3+(BPRESSB
      $          *(1-RP)/(1+RP))/H)*4*ARMV*PI*BORE*(RPM/60)*NPRESSB*NCB
        WRITE(9,400)  RPM,BORE,PBRING
        WRITE(6,400)  RPM,BORE,PBRING
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   42 CONTINUE
      WRITE(9,*) '   '
   41 CONTINUE
  400 FORMAT(1X,F7.2,3X,F7.5,3X,F7.2)
C*****-------------------------********-------------------------******C
      WRITE(9,*) ' * POWER LOSS VARY WITH CRANK ARM '
      WRITE(9,*) '   CRANK ARM (m) & POWER LOSS (W) '
      DO 51 I = 0,RPMN,1
       DO 52 J = 0,N,1
          DARM = (ARMH-ARML)/N
           RPM = RPML + I*DRPM
           ARM = ARML + J*DARM
      CALL NUM1(BPRESSB,BOILB,RP,RO,H,HP1,HO1,HP2,HO2,HP3,HO3)
        BOREV = BOREB*SQRT(ARMB/ARM)
       PARING = VISB*ARM*2*PI*(RPM/60)*(4*HO1-3*(HO2**2)/HO3+BOILB
     $             *(1-RO)/(1+RO))*4*ARM*PI*BOREV*(RPM/60)*NOILB*NCB +
     $             VIS*ARM*2*PI*(RPM/60)*(4*HP1-3*(HP2**2)/HP3+(BPRESSB
     $             *(1-RP)/(1+RP))/H)*4*ARM*PI*BOREV*(RPM/60)*NPRESSB*NCB
       WRITE(9,500) RPM,ARM,PARING
       WRITE(6,500) RPM,ARM,PARING
   52 CONTINUE
       WRITE(9,*) '    '
   51 CONTINUE
  500 FORMAT(1X,F7.2,3X,F7.5,3X,F7.2)
      RETURN
      END
C*****-------------------------********-------------------------******C
C                (P5) SUBROUTINE FOR CAM LOAD                          C
C*****-------------------------********-------------------------******C
      SUBROUTINE P5(N,RPMH,RPML,RPMN,FML,FMH,SCL,SCH,PLL,PLH,BRL,BRH
     $          ,TRL,TRH,VLL,VLH,NVCB,NCB,FMB,SCB,PLB,BRB,TRB,VLB,SDEGB
     $          ,PFCAM,PSCAM,PPCAM,PBCAM,PTCAM,PVCAM,PI,FCOE,POINT,RPMMAX)
        FB = (BRB**2-TRB**2+(BRB+VLB-TRB)**2-2*BRB*(BRB+VLB-TRB)
     $         *SIN(SDEGB*PI/180))/(2*(BRB-TRB-(BRB+VLB-TRB)
     $         *SIN(SDEGB*PI/180)))
       IF (POINT.EQ.5) THEN
            RPMH = 3000.
          RPMMAX = RPMMAX
       ENDIF
       CDEGB = ACOS( (FB-BRB)*COS(SDEGB*PI/180)/(FB-TRB) )*180/PI
       OPEN(UNIT=9,FILE='RESULT2.OUT',STATUS='OLD')
       WRITE(9,*) 'POWER LOSS CAM LOAD '
       WRITE(9,*) ' * POWER LOSS VARY WITH FOLLOWER MASS '
       WRITE(9,*) '   FOLLOWER MASS(kg) & POWER LOSS (W) '
        DRPM = (RPMH-RPML)/RPMN
       DO 11 I = 0,RPMN,1
       DO 12 J = 0,N,1
            DFM = (FMH-FML)/N
            RPM = RPML + I*DRPM
           RPMC = RPM/2
           RADC = (RPMC*2*PI/60)
             FM = FML + J*DFM
C.....SUBPROGRAM TMEAN1 FOR CALCULATE MEAN TORQUE
      CALL TMEAN1(FCOE,SDEGB,FB,CDEGB,FM,SCB,PLB,BRB,TRB,VLB,RADC,TOR1
     $     ,PI)
        PFCAM = -TOR1*RADC*NCB*NVCB
       WRITE(9,100) RPM,FM,PFCAM
       WRITE(6,100) RPM,FM,PFCAM
   12 CONTINUE
       WRITE(9,*) '   '
   11 CONTINUE
  100 FORMAT(1X,F7.2,3X,F6.3,3X,F7.2)
C*****-------------------------********-------------------------******C
      WRITE(9,*) ' * POWER LOSS VARY WITH SRING CONSTANT '
      WRITE(9,*) '   SPRING CONSTANT (N/m) & POWER LOSS (W) '
      DO 21 I = 0,RPMN,1
       DO 22 J = 0,N,1
           DSC = (SCH-SCL)/N
           RPM = RPML + I*DRPM
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          RPMC = RPM/2
          RADC = (RPMC*2*PI/60)
            SC = SCL + J*DSC
C........SUBPROGRAM TMEAN2 FOR CALCULATE MEAN TORQUE
       CALL TMEAN2(FCOE,SDEGB,FB,CDEGB,FMB,SC,PLB,BRB,TRB,VLB,RADC,TOR2
     $,PI)
          PSCAM = -TOR2*RADC*NCB*NVCB
       WRITE(9,200) RPM,SC,PSCAM
       WRITE(6,200) RPM,SC,PSCAM
    22 CONTINUE
       WRITE(9,*) '  '
    21 CONTINUE
   200 FORMAT(1X,F7.2,3X,F8.2,3X,F7.2)
C*****-------------------------********-------------------------******C
       WRITE(9,*) ' * POWER LOSS VARY WITH SPRING PRELOAD '
       WRITE(9,*) '   SPRING PRELOAD (N) & POWER LOSS (W) '
       DO 31 I = 0,RPMN,1
       DO 32 J = 0,N,1
          DPL = (PLH-PLL)/N
          RPM = RPML + I*DRPM
          RPMC = RPM/2
          RADC = (RPMC*2*PI/60)
            PL = PLL + J*DPL
C........SUBPROGRAM TMEAN3 FOR CALCULATE MEAN TORQUE
       CALL TMEAN3(FCOE,SDEGB,FB,CDEGB,FMB,SCB,PL,BRB,TRB,VLB,RADC,TOR3
     $,PI)
          PPCAM = -TOR3*RADC*NCB*NVCB
       WRITE(9,300) RPM,PL,PPCAM
       WRITE(6,300) RPM,PL,PPCAM
    32 CONTINUE
       WRITE(9,*) '  '
    31 CONTINUE
   300 FORMAT(1X,F7.2,3X,F6.2,3X,F7.2)
C*****-------------------------********-------------------------******C
       WRITE(9,*) ' * POWER LOSS VARY WITH BASE RADIUS '
       WRITE(9,*) '   BASE RADIUS (mm.) & POWER LOSS (W) '
       DO 41 I = 0,RPMN,1
       DO 42 J = 0,N,1
          DBR = (BRH-BRL)/N
          RPM = RPML + I*DRPM
          RPMC = RPM/2
          RADC = (RPMC*2*PI/60)
            BR = BRL + J*DBR
          FBR = (BR**2-TRB**2+(BR+VLB-TRB)**2-2*BR*(BR+VLB-TRB)
     $             *SIN(SDEGB*PI/180))
     $        /(2*(BR-TRB-(BR+VLB-TRB)*SIN(SDEGB*PI/180)))
       CDEGBR = ACOS( (FBR-BR)*COS(SDEGB*PI/180)/(FBR-TRB) )*180/PI
C........SUBPROGRAM TMEAN4 FOR CALCULATE MEAN TORQUE
       CALL TMEAN4(FCOE,SDEGB,FBR,CDEGBR,FMB,SCB,PLB,BR,TRB,VLB,RADC
     $,TOR4,PI)
          PBCAM = -TOR4*RADC*NCB*NVCB
       WRITE(9,400) RPM,BR,PBCAM
       WRITE(6,400) RPM,BR,PBCAM
    42 CONTINUE
       WRITE(9,*) '  '
    41 CONTINUE
   400 FORMAT(1X,F7.2,3X,F6.3,3X,F7.2)
C*****-------------------------********-------------------------******C
       WRITE(9,*) ' * POWER LOSS VARY WITH TIP RADIUS '
       WRITE(9,*) '   TIP RADIUS (mm.) & POWER LOSS (W) '
       DO 51 I = 0,RPMN,1
       DO 52 J = 0,N,1
          DTR = (TRH-TRL)/N
          RPM = RPML + I*DRPM
          RPMC = RPM/2
          RADC = (RPMC*2*PI/60)
            TR = TRL + J*DTR
          FTR = (BRB**2-TR**2+(BRB+VLB-TR)**2-2*BRB*(BRB+VLB-TR)
     $             *SIN(SDEGB*PI/180))
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     $              /(2*(BRB-TR-(BRB+VLB-TR)*SIN(SDEGB*PI/180)))
       CDEGTR = ACOS( (FTR-BRB)*COS(SDEGB*PI/180)/(FTR-TR) )*180/PI
C.....SUBPROGRAM TMEAN5 FOR CALCULATE MEAN TORQUE
      CALL TMEAN5(FCOE,SDEGB,FTR,CDEGTR,FMB,SCB,PLB,BRB,TR,VLB,RADC
     $,TOR5,PI)
        PTCAM = -TOR5*RADC*NCB*NVCB
       WRITE(9,500) RPM,TR,PTCAM
       WRITE(6,500) RPM,TR,PTCAM
   52 CONTINUE
       WRITE(9,*) '  '
   51 CONTINUE
  500 FORMAT(1X,F7.2,3X,F6.3,3X,F7.2)
C*****-------------------------********-------------------------******C
      WRITE(9,*) ' * POWER LOSS VARY WITH TIP RADIUS '
      WRITE(9,*) '   BASE , TIP RADIUS (mm.) & POWER LOSS (W) '
      DO 511 I = 0,RPMN,1
       DO 521 J = 0,N,1
         DO 531 K = 0,N,1
            DRPM = (RPMH-RPML)/RPMN
             DBR = (BRH-BRL)/N
             DTR = (TRH-TRL)/N
             RPM = RPML + I*DRPM
             BR = BRL + J*DBR
             TR = TRL + K*DTR
            RPMC = RPM/2
            RADC = (RPMC*2*PI/60)
            FBTR = (BR**2-TR**2+(BR+VLB-TR)**2
     $                -2*BR*(BR+VLB-TR)*SIN(SDEGB*PI/180))
     $                /(2*(BR-TR-(BR+VLB-TR)
     $                *SIN(SDEGB*PI/180)))
        CDEGBTR = (ACOS((FBTR-BR)*COS(SDEGB*PI/180)
     $                /(FBTR-TR)))*180/PI
C.....SUBPROGRAM TMEA51 FOR CALCULATE MEAN TORQUE
      CALL TMEAN51(FCOE,SDEGB,FBTR,CDEGBTR,FMB,SCB,PLB,BR,TR
     $     ,VLB,RADC,TOR51,PI)
         PBTCAM = -TOR51*RADC*NCB*NVCB
       WRITE(9,501) RPM,BR,TR,PBTCAM
       WRITE(6,501) RPM,BR,TR,PBTCAM
  531 CONTINUE
  521 CONTINUE
       WRITE(9,*) '  '
  511 CONTINUE
  501 FORMAT(1X,F7.2,3X,F6.3,3X,F6.3,3X,F7.2)
C*****-------------------------********-------------------------******C
      WRITE(9,*) ' * POWER LOSS VARY WITH VALVE LIFT '
      WRITE(9,*) '   VALVE LIFT (mm.) & POWER LOSS (W) '
      DO 61 I = 0,RPMN,1
       DO 62 J = 0,N,1
           DVL = (VLH-VLL)/N
           RPM = RPML + I*DRPM
          RPMC = RPM/2
          RADC = (RPMC*2*PI/60)
            VL = VLL + J*DVL
           FVL = (BRB**2-TRB**2+(BRB+VL-TRB)**2-2*BRB*(BRB+VL-TRB)
     $             *SIN(SDEGB*PI/180))
     $             /(2*(BRB-TRB-(BRB+VL-TRB)*SIN(SDEGB*PI/180)))
       CDEGVL = (ACOS((FVL-BRB)*COS(SDEGB*PI/180)
     $             /(FVL-TRB)))*180/PI
C.....SUBPROGRAM TMEAN6 FOR CALCULATE MEAN TORQUE
      CALL TMEAN6(FCOE,SDEGB,FVL,CDEGVL,FMB,SCB,PLB,BRB,TRB,VL,RADC
     $,TOR6,PI)
        PVCAM = -TOR6*RADC*NCB*NVCB
       WRITE(9,600) RPM,VL,PVCAM
       WRITE(6,600) RPM,VL,PVCAM
   62 CONTINUE
       WRITE(6,*) '  '
   61 CONTINUE
  600 FORMAT(1X,F7.2,3X,F7.2,3X,F7.2)
      RETURN
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      END
C*****-------------------------********-------------------------******C
C                  (P6) SUBROUTINE FOR ACCESSORIES LOAD                 C
C*****-------------------------********-------------------------******C
      SUBROUTINE P6(N,RPMH,RPML,RPMN,BCOMB,SCOMB,NCB,BOREB,ARMB,RKB,EMB,
     $ECB,RDALTB,RLALTB,QH,QL,H1,H2,V1,RDALTL,RDALTH,RLALTL,RLALTH,RCOM,
     $NCOM,PCLE,EVAPP,CONDP,CORRK,RALT,PWP,PAIRQ,PALTD,PALTL,PI,POINT,
     $FRAC,RPMMAX)
       AMPB = 50.
      VOLTB = 12.
       VOLEEF = 1.+(PCLE/100.)*(1.-CONDP/EVAPP)
       IF (POINT.EQ.6) THEN
            RPMH = 2600.
         RPMMAX = RPMMAX
       ENDIF
       DRPM = (RPMH-RPML)/RPMN
      OPEN(UNIT=9,FILE='RESULT2.OUT',STATUS='OLD')
       WRITE(9,*) 'POWER LOSS FROM ACCESSORIES LOAD      '
       WRITE(9,*) ' * POWER LOSS VARY WITH COOLING LOAD '
       WRITE(9,*) '   COOLING LOAD (W) & POWER LOSS (W) '
      DO 11 I = 1,2,1
       DO 12 J = 0,N,1
            DQ = (QH-QL)/N
             Q = QL + J*DQ
       DO 13 K = 0,RPMN,1
        IF (I.EQ.1) THEN
       RPMCOOL = Q/(H1-H2)*4.*60.*V1/
     $             (PI*SCOMB*NCOM*VOLEEF*RCOM*(BCOMB)**2)
         DRPMC = (RPMCOOL-RPML)/RPMN
          RPMV = RPML + K*DRPMC
         PAIRQ = (PI/4.)*(BCOMB**2.)*SCOMB*NCOM*RCOM*(RPMV/60.)*VOLEEF
     $            *(RKB/(RKB-1.))*(1.-(CONDP/EVAPP)**((RKB-1.)/RKB))
     $            *EVAPP*(1./(EMB*ECB))*(-1.)
        ELSE
         DRPMC = (RPMH-RPMCOOL)/RPMN
          RPMV = RPMCOOL + K*DRPMC
         PAIRQ = Q/(H1-H2)*EVAPP*V1*(RKB/(RKB-1.))
     $            *(1.-(CONDP/EVAPP)**((RKB-1.)/RKB))
     $            *(1./(EMB*ECB))*(-1.)
        ENDIF
       WRITE(9,101) RPMV,Q,PAIRQ
       WRITE(6,101) RPMV,Q,PAIRQ
   13 CONTINUE
       WRITE(9,*) '    '
   12 CONTINUE
       WRITE(9,*) '    '
   11 CONTINUE
  101 FORMAT(1X,F7.2,3X,F7.2,3X,F8.2)
C*****-------------------------********-------------------------******C
       WRITE(9,*) ' * POWER LOSS VARY WITH ROTOR DIAMETER  '
       WRITE(9,*) '   ROTOR DIAMETER (m) & POWER LOSS (W)  '
      DO 21 I = 0,RPMN,1
       DO 22 J = 0,N,1
        DRDALT = (RDALTH - RDALTL)/N
           RPM = RPML + I*DRPM
         RDALT = RDALTL + J*DRDALT
         PALTD = AMPB*VOLTB + (100./FRAC)*(1./3.)*CORRK*
     $            ((RALT*PI*RDALT*RPM/3048.)**2.5)*1000
     $            *(RDALT/0.0254)*((RLALTB/0.0254)**0.5)
       WRITE(9,201) RPM,RDALT,PALTD
       WRITE(6,201) RPM,RDALT,PALTD
   22 CONTINUE
       WRITE(9,*) '    '
   21 CONTINUE
  201 FORMAT(1X,F7.2,3X,F7.4,3X,F7.2)
C*****-------------------------********-------------------------******C
       WRITE(9,*) ' * POWER LOSS VARY WITH ROTOR LENGTH  '
       WRITE(9,*) '   ROTOR LENGTH (m) & POWER LOSS (W)  '
      DO 23 I = 0,RPMN,1
```

```
      DO 24 J = 0,N,1
       DRLALT = (RLALTH - RLALTL)/N
          RPM = RPML + I*DRPM
        RLALT = RLALTL + J*DRLALT
        PALTL = AMPB*VOLTB + (100./FRAC)*(1/3.)*CORRK*
     $             ((RALT*PI*RDALTB*RPM/3048.)**2.5)*1000
     $             *(RDALTB/0.0254)*((RLALT/0.0254)**0.5)
       WRITE(9,202) RPM,RLALT,PALTL
       WRITE(6,202) RPM,RLALT,PALTL
   24 CONTINUE
       WRITE(9,*) '    '
   23 CONTINUE
  202 FORMAT(1X,F7.2,3X,F7.4,3X,F7.2)
C*****-------------------------********-------------------------------******C
       WRITE(9,*) ' * POWER LOSS VARY WITH WATER&OIL PUMP   '
       WRITE(9,*) '   ENGINE SPEED (rpm) & POWER LOSS (W)   '
        RPMH = RPMMAX
        DRPM = (RPMH-RPML)/RPMN
       DO 25 I = 0,RPMN,1
          RPM = RPML + I*DRPM
          PWP = (269./12.)*((RPM/1000.)**1.5)*RPM
     $             *(2.*ARMB*NCB*PI*(BOREB**2.)/4.)
       WRITE(9,203) RPM,PWP
       WRITE(6,203) RPM,PWP
   25 CONTINUE
       WRITE(9,*) '    '
  203 FORMAT(1X,F7.2,3X,F7.2)
       RETURN
       END
C*****-------------------------********-------------------------------******C
C                (P7) SUBROUTINE FOR PUMPING LOSSES                        C
C*****-------------------------********-------------------------------******C
       SUBROUTINE P7(N,RPMH,RPML,RPMN,DHH,DHL,M,DVL,DVH,RCL,RCH,NCB,
      $BOREB,ARMB,DVB,RCB,NVB,DENHG,PE,PA,PDPUMP,PRPUMP,PI,POINT,RPMMAX)
       IF (POINT.EQ.7) THEN
            RPMH = 4000.
         RPMMAX = RPMMAX
       ENDIF
       DRPM = (RPMH-RPML)/RPMN
        DDH = (DHH-DHL)/M
       OPEN(UNIT=9,FILE='RESULT2.OUT',STATUS='OLD')
       WRITE(9,*) 'POWER LOSS FROM PUMPING LOSSES '
       WRITE(9,*) ' * POWER LOSS VARY WITH VALVE DIAMETER '
       WRITE(9,*) '   VALVE DAIMETER (m) & PUMPING LOSS (W) '
       DO 11 I = 0,RPMN,1
        DO 12 J = 0,M,1
          DO 13 K = 0,N,1
             DDV = (DVH-DVL)/N
             RPM = RPML + I*DRPM
              DH = DHL + J*DDH
              DV = DVL + K*DDV
             PIA = 9.81*DENHG*DH*0.0254/1000
           CIMEP = 12.87*PA*((PIA/PA)-0.1)
             PIG = PA-(CIMEP/12.8)-10.14
               F = (NVB*NCB*(DV**2))/(2*ARMB*PI*NCB*(BOREB**2)/4)
      PDPUMP = (PA-(CIMEP/12.8)-10.14+PE*(((CIMEP*RPM)/(3904000))**2) +
     $          8.9667*(SQRT(CIMEP/1124.3))*((RPM/1000)**1.7)
     $          *((2.984/F)**1.28) + (SQRT((PA-PIG)/97.94))
     $          *(11.86*(RCB**0.4)-(3.38+0.103*RCB)*((RPM/1000)**1.185)))
     $          *1000*(2*ARMB*PI*NCB*(BOREB**2)/4)*(RPM/120)
       WRITE(9,100) RPM,DH,DV,PDPUMP
       WRITE(6,100) RPM,DH,DV,PDPUMP
   13 CONTINUE
       WRITE(9,*) '   '
   12 CONTINUE
       WRITE(9,*) '   '
   11 CONTINUE
  100 FORMAT(1X,F7.2,3X,F5.2,3X,F9.6,2X,F9.2)
C*****-------------------------********-------------------------------******C
```

```
      WRITE(9,*) ' * POWER LOSS VARY WITH COMPRESSION RATIO '
      WRITE(9,*) '   COMPRESSION RATIO & PUMPING LOSS (W) '
      DO 21 I = 0,RPMN,1
      DO 22 J = 0,M,1
        DO 23 K = 0,N,1
           DRC = (RCH-RCL)/N
           RPM = RPML + I*DRPM
            DH = DHL + J*DDH
            RC = RCL + K*DRC
           PIA = 9.81*DENHG*DH*0.0254/1000
         CIMEP = 12.87*PA*((PIA/PA)-0.1)
           PIG = PA-(CIMEP/12.8)-10.14
            F = (NVB*NCB*(DVB**2))/(2*ARMB*PI*NCB*(BOREB**2)/4)
      PRPUMP = (PA-(CIMEP/12.8)-10.14+PE*(((CIMEP*RPM)/(3904000))**2) +
     $          8.9667*(SQRT(CIMEP/1124.3))*((RPM/1000)**1.7)
     $          *((2.984/F)**1.28) + (SQRT((PA-PIG)/97.94))
     $          *(11.86*(RC**0.4)-(3.38+0.103*RC)*((RPM/1000)**1.185)))
     $          *1000*(2*ARMB*PI*NCB*(BOREB**2)/4)*(RPM/120)
       WRITE(9,200) RPM,DH,RC,PRPUMP
       WRITE(6,200) RPM,DH,RC,PRPUMP
   23 CONTINUE
       WRITE(9,*) '  '
   22 CONTINUE
       WRITE(9,*) '  '
   21 CONTINUE
  200 FORMAT(1X,F7.2,3X,F6.2,3X,F6.2,3X,F9.2)
      RETURN
      END
C*****-------------------------********-------------------------******C
C       (P8) SUBROUTINE FOR CALCULATION ENGINE POWER REQUIRED          C
C*****-------------------------********-------------------------******C
      SUBROUTINE P8(N,CDB,AREAB,FRB,MGB,WR,RPMH,RPML,RPMN,CDL,CDH,AFL,
     $   AFH,FRL,FRH,MGL,MGH,G1,G2,G3,G4,G5,GD,PI,AIRDEN,PAIRC,PAIRA,
     $   PROLLF,PROLLM,POINT,RPMMAX)
       IF (POINT.EQ.8) THEN
            RPMH = RPMMAX
         RPMMAX = RPMMAX
       ENDIF
         DRPM = (RPMH-RPML)/RPMN
      OPEN(UNIT=9,FILE='RESULT2.OUT',STATUS='OLD')
C*****-------------------------********-------------------------******C
       WRITE(9,*) ' * POWER LOSS VARY WITH CD '
       WRITE(9,*) '   CD & POWER LOSS (W) '
      DO 11 I = 0,RPMN,1
       DO 12 J = 0,N,1
           RPM = RPML + I*DRPM
           DCD = (CDH-CDL)/N
            CD = CDL + J*DCD
      CALL SEL1(RPM,GN,G1,G2,G3,G4,G5,GD,TEFF,GT)
         PAIRC = 0.5*CD*AIRDEN*AREAB*(((RPM/60)*2*PI*WR/GT)**3)
            V1 = (RPM/60)*2*PI*WR/GT*3.6
        WRITE(9,100) V1,CD,PAIRC
        WRITE(6,100) V1,CD,PAIRC
   12 CONTINUE
        WRITE(9,*) '  '
   11 CONTINUE
  100 FORMAT(1X,F7.2,3X,F7.4,3X,F10.2)
C*****-------------------------********-------------------------******C
       WRITE(9,*) ' * POWER LOSS VARY WITH FRONTAL AREA '
       WRITE(9,*) '   A (m^2) & POWER LOSS (W) '
      DO 21 I = 0,RPMN,1
       DO 22 J = 0,N,1
           RPM = RPML + I*DRPM
           DAF = (AFH-AFL)/N
            AF = AFL + J*DAF
      CALL SEL1(RPM,GN,G1,G2,G3,G4,G5,GD,TEFF,GT)
         PAIRA = 0.5*CDB*AIRDEN*AF*( (RPM/60)*2*PI*WR/GT )**3
            V2 = (RPM/60)*2*PI*WR/GT*3.6
        WRITE(9,200) V2,AF,PAIRA
```

```
      WRITE(6,200) V2,AF,PAIRA
   22 CONTINUE
      WRITE(9,*) '  '
   21 CONTINUE
  200 FORMAT(1X,F7.2,3X,F7.3,3X,F10.2)
C*****-------------------------********-------------------------******C
      WRITE(9,*) ' * POWER LOSS VARY WITH ROLLING COEFFICENT '
      WRITE(9,*) '   f & POWER LOSS (W) '
      DO 31 I = 0,RPMN,1
      DO 32 J = 0,N,1
          RPM = RPML + I*DRPM
          DFR = (FRH-FRL)/N
           FR = FRL + J*DFR
      CALL SEL1(RPM,GN,G1,G2,G3,G4,G5,GD,TEFF,GT)
        PROLLF = FR*MGB*9.81*( (RPM/60)*2*PI*WR/GT )
            V3 = (RPM/60)*2*PI*WR/GT*3.6
        WRITE(9,300) V3,FR,PROLLF
        WRITE(6,300) V3,FR,PROLLF
   32 CONTINUE
      WRITE(9,*) '  '
   31 CONTINUE
  300 FORMAT(1X,F7.2,3X,F9.7,3X,F9.2)
C*****-------------------------********-------------------------******C
      WRITE(9,*) ' * POWER LOSS VARY WITH VEHICLE MASS '
      WRITE(9,*) '   M & POWER LOSS (W) '
      DO 41 I = 0,RPMN,1
      DO 42 J = 0,N,1
          RPM = RPML + I*DRPM
          DMG = (MGH-MGL)/N
          VMG = MGL + J*DMG
      CALL SEL1(RPM,GN,G1,G2,G3,G4,G5,GD,TEFF,GT)
        PROLLM = FRB*VMG*9.81*( (RPM/60)*2*PI*WR/GT )
            V4 = (RPM/60)*2*PI*WR/GT*3.6
        WRITE(9,400) V4,VMG,PROLLM
        WRITE(6,400) V4,VMG,PROLLM
   42 CONTINUE
      WRITE(9,*) '  '
   41 CONTINUE
  400 FORMAT(1X,F7.2,3X,F9.3,3X,F9.2)
      RETURN
      END
C*****-------------------------********-------------------------******C
C          THIS PARTS ARE SUBPROGRAM FOR NUMERICAL CALCULATION          C
C*****-------------------------********-------------------------******C
C                           SUBROUTINE NUM 1                            C
C*****-------------------------********-------------------------******C
      SUBROUTINE NUM1(BPRESSB,BOILB,RP,RO,H,HP1,HO1,HP2,HO2,HP3,HO3)
      N     = 100
      A     = 0.
      A1P   = 0.0015
      A1O   = 0.0025
      BP    = RP*(BPRESSB/(1+RP))
      BO    = RO*(BOILB/(1+RO))
      DHP   = (BP-A)/N
      DHO   = (BO-A)/N
      SUMP1 = 0.
      SUMO1 = 0.
      SUMP2 = 0.
      SUMO2 = 0.
      SUMP3 = 0.
      SUMO3 = 0.
      DO 10 I = 1,N-1
       XP = I*DHP
       XO = I*DHO
       FXP1 = 1/(A1P*XP**2-((1+RP)/(1000*RP)+(A1P*RP*BPRESSB)/
     $         (1+RP))*XP+H+BPRESSB/1000)
       FXO1 = 1/(A1O*XO**2-((1+RO)/(1000*RO)+(A1O*RO*BOILB)/
     $         (1+RP))*XO+H+BOILB/1000)
       FXP2 = (1/(A1P*XP**2-((1+RP)/(1000*RP)+(A1P*RP*BPRESSB)/
```

```
     $          (1+RP))*XP+H+BPRESSB/1000))**2
          FXO2 = (1/(A1O*XO**2-((1+RO)/(1000*RO)+(A1O*RO*BOILB)/
     $          (1+RP))*XO+H+BOILB/1000))**2
          FXP3 = (1/(A1P*XP**2-((1+RP)/(1000*RP)+(A1P*RP*BPRESSB)/
     $          (1+RP))*XP+H+BPRESSB/1000))**3
          FXO3 = (1/(A1O*XO**2-((1+RO)/(1000*RO)+(A1O*RO*BOILB)/
     $          (1+RP))*XO+H+BOILB/1000))**3
          SUMP1 = SUMP1 + FXP1
          SUMO1 = SUMO1 + FXO1
          SUMP2 = SUMP2 + FXP2
          SUMO2 = SUMO2 + FXO2
          SUMP3 = SUMP3 + FXP3
          SUMO3 = SUMO3 + FXO3
       10 CONTINUE
          FXP01 = 1/(H+BPRESSB/1000)
          FXO01 = 1/(H+BOILB/1000)
          FXP02 = (1/(H+BPRESSB/1000))**2
          FXO02 = (1/(H+BOILB/1000))**2
          FXP03 = (1/(H+BPRESSB/1000))**3
          FXO03 = (1/(H+BOILB/1000))**3
          FXPN1 = 1/H
          FXON1 = 1/H
          FXPN2 = (1/H)**2
          FXON2 = (1/H)**2
          FXPN3 = (1/H)**3
          FXON3 = (1/H)**3
          HP1   = (+FXP01+FXPN1+2*SUMP1)*DHP/2
          HO1   = (+FXO01+FXON1+2*SUMO1)*DHO/2
          HP2   = (+FXP02+FXPN2+2*SUMP2)*DHP/2
          HO2   = (+FXO02+FXON2+2*SUMO2)*DHO/2
          HP3   = (+FXP03+FXPN3+2*SUMP3)*DHP/2
          HO3   = (+FXO03+FXON3+2*SUMO3)*DHO/2
          RETURN
          END
C*****-------------------------*********-------------------------------******C
C                          SUBROUTINE NUM 2                                   C
C*****-------------------------*********-------------------------------******C
          SUBROUTINE NUM2(BPRESS,BOILB,RP,RO,H,HP4,HO4,HP5,HO5,HP6,HO6)
          N     = 100
          A     = 0.
          A1P   = 0.0015
          A1O   = 0.0025
          BP    = RP*(BPRESS/(1+RP))
          BO    = RO*(BOILB/(1+RO))
          DHP   = (BP-A)/N
          DHO   = (BO-A)/N
          SUMP4 = 0.
          SUMO4 = 0.
          SUMP5 = 0.
          SUMO5 = 0.
          SUMP6 = 0.
          SUMO6 = 0.
          DO 10 I = 1,N-1
            XP = I*DHP
            XO = I*DHO
            FXP4 = 1/(A1P*XP**2-((1+RP)/(1000*RP)+(A1P*RP*BPRESS)/
     $          (1+RP))*XP+H+BPRESS/1000)
            FXO4 = 1/(A1O*XO**2-((1+RO)/(1000*RO)+(A1O*RO*BOILB)/
     $          (1+RP))*XO+H+BOILB/1000)
            FXP5 = (1/(A1P*XP**2-((1+RP)/(1000*RP)+(A1P*RP*BPRESS)/
     $          (1+RP))*XP+H+BPRESS/1000))**2
            FXO5 = (1/(A1O*XO**2-((1+RO)/(1000*RO)+(A1O*RO*BOILB)/
     $          (1+RP))*XO+H+BOILB/1000))**2
            FXP6 = (1/(A1P*XP**2-((1+RP)/(1000*RP)+(A1P*RP*BPRESS)/
     $          (1+RP))*XP+H+BPRESS/1000))**3
            FXO6 = (1/(A1O*XO**2-((1+RO)/(1000*RO)+(A1O*RO*BOILB)/
     $          (1+RP))*XO+H+BOILB/1000))**3
            SUMP4 = SUMP4 + FXP4
            SUMO4 = SUMO4 + FXO4
```

```
      SUMP5 = SUMP5 + FXP5
      SUMO5 = SUMO5 + FXO5
      SUMP6 = SUMP6 + FXP6
      SUMO6 = SUMO6 + FXO6
   10 CONTINUE
      FXP04 = 1/(H+BPRESS/1000)
      FXO04 = 1/(H+BOILB/1000)
      FXP05 = (1/(H+BPRESS/1000))**2
      FXO05 = (1/(H+BOILB/1000))**2
      FXP06 = (1/(H+BPRESS/1000))**3
      FXO06 = (1/(H+BOILB/1000))**3
      FXPN4 = 1/H
      FXON4 = 1/H
      FXPN5 = (1/H)**2
      FXON5 = (1/H)**2
      FXPN6 = (1/H)**3
      FXON6 = (1/H)**3
      HP4   = (+FXP04+FXPN4+2*SUMP4)*DHP/2
      HO4   = (+FXO04+FXON4+2*SUMO4)*DHO/2
      HP5   = (+FXP05+FXPN5+2*SUMP5)*DHP/2
      HO5   = (+FXO05+FXON5+2*SUMO5)*DHO/2
      HP6   = (+FXP06+FXPN6+2*SUMP6)*DHP/2
      HO6   = (+FXO06+FXON6+2*SUMO6)*DHO/2
      RETURN
      END
C*****------------------------********-----------------------------******C
C                          SUBROUTINE NUM 3                             C
C*****------------------------********-----------------------------******C
      SUBROUTINE NUM3(BPRESSB,BOIL,RP,RO,H,HP7,HO7,HP8,HO8,HP9,HO9)
      N     = 100
      A     = 0.
      A1P   = 0.0015
      A1O   = 0.0025
      BP    = RP*(BPRESSB/(1+RP))
      BO    = RO*(BOIL/(1+RO))
      DHP   = (BP-A)/N
      DHO   = (BO-A)/N
      SUMP7 = 0.
      SUMO7 = 0.
      SUMP8 = 0.
      SUMO8 = 0.
      SUMP9 = 0.
      SUMO9 = 0.
      DO 10 I = 1,N-1
       XP = I*DHP
       XO = I*DHO
       FXP7 = 1/(A1P*XP**2-((1+RP)/(1000*RP)+(A1P*RP*BPRESSB)/
     $         (1+RP))*XP+H+BPRESSB/1000)
       FXO7 = 1/(A1O*XO**2-((1+RO)/(1000*RO)+(A1O*RO*BOIL)/
     $         (1+RP))*XO+H+BOIL/1000)
       FXP8 = (1/(A1P*XP**2-((1+RP)/(1000*RP)+(A1P*RP*BPRESSB)/
     $         (1+RP))*XP+H+BPRESSB/1000))**2
       FXO8 = (1/(A1O*XO**2-((1+RO)/(1000*RO)+(A1O*RO*BOIL)/
     $         (1+RP))*XO+H+BOIL/1000))**2
       FXP9 = (1/(A1P*XP**2-((1+RP)/(1000*RP)+(A1P*RP*BPRESSB)/
     $         (1+RP))*XP+H+BPRESSB/1000))**3
       FXO9 = (1/(A1O*XO**2-((1+RO)/(1000*RO)+(A1O*RO*BOIL)/
     $         (1+RP))*XO+H+BOIL/1000))**3
       SUMP7 = SUMP7 + FXP7
       SUMO7 = SUMO7 + FXO7
       SUMP8 = SUMP8 + FXP8
       SUMO8 = SUMO8 + FXO8
       SUMP9 = SUMP9 + FXP9
       SUMO9 = SUMO9 + FXO9
   10 CONTINUE
      FXP07 = 1/(H+BPRESSB/1000)
      FXO07 = 1/(H+BOIL/1000)
      FXP08 = (1/(H+BPRESSB/1000))**2
      FXO08 = (1/(H+BOIL/1000))**2
```

```
      FXP09 = (1/(H+BPRESSB/1000))**3
      FXO09 = (1/(H+BOIL/1000))**3
      FXPN7 = 1/H
      FXON7 = 1/H
      FXPN8 = (1/H)**2
      FXON8 = (1/H)**2
      FXPN9 = (1/H)**3
      FXON9 = (1/H)**3
      HP7   = (+FXP07+FXPN7+2*SUMP7)*DHP/2
      HO7   = (+FXO07+FXON7+2*SUMO7)*DHO/2
      HP8   = (+FXP08+FXPN8+2*SUMP8)*DHP/2
      HO8   = (+FXO08+FXON8+2*SUMO8)*DHO/2
      HP9   = (+FXP09+FXPN9+2*SUMP9)*DHP/2
      HO9   = (+FXO09+FXON9+2*SUMO9)*DHO/2
      RETURN
      END
C*****-------------------------********-------------------------******C
C                          SUBROUTINE  MEAN 1                         C
C*****-------------------------********-------------------------******C
      SUBROUTINE MEAN1(CONLB,ARMB,VBMEAN1,VSMEAN1)
      PI    = 2.*ASIN(1.)
      R     = CONLB/ARMB
      N     = 360
      DEG1  = 0.
      DEG2  = 2*PI
      DDEG  = (DEG2-DEG1)/N
      BSUMP = 0.
      SSUMP = 0.
      DO 11 I = 1,N-1
      X     = I*DDEG
      FXB   = ( 1+COS(X)/SQRT(R**2-(SIN(X))**2) )**2
      FXS   = ((COS(X)/R)**2)*((1+(SIN(X)**2)/(R**2-SIN(X)**2)))
      BSUMP = BSUMP + FXB
      SSUMP = SSUMP + FXS
   11 CONTINUE
      FXB0 = (1+COS(DEG1)/SQRT(R**2-(SIN(DEG1))**2))**2
      FXBN = (1+COS(DEG2)/SQRT(R**2-(SIN(DEG2))**2))**2
      FXS0 = ((COS(DEG1)/R)**2)
     $        *((1+(SIN(DEG1)**2)/(R**2-SIN(DEG1)**2)))
      FXSN = ((COS(DEG2)/R)**2)
     $        *((1+(SIN(DEG2)**2)/(R**2-SIN(DEG2)**2)))
      BIG  = (+FXB0+FXBN+2*BSUMP)*DDEG/2
      SML  = (+FXS0+FXSN+2*SSUMP)*DDEG/2
      VBMEAN1 = BIG/(2*PI)
      VSMEAN1 = SML/(2*PI)
      RETURN
      END
C*****-------------------------********-------------------------******C
C                          SUBROUTINE  MEAN 2                         C
C*****-------------------------********-------------------------******C
      SUBROUTINE MEAN2(CONLB,ARM,VBMEAN2,VSMEAN2)
      PI    = 2.*ASIN(1.)
      R     = CONLB/ARM
      N     = 360
      DEG1  = 0.
      DEG2  = 2*PI
      DDEG  = (DEG2-DEG1)/N
      BSUMP = 0.
      SSUMP = 0.
      DO 12 I = 1,N-1
      X   = I*DDEG
      FXB = (1+COS(X)/SQRT(R**2-(SIN(X))**2))**2
      FXS = ((COS(X)/R)**2)*((1+(SIN(X)**2)/(R**2-SIN(X)**2)))
      BSUMP = BSUMP + FXB
      SSUMP = SSUMP + FXS
   12 CONTINUE
      FXB0 = (1+COS(DEG1)/SQRT(R**2-(SIN(DEG1))**2))**2
      FXBN = (1+COS(DEG2)/SQRT(R**2-(SIN(DEG2))**2))**2
      FXS0 = ((COS(DEG1)/R)**2)
```

```
     $          *((1+(SIN(DEG1)**2)/(R**2-SIN(DEG1)**2)))
      FXSN = ((COS(DEG2)/R)**2)
     $          *((1+(SIN(DEG2)**2)/(R**2-SIN(DEG2)**2)))
      BIG  = (+FXB0+FXBN+2*BSUMP)*DDEG/2
      SML  = (+FXS0+FXSN+2*SSUMP)*DDEG/2
      VBMEAN2 = BIG/(2*PI)
      VSMEAN2 = SML/(2*PI)
      RETURN
      END
C*****-------------------------********-------------------------------******C
C                          SUBROUTINE  MEAN 3                              C
C*****-------------------------********-------------------------------******C
      SUBROUTINE MEAN3(CONL,ARMB,VBMEAN3,VSMEAN3)
      PI    = 2.*ASIN(1.)
      R     = CONL/ARMB
      N     = 100
      DEG1  = 0.
      DEG2  = 2*PI
      DDEG  = (DEG2-DEG1)/N
      BSUMP = 0.
      SSUMP = 0.
      DO 13 I = 1,N-1
      X     = I*DDEG
      FXB   = (1+COS(X)/SQRT(R**2-(SIN(X))**2))**2
      FXS   = ((COS(X)/R)**2)*((1+(SIN(X)**2)/(R**2-SIN(X)**2)))
      BSUMP = BSUMP + FXB
      SSUMP = SSUMP + FXS
   13 CONTINUE
      FXB0 = (1+COS(DEG1)/SQRT(R**2-(SIN(DEG1))**2))**2
      FXBN = (1+COS(DEG2)/SQRT(R**2-(SIN(DEG2))**2))**2
      FXS0 = ((COS(DEG1)/R)**2)
     $          *((1+(SIN(DEG1)**2)/(R**2-SIN(DEG1)**2)))
      FXSN = ((COS(DEG2)/R)**2)
     $          *((1+(SIN(DEG2)**2)/(R**2-SIN(DEG2)**2)))
      BIG  = (+FXB0+FXBN+2*BSUMP)*DDEG/2
      SML  = (+FXS0+FXSN+2*SSUMP)*DDEG/2
      VBMEAN3 = BIG/(2*PI)
      VSMEAN3 = SML/(2*PI)
      RETURN
      END
C*****-------------------------********-------------------------------******C
C                          SUBROUTINE  MEAN 4                              C
C*****-------------------------********-------------------------------******C
      SUBROUTINE MEAN4(R,VBMEAN4,VSMEAN4)
      PI    = 2.*ASIN(1.)
      N     = 100
      DEG1  = 0.
      DEG2  = 2*PI
      DDEG  = (DEG2-DEG1)/N
      BSUMP = 0.
      SSUMP = 0.
      DO 13 I = 1,N-1
      X     = I*DDEG
      FXB   = (1+COS(X)/SQRT(R**2-(SIN(X))**2))**2
      FXS   = ((COS(X)/R)**2)*((1+(SIN(X)**2)/(R**2-SIN(X)**2)))
      BSUMP = BSUMP + FXB
      SSUMP = SSUMP + FXS
   13 CONTINUE
      FXB0 = (1+COS(DEG1)/SQRT(R**2-(SIN(DEG1))**2))**2
      FXBN = (1+COS(DEG2)/SQRT(R**2-(SIN(DEG2))**2))**2
      FXS0 = ((COS(DEG1)/R)**2)
     $          *((1+(SIN(DEG1)**2)/(R**2-SIN(DEG1)**2)))
      FXSN = ((COS(DEG2)/R)**2)
     $          *((1+(SIN(DEG2)**2)/(R**2-SIN(DEG2)**2)))
      BIG  = (+FXB0+FXBN+2*BSUMP)*DDEG/2
      SML  = (+FXS0+FXSN+2*SSUMP)*DDEG/2
      VBMEAN4 = BIG/(2*PI)
      VSMEAN4 = SML/(2*PI)
      RETURN
```

```
      END
C*****-------------------------********-------------------------******C
C                          SUBROUTINE TOR 1                           C
C*****-------------------------********-------------------------******C
      SUBROUTINE TMEAN1(FCOE,SDEGB,FB,CDEGB,FM,SCB,PLB,BRB,TRB,VLB,RADC
     $           ,TOR1,PI)
       N    = 360
       D1   = SDEGB
       D2   = CDEGB
       D3   = 180-CDEGB
       D4   = 180-SDEGB
       DEG0 = 0.
       DEGN = 360.
       DDEG = (DEGN-DEG0)/N
       SUMP = 0.
      DO 10 I = 0,N,1
       X = I*DDEG
      IF ((X.GE.D1).AND.(X.LT.D2)) THEN
       S  = (FB-BRB)*(1-COS( (X-D1)*PI/180 ))/1000
       V  = (FB-BRB)*RADC*SIN( (X-D1)*PI/180 )/1000
       A  = (FB-BRB)*(RADC**2)*COS( (X-D1)*PI/180 )/1000
       FX = -1*(SCB*S+PLB+FM*A)*(FCOE*(BRB/1000+S)+V/RADC)
      ELSE
       IF ((X.GE.D2).AND.(X.LE.D3)) THEN
          S  = ((BRB+VLB-TRB)*SIN( X*PI/180 )+TRB-BRB)/1000
          V  = (BRB+VLB-TRB)*RADC*COS( X*PI/180 )/1000
          A  = -1*(BRB+VLB-TRB)*(RADC**2)*SIN( X*PI/180 )/1000
          FX = -1*(SCB*S+PLB+FM*A)*(FCOE*(BRB/1000+S)+V/RADC)
       ELSE
        IF ((X.GT.D3).AND.(X.LE.D4)) THEN
           S  = (FB-BRB)*(1+COS( (X+D1)*PI/180 ))/1000
           V  = -1*(FB-BRB)*RADC*SIN( (X+D1)*PI/180 )/1000
           A  = -1*(FB-BRB)*(RADC**2)*COS( (X+D1)*PI/180 )/1000
           FX = -1*(SCB*S+PLB+FM*A)*(FCOE*(BRB/1000+S)+V/RADC)
        ELSE
           FX = 0
        ENDIF
       ENDIF
      ENDIF
       SUMP = SUMP + FX
   10 CONTINUE
       TOR1 = SUMP/N
       RETURN
      END
C*****-------------------------********-------------------------******C
C                          SUBROUTINE TOR 2                           C
C*****-------------------------********-------------------------******C
      SUBROUTINE TMEAN2(FCOE,SDEGB,FB,CDEGB,FMB,SC,PLB,BRB,TRB,VLB,RADC
     $           ,TOR2,PI)
       N    = 360
       D1   = SDEGB
       D2   = CDEGB
       D3   = 180-CDEGB
       D4   = 180-SDEGB
       DEG0 = 0.
       DEGN = 360.
       DDEG = (DEGN-DEG0)/N
       SUMP = 0.
      DO 10 I = 0,N,1
       X = I*DDEG
      IF ((X.GE.D1).AND.(X.LT.D2)) THEN
        S  = (FB-BRB)*(1-COS( (X-D1)*PI/180 ))/1000
        V  = (FB-BRB)*RADC*SIN( (X-D1)*PI/180 )/1000
        A  = (FB-BRB)*(RADC**2)*COS( (X-D1)*PI/180 )/1000
        FX = -1*(SC*S+PLB+FMB*A)*(FCOE*(BRB/1000+S)+V/RADC)
      ELSE
       IF ((X.GE.D2).AND.(X.LE.D3)) THEN
          S  = ((BRB+VLB-TRB)*SIN( X*PI/180 )+TRB-BRB)/1000
          V  = (BRB+VLB-TRB)*RADC*COS( X*PI/180 )/1000
```

```
          A  = -1*(BRB+VLB-TRB)*(RADC**2)*SIN( X*PI/180 )/1000
          FX = -1*(SC*S+PLB+FMB*A)*(FCOE*(BRB/1000+S)+V/RADC)
        ELSE
         IF ((X.GT.D3).AND.(X.LE.D4)) THEN
            S  = (FB-BRB)*(1+COS( (X+D1)*PI/180 ))/1000
            V  = -1*(FB-BRB)*RADC*SIN( (X+D1)*PI/180 )/1000
            A  = -1*(FB-BRB)*(RADC**2)*COS( (X+D1)*PI/180 )/1000
            FX = -1*(SC*S+PLB+FMB*A)
     $              *(FCOE*(BRB/1000+S)+V/RADC)
         ELSE
            FX = 0
         ENDIF
        ENDIF
       ENDIF
        SUMP = SUMP + FX
    10 CONTINUE
        TOR2 = SUMP/N
        RETURN
       END
C*****-------------------------********-------------------------******C
C                              SUBROUTINE TOR 3                        C
C*****-------------------------********-------------------------******C
       SUBROUTINE TMEAN3(FCOE,SDEGB,FB,CDEGB,FMB,SCB,PL,BRB,TRB,VLB,RADC
      $            ,TOR3,PI)
        N    = 360
        D1   = SDEGB
        D2   = CDEGB
        D3   = 180-CDEGB
        D4   = 180-SDEGB
        DEG0 = 0.
        DEGN = 360.
        DDEG = (DEGN-DEG0)/N
        SUMP = 0.
       DO 10 I = 0,N,1
        X = I*DDEG
        IF ((X.GE.D1).AND.(X.LT.D2)) THEN
         S  = (FB-BRB)*(1-COS( (X-D1)*PI/180 ))/1000
         V  = (FB-BRB)*RADC*SIN( (X-D1)*PI/180 )/1000
         A  = (FB-BRB)*(RADC**2)*COS( (X-D1)*PI/180 )/1000
         FX = -1*(SCB*S+PL+FMB*A)*(FCOE*(BRB/1000+S)+V/RADC)
        ELSE
         IF ((X.GE.D2).AND.(X.LE.D3)) THEN
            S  = ((BRB+VLB-TRB)*SIN( X*PI/180 )+TRB-BRB)/1000
            V  = (BRB+VLB-TRB)*RADC*COS( X*PI/180 )/1000
            A  = -1*(BRB+VLB-TRB)*(RADC**2)*SIN( X*PI/180 )/1000
            FX = -1*(SCB*S+PL+FMB*A)*(FCOE*(BRB/1000+S)+V/RADC)
         ELSE
          IF ((X.GT.D3).AND.(X.LE.D4)) THEN
             S  = (FB-BRB)*(1+COS( (X+D1)*PI/180 ))/1000
             V  = -1*(FB-BRB)*RADC*SIN( (X+D1)*PI/180 )/1000
             A  = -1*(FB-BRB)*(RADC**2)*COS( (X+D1)*PI/180 )/1000
             FX = -1*(SCB*S+PL+FMB*A)*(FCOE*(BRB/1000+S)+V/RADC)
          ELSE
             FX = 0
          ENDIF
         ENDIF
        ENDIF
         SUMP = SUMP + FX
    10 CONTINUE
        TOR3 = SUMP/N
        RETURN
       END
C*****-------------------------********-------------------------******C
C                              SUBROUTINE TOR 4                        C
C*****-------------------------********-------------------------******C
       SUBROUTINE TMEAN4(FCOE,SDEGB,FBR,CDEGBR,FMB,SCB,PLB,BR,TRB,VLB
      $            ,RADC,TOR4,PI)
        N    = 360
        D1   = SDEGB
```

```
      D2   = CDEGBR
      D3   = 180-CDEGBR
      D4   = 180-SDEGB
      DEG0 = 0.
      DEGN = 360.
      DDEG = (DEGN-DEG0)/N
      SUMP = 0.
      DO 10 I = 0,N,1
      X = I*DDEG
      IF  ((X.GE.D1).AND.(X.LT.D2))  THEN
        S  = (FBR-BR)*(1-COS( (X-D1)*PI/180 ))/1000
        V  = (FBR-BR)*RADC*SIN( (X-D1)*PI/180 )/1000
        A  = (FBR-BR)*(RADC**2)*COS( (X-D1)*PI/180 )/1000
        FX = -1*(SCB*S+PLB+FMB*A)*(FCOE*(BR/1000+S)+V/RADC)
      ELSE
        IF  ((X.GE.D2).AND.(X.LE.D3))  THEN
          S  = ((BR+VLB-TRB)*SIN( X*PI/180 )+TRB-BR)/1000
          V  = (BR+VLB-TRB)*RADC*COS( X*PI/180 )/1000
          A  = -1*(BR+VLB-TRB)*(RADC**2)*SIN( X*PI/180 )/1000
          FX = -1*(SCB*S+PLB+FMB*A)*(FCOE*(BR/1000+S)+V/RADC)
        ELSE
          IF  ((X.GT.D3).AND.(X.LE.D4))  THEN
            S  = (FBR-BR)*(1+COS( (X+D1)*PI/180 ))/1000
            V  = -1*(FBR-BR)*RADC*SIN( (X+D1)*PI/180 )/1000
            A  = -1*(FBR-BR)*(RADC**2)*COS( (X+D1)*PI/180 )/1000
            FX = -1*(SCB*S+PLB+FMB*A)*(FCOE*(BR/1000+S)+V/RADC)
          ELSE
            FX = 0
        ENDIF
        ENDIF
      ENDIF
      SUMP = SUMP + FX
   10 CONTINUE
      TOR4 = SUMP/N
      RETURN
      END
C*****-----------------------*********-------------------------------******C
C                            SUBROUTINE TOR 51                             C
C*****-----------------------*********-------------------------------******C
      SUBROUTINE TMEAN51(FCOE,SDEGB,FBTR,CDEGBTR,FMB,SCB,PLB,BR,TR,VLB,
     $                   RADC,TOR51,PI)
      N    = 360
      D1   = SDEGB
      D2   = CDEGBTR
      D3   = 180-CDEGBTR
      D4   = 180-SDEGB
      DEG0 = 0.
      DEGN = 360.
      DDEG = (DEGN-DEG0)/N
      SUMP = 0.
      DO 10 I = 0,N,1
      X = I*DDEG
      IF ((X.GE.D1).AND.(X.LT.D2)) THEN
        S  = (FBTR-BR)*(1-COS( (X-D1)*PI/180 ))/1000
        V  = (FBTR-BR)*RADC*SIN( (X-D1)*PI/180 )/1000
        A  = (FBTR-BR)*(RADC**2)*COS( (X-D1)*PI/180 )/1000
        FX = -1*(SCB*S+PLB+FMB*A)*(FCOE*(BR/1000+S)+V/RADC)
      ELSE
       IF ((X.GE.D2).AND.(X.LE.D3)) THEN
          S  = ((BR+VLB-TR)*SIN( X*PI/180 )+TR-BR)/1000
          V  = (BR+VLB-TR)*RADC*COS( X*PI/180 )/1000
          A  = -1*(BR+VLB-TR)*(RADC**2)*SIN( X*PI/180 )/1000
          FX = -1*(SCB*S+PLB+FMB*A)*(FCOE*(BR/1000+S)+V/RADC)
       ELSE
        IF ((X.GT.D3).AND.(X.LE.D4)) THEN
          S  = (FBTR-BR)*(1+COS( (X+D1)*PI/180 ))/1000
          V  = -1*(FBTR-BR)*RADC*SIN( (X+D1)*PI/180 )/1000
          A  = -1*(FBTR-BR)*(RADC**2)*COS( (X+D1)*PI/180 )/1000
          FX = -1*(SCB*S+PLB+FMB*A)*(FCOE*(BR/1000+S)+V/RADC)
```

```
        ELSE
           FX = 0
        ENDIF
       ENDIF
      ENDIF
       SUMP = SUMP + FX
   10 CONTINUE
       TOR51 = SUMP/N
       RETURN
      END
C*****-------------------------*********-------------------------------******C
C                          SUBROUTINE TOR 5                                   C
C*****-------------------------*********-------------------------------******C
      SUBROUTINE TMEAN5(FCOE,SDEGB,FTR,CDEGTR,FMB,SCB,PLB,BRB,TR,VLB
     $           ,RADC,TOR5,PI)
       N    = 360
       D1   = SDEGB
       D2   = CDEGTR
       D3   = 180-CDEGTR
       D4   = 180-SDEGB
       DEG0 = 0.
       DEGN = 360.
       DDEG = (DEGN-DEG0)/N
       SUMP = 0.
      DO 10 I = 0,N,1
       X = I*DDEG
       IF ((X.GE.D1).AND.(X.LT.D2)) THEN
         S  = (FTR-BRB)*(1-COS( (X-D1)*PI/180 ))/1000
         V  = (FTR-BRB)*RADC*SIN( (X-D1)*PI/180 )/1000
         A  = (FTR-BRB)*(RADC**2)*COS( (X-D1)*PI/180 )/1000
         FX = -1*(SCB*S+PLB+FMB*A)*(FCOE*(BRB/1000+S)+V/RADC)
       ELSE
        IF ((X.GE.D2).AND.(X.LE.D3)) THEN
           S  = ((BRB+VLB-TR)*SIN( X*PI/180 )+TR-BRB)/1000
           V  = (BRB+VLB-TR)*RADC*COS( X*PI/180 )/1000
           A  = -1*(BRB+VLB-TR)*(RADC**2)*SIN( X*PI/180 )/1000
           FX = -1*(SCB*S+PLB+FMB*A)*(FCOE*(BRB/1000+S)+V/RADC)
        ELSE
         IF ((X.GT.D3).AND.(X.LE.D4)) THEN
            S  = (FTR-BRB)*(1+COS( (X+D1)*PI/180 ))/1000
            V  = -1*(FTR-BRB)*RADC*SIN( (X+D1)*PI/180 )/1000
            A  = -1*(FTR-BRB)*(RADC**2)*COS( (X+D1)*PI/180 )/1000
            FX = -1*(SCB*S+PLB+FMB*A)*(FCOE*(BRB/1000+S)+V/RADC)
         ELSE
            FX = 0
         ENDIF
        ENDIF
       ENDIF
       SUMP = SUMP + FX
   10 CONTINUE
       TOR5 = SUMP/N
       RETURN
      END
C*****-------------------------*********-------------------------------******C
C                          SUBROUTINE TOR 6                                   C
C*****-------------------------*********-------------------------------******C
      SUBROUTINE TMEAN6(FCOE,SDEGB,FVL,CDEGVL,FMB,SCB,PLB,BRB,TRB,VL
     $           ,RADC,TOR6,PI)
       N    = 360
       D1   = SDEGB
       D2   = CDEGVL
       D3   = 180-CDEGVL
       D4   = 180-SDEGB
       DEG0 = 0.
       DEGN = 360.
       DDEG = (DEGN-DEG0)/N
       SUMP = 0.
      DO 10 I = 0,N,1
       X = I*DDEG
```

```
      IF ((X.GE.D1).AND.(X.LT.D2)) THEN
       S  = (FVL-BRB)*(1-COS( (X-D1)*PI/180 ))/1000
       V  = (FVL-BRB)*RADC*SIN( (X-D1)*PI/180 )/1000
       A  = (FVL-BRB)*(RADC**2)*COS( (X-D1)*PI/180 )/1000
       FX = -1*(SCB*S+PLB+FMB*A)*(FCOE*(BRB/1000+S)+V/RADC)
      ELSE
       IF ((X.GE.D2).AND.(X.LE.D3)) THEN
          S  = ((BRB+VL-TRB)*SIN( X*PI/180 )+TRB-BRB)/1000
          V  = (BRB+VL-TRB)*RADC*COS( X*PI/180 )/1000
          A  = -1*(BRB+VL-TRB)*(RADC**2)*SIN( X*PI/180 )/1000
          FX = -1*(SCB*S+PLB+FMB*A)*(FCOE*(BRB/1000+S)+V/RADC)
       ELSE
        IF ((X.GT.D3).AND.(X.LE.D4)) THEN
           S  = (FVL-BRB)*(1+COS( (X+D1)*PI/180 ))/1000
           V  = -1*(FVL-BRB)*RADC*SIN( (X+D1)*PI/180 )/1000
           A  = -1*(FVL-BRB)*(RADC**2)*COS( (X+D1)*PI/180 )/1000
           FX = -1*(SCB*S+PLB+FMB*A)*(FCOE*(BRB/1000+S)+V/RADC)
        ELSE
           FX = 0
        ENDIF
       ENDIF
      ENDIF
       SUMP = SUMP + FX
   10 CONTINUE
      TOR6 = SUMP/N
      RETURN
      END
C*****------------------------*********-----------------------------******C
C                            SUBROUTINE TOR 7                             C
C*****------------------------*********-----------------------------******C
      SUBROUTINE TMEAN7(FCOE,SDEGB,FB,CDEGB,FMB,SCB,PLB,BRB,TRB,VLB,RADC
     $,TOR7,PI)
       N    = 360
       D1   = SDEGB
       D2   = CDEGB
       D3   = 180-CDEGB
       D4   = 180-SDEGB
       DEG0 = 0.
       DEGN = 360.
       DDEG = (DEGN-DEG0)/N
       SUMP = 0.
      DO 10 I=0,N,1
       X = I*DDEG
       IF ((X.GE.D1).AND.(X.LT.D2)) THEN
        S  = (FB-BRB)*(1-COS( (X-D1)*PI/180 ))/1000
        V  = (FB-BRB)*RADC*SIN( (X-D1)*PI/180 )/1000
        A  = (FB-BRB)*(RADC**2)*COS( (X-D1)*PI/180 )/1000
        FX = -1*(SCB*S+PLB+FMB*A)*(FCOE*(BRB/1000+S)+V/RADC)
       ELSE
        IF ((X.GE.D2).AND.(X.LE.D3)) THEN
           S  = ((BRB+VLB-TRB)*SIN( X*PI/180 )+TRB-BRB)/1000
           V  = (BRB+VLB-TRB)*RADC*COS( X*PI/180 )/1000
           A  = -1*(BRB+VLB-TRB)*(RADC**2)*SIN( X*PI/180 )/1000
           FX = -1*(SCB*S+PLB+FMB*A)*(FCOE*(BRB/1000+S)+V/RADC)
        ELSE
         IF ((X.GT.D3).AND.(X.LE.D4)) THEN
            S  = (FB-BRB)*(1+COS( (X+D1)*PI/180 ))/1000
            V  = -1*(FB-BRB)*RADC*SIN( (X+D1)*PI/180 )/1000
            A  = -1*(FB-BRB)*(RADC**2)*COS( (X+D1)*PI/180 )/1000
            FX = -1*(SCB*S+PLB+FMB*A)*(FCOE*(BRB/1000+S)+V/RADC)
         ELSE
            FX = 0
         ENDIF
        ENDIF
       ENDIF
       SUMP = SUMP + FX
   10 CONTINUE
      TOR7 = SUMP/N
      RETURN
```

```
      END
C*****-------------------------*********-------------------------******C
C                          SUBROUTINE TOR 71                           C
C*****-------------------------*********-------------------------******C
      SUBROUTINE TMEAN71(FCOE,SDEGB,FB,CDEGB,FM,SC,PL,BR,TR,VL,RADC,
     $           TOR7,PI)
       N    = 360
       D1   = SDEGB
       D2   = CDEGB
       D3   = 180-CDEGB
       D4   = 180-SDEGB
       DEG0 = 0.
       DEGN = 360.
       DDEG = (DEGN-DEG0)/N
       SUMP = 0.
      DO 10 I=0,N,1
       X = I*DDEG
       IF ((X.GE.D1).AND.(X.LT.D2)) THEN
         S  = (FB-BR)*(1-COS( (X-D1)*PI/180 ))/1000
         V  = (FB-BR)*RADC*SIN( (X-D1)*PI/180 )/1000
         A  = (FB-BR)*(RADC**2)*COS( (X-D1)*PI/180 )/1000
         FX = -1*(SC*S+PL+FM*A)*(FCOE*(BR/1000+S)+V/RADC)
       ELSE
        IF ((X.GE.D2).AND.(X.LE.D3)) THEN
           S  = ((BR+VL-TR)*SIN( X*PI/180 )+TR-BR)/1000
           V  = (BR+VL-TR)*RADC*COS( X*PI/180 )/1000
           A  = -1*(BR+VL-TR)*(RADC**2)*SIN( X*PI/180 )/1000
           FX = -1*(SC*S+PL+FM*A)*(FCOE*(BR/1000+S)+V/RADC)
        ELSE
         IF ((X.GT.D3).AND.(X.LE.D4)) THEN
            S  = (FB-BR)*(1+COS( (X+D1)*PI/180 ))/1000
            V  = -1*(FB-BR)*RADC*SIN( (X+D1)*PI/180 )/1000
            A  = -1*(FB-BR)*(RADC**2)*COS( (X+D1)*PI/180 )/1000
            FX = -1*(SC*S+PL+FM*A)*(FCOE*(BR/1000+S)+V/RADC)
         ELSE
            FX = 0
         ENDIF
        ENDIF
       ENDIF
       SUMP = SUMP + FX
   10 CONTINUE
       TOR7 = SUMP/N
       RETURN
       END
C*****-------------------------*********-------------------------******C
C                    (SEL1) SUBROUTINE FOR CALCULATION                 C
C*****-------------------------*********-------------------------******C
      SUBROUTINE SEL1(RPM,GN,G1,G2,G3,G4,G5,GD,TEFF,GT)
      IF (RPM.LE.1200.) THEN
          GN = 1.
      ELSE
       IF (RPM.LE.1800.) THEN
           GN = 2.
       ELSE
         IF (RPM.LE.2000.) THEN
             GN = 3.
         ELSE
           IF (RPM.LE.2200.) THEN
               GN = 4.
           ELSE
               GN = 5.
           ENDIF
         ENDIF
       ENDIF
      ENDIF
      IF ( GN.EQ.1 ) THEN
          GT = G1*GD
        TEFF = 0.8
      ELSE
```

```
 IF ( GN.EQ.2 ) THEN
      GT = G2*GD
    TEFF = 0.8
 ELSE
   IF ( GN.EQ.3 ) THEN
      GT = G3*GD
    TEFF = 0.85
   ELSE
     IF ( GN.EQ.4 ) THEN
        GT = G4*GD
      TEFF = 0.9
     ELSE
       IF ( GN.EQ.5 ) THEN
         GT = G5*GD
        TEFF = 0.9
       ELSE
WRITE(6,*) ' ENTER NEW GEAR NUMBER '
   ENDIF
  ENDIF
 ENDIF
 ENDIF
ENDIF
RETURN
END
```

สถาบันวิทยบริการ
จุฬาลงกรณ์มหาวิทยาลัย

ภาคผนวก ฉ

รายละเอียดโปรแกรม OPTIMUM

โปรแกรม optimum สามารถแสดงรายละเอียดดังต่อไปนี้

```
C*****-----------------------********-------------------------------******C
C               PROGRAM FOR DETERMINATION OPTIMUN PARAMETERS              C
C                                WRITEN BY                                C
C                         MR. PAIRAT LERTARAYAPONG                        C
C*****-----------------------********-------------------------------******C
      PROGRAM OPTIMUM
      WRITE(6,*) ' ENTER ENGINE DISPLACEMENT VOLUME          : (CC) '
       READ(*,*)  VDB
      WRITE(6,*) ' ENTER AMOUNT OF INTERVAL OF PARAMETERS    : (TIMES)'
       READ(*,*)  N
      WRITE(6,*) ' ENTER ENGINE UPPER LIMIT SPEED            : (RPM) '
       READ(*,*)   RPMH
      WRITE(6,*) ' ENTER ENGINE LOWER LIMIT SPEED            : (RPM) '
       READ(*,*)  RPML
      WRITE(6,*) ' ENTER AMOUNT OF INTERVAL OF ENGINE SPEED  : (TIMES)'
       READ(*,*)  RPMN
      WRITE(6,*) ' ENTER OPERATION ENGINE SPEED              : (RPM) '
       READ(*,*)  ORPM
C*****-----------------------********-------------------------------******C
      AIRDEN = 1.17
       DENHG = 13550.
        FCOE = 0.11
       CORRK = 0.06
        RALT = 2.
        PCLE = 4.5
        RCOM = 1.18
        NCOM = 1.
         DHE = 10.
          RP = 0.5
          RO = 1.
          PI = 2.*ASIN(1.)
          PA = 101.325
         ESM = 0.9
          EC = 0.9
           E = 0.9
           H = 0.005
          PE = 9.81*DENHG*DHE*0.0254/1000.
          H1 = 185.*1000.
          H2 = 95.7*1000.
          V1 = 0.0666252
        FRAC = 25.
        AMPB = 50.
       VOLTB = 12.
C*****-----------------------********-------------------------------******C
C                    CONSTANT VALUE FOR CALCULATION                       C
C  AIRDEN  =  AIR DENSITY                                : (kg/m^3)      C
C   DENHG  =  MERCURY DENSITY                            : (kg/m^3)      C
C    FCOE  =  FRICTION COEFFICIENT IN CAM SURFACE                        C
C     RCOM =  PULLEY RATIO AT COMPRESSOR                                 C
C     NCOM =  NUMBER OF CYLINDER AT COMPRESSOR                           C
C     PCLE =  PERCENT CLEARANCE AT COMPRESSOR             : (%)          C
C     FRAC =  PERCENT BETWEEN MECH. LOSS WITH TOTAL LOSS  : (%)          C
C    CORRK =  CORRECTION FACTOR OF ALTERNATOR                            C
C     RALT =  PULLEY RATIO AT ALTERNATOR                                 C
C      RP  =  PRESSURE RING CONSTANT                                     C
C      RO  =  OIL RING CONSTANT                                          C
C      PA  =  AMBIENT PRESSURE                            : (kPa)        C
```

```
C     DHE  =  EXHAUST MANIFOLD PRESSURE AT FULL LOAD          : (INCH)    C
C       H  =  OIL MINIMUM THICKNESS                           : (mm)      C
C      PE  =  EXHAUST MANIFOLD PRESSURE AT FULL LOAD          : (kPa)     C
C      EC  =  ECCENTRICITY RATIO IN CRANK-SHAFT BEARING                   C
C       E  =  ECCENTRICITY RATIO IN CONNECTION ROD BIG-END                C
C     ESM  =  ECCENTRICITY RATIO IN CONNECTION ROD SMALL-END              C
C      H1  =  ENTHALPY AT SATURATED VAPOUR                  : (kJ/kg)   C
C      H2  =  ENTHALPY AT SATURATED LIQUID                  : (kJ/kg)   C
C      V1  =  SPECIFICE VOLUME OF REFRIGERANT               : (m^3/kg)  C
C*****-------------------------********-------------------------******C
      OPEN(UNIT=7,FILE='BASE.DAT',STATUS='OLD')
      READ(7,*) VISB,RCRANKB,CRANKLB,CCRANKB,BN,QB
      READ(7,*) RKB,EMB,ECB,CONDP,EVAPP,BCOMB,SCOMB
      READ(7,*) BPRESSB,BOILB,NPRESSB,NOILB
      READ(7,*) BRCONB,BCCONB,BLCONB
      READ(7,*) SRCONB,SCCONB,SLCONB
      READ(7,*) NCB,BOREB,ARMB,CONLB
      READ(7,*) NVCB,SDEGB,TRB,VLB
      READ(7,*) FMB,SCB,PLB,BRB
      READ(7,*) RDALTB,RLALTB
      READ(7,*) DVB,RCB,NVB
      READ(7,*) PCB,PISLB
      READ(7,*) G1,G2,G3,G4,G5,GD
      READ(7,*) CDB,AREAB,FRB,MGB,WR
C----------------------DATA LIMIT FOR CALCULATION--------------------C
      READ(7,*) RCRANKL,RCRANKH
      READ(7,*) CRANKLL,CRANKLH
      READ(7,*) CCRANKL,CCRANKH
      READ(7,*) BRCONL,BRCONH
      READ(7,*) BCCONL,BCCONH
      READ(7,*) BLCONL,BLCONH
      READ(7,*) SRCONL,SRCONH
      READ(7,*) SCCONL,SCCONH
      READ(7,*) SLCONL,SLCONH
      READ(7,*) BPRESSL,BPRESSH
      READ(7,*) BOILL,BOILH
      READ(7,*) BOREL,BOREH
      READ(7,*) VISL,VISH
      READ(7,*) ARML,ARMH
      READ(7,*) RDALTL,RDALTH
      READ(7,*) RLALTL,RLALTH
      READ(7,*) CONLL,CONLH
      READ(7,*) PISLL,PISLH
      READ(7,*) DVL,DVH
      READ(7,*) RCL,RCH
      READ(7,*) PCL,PCH
      READ(7,*) FML,FMH
      READ(7,*) SCL,SCH
      READ(7,*) PLL,PLH
      READ(7,*) BRL,BRH
      READ(7,*) TRL,TRH
      READ(7,*) VLL,VLH
      READ(7,*) QL,QH
      READ(7,*) CDL,CDH
      READ(7,*) AFL,AFH
      READ(7,*) FRL,FRH
      READ(7,*) MGL,MGH
C*****-------------------------********-------------------------******C
C                          ENGINE PARAMETERS                          C
C  VIS    = ABSOLUTE VISCOSITY                          : (Pa.s)    C
C  RCRANK = RADIUS OF CRANK-SHAFT BEARING               : (m)       C
C  CRANKL = CRANK-SHAFT BEARING WIDTH                   : (m)       C
C  CCRANK = RADIUS CLEARANCE IN CRANK-SHAFT BEARING     : (m)       C
C  BN     = AMOUNT OF BEARING SUPPORT                               C
C  RKB    = REFRIGERANT ISENTROPIC INDEX                            C
C  EMB    = MECHANICAL EFFICIENCY                                   C
C  ECB    = COMPRESSION EFFICIENCY                                  C
C  CONDP  = CONDENSOR PRESSURE                          : (Pa)      C
C  EVAPP  = EVAPOURATOR PRESSURE                        : (Pa)      C
```

```
C  BCOMB  = PISTON BORE AT COMPRESSOR                                  : (m)      C
C  SCOMB    COMPRESSOR STROKE LENGTH                                  : (m)      C
C  BPRESS = PRESSURE RING SURFACE DEPTH                               : (mm)     C
C  BOIL   = OIL RING SURFACE DEPTH                                    : (mm)     C
C  NPRESS = AMOUNT OF PRESSURE RING                                              C
C  NOIL   = AMOUNT OF OIL RING                                                   C
C  BRCON  = RADIUS OF CONNECTING ROD BEARING AT BIG-END               : (m)      C
C  BCCON  = RADIUS CLEARANCE IN CONNECTING ROD BIG-END                : (m)      C
C  BLCON  = CONNECTING ROD BEARING WIDTH AT BIG-END                   : (m)      C
C  SRCON  = RADIUS OF CONNECTING ROD BEARING AT SMALL-END             : (m)      C
C  SCCON  = RADIUS CLEARANCE IN CONNECTING ROD SMALL-END              : (m)      C
C  SLCON  = CONNECTING ROD BEARING WIDTH AT SMALL-END                 : (m)      C
C  NCB    = NUMBER OF CYLINDER                                                   C
C  BORE   = PISTON BORE                                               : (m)      C
C  ARM    = CRANK ARM                                                 : (m)      C
C  CONL   = CONNECTING ROD LENGTH                                     : (m)      C
C  NVCB   = NUMBER VALVE PER CYLINDER                                            C
C  SDEGB  = STARTING ANGLE                                            : (deg.)   C
C  TR     = TIP RADIUS OF CAM                                         : (mm)     C
C  BR     = BASE RADIUS OF CAM                                        : (mm)     C
C  VL     = VALVE FOLLOWER LIFT                                       : (mm)     C
C  FM     = VALVE FOLLOWER MASS                                       : (mm)     C
C  SC     = SPRING STIFFNSS                                           : (N/m)    C
C  PL     = VALVE PRELOAD                                             : (N)      C
C  RDALTB = ROTOR DIAMETER OF ALTERATOR                               : (m)      C
C  RLALTB = ROTOR LENGTH OF ALTERATOR                                 : (m)      C
C  DV     = INLET VALVE DIAMETER                                      : (m)      C
C  RC     = COMPRESSION RATIO                                                    C
C  NVB    = NUMBER OF INLET VALVE PER CYLINDER                                   C
C  PC     = PISTON CLEARANCE                                          : (m)      C
C  PISL   = PISTON SKIRT LENGTH                                       : (m)      C
C  G      = GEAR RATIO IN 1-5 AND DIFFERENT                                      C
C  CD     = DRAG COEFFICIENT                                                     C
C  AREA   = FRONTAL AREA                                              : (m^3)    C
C  FR     = ROLLING COFFICIENT                                                   C
C  MG     = VEHICLE MASS                                              : (kg)     C
C  WR     = WHEEL RADIUS                                              : (m)      C
C*****-------------------------********-------------------------------******C
C                    MAIN PROGRAM FOR CALCULATION                             C
C*****-------------------------********-------------------------------******C
      DO 100 I1 = 0,RPMN,1
         DRPM = (RPMH-RPML)/RPMN
          RPM = RPML + I1*DRPM
         RPMC = RPM/2
         RADC = (RPMC*2*PI/60)
C*****-------------------------********-------------------------------******C
        PMIN1 = 99999.
       DO 1 J1 = 0,N,1
       DRCRANK = (RCRANKH-RCRANKL)/N
        RCRANK = RCRANKL + J1*DRCRANK
       PRCRANK = VISB*(RCRANK**3)*CRANKLB*((2*PI)
     $             /(CCRANKB*SQRT(1-EC**2)))*((2*PI*(RPM/60))**2)*BN
      WRITE(6,101) RPM,RCRANK,PRCRANK
       IF ( PMIN1.GT.PRCRANK ) THEN
          PMIN1 = PRCRANK
          XMIN1 = RCRANK
       ENDIF
    1 CONTINUE
  101 FORMAT(1X,F7.2,3X,F7.5,3X,F7.2)
C*****-------------------------********-------------------------------******C
        PMIN2 = 99999.
       DO 2 J2 = 0,N,1
       DLCRANK = (CRANKLH-CRANKLL)/N
        CRANKL = CRANKLL + J2*DLCRANK
       PLCRANK = VISB*(RCRANKB**3)*CRANKL*((2*PI)
     $             /(CCRANKB*SQRT(1-EC**2)))*((2*PI*(RPM/60))**2)*BN
      WRITE(6,102) RPM,CRANKL,PLCRANK
       IF ( PMIN2.GT.PLCRANK ) THEN
          PMIN2 = PLCRANK
```

```
          XMIN2 = CRANKL
        ENDIF
      2 CONTINUE
    102 FORMAT(1X,F7.2,3X,F7.5,3X,F7.2)
C*****-------------------------*********-------------------------------******C
        PMIN3 = 99999.
        DO 3 J3 = 0,N,1
        DCCRANK = (CCRANKH-CCRANKL)/N
         CCRANK = CCRANKL + J3*DCCRANK
        PCCRANK = VISB*(RCRANKB**3)*CRANKLB*((2*PI)
     $              /(CCRANK*SQRT(1-EC**2)))*((2*PI*(RPM/60))**2)*BN
        WRITE(6,103) RPM,CCRANK,PCCRANK
        IF ( PMIN3.GT.PCCRANK ) THEN
           PMIN3 = PCCRANK
           XMIN3 = CCRANK
        ENDIF
      3 CONTINUE
    103 FORMAT(1X,F7.2,3X,E8.2,3X,F7.2)
C*****-------------------------*********-------------------------------******C
       IF (RPM.LE.1300.) THEN
         DH = 9.9
       ELSE
        IF (RPM.LE.1700.) THEN
          DH = 10.2
        ELSE
        IF (RPM.LE.2000.) THEN
           DH = 11.
        ELSE
         IF (RPM.LE.2400.) THEN
            DH = 12.
         ELSE
          IF (RPM.LE.2700.) THEN
             DH = 13..
          ELSE
           IF (RPM.LE.3000.) THEN
              DH = 13.7
           ELSE
            IF (RPM.LE.3400.) THEN
               DH = 14.9
            ELSE
             IF (RPM.LE.3700.) THEN
               DH = 15.9
             ELSE
              IF (RPM.LE.4000.) THEN
                DH = 16.5
              ELSE
               WRITE(*,*) ' OVER ENGINE SPEED '
              ENDIF
             ENDIF
            ENDIF
           ENDIF
          ENDIF
         ENDIF
        ENDIF
       ENDIF
       ENDIF
       ENDIF
         PMIN6 = 99999.
         DO 6 J6 = 0,N,1
             DDV = (DVH-DVL)/N
              DV = DVL + J6*DDV
             PIA = 9.81*DENHG*DH*0.0254/1000
           CIMEP = 12.87*PA*((PIA/PA)-0.1)
             PIG = PA-(CIMEP/12.8)-10.14
              F = (NVB*NCB*(DV**2))/(2*ARMB*PI*NCB*(BOREB**2)/4)
      PDPUMP = (PA-(CIMEP/12.8)-10.14+PE*(((CIMEP*RPM)/(3904000))**2) +
     $          8.9667*(SQRT(CIMEP/1124.3))*((RPM/1000)**1.7)
     $          *((2.984/F)**1.28) + (SQRT((PA-PIG)/97.94))
     $          *(11.86*(RCB**0.4)-(3.38+0.103*RCB)*((RPM/1000)**1.185)))
     $          *1000*(2*ARMB*PI*NCB*(BOREB**2)/4)*(RPM/120)
```

```
      WRITE(6,106) RPM,DV,PDPUMP
      IF ( PMIN6.GT.PDPUMP ) THEN
         PMIN6 = PDPUMP
         XMIN6 = DV
       ENDIF
    6 CONTINUE
  106 FORMAT(1X,F7.2,3X,F5.3,3X,F7.2)
C*****-------------------------*********-------------------------------******C
        XMIN7 = RCH
C*****-------------------------*********-------------------------------******C
        PMIN8 = 99999.
      DO 8 J8 = 0,N,1
          DPC = (PCH-PCL)/N
           PC = PCL + J8*DPC
       PCPPIS = (VISB*PI*BOREB*PISLB/PC)*((ARMB*(RPM/15))**2)*NCB
        WRITE(6,108) RPM,PC,PCPPIS
      IF ( PMIN8.GT.PCPPIS ) THEN
         PMIN8 = PCPPIS
         XMIN8 = PC
       ENDIF
    8 CONTINUE
  108 FORMAT(1X,F7.2,3X,F9.6,3X,F7.2)
C*****-------------------------*********-------------------------------******C
        PMIN9 = 99999.
      DO 9 J9 = 0,N,1
        DPISL = (PISLH-PISLL)/N
         PISL = PISLL + J9*DPISL
        PLPIS = (VISB*PI*BOREB*PISL/PCB)*((ARMB*(RPM/15))**2)*NCB
        WRITE(6,109) RPM,PISL,PLPIS
       IF ( PMIN9.GT.PLPIS ) THEN
         PMIN9 = PLPIS
         XMIN9 = PISL
      ENDIF
    9 CONTINUE
  109 FORMAT(1X,F7.2,3X,F6.4,3X,F7.2)
C*****-------------------------*********-------------------------------******C
        PMIN10 = 99999.
      DO 10 J10 = 0,N,1
      DBPRESS = (BPRESSH-BPRESSL)/N
       BPRESS = BPRESSL + J10*DBPRESS
       CALL NUM2(BPRESS,BOILB,RP,RO,H,HP4,HO4,HP5,HO5,HP6,HO6)
      PBPRING = VISB*ARMB*2*PI*(RPM/60)*(4*HO4-3*(HO5**2)/HO6+BOILB
     $          *(1-RO)/(1+RO))*4*ARMB*PI*BOREB*(RPM/60)*NOILB*NCB +
     $          VISB*ARMB*2*PI*(RPM/60)*(4*HP4-3*(HP5**2)/HP6+(BPRESS
     $          *(1-RP)/(1+RP))/H)*4*ARMB*PI*BOREB*(RPM/60)*NPRESSB*NCB
       WRITE(6,110) RPM,BPRESS,PBPRING
       IF ( PMIN10.GT.PBPRING ) THEN
         PMIN10 = PBPRING
         XMIN10 = BPRESS
       ENDIF
   10 CONTINUE
  110 FORMAT(1X,F7.2,3X,F3.1,3X,F7.2)
C*****-------------------------*********-------------------------------******C
        PMIN11 = 99999.
      DO 11 J11 = 0,N,1
        DBOIL = (BOILH-BOILL)/N
         BOIL = BOILL + J11*DBOIL
       CALL NUM3(BPRESSB,BOIL,RP,RO,H,HP7,HO7,HP8,HO8,HP9,HO9)
       PBORING = VISB*ARMB*2*PI*(RPM/60)*(4*HO7-3*(HO8**2)/HO9+BOIL
     $           *(1-RO)/(1+RO))*4*ARMB*PI*BOREB*(RPM/60)*NOILB*NCB +
     $           VISB*ARMB*2*PI*(RPM/60)*(4*HP7-3*(HP8**2)/HP9+(BPRESSB
     $           *(1-RP)/(1+RP))/H)*4*ARMB*PI*BOREB*(RPM/60)*NPRESSB*NCB
       WRITE(6,111) RPM,BOIL,PBORING
       IF ( PMIN11.GT.PBORING ) THEN
         PMIN11 = PBORING
         XMIN11 = BOIL
       ENDIF
   11 CONTINUE
  111 FORMAT(1X,F7.2,3X,F3.1,3X,F7.2)
```

```
C*****-----------------------********-----------------------------******C
         PMIN12 = 99999.
       DO 12 J12 = 0,N,1
        DBRCON = (BRCONH-BRCONL)/N
         BRCON = BRCONL + J12*DBRCON
       CALL MEAN1(CONLB,ARMB,VBMEAN1,VSMEAN1)
        PBRCON = VISB*(BRCON**3)*BLCONB*((2*PI)/(BCCONB*SQRT(1-E**2)))
     $           *((2*PI*(RPM/60))**2)*NCB*VBMEAN1 +
     $          VISB*(SRCONB**3)*SLCONB*((2*PI)/(SCCONB*SQRT(1-ESM**2)))
     $           *((2*PI*(RPM/60))**2)*NCB*VSMEAN1
        WRITE(6,112) RPM,BRCON,PBRCON
        IF ( PMIN12.GT.PBRCON ) THEN
           PMIN12 = PBRCON
           XMIN12 = BRCON
        ENDIF
   12 CONTINUE
  112 FORMAT(1X,F7.2,3X,F6.4,3X,F7.2)
C*****-----------------------********-----------------------------******C
         PMIN13 = 99999.
       DO 13 J13 = 0,N,1
        DBCCON = (BCCONH-BCCONL)/N
         BCCON = BCCONL + J13*DBCCON
       CALL MEAN1(CONLB,ARMB,VBMEAN1,VSMEAN1)
        PBCCON = VISB*(BRCONB**3)*BLCONB*((2*PI)/(BCCON*SQRT(1-E**2)))
     $           *((2*PI*(RPM/60))**2)*NCB*VBMEAN1 +
     $          VISB*(SRCONB**3)*SLCONB*((2*PI)/(SCCONB*SQRT(1-ESM**2)))
     $           *((2*PI*(RPM/60))**2)*NCB*VSMEAN1
        WRITE(6,113) RPM,BCCON,PBCCON
        IF ( PMIN13.GT.PBCCON ) THEN
           PMIN13 = PBCCON
           XMIN13 = BCCON
        ENDIF
   13 CONTINUE
  113 FORMAT(1X,F7.2,3X,F8.2,3X,F7.2)
C*****-----------------------********-----------------------------******C
         PMIN14 = 99999.
       DO 14 J14 = 0,N,1
        DBLCON = (BLCONH-BLCONL)/N
         BLCON = BLCONL + J14*DBLCON
        CALL MEAN1(CONLB,ARMB,VBMEAN1,VSMEAN1)
       PBLCON = VISB*(BRCONB**3)*BLCON*((2*PI)/(BCCONB*SQRT(1-E**2)))
     $          *((2*PI*(RPM/60))**2)*NCB*VBMEAN1 +
     $          VISB*(SRCONB**3)*SLCONB*((2*PI)/(SCCONB*SQRT(1-ESM**2)))
     $          *((2*PI*(RPM/60))**2)*NCB*VSMEAN1
        WRITE(6,114) RPM,BLCON,PBLCON
        IF ( PMIN14.GT.PBLCON ) THEN
           PMIN14 = PBLCON
           XMIN14 = BLCON
        ENDIF
   14 CONTINUE
  114 FORMAT(1X,F7.2,3X,F5.3,3X,F7.2)
C*****-----------------------********-----------------------------******C
         PMIN15 = 99999.
       DO 15 J15 = 0,N,1
        DSRCON = (SRCONH-SRCONL)/N
         SRCON = SRCONL + J15*DSRCON
       CALL MEAN1(CONLB,ARMB,VBMEAN1,VSMEAN1)
      PSRCON = VISB*(BRCONB**3)*BLCONB*((2*PI)/(BCCONB*SQRT(1-E**2)))
     $          *((2*PI*(RPM/60))**2)*NCB*VBMEAN1 +
     $          VISB*(SRCON**3)*SLCONB*((2*PI)/(SCCONB*SQRT(1-ESM**2)))
     $          *((2*PI*(RPM/60))**2)*NCB*VSMEAN1
        WRITE(6,115) RPM,SRCON,PSRCON
        IF ( PMIN15.GT.PSRCON ) THEN
           PMIN15 = PSRCON
           XMIN15 = SRCON
        ENDIF
   15 CONTINUE
  115 FORMAT(1X,F7.2,3X,F6.4,3X,F7.2)
C*****-----------------------********-----------------------------******C
```

```
          PMIN16 = 99999.
        DO 16 J16 = 0,N,1
         DSCCON = (SCCONH-SCCONL)/N
            SCCON = SCCONL + J16*DSCCON
        CALL MEAN1(CONLB,ARMB,VBMEAN1,VSMEAN1)
         PSCCON = VISB*(BRCONB**3)*BLCONB*((2*PI)/(BCCONB*SQRT(1-E**2)))
     $           *((2*PI*(RPM/60))**2)*NCB*VBMEAN1 +
     $           VISB*(SRCONB**3)*SLCONB*((2*PI)/(SCCON*SQRT(1-ESM**2)))
     $           *((2*PI*(RPM/60))**2)*NCB*VSMEAN1
         WRITE(6,116) RPM,SCCON,PSCCON
         IF ( PMIN16.GT.PSCCON ) THEN
            PMIN16 = PSCCON
            XMIN16 = SCCON
         ENDIF
   16 CONTINUE
  116 FORMAT(1X,F7.2,3X,E8.2,3X,F7.2)
C*****-------------------------*********-------------------------******C
          PMIN17 = 99999.
        DO 17 J17 = 0,N,1
         DSLCON = (SLCONH-SLCONL)/N
          SLCON = SLCONL + J17*DSLCON
        CALL MEAN1(CONLB,ARMB,VBMEAN1,VSMEAN1)
         PSLCON = VISB*(BRCONB**3)*BLCONB*((2*PI)/(BCCONB*SQRT(1-E**2)))
     $           *((2*PI*(RPM/60))**2)*NCB*VBMEAN1 +
     $           VISB*(SRCONB**3)*SLCON*((2*PI)/(SCCONB*SQRT(1-ESM**2)))
     $           *((2*PI*(RPM/60))**2)*NCB*VSMEAN1
         WRITE(6,117) RPM,SLCON,PSLCON
         IF ( PMIN17.GT.PSLCON ) THEN
            PMIN17 = PSLCON
            XMIN17 = SLCON
         ENDIF
   17 CONTINUE
  117 FORMAT(1X,F7.2,3X,F5.3,3X,F7.2)
C*****-------------------------*********-------------------------******C
          XMIN18 = CONLH
C*****-------------------------*********-------------------------******C
          PMIN19 = 99999.
        DO 19 J19 = 0,N,1
            DFM = (FMH-FML)/N
             FM = FML + J19*DFM
        CALL TMEAN1(FCOE,SDEGB,FB,CDEGB,FM,SCB,PLB,BRB,TRB,VLB,RADC,TOR1
     $      ,PI)
           PFCAM = -TOR1*RADC*NCB*NVCB
         WRITE(6,119) RPM,FM,PFCAM
         IF ( PMIN19.GT.PFCAM ) THEN
            PMIN19 = PFCAM
            XMIN19 = FM
         ENDIF
   19 CONTINUE
  119 FORMAT(1X,F7.2,3X,F4.2,3X,F7.2)
C*****-------------------------*********-------------------------******C
          PMIN20 = 99999.
        DO 20 J20 = 0,N,1
            DSC = (SCH-SCL)/N
             SC = SCL + J20*DSC
        CALL TMEAN2(FCOE,SDEGB,FB,CDEGB,FMB,SC,PLB,BRB,TRB,VLB,RADC,TOR2
     $,PI)
           PSCAM = -TOR2*RADC*NCB*NVCB
         WRITE(6,120) RPM,SC,PSCAM
         IF ( PMIN20.GT.PSCAM ) THEN
            PMIN20 = PSCAM
            XMIN20 = SC
         ENDIF
   20 CONTINUE
  120 FORMAT(1X,F7.2,3X,F7.1,3X,F7.2)
C*****-------------------------*********-------------------------******C
          PMIN21 = 99999.
        DO 21 J21 = 0,N,1
            DPL = (PLH-PLL)/N
```

```
            PL = PLL + J21*DPL
         CALL TMEAN3(FCOE,SDEGB,FB,CDEGB,FMB,SCB,PL,BRB,TRB,VLB,RADC,TOR3
        $,PI)
            PPCAM = -TOR3*RADC*NCB*NVCB
          WRITE(6,121) RPM,PL,PPCAM
          IF ( PMIN21.GT.PPCAM ) THEN
             PMIN21 = PPCAM
             XMIN21 = PL
          ENDIF
       21 CONTINUE
      121 FORMAT(1X,F7.2,3X,F5.1,3X,F7.2)
C*****-------------------------********-------------------------******C
          PMIN22 = 99999.
         DO 22 J22 = 0,N,1
               DBR = (BRH-BRL)/N
                BR = BRL + J22*DBR
           DO 23 J23 = 0,N,1
                DTR = (TRH-TRL)/N
                TR = TRL + J23*DTR
               FBTR = (BR**2-TR**2+(BR+VLB-TR)**2
        $                -2*BR*(BR+VLB-TR)*SIN(SDEGB*PI/180))
        $                /(2*(BR-TR-(BR+VLB-TR)
        $                *SIN(SDEGB*PI/180)))
            CDEGBTR = (ACOS((FBTR-BR)*COS(SDEGB*PI/180)
        $                /(FBTR-TR)))*180/PI
         CALL TMEAN51(FCOE,SDEGB,FBTR,CDEGBTR,FMB,SCB,PLB,BR,TR
        $     ,VLB,RADC,TOR51,PI)
              PBTCAM = -TOR51*RADC*NCB*NVCB
           WRITE(6,122) RPM,BR,TR,PBTCAM
           IF ( PMIN22.GT.PBTCAM ) THEN
              PMIN22 = PBTCAM
              XMIN22 = BR
              XMIN23 = TR
           ENDIF
       23 CONTINUE
       22 CONTINUE
      122 FORMAT(1X,F7.2,3X,F5.2,3X,F4.2,3X,F7.2)
C*****-------------------------********-------------------------******C
            PMIN24 = 99999.
          DO 24 J24 = 0,N,1
               DDVL = (VLH-VLL)/N
                VL = VLL + J24*DDVL
               FVL = (BRB**2-TRB**2+(BRB+VL-TRB)**2-2*BRB*(BRB+VL-TRB)
        $                *SIN(SDEGB*PI/180))
        $                /(2*(BRB-TRB-(BRB+VL-TRB)*SIN(SDEGB*PI/180)))
            CDEGVL = (ACOS((FVL-BRB)*COS(SDEGB*PI/180)
        $                /(FVL-TRB)))*180/PI
         CALL TMEAN6(FCOE,SDEGB,FVL,CDEGVL,FMB,SCB,PLB,BRB,TRB,VL,RADC
        $,TOR6,PI)
            PVCAM = -TOR6*RADC*NCB*NVCB
          WRITE(6,124) RPM,VL,PVCAM
           IF ( PMIN24.GT.PVCAM ) THEN
              PMIN24 = PVCAM
              XMIN24 = VL
           ENDIF
       24 CONTINUE
      124 FORMAT(1X,F7.2,3X,F4.1,3X,F7.2)
C*****-------------------------********-------------------------******C
         CALL P311(RPM,BOREL,BOREH,VISL,VISH,CONLB,BN,NPRESSB,NOILB,
        $     NCB,RP,RO,PI,H,EC,E,ESM,RCRANKB,CRANKLB,CCRANKB,BPRESSB,
        $     BOILB,BRCONB,BCCONB,BLCONB,SRCONB,SCCONB,SLCONB,PCB,PISLB,
        $     VDB,XMIN25,XMIN26,XMIN27)
C*****-------------------------********-------------------------******C
            RPM = RPML + I1*DRPM
         CALL SEL1(RPM,GN,G1,G2,G3,G4,G5,GD,TEFF,GT)
           PMIN28 = 99999.
          DO 28 K28 = 0,N,1
              DCD = (CDH-CDL)/N
               CD = CDL + K28*DCD
```

```
        PAIRC = 0.5*CD*AIRDEN*AREAB*( (RPM/60)*2*PI*WR/GT )**3
      IF (PMIN28.GT.PAIRC) THEN
        PMIN28 = PAIRC
        XMIN28 = CD
      ENDIF
   28 CONTINUE
C*****-------------------------********-------------------------******C
         PMIN29 = 99999.
       DO 29 K29 = 0,N,1
            DAF = (AFH-AFL)/N
             AF = AFL + K29*DAF
         PAIRA = 0.5*CDB*AIRDEN*AF*( (RPM/60)*2*PI*WR/GT )**3
      IF (PMIN29.GT.PAIRA) THEN
         PMIN29 = PAIRA
         XMIN29 = AF
      ENDIF
   29 CONTINUE
C*****-------------------------********-------------------------******C
         PMIN30 = 99999.
       DO 30 K30 = 0,N,1
            DFR = (FRH-FRL)/N
             FR = FRL + K30*DFR
        PROLLF = FR*MGB*9.81*( (RPM/60)*2*PI*WR/GT )
      IF (PMIN30.GT.PROLLF) THEN
        PMIN30 = PROLLF
        XMIN30 = FR
      ENDIF
   30 CONTINUE
C*****-------------------------********-------------------------******C
         PMIN31 = 99999.
       DO 31 K31 = 0,N,1
            DMG = (MGH-MGL)/N
            VMG = MGL + K31*DMG
        PROLLM = FRB*VMG*9.81*( (RPM/60)*2*PI*WR/GT )
      IF (PMIN31.GT.PROLLM) THEN
        PMIN31 = PROLLM
        XMIN31 = VMG
      ENDIF
   31 CONTINUE
C*****-------------------------********-------------------------******C
      CALL ACCESS(N,RPM,BCOMB,SCOMB,RKB,EMB,ECB,RDALTB,RLALTB,QL,QH,
     $RDALTL,RDALTH,RLALTL,RLALTH,RCOM,NCOM,PCLE,H1,H2,V1,FRAC,EVAPP,
     $CONDP,CORRK,RALT,PAIRQ,PALTD,PALTL,PI,Q,AMPB,VOLTB,RDALT,RLALT,
     $XACC1,XACC3,XACC4)
C*****-------------------------********-------------------------******C
      OPEN(UNIT=1,FILE='RESULT3.OUT',STATUS='OLD')
       WRITE(1,140) RPM,VDB
       WRITE(1,141) XMIN1
       WRITE(1,142) XMIN2
       WRITE(1,143) XMIN3
       WRITE(1,146) XMIN6
       WRITE(1,148) XMIN8
       WRITE(1,149) XMIN9
       WRITE(1,150) XMIN10
       WRITE(1,151) XMIN11
       WRITE(1,152) XMIN12
       WRITE(1,153) XMIN13
       WRITE(1,154) XMIN14
       WRITE(1,155) XMIN15
       WRITE(1,156) XMIN16
       WRITE(1,157) XMIN17
       WRITE(1,159) XMIN19
       WRITE(1,160) XMIN20
       WRITE(1,161) XMIN21
       WRITE(1,162) XMIN22
       WRITE(1,163) XMIN23
       WRITE(1,164) XMIN24
       WRITE(1,165) XMIN25
       WRITE(1,166) XMIN26
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      WRITE(1,167) XMIN27
      WRITE(1,168) XMIN28
      WRITE(1,169) XMIN29
      WRITE(1,170) XMIN30
      WRITE(1,171) XMIN31
      WRITE(1,172) XACC1
      WRITE(1,174) XACC3
      WRITE(1,175) XACC4
      WRITE(1,*) '  '
  100 CONTINUE
C*****-------------------------********-------------------------------******C
  140 FORMAT(' ENGINE SPEED : ',F7.2,'  (RPM) :  ',F6.1,'   (CC)       ')
  141 FORMAT(' RADIUS OF BEARING IN CRANKSHAFT   : ',T48,F8.5,' (m)    ')
  142 FORMAT(' BEARING WIDTH IN CRANKSHAFT       : ',T48,F8.5,' (m)    ')
  143 FORMAT(' RADIUS CLEARANCE IN CRANKSHAFT    : ',T48,E8.2,' (m)    ')
  146 FORMAT(' INLET VALVE DIAMETER              : ',T48,F8.4,' (m)    ')
  148 FORMAT(' PISTON CLEARANCE                  : ',T48,F8.6,' (m)    ')
  149 FORMAT(' SKIRT LENGTH                      : ',T48,F8.4,' (m)    ')
  150 FORMAT(' PRESSURE RING DEPTH               : ',T48,F8.1,' (mm)   ')
  151 FORMAT(' OIL RING DEPTH                    : ',T48,F8.1,' (mm)   ')
  152 FORMAT(' RADIUS BEARING AT BIG-END SIDE    : ',T48,F8.4,' (m)    ')
  153 FORMAT(' RADIUS CLEARANCE AT BIG-END SIDE  : ',T48,E8.2,' (m)    ')
  154 FORMAT(' BEARING WIDTH AT BIG-END SIDE     : ',T48,F8.3,' (m)    ')
  155 FORMAT(' RADIUS BEARING AT SMALL-END SIDE  : ',T48,F8.4,' (m)    ')
  156 FORMAT(' RADIUS CLEARANCE AT SMALL-END SIDE: ',T48,E8.2,' (m)    ')
  157 FORMAT(' BEARING WIDTH AT SMALL-END SIDE   : ',T48,F8.3,' (m)    ')
  159 FORMAT(' VALVE FOLLOWER MASS               : ',T48,F8.4,' (kg)   ')
  160 FORMAT(' SPRING STIFFNESS                  : ',T48,F8.1,' (N/m)  ')
  161 FORMAT(' VALVE PRELOAD                     : ',T48,F8.1,' (N)    ')
  162 FORMAT(' BASE RADIUS                       : ',T48,F8.2,' (mm)   ')
  163 FORMAT(' TIP RADIUS                        : ',T48,F8.2,' (mm)   ')
  164 FORMAT(' VALVE LIFT                        : ',T48,F8.1,' (mm)   ')
  165 FORMAT(' ABSOLUTE VISCOSITY                : ',T48,F8.4,' (Pa.s) ')
  166 FORMAT(' BORE                              : ',T48,F8.4,' (m)    ')
  167 FORMAT(' CRANK ARM                         : ',T48,F8.5,' (m)    ')
  168 FORMAT(' DRAG COEFFICIENT                  : ',T48,F8.2,'        ')
  169 FORMAT(' FRONTAL AREA                      : ',T48,F8.2,' (m^2)  ')
  170 FORMAT(' ROLLING COEFFICENT                : ',T48,F8.5,'        ')
  171 FORMAT(' VEHICLE MASS                      : ',T48,F8.1,' (kg)   ')
  172 FORMAT(' COOLING LOAD                      : ',T48,F7.2,' (W)    ')
  174 FORMAT(' ROTOR DIAMETER IN ALTERNATOR      : ',T48,F7.4,' (m)    ')
  175 FORMAT(' ROTOR LENGTH IN ALTERNATOR        : ',T48,F7.4,' (m)    ')
C*****-------------------------********-------------------------------******C
C                    POWER REQUIRED IN BASE LINE DATA                      C
C*****-------------------------********-------------------------------******C
      OPEN(UNIT=1,FILE='RESULT3.OUT',STATUS='OLD')
       WRITE(1,*) 'RPM:PCRANK:PAIR:PWP:PALTER:PPUMP:PPIS:PRING:PCON:PC
     $AM:PTOTAL'
       WRITE(1,*) 'POWER REQUIRED AT BASE LINE DATA '
      DO 210 I2 = 0,RPMN,1
          DRPM = (RPMH-RPML)/RPMN
           RPM = RPML + I2*DRPM
          RPMC = RPM/2
          RADC = (RPMC*2*PI/60)
      IF (RPM.LE.1300.) THEN
         DHM = 9.9
      ELSE
       IF (RPM.LE.1700.) THEN
          DHM = 10.2
       ELSE
       IF (RPM.LE.2000.) THEN
           DHM = 11.
       ELSE
        IF (RPM.LE.2400.) THEN
            DHM = 12.
        ELSE
         IF (RPM.LE.2700.) THEN
             DHM = 13.
         ELSE
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            IF (RPM.LE.3000.) THEN
                DHM = 13.7
            ELSE
             IF (RPM.LE.3400.) THEN
                DHM = 14.9
             ELSE
              IF (RPM.LE.3700.) THEN
                 DHM = 15.9
              ELSE
               IF (RPM.LE.4000.) THEN
                  DHM = 16.5
               ELSE
                WRITE(*,*) ' OVER ENGINE SPEED '
               ENDIF
              ENDIF
             ENDIF
            ENDIF
           ENDIF
          ENDIF
         ENDIF
        ENDIF
            PIA = 9.81*DENHG*DHM*0.0254/1000
          CIMEP = 12.87*PA*((PIA/PA)-0.1)
            PIG = PA-(CIMEP/12.8)-10.14
            FBB = (NVB*NCB*(DVB**2))/(2*ARMB*PI*NCB*(BOREB**2)/4)
             FB = (BRB**2-TRB**2+(BRB+VLB-TRB)**2-2*BRB*(BRB+VLB-TRB)
     $              *SIN(SDEGB*PI/180))/(2*(BRB-TRB-(BRB+VLB-TRB)
     $              *SIN(SDEGB*PI/180)))
      CDEGB = ACOS( (FB-BRB)*COS(SDEGB*PI/180)/(FB-TRB) )*180/PI
      CALL NUM1(BPRESSB,BOILB,RP,RO,H,HP1,HO1,HP2,HO2,HP3,HO3)
      CALL MEAN1(CONLB,ARMB,VBMEAN1,VSMEAN1)
      CALL TMEAN7(FCOE,SDEGB,FB,CDEGB,FMB,SCB,PLB,BRB,TRB,VLB,RADC,
     $            TOR7,PI)
C.............POWER LOSS FROM CRANK SHAFT BEARING
       PCRANK = VISB*(RCRANKB**3)*CRANKLB*((2*PI)
     $         /(CCRANKB*SQRT(1-EC**2)))*((2*PI*(RPM/60))**2)*BN
C.............POWER LOSS FROM AIR CONDITIONING
        VOLEEF = 1.+(PCLE/100.)*(1.-CONDP/EVAPP)
      RPMCOOL = QB/(H1-H2)*4.*60.*V1/
     $           (PI*SCOMB*NCOM*VOLEEF*RCOM*(BCOMB)**2)
      IF (RPM.LE.RPMCOOL) THEN
         PAIR = (PI/4.)*(BCOMB**2.)*SCOMB*NCOM*RCOM*(RPM/60.)*VOLEEF
     $           *(RKB/(RKB-1.))*(1.-(CONDP/EVAPP)**((RKB-1.)/RKB))
     $           *EVAPP*(1./(EMB*ECB))*(-1.)
      ELSE
         PAIR = QB/(H1-H2)*EVAPP*V1*(RKB/(RKB-1.))
     $           *(1.-(CONDP/EVAPP)**((RKB-1.)/RKB))
     $           *(1./(EMB*ECB))*(-1.)
      ENDIF
C.............POWER LOSS FROM WATER PUMP AND OIL PUMP
       PWP = 269.*((RPM/1000.)**1.5)/12.*(RPM*VDB/1000000.)
C.............POWER LOSS FROM ALTERNATOR LOAD
      PALTER = AMPB*VOLTB + (100./FRAC)*(1/3.)*CORRK
     $         *((RALT*PI*RDALTB*RPM/3048.)**2.5)*1000.
     $         *(RDALTB/0.0254)*(RLALTB/0.0254)**0.5
C.............POWER LOSS FROM ACCESSORIES LOAD
      PACC = PAIR+PWP+PALTER
C.............POWER LOSS FROM PUMPING LOSSES
      PPUMP = (PA-(CIMEP/12.8)-10.14+PE*(((CIMEP*RPM)/(3904000))**2) +
     $         8.9667*(SQRT(CIMEP/1124.3))*((RPM/1000)**1.7)*
     $         ((2.984/FBB)**1.28)  +
     $         (SQRT((PA-PIG)/97.94))*(11.86*(RCB**0.4)-(3.38+0.103*RCB)
     $         *((RPM/1000.)**1.185)))*1000.*(2.*ARMB*PI*NCB*(BOREB**2.)
     $         /4.)*(RPM/120.)
C.............POWER LOSS FROM PISTON SKIRT
      PPIS = (VISB*PI*BOREB*PISLB/PCB)*((ARMB*(RPM/15))**2)*NCB
C.............POWER LOSS FROM PISTON RING
      PRING = VISB*ARMB*2*PI*(RPM/60)*(4*HO1-3*(HO2**2)/HO3+BOILB*
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     $          (1-RO)/(1+RO))*4*ARMB*PI*BOREB*(RPM/60)*NOILB*NCB +
     $          VISB*ARMB*2*PI*(RPM/60)*(4*HP1-3*(HP2**2)/HP3+(BPRESSB*
     $          (1-RP)/(1+RP))/H)*4*ARMB*PI*BOREB*(RPM/60)*NPRESSB*NCB
C.............POWER LOSS FROM CONNECTING ROD
      PCON = VISB*(BRCONB**3)*BLCONB*((2*PI)/(BCCONB*SQRT(1-E**2)))
     $          *((2*PI*(RPM/60))**2)*NCB*VBMEAN1 +
     $          VISB*(SRCONB**3)*SLCONB*((2*PI)/(SCCONB*SQRT(1-ESM**2)))
     $          *((2*PI*(RPM/60))**2)*NCB*VSMEAN1
C.............POWER LOSS FROM CAM LOAD
      PCAM = -TOR7*RADC*NCB*NVCB
      PTOTAL = PCRANK+PAIR+PWP+PALTER+PPUMP+PPIS+PRING+PCON+PCAM
      OPEN(UNIT=1,FILE='RESULT3.OUT',STATUS='OLD')
      WRITE(1,202) RPM,PCRANK,PAIR,PWP,PALTER,PPUMP,PPIS,PRING,
     $             PCON,PCAM,PTOTAL
      WRITE(6,202) RPM,PCRANK,PAIR,PWP,PALTER,PPUMP,PPIS,PRING,
     $             PCON,PCAM,PTOTAL
  202 FORMAT(F6.1,1X,F6.1,1X,F6.1,1X,F6.1,1X,F6.1,1X,F6.1,1X,F6.1,
     $1X,F6.1,1X,F6.1,1X,F6.1,1X,F7.1)
  210 CONTINUE
      WRITE(1,*) '  '
      WRITE(6,*) '  '
      WRITE(1,*) ' POWER REQUIRED AT OPTIMUM DATA '
C*****-------------------------********-------------------------******C
C                  POWER REQUIRED IN OPTIMUM DATA                     C
C*****-------------------------********-------------------------******C
      DO 211 I3 = 0,RPMN,1
         DRPM = (RPMH-RPML)/RPMN
          RPM = RPML + I3*DRPM
         RPMC = RPM/2.
         RADC = (RPMC*2*PI/60.)
        XMIN7 = RCH
       XMIN18 = CONLH
      IF (RPM.LE.1300.) THEN
        DHM = 9.9
      ELSE
       IF (RPM.LE.1700.) THEN
          DHM = 10.2
       ELSE
       IF (RPM.LE.2000.) THEN
           DHM = 11.
       ELSE
        IF (RPM.LE.2400.) THEN
            DHM = 12.
        ELSE
         IF (RPM.LE.2700.) THEN
             DHM = 13.
         ELSE
          IF (RPM.LE.3000.) THEN
              DHM = 13.7
          ELSE
           IF (RPM.LE.3400.) THEN
             DHM = 14.9
           ELSE
            IF (RPM.LE.3700.) THEN
              DHM = 15.9
            ELSE
             IF (RPM.LE.4000.) THEN
               DHM = 16.5
             ELSE
              WRITE(*,*) ' OVER ENGINE SPEED '
             ENDIF
            ENDIF
           ENDIF
          ENDIF
         ENDIF
        ENDIF
       ENDIF
      ENDIF
       ENDIF
      ENDIF
```

```
          PIA = 9.81*DENHG*DHM*0.0254/1000.
        CIMEP = 12.87*PA*((PIA/PA)-0.1)
          PIG = PA-(CIMEP/12.8)-10.14
          FMM = (NVB*NCB*(XMIN6**2))*1000000./VDB
          FBM = (XMIN22**2.-XMIN23**2.+(XMIN22+XMIN24-XMIN23)**2.-
     $            2.*XMIN22*(XMIN22+XMIN24-XMIN23)*SIN(SDEGB*PI/180.))
     $            /(2.*(XMIN22-XMIN23-(XMIN22+XMIN24-XMIN23)
     $            *SIN(SDEGB*PI/180.)))
        CDEGM = ACOS( (FBM-XMIN22)*COS(SDEGB*PI/180.)/(FBM-XMIN23))
     $            *180./PI
        CALL NUM4(XMIN10,XMIN11,RP,RO,H,HP11,HO11,HP21,HO21,HP31,HO31)
        CALL MEAN14(XMIN18,XMIN27,VBMEAN14,VSMEAN14,PI)
        CALL TMEAN71(FCOE,SDEGB,FBM,CDEGM,XMIN19,XMIN20,XMIN21,XMIN22
     $       ,XMIN23,XMIN24,RADC,TOR71,PI)
C.............POWER LOSS FROM CRANK SHAFT BEARING
       PCRANKM = XMIN25*(XMIN1**3.)*XMIN2*((2.*PI)
     $           /(XMIN3*SQRT(1.-EC**2.)))*((2.*PI*(RPM/60.))**2.)*BN
C.............POWER LOSS FROM AIR CONDITIONING
        VOLEEF = 1.+(PCLE/100.)*(1.-CONDP/EVAPP)
       RPMCOOL = XACC1/(H1-H2)*4.*60.*V1/
     $             (PI*SCOMB*NCOM*VOLEEF*RCOM*(BCOMB)**2.)
       IF (RPM.LE.RPMCOOL) THEN
         PAIRM = (PI/4.)*(BCOMB**2.)*SCOMB*NCOM*RCOM*(RPM/60.)*VOLEEF
     $             *(RKB/(RKB-1.))*(1.-(CONDP/EVAPP)**((RKB-1.)/RKB))
     $             *EVAPP*(1./(EMB*ECB))*(-1.)
       ELSE
         PAIRM = XACC1/(H1-H2)*EVAPP*V1*(RKB/(RKB-1.))
     $             *(1.-(CONDP/EVAPP)**((RKB-1.)/RKB))
     $             *(1./(EMB*ECB))*(-1.)
       ENDIF
C.............POWER LOSS FROM WATER PUMP AND OIL PUMP
        PWPM = 269.*((RPM/1000.)**1.5)/12.*RPM*VDB/1000000.
C............POWER LOSS FROM ALTERNATOR LOAD
      PALTERM = AMPB*VOLTB + (100./FRAC)*(1/3.)*CORRK
     $          *((RALT*PI*XACC3*RPM/3048.)**2.5)*1000.
     $          *(XACC3/0.0254)*(XACC4/0.0254)**0.5
C.............POWER LOSS FROM PUMPING LOSSES
       PPUMPM = (PA-(CIMEP/12.8)-10.14+PE*(((CIMEP*RPM)/(3904000))**2) +
     $          8.9667*(SQRT(CIMEP/1124.3))*((RPM/1000)**1.7)*
     $          ((2.984/FMM)**1.28)  +
     $          (SQRT((PA-PIG)/97.94))*(11.86*(XMIN7**0.4)
     $         -(3.38+0.103*XMIN7)*((RPM/1000)**1.185)))*VDB/1000
     $          *(RPM/120)
C.............POWER LOSS FROM PISTON SKIRT
       PPISM = (XMIN25*PI*XMIN26*XMIN9/XMIN8)*((XMIN27*(RPM/15))**2)
     $          *NCB
C.............POWER LOSS FROM PISTON RING
       PRINGM = XMIN25*XMIN27*2*PI*(RPM/60)*(4*HO11-3*(HO21**2)/HO31+
     $          XMIN11*(1-RO)/(1+RO))*4*XMIN27*PI*XMIN26*(RPM/60)
     $         *NOILB*NCB +
     $          XMIN25*XMIN27*2*PI*(RPM/60)*(4*HP11-3*(HP21**2)/HP31+
     $          (XMIN10*(1-RP)/(1+RP))/H)*4*XMIN27*PI*XMIN26*(RPM/60)
     $         *NPRESSB*NCB
C.............POWER LOSS FROM CONNECTING ROD
       PCONM = XMIN25*(XMIN12**3)*XMIN14*((2*PI)/(XMIN13*SQRT(1-E**2)))
     $          *((2*PI*(RPM/60))**2)*NCB*VBMEAN14 +
     $          XMIN25*(XMIN15**3)*XMIN17*((2*PI)/
     $          (XMIN16*SQRT(1-ESM**2)))*((2*PI*(RPM/60))**2)*NCB
     $          *VSMEAN14
C.............POWER LOSS FROM CAM LOAD
       PCAMM = -TOR71*RADC*NCB*NVCB
      PTOTALM = PCRANKM+PAIRM+PWPM+PALTERM+PPUMPM+PPISM+PRINGM+PCONM
     $          +PCAMM
       OPEN(UNIT=1,FILE='RESULT3.OUT',STATUS='OLD')
       WRITE(1,203)  RPM,PCRANKM,PAIRM,PWPM,PALTERM,PPUMPM,PPISM,
     $               PRINGM,PCONM,PCAMM,PTOTALM
       WRITE(6,203)  RPM,PCRANKM,PAIRM,PWPM,PALTERM,PPUMPM,PPISM,
     $               PRINGM,PCONM,PCAMM,PTOTALM
  203  FORMAT(F6.1,1X,F6.1,1X,F6.1,1X,F6.1,1X,F6.1,1X,F6.1,1X,F6.1,
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```
     $1X,F6.1,1X,F6.1,1X,F6.1,1X,F7.1)
  211 CONTINUE
C*****-------------------------********-------------------------******C
C                ROAD LOAD POWER AND TRANSMITTION LOSS                 C
C*****-------------------------********-------------------------******C
       WRITE(6,*) '  '
       WRITE(1,*) '  '
       WRITE(1,*) ' (RPM) : (km/hr) : AIR-LOAD (W) : ROLLING-LOAD (W) :
      $ TRANSMISSION (W) '
       WRITE(6,*) ' (RPM) : (km/hr) : AIR-LOAD (W) : ROLLING-LOAD (W) :
      $ TRANSMISSION (W) '
       DO 212 I4 = 0,RPMN,1
           DRPM = (RPMH-RPML)/RPMN
            RPM = RPML + I4*DRPM
       CALL SEL1(RPM,GN,G1,G2,G3,G4,G5,GD,TEFF,GT)
       SPEED = (RPM/60)*2*PI*WR*3.6/GT
       PAIRR = 0.5*CDB*AIRDEN*AREAB*( (RPM/60)*2*PI*WR/GT )**3
       PROLL = FRB*MGB*( (RPM/60)*2*PI*WR/GT )*9.81
       PTRAN = (1/TEFF-1)*(PAIRR+PROLL)
        WRITE(1,205) RPM,SPEED,PAIRR,PROLL,PTRAN
        WRITE(6,205) RPM,SPEED,PAIRR,PROLL,PTRAN
  212 CONTINUE
       WRITE(6,*) '  '
       WRITE(1,*) '  '
       WRITE(1,*) ' ROAD LOAD AND TRANSMISSION AT OPTIMUM DATA'
       WRITE(1,204) GN
       WRITE(1,*) ' (RPM) : (km/hr) : AIR-LOAD (W) : ROLLING-LOAD (W) :
      $ TRANSMISSION (W) '
       WRITE(6,*) ' (RPM) : (km/hr) : AIR-LOAD (W) : ROLLING-LOAD (W) :
      $ TRANSMISSION (W) '
       DO 213 I5 = 0,RPMN,1
           DRPM = (RPMH-RPML)/RPMN
            RPM = RPML + I5*DRPM
       CALL SEL1(RPM,GN,G1,G2,G3,G4,G5,GD,TEFF,GT)
          SPEED = (RPM/60)*2*PI*WR*3.6/GT
         PAIRRM = 0.5*XMIN28*AIRDEN*XMIN29*( (RPM/60)*2*PI*WR/GT )**3
         PROLLM = XMIN30*XMIN31*( (RPM/60)*2*PI*WR/GT )*9.81
         PTRANM = (1/TEFF-1)*(PAIRRM+PROLLM)
         WRITE(1,205) RPM,SPEED,PAIRRM,PROLLM,PTRANM
         WRITE(6,205) RPM,SPEED,PAIRRM,PROLLM,PTRANM
  213 CONTINUE
  204 FORMAT(1X,' DRIVE GEAR NUMBER ',F4.0)
  205 FORMAT(1X,F6.1,T12,F5.1,T24,F9.2,T36,F7.2,T48,F7.2)
C*****-------------------------********-------------------------******C
C=============================================================================C
C           XMIN1 = RADIUS OF BEARING IN CRANKSHAFT                           C
C           XMIN2 = BEARING WIDTH IN CRANKSHAFT                               C
C           XMIN3 = RADIUS CLEARANCE IN CRANKSHAFT                            C
C           XMIN6 = INLET VALVE DIAMETER                                      C
C           XMIN7 = COMPRESION RATIO                                          C
C           XMIN8 = PISTON CLEARANCE                                          C
C           XMIN9 = SKIRT LENGTH                                              C
C          XMIN10 = PRESSURE RING DEPTH                                       C
C          XMIN11 = OIL RING DEPTH                                            C
C          XMIN12 = RADIUS OF BEARING AT BIG-END SIDE                         C
C          XMIN13 = RADIUS CLEARANCE AT BIG-END SIDE                          C
C          XMIN14 = BEARING WIDTH AT BIG-END SIDE                             C
C          XMIN15 = RADIUS OF BEARING AT SMALL-END SIDE                       C
C          XMIN16 = RADIUS CLEARANCE AT SMALL-END SIDE                        C
C          XMIN17 = BEARING WIDTH AT SMALL-END SIDE                           C
C          XMIN18 = CONNECTING ROD LENGTH                                     C
C          XMIN19 = VALVE FOLLOWER MASS                                       C
C          XMIN20 = SPRING STIFFNESS                                          C
C          XMIN21 = VALVE PRELOAD                                             C
C          XMIN22 = BASE RADIUS                                               C
C          XMIN23 = TIP RADIUS                                                C
C          XMIN24 = VALVE LIFT                                                C
C          XMIN25 = ABSOLUTE VISCOSITY                                        C
C          XMIN26 = BORE                                                      C
```

```
C          XMIN27 = CRANK ARM                                                  C
C          XMIN28 = DRAG COEFFICIENT                                           C
C          XMIN29 = FRONTAL AREA                                               C
C          XMIN30 = ROLLING COEFFICENT                                         C
C          XMIN31 = VEHICLE MASS                                               C
C           XACC1 = COOLING LOAD                                               C
C           XACC3 = ROTOR DIAMETER IN ALTERNATOR                               C
C           XACC4 = ROTOR LENGTH IN ALTERNATOR                                 C
C=============================================================================C
C*****-----------------------*********-------------------------------******C
C                    POWER REQUIRED AT OPERATION CONDITON                     C
C*****-----------------------*********-------------------------------******C
      OPEN(UNIT=1,FILE='RESULT3.OUT',STATUS='OLD')
         RPMC = ORPM/2
         RADC = (RPMC*2*PI/60)
      IF (ORPM.LE.1300.) THEN
         DHM = 9.9
      ELSE
       IF (ORPM.LE.1700.) THEN
          DHM = 10.2
       ELSE
       IF (ORPM.LE.2000.) THEN
            DHM = 11.
       ELSE
        IF (ORPM.LE.2400.) THEN
             DHM = 12.
        ELSE
         IF (ORPM.LE.2700.) THEN
              DHM = 13.
         ELSE
          IF (ORPM.LE.3000.) THEN
              DHM = 13.7
          ELSE
           IF (ORPM.LE.3400.) THEN
              DHM = 14.9
           ELSE
            IF (ORPM.LE.3700.) THEN
                DHM = 15.9
            ELSE
             IF (ORPM.LE.4000.) THEN
                 DHM = 16.5
             ELSE
              WRITE(*,*) ' OVER ENGINE SPEED '
             ENDIF
            ENDIF
           ENDIF
          ENDIF
         ENDIF
        ENDIF
       ENDIF
       ENDIF
      ENDIF
         PIA = 9.81*DENHG*DHM*0.0254/1000
       CIMEP = 12.87*PA*((PIA/PA)-0.1)
         PIG = PA-(CIMEP/12.8)-10.14
         FBO = (NVB*NCB*(DVB**2))/(2*ARMB*PI*NCB*(BOREB**2)/4)
          FB = (BRB**2-TRB**2+(BRB+VLB-TRB)**2-2*BRB*(BRB+VLB-TRB)
     $             *SIN(SDEGB*PI/180))/(2*(BRB-TRB-(BRB+VLB-TRB)
     $             *SIN(SDEGB*PI/180)))
      CDEGB = ACOS( (FB-BRB)*COS(SDEGB*PI/180)/(FB-TRB) )*180/PI
      CALL NUM1(BPRESSB,BOILB,RP,RO,H,HP1,HO1,HP2,HO2,HP3,HO3)
      CALL MEAN1(CONLB,ARMB,VBMEAN1,VSMEAN1)
      CALL TMEAN7(FCOE,SDEGB,FB,CDEGB,FMB,SCB,PLB,BRB,TRB,VLB,RADC
     $            ,TOR7,PI)
C.............POWER LOSS FROM CRANK SHAFT BEARING
      PCRAN1 = VISB*(RCRANKB**3)*CRANKLB*((2*PI)
     $        /(CCRANKB*SQRT(1-EC**2)))*((2*PI*(ORPM/60))**2)*BN
C.............POWER LOSS FROM AIR CONDITIONING
       VOLEEF = 1.+(PCLE/100.)*(1.-CONDP/EVAPP)
```

```
      RPMCOOL = QB/(H1-H2)*4.*60.*V1/
     $            (PI*SCOMB*NCOM*VOLEEF*RCOM*(BCOMB)**2)
      IF (ORPM.LE.RPMCOOL) THEN
       PAIR1 = (PI/4.)*(BCOMB**2.)*SCOMB*NCOM*RCOM*(ORPM/60.)*VOLEEF
     $           *(RKB/(RKB-1.))*(1.-(CONDP/EVAPP)**((RKB-1.)/RKB))
     $           *EVAPP*(1./(EMB*ECB))*(-1.)
      ELSE
       PAIR1 = QB/(H1-H2)*EVAPP*V1*(RKB/(RKB-1.))
     $           *(1.-(CONDP/EVAPP)**((RKB-1.)/RKB))
     $           *(1./(EMB*ECB))*(-1.)
      ENDIF
C.............POWER LOSS FROM WATER PUMP AND OIL PUMP
      PWP1 = 269.*((ORPM/1000)**1.5)/12.*ORPM*VDB/1000000
C.............POWER LOSS FROM ALTERNATOR LOAD
      PALT1 = AMPB*VOLTB + (100./FRAC)*(1./3.)*CORRK
     $        *((RALT*PI*RDALTB*ORPM/3048.)**2.5)*1000.
     $        *(RDALTB/0.0254)*(RLALTB/0.0254)**0.5
C.............POWER LOSS FROM PUMPING LOSSES
      PPUMP1 = (PA-(CIMEP/12.8)-10.14+PE*(((CIMEP*ORPM)/(3904000))**2) +
     $        8.9667*(SQRT(CIMEP/1124.3))*((ORPM/1000)**1.7)*
     $        ((2.984/FBO)**1.28)  +
     $        (SQRT((PA-PIG)/97.94))*(11.86*(RCB**0.4)-(3.38+0.103*RCB)
     $        *((ORPM/1000)**1.185)))*1000*(2*ARMB*PI*NCB*(BOREB**2)/4)
     $        *(ORPM/120)
C.............POWER LOSS FROM PISTON SKIRT
      PPIS1 = (VISB*PI*BOREB*PISLB/PCB)*((ARMB*(ORPM/15))**2)*NCB
C.............POWER LOSS FROM PISTON RING
      PRING1 = VISB*ARMB*2*PI*(ORPM/60)*(4*HO1-3*(HO2**2)/HO3+BOILB*
     $        (1-RO)/(1+RO))*4*ARMB*PI*BOREB*(ORPM/60)*NOILB*NCB +
     $        VISB*ARMB*2*PI*(ORPM/60)*(4*HP1-3*(HP2**2)/HP3+(BPRESSB*
     $        (1-RP)/(1+RP))/H)*4*ARMB*PI*BOREB*(ORPM/60)*NPRESSB*NCB
C.............POWER LOSS FROM CONNECTING ROD
      PCON1 = VISB*(BRCONB**3)*BLCONB*((2*PI)/(BCCONB*SQRT(1-E**2)))
     $        *((2*PI*(ORPM/60))**2)*NCB*VBMEAN1 +
     $        VISB*(SRCONB**3)*SLCONB*((2*PI)/(SCCONB*SQRT(1-ESM**2)))
     $        *((2*PI*(ORPM/60))**2)*NCB*VSMEAN1
C.............POWER LOSS FROM CAM LOAD
      PCAM1 = -TOR7*RADC*NCB*NVCB
C.............TOTAL ENGINE POWER LOSS AT BASE LINE DATA
      PTOT1 = PCRAN1+PAIR1+PWP1+PALT1+PPUMP1+PPIS1+PRING1+PCON1+PCAM1
C.............POWER LOSS FROM ROAD LOAD
      PAIRR1 = 0.5*CDB*AIRDEN*AREAB*( (ORPM/60)*2*PI*WR/GT )**3
      PROLL1 = FRB*MGB*( (ORPM/60)*2*PI*WR/GT )*9.81
      PTRAN1 = (1/TEFF-1)*(PAIRR1+PROLL1)
      BREAK1 = PAIRR1 + PROLL1 + PTRAN1
C.............POWER FRACTION EACH ENGINE POWER LOSS
       PP1 = PCRAN1/PTOT1*100
       PP2 = PAIR1/PTOT1*100
       PP3 = PWP1/PTOT1*100
       PP4 = PALT1/PTOT1*100
       PP5 = PPUMP1/PTOT1*100
       PP6 = PPIS1/PTOT1*100
       PP7 = PRING1/PTOT1*100
       PP8 = PCON1/PTOT1*100
       PP9 = PCAM1/PTOT1*100
      WRITE(1,*) ' '
      WRITE(1,*) 'ENGINE POWER SHARING AT BASE LINE DATA '
      WRITE(1,*) 'CRANK% : AIR% : PUMP% : ALT% : PUMPING% : PIS% : RING%
     $ : CON% : CAM% '
      WRITE(1,214) PP1,PP2,PP3,PP4,PP5,PP6,PP7,PP8,PP9
      WRITE(1,*) ' '
  214 FORMAT(2X,F5.2,2X,F5.2,2X,F5.2,2X,F5.2,2X,F5.2,2X,F5.2,2X,F5.2,2X,
     $F5.2,2X,F5.2)
C*****------------------------********-----------------------------******C
          FMO = (NVB*NCB*(XMIN6**2))*1000000/VDB
          FBM = (XMIN22**2-XMIN23**2+(XMIN22+XMIN24-XMIN23)**2 -
     $           2*XMIN22*(XMIN22+XMIN24-XMIN23)*SIN(SDEGB*PI/180))
     $           /(2*(XMIN22-XMIN23-(XMIN22+XMIN24-XMIN23)
     $           *SIN(SDEGB*PI/180)))
```

```
        CDEGM = ACOS( (FBM-XMIN22)*COS(SDEGB*PI/180)/(FBM-XMIN23) )
     $             *180/PI
      CALL NUM4(XMIN10,XMIN11,RP,RO,H,HP11,HO11,HP21,HO21,HP31,HO31)
      CALL MEAN14(XMIN18,XMIN27,VBMEAN14,VSMEAN14,PI)
      CALL TMEAN71(FCOE,SDEGB,FBM,CDEGM,XMIN19,XMIN20,XMIN21,XMIN22
     $       ,XMIN23,XMIN24,RADC,TOR71,PI)
C.............POWER LOSS FROM CRANK SHAFT BEARING
      PCRAN2 = XMIN25*(XMIN1**3)*XMIN2*((2*PI)
     $          /(XMIN3*SQRT(1-EC**2)))*((2*PI*(ORPM/60))**2)*BN
C.............POWER LOSS FROM AIR CONDITIONING
      VOLEEF = 1.+(PCLE/100.)*(1.-CONDP/EVAPP)
      RPMCOOL = XACC1/(H1-H2)*4.*60.*V1/
     $            (PI*SCOMB*NCOM*VOLEEF*RCOM*(BCOMB)**2.)
      IF (ORPM.LE.RPMCOOL) THEN
       PAIR2 = (PI/4.)*(BCOMB**2.)*SCOMB*NCOM*RCOM*(ORPM/60.)*VOLEEF
     $           *(RKB/(RKB-1.))*(1.-(CONDP/EVAPP)**((RKB-1.)/RKB))
     $           *EVAPP*(1./(EMB*ECB))*(-1.)
      ELSE
       PAIR2 = XACC1/(H1-H2)*EVAPP*V1*(RKB/(RKB-1.))
     $           *(1.-(CONDP/EVAPP)**((RKB-1.)/RKB))
     $           *(1./(EMB*ECB))*(-1.)
      ENDIF
C.............POWER LOSS FROM WATER PUMP AND OIL PUMP
      PWP2 = 269.*((ORPM/1000)**1.5)/12.*ORPM*VDB/1000000
C.............POWER LOSS FROM ALTERNATOR LOAD
      PALT2 = AMPB*VOLTB + (100./FRAC)*(1/3.)*CORRK
     $          *((RALT*PI*XACC3*ORPM/3048.)**2.5)*1000.
     $          *(XACC3/0.0254)*(XACC4/0.0254)**0.5
C.............POWER LOSS FROM PUMPING LOSSES
      PPUMP2 = (PA-(CIMEP/12.8)-10.14+PE*(((CIMEP*ORPM)/(3904000))**2)+
     $          8.9667*(SQRT(CIMEP/1124.3))*((ORPM/1000)**1.7)*
     $          ((2.984/FMO)**1.28)  +
     $          (SQRT((PA-PIG)/97.94))*(11.86*(XMIN7**0.4)
     $          -(3.38+0.103*XMIN7)*((ORPM/1000)**1.185)))*VDB/1000
     $          *(ORPM/120)
C.............POWER LOSS FROM PISTON SKIRT
      PPIS2 = (XMIN25*PI*XMIN26*XMIN9/XMIN8)*((XMIN27*(ORPM/15))**2)
     $          *NCB
C.............POWER LOSS FROM PISTON RING
      PRING2 = XMIN25*XMIN27*2*PI*(ORPM/60)*(4*HO11-3*(HO21**2)/HO31 +
     $          BOILB*(1-RO)/(1+RO))*4*XMIN27*PI*XMIN26*(ORPM/60)*
     $          NOILB*NCB + XMIN25*XMIN27*2*PI*(ORPM/60)*
     $          (4*HP11-3*(HP21**2)/HP31 + (BPRESSB*(1-RP)/(1+RP))/H)*
     $          4*XMIN27*PI*XMIN26*(ORPM/60)*NPRESSB*NCB
C.............POWER LOSS FROM CONNECTING ROD
      PCON2 = XMIN25*(XMIN12**3)*XMIN14*((2*PI)/(XMIN13*SQRT(1-E**2)))
     $          *((2*PI*(ORPM/60))**2)*NCB*VBMEAN14 +
     $          XMIN25*(XMIN15**3)*XMIN17*((2*PI)/
     $          (XMIN16*SQRT(1-ESM**2)))*((2*PI*(ORPM/60))**2)*NCB
     $          *VSMEAN14
C.............POWER LOSS FROM CAM LOAD
      PCAM2 = -TOR71*RADC*NCB*NVCB
C.............TOTAL ENGINE POWER LOSS AT OPTIMUM DATA
      PTOT2 = PCRAN2+PAIR2+PWP2+PALT2+PPUMP2+PPIS2+PRING2+PCON2
     $          +PCAM2
C.............POWER LOSS FROM ROAD LOAD
      VELO = (ORPM/60)*2*PI*WR*3.6/GT
      PAIRR2 = 0.5*XMIN28*AIRDEN*XMIN29*( (ORPM/60)*2*PI*WR/GT )**3
      PROLL2 = XMIN30*XMIN31*( (ORPM/60)*2*PI*WR/GT )*9.81
      PTRAN2 = (1/TEFF-1)*(PAIRR1+PROLL1)
      BREAK2 = PAIRR2 + PROLL2 + PTRAN2
C.............POWER FRACTION EACH ENGINE POWER LOSS
        DP1 = (PCRAN1-PCRAN2)*100/PCRAN1
        DP2 = (PAIR1-PAIR2)*100/PAIR1
        DP3 = (PALT1-PALT2)*100/PALT1
        DP4 = (PPUMP1-PPUMP2)*100/PPUMP1
        DP5 = (PPIS1-PPIS2)*100/PPIS1
        DP6 = (PRING1-PRING2)*100/PRING1
        DP7 = (PCON1-PCON2)*100/PCON1
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      DP8 = (PCAM1-PCAM2)*100/PCAM1
      DP9 = (PTOT1-PTOT2)*100/PTOT1
     DP10 = (PAIRR1-PAIRR2)*100/PAIRR1
     DP11 = (PROLL1-PROLL2)*100/PROLL1
     DP12 = (BREAK1-BREAK2)*100/BREAK1
      TDP = PCRAN1-PCRAN2+PAIR1-PAIR2+PALT1-PALT2+PPUMP1-PPUMP2+
     $        PPIS1-PPIS2+PRING1-PRING2+PCON1-PCON2+PCAM1-PCAM2
      FD1 = (PCRAN1-PCRAN2)/TDP*100
      FD2 = (PAIR1-PAIR2)/TDP*100
      FD3 = (PALT1-PALT2)/TDP*100
      FD4 = (PPUMP1-PPUMP2)/TDP*100
      FD5 = (PPIS1-PPIS2)/TDP*100
      FD6 = (PRING1-PRING2)/TDP*100
      FD7 = (PCON1-PCON2)/TDP*100
      FD8 = (PCAM1-PCAM2)/TDP*100
     TDPV = PAIRR1-PAIRR2+PROLL1-PROLL2
     FD10 = DP10/TDPV
     FD11 = DP11/TDPV
     FD12 = DP12/TDPV
     WRITE(1,215) ORPM,DHM
     WRITE(1,*) 'POWER AT BASE LINE DATA : OPTIMUM DATA : DECREASING %'
     WRITE(1,*) ' '
     WRITE(1,216) PCRAN1,PCRAN2,DP1
     WRITE(1,217) PAIR1,PAIR2,DP2
     WRITE(1,218) PALT1,PALT2,DP3
     WRITE(1,219) PPUMP1,PPUMP2,DP4
     WRITE(1,220) PPIS1,PPIS2,DP5
     WRITE(1,221) PRING1,PRING2,DP6
     WRITE(1,222) PCON1,PCON2,DP7
     WRITE(1,223) PCAM1,PCAM2,DP8
     WRITE(1,*) ' '
     WRITE(1,*) ' TOTAL ENGINE POWER LOSS AT BASE LINE : OPTIMUM : DECR
    $EASING % '
     WRITE(1,224) PTOT1,PTOT2,DP9
     WRITE(1,225) VELO,GN
     WRITE(1,*) 'POWER AT BASE LINE DATA : OPTIMUM DATA : DECREASING %'
     WRITE(1,226) PAIRR1,PAIRR2,DP10
     WRITE(1,227) PROLL1,PROLL2,DP11
     WRITE(1,228) BREAK1,BREAK2,DP12
     WRITE(1,*) ' FRACTION OF DECREASING OF ENGINE POWER LOSS  '
     WRITE(1,*) ' CRANK:AIR:ALTERNATOT:PUMPING:SKIRT:RING:CON-ROD:CAM '
     WRITE(1,229) FD1,FD2,FD3,FD4,FD5,FD6,FD7,FD8
     WRITE(6,*) ' '
     WRITE(6,215) ORPM,DHM
     WRITE(6,*) ' POWER AT BASE LINE DATA : OPTIMUM DATA : DECREASING%'
     WRITE(6,216) PCRAN1,PCRAN2,DP1
     WRITE(6,217) PAIR1,PAIR2,DP2
     WRITE(6,218) PALT1,PALT2,DP3
     WRITE(6,219) PPUMP1,PPUMP2,DP4
     WRITE(6,220) PPIS1,PPIS2,DP5
     WRITE(6,221) PRING1,PRING2,DP6
     WRITE(6,222) PCON1,PCON2,DP7
     WRITE(6,223) PCAM1,PCAM2,DP8
     WRITE(6,*) ' '
     WRITE(6,*) ' TOTAL POWER AT BASE LINE : OPTIMUM : DECREASING %'
     WRITE(6,224) PTOT1,PTOT2,DP9
     WRITE(6,225) VELO,GN
     WRITE(6,*)' POWER AT BASE LINE DATA : OPTIMUM DATA : DECREASING %'
     WRITE(6,226) PAIRR1,PAIRR2,DP10
     WRITE(6,227) PROLL1,PROLL2,DP11
     WRITE(6,*) ' BREAK POWER AT BASE LINE : OPTIMUM : DECREASING % '
     WRITE(6,228) BREAK1,BREAK2,DP12
     WRITE(6,*) ' FRACTION OF DECREASING OF ENGINE POWER LOSS  '
     WRITE(6,*) ' CRANK:AIR:ALTERNATOR:PUMPING:SKIRT:RING:CON-ROD:CAM '
     WRITE(6,229) FD1,FD2,FD3,FD4,FD5,FD6,FD7,FD8
215  FORMAT(' ENGINE SPEED  ',F6.1,'  (RPM) :  MANIFOLD  ',F4.1,
    $' (INCH)')
216  FORMAT(' CRANK-SHAFT        :',T30,F7.2,2X,F7.2,2X,F5.2)
217  FORMAT(' AIR CONDITIONING   :',T30,F7.2,2X,F7.2,2X,F5.2)
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```
  218 FORMAT(' ALTERNATOR          :',T30,F7.2,2X,F7.2,2X,F5.2)
  219 FORMAT(' PUMPING             :',T30,F7.2,2X,F7.2,2X,F5.2)
  220 FORMAT(' PISTON SKIRT        :',T30,F7.2,2X,F7.2,2X,F5.2)
  221 FORMAT(' PISTON RING         :',T30,F7.2,2X,F7.2,2X,F5.2)
  222 FORMAT(' CONNECTING ROD      :',T30,F7.2,2X,F7.2,2X,F5.2)
  223 FORMAT(' CAM LOAD            :',T30,F7.2,2X,F7.2,2X,F5.2)
  224 FORMAT(' TOTAL               :',T30,F8.2,2X,F8.2,2X,F5.2)
  225 FORMAT(' VEHICLE SPEED  ',F6.2,' (km/hr)   :  GEAR NUMBER  ',F3.1)
  226 FORMAT(' AIR LOAD            : ',T30,F8.2,2X,F8.2,2X,F5.2)
  227 FORMAT(' ROLLINE LOAD        : ',T30,F8.2,2X,F8.2,2X,F5.2)
  228 FORMAT(' BREAK POWER         : ',T30,F8.2,2X,F8.2,2X,F5.2)
  229 FORMAT(2X,F5.2,2X,F5.2,2X,F5.2,2X,F5.2,2X,F5.2,2X,F5.2,2X,F5.2,2X,
     $F5.2)
      STOP
      END
C*****-------------------------*********-------------------------------******C
C                                                                            C
C                            END MAIN PROGRAM                                C
C*****-------------------------*********-------------------------------******C
C*****-------------------------*********-------------------------------******C
C*****-------------------------*********-------------------------------******C
C             MULTIVARIABLE OPTIMIZATION SEARCH METHOD                       C
C*****-------------------------*********-------------------------------******C
      SUBROUTINE P311(RPM,BOREL,BOREH,VISL,VISH,CONLB,BN,NPRESSB,NOILB,
     $     NCB,RP,RO,PI,H,EC,E,ESM,RCRANKB,CRANKLB,CCRANKB,BPRESSB,
     $     BOILB,BRCONB,BCCONB,BLCONB,SRCONB,SCCONB,SLCONB,PCB,PISLB,
     $     VDB,XMIN25,XMIN26,XMIN27)
       YMIN25 = 999999.
       YMIN26 = 999999.
         TOL1 = 0.005
         TOL2 = 0.005
           N1 = 20
          XI1 = VISL
          XI2 = BOREL
          DX1 = (VISH-VISL)/N1
          DX2 = (BOREH-BOREL)/N1
       DO 200 I = 1,50
        DO 25 J25 = 0,N1
             BORE = XI2 + J25*DX2
              ARM = VDB*2/(PI*(BORE**2)*NCB*1000000)
C       Y25 = f25(XI1,BORE)
       CALL NUM1(BPRESSB,BOILB,RP,RO,H,HP1,HO1,HP2,HO2,HP3,HO3)
       CALL MEAN11(CONLB,ARM,VBMEAN11,VSMEAN11)
        Y25 = XI1*(RCRANKB**3)*CRANKLB*((2*PI)/
     $          (CCRANKB*SQRT(1-EC**2)))*((2*PI*(RPM/60))**2)*BN
C.........PISTON SKIRT
     $        + (XI1*PI*BORE*PISLB/PCB)*((ARM*(RPM/15))**2)*NCB
C.........PISTON RING
     $        + XI1*ARM*2*PI*(RPM/60)*(4*HO1-3*(HO2**2)/HO3+BOILB
     $        *(1-RO)/(1+RO))*4*ARM*PI*BORE*(RPM/60)*NOILB*NCB +
     $        XI1*ARM*2*PI*(RPM/60)*(4*HP1-3*(HP2**2)/HP3+(BPRESSB
     $        *(1-RP)/(1+RP))/H)*4*ARM*PI*BORE*(RPM/60)*NPRESSB*NCB
C.........CONNECTING ROD
     $        + XI1*(BRCONB**3)*BLCONB*((2*PI)/(BCCONB*SQRT(1-E**2)))
     $        *((2*PI*(RPM/60))**2)*NCB*VBMEAN11 +
     $        XI1*(SRCONB**3)*SLCONB*((2*PI)/(SCCONB*SQRT(1-ESM**2)))
     $        *((2*PI*(RPM/60))**2)*NCB*VSMEAN11
       IF (YMIN25.GT.Y25) THEN
            YMIN25 = Y25
            XMIN25 = XI1
            XMIN26 = BORE
            XMIN27 = ARM
        ENDIF
   25 CONTINUE
      IF ( ( ABS(XMIN25-XI1).LE.TOL1 ).AND.( ABS(XMIN26-XI2).LE.TOL2 ) )
     $ THEN
       GOTO 1000
       ENDIF
         DX1 = (VISH-XMIN25)/N1
         DX2 = (BOREH-XMIN26)/N1
       DO 26 K26 = 0,N1
```

```
            VIS = XI1 + K26*DX1
C       Y26 = f26(VIS,XMIN26)
        CALL NUM1(BPRESSB,BOILB,RP,RO,H,HP1,HO1,HP2,HO2,HP3,HO3)
        CALL MEAN12(CONLB,XMIN27,VBMEAN12,VSMEAN12)
        Y26 = VIS*(RCRANKB**3)*CRANKLB*((2*PI)/
     $          (CCRANKB*SQRT(1-EC**2)))*((2*PI*(RPM/60))**2)*BN
C       PISTON SKIRT
     $      + (VIS*PI*XMIN27*PISLB/PCB)*((XMIN27*(RPM/15))**2)*NCB
C       PISTON RING
     $      + VIS*XMIN27*2*PI*(RPM/60)*(4*HO1-3*(HO2**2)/HO3+BOILB
     $        *(1-RO)/(1+RO))*4*XMIN27*PI*XMIN26*(RPM/60)*NOILB*NCB +
     $        VIS*XMIN27*2*PI*(RPM/60)*(4*HP1-3*(HP2**2)/HP3+(BPRESSB
     $        *(1-RP)/(1+RP))/H)*4*XMIN27*PI*XMIN26*(RPM/60)*NPRESSB*NCB
C       CONNECTING ROD
     $      + VIS*(BRCONB**3)*BLCONB*((2*PI)/(BCCONB*SQRT(1-E**2)))
     $        *((2*PI*(RPM/60))**2)*NCB*VBMEAN12 +
     $        VIS*(SRCONB**3)*SLCONB*((2*PI)/(SCCONB*SQRT(1-ESM**2)))
     $        *((2*PI*(RPM/60))**2)*NCB*VSMEAN12
        IF (YMIN26.GT.Y26) THEN
            YMIN26 = Y26
            XMIN25 = VIS
            XMIN26 = XMIN26
         ENDIF
   26 CONTINUE
       IF ( ( ABS(XMIN25-XI1).LE.TOL1 ).AND.( ABS(XMIN26-XI2).LE.TOL2 ) )
     $              THEN
        GOTO 1000
       ENDIF
          XI1 = XMIN25
          XI2 = XMIN26
          DX1 = (VISH-XMIN25)/N1
          DX2 = (BOREH-XMIN26)/N1
  200 CONTINUE
 1000 RETURN
       END
C*****-----------------------*********-----------------------------******C
C                 SUBROUTINE FOR ACCESSORIES LOAD                       C
C*****-----------------------*********-----------------------------******C
       SUBROUTINE ACCESS(N,RPM,BCOMB,SCOMB,RKB,EMB,ECB,RDALTB,RLALTB,
      $QL,QH,RDALTL,RDALTH,RLALTL,RLALTH,RCOM,NCOM,PCLE,H1,H2,V1,FRAC,
      $EVAPP,CONDP,CORRK,RALT,PAIRQ,PALTD,PALTL,PI,Q,AMPB,VOLTB,
      $RDALT,RLALT,XACC1,XACC3,XACC4)
          PACC1 = 99999.
          PACC3 = 99999.
          PACC4 = 99999.
         VOLEEF = 1.+(PCLE/100.)*(1.-CONDP/EVAPP)
        RPMCOOL = Q/(H1-H2)*4.*60.*V1/
     $              (PI*SCOMB*NCOM*VOLEEF*RCOM*(BCOMB)**2)
         DO 1 J = 0,N,1
             DQ = (QH-QL)/N
              Q = QL + J*DQ
        IF (RPM.LE.RPMCOOL) THEN
          PAIRQ = (PI/4.)*(BCOMB**2.)*SCOMB*NCOM*RCOM*(RPM/60.)*VOLEEF
     $              *(RKB/(RKB-1.))*(1.-(CONDP/EVAPP)**((RKB-1.)/RKB))
     $              *EVAPP*(1./(EMB*ECB))*(-1.)
         ELSE
          PAIRQ = Q/(H1-H2)*EVAPP*V1*(RKB/(RKB-1.))
     $              *(1.-(CONDP/EVAPP)**((RKB-1.)/RKB))
     $              *(1./(EMB*ECB))*(-1.)
         ENDIF
        IF (PACC1.GT.PAIRQ) THEN
          PACC1 = PAIRQ
          XACC1 = Q
         ENDIF
C*****-----------------------*********-----------------------------******C
         DRDALT = (RDALTH - RDALTL)/N
          RDALT = RDALTL + J*DRDALT
          PALTD = AMPB*VOLTB + (100./FRAC)*(1./3.)*CORRK
     $              *((RALT*PI*RDALT*RPM/3048.)**2.5)*1000
```

```
     $            *(RDALT/0.0254)*((RLALTB/0.0254)**0.5)
      IF (PACC3.GT.PALTD) THEN
         PACC3 = PALTD
         XACC3 = RDALT
      ENDIF
C*****-------------------------********-------------------------******C
       DRLALT = (RLALTH - RLALTL)/N
        RLALT = RLALTL + J*DRLALT
        PALTL = AMPB*VOLTB + (100./FRAC)*(1/3.)*CORRK
     $             *((RALT*PI*RDALTB*RPM/3048.)**2.5)*1000
     $             *(RDALTB/0.0254)*(RLALT/0.0254)**0.5
      IF (PACC4.GT.PALTL) THEN
         PACC4 = PALTL
         XACC4 = RLALT
      ENDIF
    1 CONTINUE
      RETURN
      END
C*****-------------------------********-------------------------******C
C           THIS PARTS FOR NUMERICAL SUBPROGRAM CALCULATION            C
C*****-------------------------********-------------------------******C
C                          SUBROUTINE NUM 1                           C
C*****-------------------------********-------------------------******C
      SUBROUTINE NUM1(BPRESSB,BOILB,RP,RO,H,HP1,HO1,HP2,HO2,HP3,HO3)
      N     = 100
      A     = 0.
      A1P   = 0.0015
      A1O   = 0.0025
      BP    = RP*(BPRESSB/(1+RP))
      BO    = RO*(BOILB/(1+RO))
      DHP   = (BP-A)/N
      DHO   = (BO-A)/N
      SUMP1 = 0.
      SUMO1 = 0.
      SUMP2 = 0.
      SUMO2 = 0.
      SUMP3 = 0.
      SUMO3 = 0.
      DO 10 I = 1,N-1
       XP = I*DHP
       XO = I*DHO
       FXP1 = 1/(A1P*XP**2-((1+RP)/(1000*RP)+(A1P*RP*BPRESSB)/
     $         (1+RP))*XP+H+BPRESSB/1000)
       FXO1 = 1/(A1O*XO**2-((1+RO)/(1000*RO)+(A1O*RO*BOILB)/
     $         (1+RP))*XO+H+BOILB/1000)
       FXP2 = (1/(A1P*XP**2-((1+RP)/(1000*RP)+(A1P*RP*BPRESSB)/
     $         (1+RP))*XP+H+BPRESSB/1000))**2
       FXO2 = (1/(A1O*XO**2-((1+RO)/(1000*RO)+(A1O*RO*BOILB)/
     $         (1+RP))*XO+H+BOILB/1000))**2
       FXP3 = (1/(A1P*XP**2-((1+RP)/(1000*RP)+(A1P*RP*BPRESSB)/
     $         (1+RP))*XP+H+BPRESSB/1000))**3
       FXO3 = (1/(A1O*XO**2-((1+RO)/(1000*RO)+(A1O*RO*BOILB)/
     $         (1+RP))*XO+H+BOILB/1000))**3
       SUMP1 = SUMP1 + FXP1
       SUMO1 = SUMO1 + FXO1
       SUMP2 = SUMP2 + FXP2
       SUMO2 = SUMO2 + FXO2
       SUMP3 = SUMP3 + FXP3
       SUMO3 = SUMO3 + FXO3
   10 CONTINUE
      FXP01 = 1/(H+BPRESSB/1000)
      FXO01 = 1/(H+BOILB/1000)
      FXP02 = (1/(H+BPRESSB/1000))**2
      FXO02 = (1/(H+BOILB/1000))**2
      FXP03 = (1/(H+BPRESSB/1000))**3
      FXO03 = (1/(H+BOILB/1000))**3
      FXPN1 = 1/H
      FXON1 = 1/H
      FXPN2 = (1/H)**2
```

```
      FXON2 = (1/H)**2
      FXPN3 = (1/H)**3
      FXON3 = (1/H)**3
      HP1   = (+FXP01+FXPN1+2*SUMP1)*DHP/2
      HO1   = (+FXO01+FXON1+2*SUMO1)*DHO/2
      HP2   = (+FXP02+FXPN2+2*SUMP2)*DHP/2
      HO2   = (+FXO02+FXON2+2*SUMO2)*DHO/2
      HP3   = (+FXP03+FXPN3+2*SUMP3)*DHP/2
      HO3   = (+FXO03+FXON3+2*SUMO3)*DHO/2
      RETURN
      END
C*****-------------------------********-------------------------------******C
C                              SUBROUTINE NUM 2                              C
C*****-------------------------********-------------------------------******C
      SUBROUTINE NUM2(BPRESS,BOILB,RP,RO,H,HP4,HO4,HP5,HO5,HP6,HO6)
      N     = 100
      A     = 0.
      A1P   = 0.0015
      A1O   = 0.0025
      BP    = RP*(BPRESS/(1+RP))
      BO    = RO*(BOILB/(1+RO))
      DHP   = (BP-A)/N
      DHO   = (BO-A)/N
      SUMP4 = 0.
      SUMO4 = 0.
      SUMP5 = 0.
      SUMO5 = 0.
      SUMP6 = 0.
      SUMO6 = 0.
      DO 10 I = 1,N-1
        XP = I*DHP
        XO = I*DHO
        FXP4 = 1/(A1P*XP**2-((1+RP)/(1000*RP)+(A1P*RP*BPRESS)/
     $          (1+RP))*XP+H+BPRESS/1000)
        FXO4 = 1/(A1O*XO**2-((1+RO)/(1000*RO)+(A1O*RO*BOILB)/
     $          (1+RP))*XO+H+BOILB/1000)
        FXP5 = (1/(A1P*XP**2-((1+RP)/(1000*RP)+(A1P*RP*BPRESS)/
     $          (1+RP))*XP+H+BPRESS/1000))**2
        FXO5 = (1/(A1O*XO**2-((1+RO)/(1000*RO)+(A1O*RO*BOILB)/
     $          (1+RP))*XO+H+BOILB/1000))**2
        FXP6 = (1/(A1P*XP**2-((1+RP)/(1000*RP)+(A1P*RP*BPRESS)/
     $          (1+RP))*XP+H+BPRESS/1000))**3
        FXO6 = (1/(A1O*XO**2-((1+RO)/(1000*RO)+(A1O*RO*BOILB)/
     $          (1+RP))*XO+H+BOILB/1000))**3
        SUMP4 = SUMP4 + FXP4
        SUMO4 = SUMO4 + FXO4
        SUMP5 = SUMP5 + FXP5
        SUMO5 = SUMO5 + FXO5
        SUMP6 = SUMP6 + FXP6
        SUMO6 = SUMO6 + FXO6
   10 CONTINUE
      FXP04 = 1/(H+BPRESS/1000)
      FXO04 = 1/(H+BOILB/1000)
      FXP05 = (1/(H+BPRESS/1000))**2
      FXO05 = (1/(H+BOILB/1000))**2
      FXP06 = (1/(H+BPRESS/1000))**3
      FXO06 = (1/(H+BOILB/1000))**3
      FXPN4 = 1/H
      FXON4 = 1/H
      FXPN5 = (1/H)**2
      FXON5 = (1/H)**2
      FXPN6 = (1/H)**3
      FXON6 = (1/H)**3
      HP4   = (+FXP04+FXPN4+2*SUMP4)*DHP/2
      HO4   = (+FXO04+FXON4+2*SUMO4)*DHO/2
      HP5   = (+FXP05+FXPN5+2*SUMP5)*DHP/2
      HO5   = (+FXO05+FXON5+2*SUMO5)*DHO/2
      HP6   = (+FXP06+FXPN6+2*SUMP6)*DHP/2
      HO6   = (+FXO06+FXON6+2*SUMO6)*DHO/2
```

```
      RETURN
      END
C*****-------------------------********-------------------------******C
C                          SUBROUTINE NUM 3                           C
C*****-------------------------********-------------------------******C
      SUBROUTINE NUM3(BPRESSB,BOIL,RP,RO,H,HP7,HO7,HP8,HO8,HP9,HO9)
       N     = 100
       A     = 0.
       A1P   = 0.0015
       A1O   = 0.0025
       BP    = RP*(BPRESSB/(1+RP))
       BO    = RO*(BOIL/(1+RO))
       DHP   = (BP-A)/N
       DHO   = (BO-A)/N
       SUMP7 = 0.
       SUMO7 = 0.
       SUMP8 = 0.
       SUMO8 = 0.
       SUMP9 = 0.
       SUMO9 = 0.
      DO 10 I = 1,N-1
        XP = I*DHP
        XO = I*DHO
        FXP7 = 1/(A1P*XP**2-((1+RP)/(1000*RP)+(A1P*RP*BPRESSB)/
     $          (1+RP))*XP+H+BPRESSB/1000)
        FXO7 = 1/(A1O*XO**2-((1+RO)/(1000*RO)+(A1O*RO*BOIL)/
     $          (1+RP))*XO+H+BOIL/1000)
        FXP8 = (1/(A1P*XP**2-((1+RP)/(1000*RP)+(A1P*RP*BPRESSB)/
     $          (1+RP))*XP+H+BPRESSB/1000))**2
        FXO8 = (1/(A1O*XO**2-((1+RO)/(1000*RO)+(A1O*RO*BOIL)/
     $          (1+RP))*XO+H+BOIL/1000))**2
        FXP9 = (1/(A1P*XP**2-((1+RP)/(1000*RP)+(A1P*RP*BPRESSB)/
     $          (1+RP))*XP+H+BPRESSB/1000))**3
        FXO9 = (1/(A1O*XO**2-((1+RO)/(1000*RO)+(A1O*RO*BOIL)/
     $          (1+RP))*XO+H+BOIL/1000))**3
        SUMP7 = SUMP7 + FXP7
        SUMO7 = SUMO7 + FXO7
        SUMP8 = SUMP8 + FXP8
        SUMO8 = SUMO8 + FXO8
        SUMP9 = SUMP9 + FXP9
        SUMO9 = SUMO9 + FXO9
   10 CONTINUE
       FXP07 = 1/(H+BPRESSB/1000)
       FXO07 = 1/(H+BOIL/1000)
       FXP08 = (1/(H+BPRESSB/1000))**2
       FXO08 = (1/(H+BOIL/1000))**2
       FXP09 = (1/(H+BPRESSB/1000))**3
       FXO09 = (1/(H+BOIL/1000))**3
       FXPN7 = 1/H
       FXON7 = 1/H
       FXPN8 = (1/H)**2
       FXON8 = (1/H)**2
       FXPN9 = (1/H)**3
       FXON9 = (1/H)**3
       HP7   = (+FXP07+FXPN7+2*SUMP7)*DHP/2
       HO7   = (+FXO07+FXON7+2*SUMO7)*DHO/2
       HP8   = (+FXP08+FXPN8+2*SUMP8)*DHP/2
       HO8   = (+FXO08+FXON8+2*SUMO8)*DHO/2
       HP9   = (+FXP09+FXPN9+2*SUMP9)*DHP/2
       HO9   = (+FXO09+FXON9+2*SUMO9)*DHO/2
      RETURN
      END
C*****-------------------------********-------------------------******C
C                          SUBROUTINE NUM 4                           C
C*****-------------------------********-------------------------******C
      SUBROUTINE NUM4(XMIN10,XMIN11,RP,RO,H,HP11,HO11,HP21,HO21,HP31,
     $                HO31)
       N     = 100
       A     = 0.
```

```
      A1P    = 0.0015
      A1O    = 0.0025
     BPRESSB = XMIN10
      BOILB = XMIN11
      BP     = RP*(BPRESSB/(1+RP))
      BO     = RO*(BOILB/(1+RO))
      DHP    = (BP-A)/N
      DHO    = (BO-A)/N
      SUMP1 = 0.
      SUMO1 = 0.
      SUMP2 = 0.
      SUMO2 = 0.
      SUMP3 = 0.
      SUMO3 = 0.
      DO 10 I = 1,N-1
        XP = I*DHP
        XO = I*DHO
        FXP1 = 1/(A1P*XP**2-((1+RP)/(1000*RP)+(A1P*RP*BPRESSB)/
     $          (1+RP))*XP+H+BPRESSB/1000)
        FXO1 = 1/(A1O*XO**2-((1+RO)/(1000*RO)+(A1O*RO*BOILB)/
     $          (1+RP))*XO+H+BOILB/1000)
        FXP2 = (1/(A1P*XP**2-((1+RP)/(1000*RP)+(A1P*RP*BPRESSB)/
     $          (1+RP))*XP+H+BPRESSB/1000))**2
        FXO2 = (1/(A1O*XO**2-((1+RO)/(1000*RO)+(A1O*RO*BOILB)/
     $          (1+RP))*XO+H+BOILB/1000))**2
        FXP3 = (1/(A1P*XP**2-((1+RP)/(1000*RP)+(A1P*RP*BPRESSB)/
     $          (1+RP))*XP+H+BPRESSB/1000))**3
        FXO3 = (1/(A1O*XO**2-((1+RO)/(1000*RO)+(A1O*RO*BOILB)/
     $          (1+RP))*XO+H+BOILB/1000))**3
        SUMP1 = SUMP1 + FXP1
        SUMO1 = SUMO1 + FXO1
        SUMP2 = SUMP2 + FXP2
        SUMO2 = SUMO2 + FXO2
        SUMP3 = SUMP3 + FXP3
        SUMO3 = SUMO3 + FXO3
   10 CONTINUE
        FXP01 = 1/(H+BPRESSB/1000)
        FXO01 = 1/(H+BOILB/1000)
        FXP02 = (1/(H+BPRESSB/1000))**2
        FXO02 = (1/(H+BOILB/1000))**2
        FXP03 = (1/(H+BPRESSB/1000))**3
        FXO03 = (1/(H+BOILB/1000))**3
        FXPN1 = 1/H
        FXON1 = 1/H
        FXPN2 = (1/H)**2
        FXON2 = (1/H)**2
        FXPN3 = (1/H)**3
        FXON3 = (1/H)**3
        HP11  = (+FXP01+FXPN1+2*SUMP1)*DHP/2
        HO11  = (+FXO01+FXON1+2*SUMO1)*DHO/2
        HP21  = (+FXP02+FXPN2+2*SUMP2)*DHP/2
        HO21  = (+FXO02+FXON2+2*SUMO2)*DHO/2
        HP31  = (+FXP03+FXPN3+2*SUMP3)*DHP/2
        HO31  = (+FXO03+FXON3+2*SUMO3)*DHO/2
        RETURN
        END
C*****-------------------------********-------------------------******C
C                          SUBROUTINE  MEAN 1                         C
C*****-------------------------********-------------------------******C
        SUBROUTINE MEAN1(CONLB,ARMB,VBMEAN1,VSMEAN1)
        PI     = 2.*ASIN(1.)
        R      = CONLB/ARMB
        N      = 360
        DEG1   = 0.
        DEG2   = 2*PI
        DDEG   = (DEG2-DEG1)/N
        BSUMP = 0.
        SSUMP = 0.
        DO 11 I = 1,N-1
```

```
      X      = I*DDEG
      FXB    = ( 1+COS(X)/SQRT(R**2-(SIN(X))**2) )**2
      FXS    = ((COS(X)/R)**2)*((1+(SIN(X)**2)/(R**2-SIN(X)**2))**2)
      BSUMP = BSUMP + FXB
      SSUMP = SSUMP + FXS
   11 CONTINUE
      FXB0 = (1+COS(DEG1)/SQRT(R**2-(SIN(DEG1))**2))**2
      FXBN = (1+COS(DEG2)/SQRT(R**2-(SIN(DEG2))**2))**2
      FXS0 = ((COS(DEG1)/R)**2)
     $         *((1+(SIN(DEG1)**2)/(R**2-SIN(DEG1)**2))**2)
      FXSN = ((COS(DEG2)/R)**2)
     $         *((1+(SIN(DEG2)**2)/(R**2-SIN(DEG2)**2))**2)
      BIG  = (+FXB0+FXBN+2*BSUMP)*DDEG/2
      SML  = (+FXS0+FXSN+2*SSUMP)*DDEG/2
      VBMEAN1 = BIG/(2*PI)
      VSMEAN1 = SML/(2*PI)
      RETURN
      END
C*****-------------------------********-------------------------------******C
C                          SUBROUTINE  MEAN 10                             C
C*****-------------------------********-------------------------------******C
      SUBROUTINE MEAN10(CONL,ARMB,VBMEAN10,VSMEAN10)
      PI     = 2.*ASIN(1.)
      R      = CONL/ARMB
      N      = 360
      DEG1   = 0.
      DEG2   = 2*PI
      DDEG   = (DEG2-DEG1)/N
      BSUMP = 0.
      SSUMP = 0.
      DO 11 I = 1,N-1
      X      = I*DDEG
      FXB    = ( 1+COS(X)/SQRT(R**2-(SIN(X))**2) )**2
      FXS    = ((COS(X)/R)**2)*((1+(SIN(X)**2)/(R**2-SIN(X)**2))**2)
      BSUMP = BSUMP + FXB
      SSUMP = SSUMP + FXS
   11 CONTINUE
      FXB0 = (1+COS(DEG1)/SQRT(R**2-(SIN(DEG1))**2))**2
      FXBN = (1+COS(DEG2)/SQRT(R**2-(SIN(DEG2))**2))**2
      FXS0 = ((COS(DEG1)/R)**2)
     $         *((1+(SIN(DEG1)**2)/(R**2-SIN(DEG1)**2))**2)
      FXSN = ((COS(DEG2)/R)**2)
     $         *((1+(SIN(DEG2)**2)/(R**2-SIN(DEG2)**2))**2)
      BIG  = (+FXB0+FXBN+2*BSUMP)*DDEG/2
      SML  = (+FXS0+FXSN+2*SSUMP)*DDEG/2
      VBMEAN10 = BIG/(2*PI)
      VSMEAN10 = SML/(2*PI)
      RETURN
      END
C*****-------------------------********-------------------------------******C
C                          SUBROUTINE  MEAN 11                             C
C*****-------------------------********-------------------------------******C
      SUBROUTINE MEAN11(CONLB,ARM,VBMEAN11,VSMEAN11)
      PI     = 2.*ASIN(1.)
      R      = CONLB/ARM
      N      = 100
      DEG1   = 0.
      DEG2   = 2*PI
      DDEG   = (DEG2-DEG1)/N
      BSUMP = 0.
      SSUMP = 0.
      DO 11 I = 1,N-1
      X      = I*DDEG
      FXB    = ( 1+COS(X)/SQRT(R**2-(SIN(X))**2) )**2
      FXS    = ((COS(X)/R)**2)*((1+(SIN(X)**2)/(R**2-SIN(X)**2))**2)
      BSUMP = BSUMP + FXB
      SSUMP = SSUMP + FXS
   11 CONTINUE
      FXB0 = (1+COS(DEG1)/SQRT(R**2-(SIN(DEG1))**2))**2
```

```
      FXBN = (1+COS(DEG2)/SQRT(R**2-(SIN(DEG2))**2))**2
      FXS0 = ((COS(DEG1)/R)**2)
     $         *((1+(SIN(DEG1)**2)/(R**2-SIN(DEG1)**2))**2)
      FXSN = ((COS(DEG2)/R)**2)
     $         *((1+(SIN(DEG2)**2)/(R**2-SIN(DEG2)**2))**2)
      BIG  = (+FXB0+FXBN+2*BSUMP)*DDEG/2
      SML  = (+FXS0+FXSN+2*SSUMP)*DDEG/2
      VBMEAN11 = BIG/(2*PI)
      VSMEAN11 = SML/(2*PI)
      RETURN
      END
C*****-------------------------********-------------------------******C
C                          SUBROUTINE  MEAN 12                        C
C*****-------------------------********-------------------------******C
      SUBROUTINE MEAN12(CONLB,XMIN27,VBMEAN12,VSMEAN12)
      PI    = 2.*ASIN(1.)
      R     = CONLB/XMIN27
      N     = 100
      DEG1  = 0.
      DEG2  = 2*PI
      DDEG  = (DEG2-DEG1)/N
      BSUMP = 0.
      SSUMP = 0.
      DO 11 I = 1,N-1
      X     = I*DDEG
      FXB   = ( 1+COS(X)/SQRT(R**2-(SIN(X))**2) )**2
      FXS   = ((COS(X)/R)**2)*((1+(SIN(X)**2)/(R**2-SIN(X)**2))**2)
      BSUMP = BSUMP + FXB
      SSUMP = SSUMP + FXS
   11 CONTINUE
      FXB0 = (1+COS(DEG1)/SQRT(R**2-(SIN(DEG1))**2))**2
      FXBN = (1+COS(DEG2)/SQRT(R**2-(SIN(DEG2))**2))**2
      FXS0 = ((COS(DEG1)/R)**2)
     $         *((1+(SIN(DEG1)**2)/(R**2-SIN(DEG1)**2))**2)
      FXSN = ((COS(DEG2)/R)**2)
     $         *((1+(SIN(DEG2)**2)/(R**2-SIN(DEG2)**2))**2)
      BIG  = (+FXB0+FXBN+2*BSUMP)*DDEG/2
      SML  = (+FXS0+FXSN+2*SSUMP)*DDEG/2
      VBMEAN12 = BIG/(2*PI)
      VSMEAN12 = SML/(2*PI)
      RETURN
      END
C*****-------------------------********-------------------------******C
C                          SUBROUTINE  MEAN 13                        C
C*****-------------------------********-------------------------******C
      SUBROUTINE MEAN13(XMIN26,ARM,VBMEAN13,VSMEAN13)
      PI    = 2.*ASIN(1.)
      R     = XMIN26/ARM
      N     = 100
      DEG1  = 0.
      DEG2  = 2*PI
      DDEG  = (DEG2-DEG1)/N
      BSUMP = 0.
      SSUMP = 0.
      DO 11 I = 1,N-1
      X     = I*DDEG
      FXB   = ( 1+COS(X)/SQRT(R**2-(SIN(X))**2) )**2
      FXS   = ((COS(X)/R)**2)*((1+(SIN(X)**2)/(R**2-SIN(X)**2))**2)
      BSUMP = BSUMP + FXB
      SSUMP = SSUMP + FXS
   11 CONTINUE
      FXB0 = (1+COS(DEG1)/SQRT(R**2-(SIN(DEG1))**2))**2
      FXBN = (1+COS(DEG2)/SQRT(R**2-(SIN(DEG2))**2))**2
      FXS0 = ((COS(DEG1)/R)**2)
     $         *((1+(SIN(DEG1)**2)/(R**2-SIN(DEG1)**2))**2)
      FXSN = ((COS(DEG2)/R)**2)
     $         *((1+(SIN(DEG2)**2)/(R**2-SIN(DEG2)**2))**2)
      BIG  = (+FXB0+FXBN+2*BSUMP)*DDEG/2
      SML  = (+FXS0+FXSN+2*SSUMP)*DDEG/2
```

```
      VBMEAN13 = BIG/(2*PI)
      VSMEAN13 = SML/(2*PI)
      RETURN
      END
C*****-------------------------********-------------------------******C
C                          SUBROUTINE  MEAN 14                        C
C*****-------------------------********-------------------------******C
      SUBROUTINE MEAN14(XMIN18,XMIN27,VBMEAN14,VSMEAN14,PI)
      R     = XMIN18/XMIN27
      N     = 360
      DEG1  = 0.
      DEG2  = 2*PI
      DDEG  = (DEG2-DEG1)/N
      BSUMP = 0.
      SSUMP = 0.
      DO 11 I = 1,N-1
      X     = I*DDEG
      FXB   = ( 1+COS(X)/SQRT(R**2-(SIN(X))**2) )**2
      FXS   = ((COS(X)/R)**2)*((1+(SIN(X)**2)/(R**2-SIN(X)**2))**2)
      BSUMP = BSUMP + FXB
      SSUMP = SSUMP + FXS
   11 CONTINUE
      FXB0 = (1+COS(DEG1)/SQRT(R**2-(SIN(DEG1))**2))**2
      FXBN = (1+COS(DEG2)/SQRT(R**2-(SIN(DEG2))**2))**2
      FXS0 = ((COS(DEG1)/R)**2)
     $         *((1+(SIN(DEG1)**2)/(R**2-SIN(DEG1)**2))**2)
      FXSN = ((COS(DEG2)/R)**2)
     $         *((1+(SIN(DEG2)**2)/(R**2-SIN(DEG2)**2))**2)
      BIG  = (+FXB0+FXBN+2*BSUMP)*DDEG/2
      SML  = (+FXS0+FXSN+2*SSUMP)*DDEG/2
      VBMEAN14 = BIG/(2*PI)
      VSMEAN14 = SML/(2*PI)
      RETURN
      END
C*****-------------------------********-------------------------******C
C                          SUBROUTINE  MEAN 2                         C
C*****-------------------------********-------------------------******C
      SUBROUTINE MEAN2(CONLB,ARM,VBMEAN2,VSMEAN2)
      PI    = 2.*ASIN(1.)
      R     = CONLB/ARM
      N     = 360
      DEG1  = 0.
      DEG2  = 2*PI
      DDEG  = (DEG2-DEG1)/N
      BSUMP = 0.
      SSUMP = 0.
      DO 12 I = 1,N-1
      X   = I*DDEG
      FXB = (1+COS(X)/SQRT(R**2-(SIN(X))**2))**2
      FXS = ((COS(X)/R)**2)*((1+(SIN(X)**2)/(R**2-SIN(X)**2))**2)
      BSUMP = BSUMP + FXB
      SSUMP = SSUMP + FXS
   12 CONTINUE
      FXB0 = (1+COS(DEG1)/SQRT(R**2-(SIN(DEG1))**2))**2
      FXBN = (1+COS(DEG2)/SQRT(R**2-(SIN(DEG2))**2))**2
      FXS0 = ((COS(DEG1)/R)**2)
     $         *((1+(SIN(DEG1)**2)/(R**2-SIN(DEG1)**2))**2)
      FXSN = ((COS(DEG2)/R)**2)
     $         *((1+(SIN(DEG2)**2)/(R**2-SIN(DEG2)**2))**2)
      BIG  = (+FXB0+FXBN+2*BSUMP)*DDEG/2
      SML  = (+FXS0+FXSN+2*SSUMP)*DDEG/2
      VBMEAN2 = BIG/(2*PI)
      VSMEAN2 = SML/(2*PI)
      RETURN
      END
C*****-------------------------********-------------------------******C
C                          SUBROUTINE  MEAN 3                         C
C*****-------------------------********-------------------------******C
      SUBROUTINE MEAN3(CONL,ARMB,VBMEAN3,VSMEAN3)
```

```
      PI    = 2.*ASIN(1.)
      R     = CONL/ARMB
      N     = 100
      DEG1  = 0.
      DEG2  = 2*PI
      DDEG  = (DEG2-DEG1)/N
      BSUMP = 0.
      SSUMP = 0.
      DO 13 I = 1,N-1
      X     = I*DDEG
      FXB   = (1+COS(X)/SQRT(R**2-(SIN(X))**2))**2
      FXS   = ((COS(X)/R)**2)*((1+(SIN(X)**2)/(R**2-SIN(X)**2))**2)
      BSUMP = BSUMP + FXB
      SSUMP = SSUMP + FXS
   13 CONTINUE
      FXB0 = (1+COS(DEG1)/SQRT(R**2-(SIN(DEG1))**2))**2
      FXBN = (1+COS(DEG2)/SQRT(R**2-(SIN(DEG2))**2))**2
      FXS0 = ((COS(DEG1)/R)**2)
     $        *((1+(SIN(DEG1)**2)/(R**2-SIN(DEG1)**2))**2)
      FXSN = ((COS(DEG2)/R)**2)
     $        *((1+(SIN(DEG2)**2)/(R**2-SIN(DEG2)**2))**2)
      BIG   = (+FXB0+FXBN+2*BSUMP)*DDEG/2
      SML   = (+FXS0+FXSN+2*SSUMP)*DDEG/2
      VBMEAN3 = BIG/(2*PI)
      VSMEAN3 = SML/(2*PI)
      RETURN
      END
C*****-----------------------*********-----------------------------******C
C                          SUBROUTINE TOR 1                             C
C*****-----------------------*********-----------------------------******C
      SUBROUTINE TMEAN1(FCOE,SDEGB,FB,CDEGB,FM,SCB,PLB,BRB,TRB,VLB,RADC
     $           ,TOR1,PI)
         N = 360
        D1 = SDEGB
        D2 = CDEGB
        D3 = 180-CDEGB
        D4 = 180-SDEGB
      DEG0 = 0.
      DEGN = 360.
      DDEG = (DEGN-DEG0)/N
      SUMP = 0.
     DO 10 I = 0,N,1
         X = I*DDEG
     IF ((X.GE.D1).AND.(X.LT.D2)) THEN
      S  = (FB-BRB)*(1-COS( (X-D1)*PI/180 ))/1000
      V  = (FB-BRB)*RADC*SIN( (X-D1)*PI/180 )/1000
      A  = (FB-BRB)*(RADC**2)*COS( (X-D1)*PI/180 )/1000
      FX = -1*(SCB*S+PLB+FM*A)*(FCOE*(BRB/1000+S)+V/RADC)
     ELSE
      IF ((X.GE.D2).AND.(X.LE.D3)) THEN
        S  = ((BRB+VLB-TRB)*SIN( X*PI/180 )+TRB-BRB)/1000
        V  = (BRB+VLB-TRB)*RADC*COS( X*PI/180 )/1000
        A  = -1*(BRB+VLB-TRB)*(RADC**2)*SIN( X*PI/180 )/1000
        FX = -1*(SCB*S+PLB+FM*A)*(FCOE*(BRB/1000+S)+V/RADC)
      ELSE
       IF ((X.GT.D3).AND.(X.LE.D4)) THEN
         S  = (FB-BRB)*(1+COS( (X+D1)*PI/180 ))/1000
         V  = -1*(FB-BRB)*RADC*SIN( (X+D1)*PI/180 )/1000
         A  = -1*(FB-BRB)*(RADC**2)*COS( (X+D1)*PI/180 )/1000
         FX = -1*(SCB*S+PLB+FM*A)*(FCOE*(BRB/1000+S)+V/RADC)
       ELSE
         FX = 0
       ENDIF
      ENDIF
     ENDIF
      SUMP = SUMP + FX
   10 CONTINUE
      TOR1 = SUMP/N
      RETURN
```

```
      END
C*****-------------------------*********-------------------------******C
C                                                                       C
C                          SUBROUTINE TOR 2                             C
C*****-------------------------*********-------------------------******C
      SUBROUTINE TMEAN2(FCOE,SDEGB,FB,CDEGB,FMB,SC,PLB,BRB,TRB,VLB,RADC
     $           ,TOR2,PI)
          N = 360
         D1 = SDEGB
         D2 = CDEGB
         D3 = 180-CDEGB
         D4 = 180-SDEGB
       DEG0 = 0.
       DEGN = 360.
       DDEG = (DEGN-DEG0)/N
       SUMP = 0.
      DO 10 I = 0,N,1
          X = I*DDEG
      IF ((X.GE.D1).AND.(X.LT.D2)) THEN
        S  = (FB-BRB)*(1-COS( (X-D1)*PI/180 ))/1000
        V  = (FB-BRB)*RADC*SIN( (X-D1)*PI/180 )/1000
        A  = (FB-BRB)*(RADC**2)*COS( (X-D1)*PI/180 )/1000
        FX = -1*(SC*S+PLB+FMB*A)*(FCOE*(BRB/1000+S)+V/RADC)
      ELSE
       IF ((X.GE.D2).AND.(X.LE.D3)) THEN
          S  = ((BRB+VLB-TRB)*SIN( X*PI/180 )+TRB-BRB)/1000
          V  = (BRB+VLB-TRB)*RADC*COS( X*PI/180 )/1000
          A  = -1*(BRB+VLB-TRB)*(RADC**2)*SIN( X*PI/180 )/1000
          FX = -1*(SC*S+PLB+FMB*A)*(FCOE*(BRB/1000+S)+V/RADC)
       ELSE
        IF ((X.GT.D3).AND.(X.LE.D4)) THEN
           S  = (FB-BRB)*(1+COS( (X+D1)*PI/180 ))/1000
           V  = -1*(FB-BRB)*RADC*SIN( (X+D1)*PI/180 )/1000
           A  = -1*(FB-BRB)*(RADC**2)*COS( (X+D1)*PI/180 )/1000
           FX = -1*(SC*S+PLB+FMB*A)
     $               *(FCOE*(BRB/1000+S)+V/RADC)
        ELSE
           FX = 0
        ENDIF
       ENDIF
      ENDIF
       SUMP = SUMP + FX
   10 CONTINUE
      TOR2 = SUMP/N
      RETURN
      END
C*****-------------------------*********-------------------------******C
C                                                                       C
C                          SUBROUTINE TOR 3                             C
C*****-------------------------*********-------------------------******C
      SUBROUTINE TMEAN3(FCOE,SDEGB,FB,CDEGB,FMB,SCB,PL,BRB,TRB,VLB,RADC
     $           ,TOR3,PI)
          N = 360
         D1 = SDEGB
         D2 = CDEGB
         D3 = 180-CDEGB
         D4 = 180-SDEGB
       DEG0 = 0.
       DEGN = 360.
       DDEG = (DEGN-DEG0)/N
       SUMP = 0.
      DO 10 I = 0,N,1
          X = I*DDEG
      IF ((X.GE.D1).AND.(X.LT.D2)) THEN
        S  = (FB-BRB)*(1-COS( (X-D1)*PI/180 ))/1000
        V  = (FB-BRB)*RADC*SIN( (X-D1)*PI/180 )/1000
        A  = (FB-BRB)*(RADC**2)*COS( (X-D1)*PI/180 )/1000
        FX = -1*(SCB*S+PL+FMB*A)*(FCOE*(BRB/1000+S)+V/RADC)
      ELSE
       IF ((X.GE.D2).AND.(X.LE.D3)) THEN
          S  = ((BRB+VLB-TRB)*SIN( X*PI/180 )+TRB-BRB)/1000
```

```
          V  = (BRB+VLB-TRB)*RADC*COS( X*PI/180 )/1000
          A  = -1*(BRB+VLB-TRB)*(RADC**2)*SIN( X*PI/180 )/1000
          FX = -1*(SCB*S+PL+FMB*A)*(FCOE*(BRB/1000+S)+V/RADC)
        ELSE
         IF ((X.GT.D3).AND.(X.LE.D4)) THEN
          S  = (FB-BRB)*(1+COS( (X+D1)*PI/180 ))/1000
          V  = -1*(FB-BRB)*RADC*SIN( (X+D1)*PI/180 )/1000
          A  = -1*(FB-BRB)*(RADC**2)*COS( (X+D1)*PI/180 )/1000
          FX = -1*(SCB*S+PL+FMB*A)*(FCOE*(BRB/1000+S)+V/RADC)
         ELSE
          FX = 0
         ENDIF
        ENDIF
       ENDIF
       SUMP = SUMP + FX
   10 CONTINUE
       TOR3 = SUMP/N
       RETURN
       END
C*****-------------------------********-------------------------------******C
C                          SUBROUTINE TOR 4                                 C
C*****-------------------------********-------------------------------******C
       SUBROUTINE TMEAN4(FCOE,SDEGB,FBR,CDEGBR,FMB,SCB,PLB,BR,TRB,VLB
      $          ,RADC,TOR4,PI)
           N = 360
          D1 = SDEGB
          D2 = CDEGBR
          D3 = 180-CDEGBR
          D4 = 180-SDEGB
         DEG0 = 0.
         DEGN = 360.
         DDEG = (DEGN-DEG0)/N
         SUMP = 0.
        DO 10 I = 0,N,1
          X = I*DDEG
        IF  ((X.GE.D1).AND.(X.LT.D2))  THEN
         S  = (FBR-BR)*(1-COS( (X-D1)*PI/180 ))/1000
         V  = (FBR-BR)*RADC*SIN( (X-D1)*PI/180 )/1000
         A  = (FBR-BR)*(RADC**2)*COS( (X-D1)*PI/180 )/1000
         FX = -1*(SCB*S+PLB+FMB*A)*(FCOE*(BR/1000+S)+V/RADC)
        ELSE
         IF  ((X.GE.D2).AND.(X.LE.D3))  THEN
          S  = ((BR+VLB-TRB)*SIN( X*PI/180 )+TRB-BR)/1000
          V  = (BR+VLB-TRB)*RADC*COS( X*PI/180 )/1000
          A  = -1*(BR+VLB-TRB)*(RADC**2)*SIN( X*PI/180 )/1000
          FX = -1*(SCB*S+PLB+FMB*A)*(FCOE*(BR/1000+S)+V/RADC)
         ELSE
          IF  ((X.GT.D3).AND.(X.LE.D4))  THEN
           S  = (FBR-BR)*(1+COS( (X+D1)*PI/180 ))/1000
           V  = -1*(FBR-BR)*RADC*SIN( (X+D1)*PI/180 )/1000
           A  = -1*(FBR-BR)*(RADC**2)*COS( (X+D1)*PI/180 )/1000
           FX = -1*(SCB*S+PLB+FMB*A)*(FCOE*(BR/1000+S)+V/RADC)
          ELSE
           FX = 0
         ENDIF
          ENDIF
        ENDIF
        SUMP = SUMP + FX
   10 CONTINUE
       TOR4 = SUMP/N
       RETURN
       END
C*****-------------------------********-------------------------------******C
C                          SUBROUTINE TOR 5                                 C
C*****-------------------------********-------------------------------******C
       SUBROUTINE TMEAN5(FCOE,SDEGB,FTR,CDEGTR,FMB,SCB,PLB,BRB,TR,VLB
      $          ,RADC,TOR5,PI)
           N = 360
          D1 = SDEGB
```

```
          D2 = CDEGTR
          D3 = 180-CDEGTR
          D4 = 180-SDEGB
        DEG0 = 0.
        DEGN = 360.
        DDEG = (DEGN-DEG0)/N
        SUMP = 0.
      DO 10 I = 0,N,1
           X = I*DDEG
      IF ((X.GE.D1).AND.(X.LT.D2)) THEN
        S  = (FTR-BRB)*(1-COS( (X-D1)*PI/180 ))/1000
        V  = (FTR-BRB)*RADC*SIN( (X-D1)*PI/180 )/1000
        A  = (FTR-BRB)*(RADC**2)*COS( (X-D1)*PI/180 )/1000
        FX = -1*(SCB*S+PLB+FMB*A)*(FCOE*(BRB/1000+S)+V/RADC)
      ELSE
       IF ((X.GE.D2).AND.(X.LE.D3)) THEN
          S  = ((BRB+VLB-TR)*SIN( X*PI/180 )+TR-BRB)/1000
          V  = (BRB+VLB-TR)*RADC*COS( X*PI/180 )/1000
          A  = -1*(BRB+VLB-TR)*(RADC**2)*SIN( X*PI/180 )/1000
          FX = -1*(SCB*S+PLB+FMB*A)*(FCOE*(BRB/1000+S)+V/RADC)
       ELSE
        IF ((X.GT.D3).AND.(X.LE.D4)) THEN
           S  = (FTR-BRB)*(1+COS( (X+D1)*PI/180 ))/1000
           V  = -1*(FTR-BRB)*RADC*SIN( (X+D1)*PI/180 )/1000
           A  = -1*(FTR-BRB)*(RADC**2)*COS( (X+D1)*PI/180 )/1000
           FX = -1*(SCB*S+PLB+FMB*A)*(FCOE*(BRB/1000+S)+V/RADC)
        ELSE
           FX = 0
        ENDIF
       ENDIF
      ENDIF
       SUMP = SUMP + FX
   10 CONTINUE
       TOR5 = SUMP/N
       RETURN
      END
C*****-------------------------********-------------------------******C
C                          SUBROUTINE TOR 51                          C
C*****-------------------------********-------------------------******C
      SUBROUTINE TMEAN51(FCOE,SDEGB,FBTR,CDEGBTR,FMB,SCB,PLB,BR,TR,VLB,
     $                   RADC,TOR51,PI)
          N = 360
         D1 = SDEGB
         D2 = CDEGBTR
         D3 = 180-CDEGBTR
         D4 = 180-SDEGB
       DEG0 = 0.
       DEGN = 360.
       DDEG = (DEGN-DEG0)/N
       SUMP = 0.
     DO 10 I = 0,N,1
          X = I*DDEG
     IF ((X.GE.D1).AND.(X.LT.D2)) THEN
       S  = (FBTR-BR)*(1-COS( (X-D1)*PI/180 ))/1000
       V  = (FBTR-BR)*RADC*SIN( (X-D1)*PI/180 )/1000
       A  = (FBTR-BR)*(RADC**2)*COS( (X-D1)*PI/180 )/1000
       FX = -1*(SCB*S+PLB+FMB*A)*(FCOE*(BR/1000+S)+V/RADC)
     ELSE
      IF ((X.GE.D2).AND.(X.LE.D3)) THEN
         S  = ((BR+VLB-TR)*SIN( X*PI/180 )+TR-BR)/1000
         V  = (BR+VLB-TR)*RADC*COS( X*PI/180 )/1000
         A  = -1*(BR+VLB-TR)*(RADC**2)*SIN( X*PI/180 )/1000
         FX = -1*(SCB*S+PLB+FMB*A)*(FCOE*(BR/1000+S)+V/RADC)
      ELSE
       IF ((X.GT.D3).AND.(X.LE.D4)) THEN
          S  = (FBTR-BR)*(1+COS( (X+D1)*PI/180 ))/1000
          V  = -1*(FBTR-BR)*RADC*SIN( (X+D1)*PI/180 )/1000
          A  = -1*(FBTR-BR)*(RADC**2)*COS( (X+D1)*PI/180 )/1000
          FX = -1*(SCB*S+PLB+FMB*A)*(FCOE*(BR/1000+S)+V/RADC)
```

```
        ELSE
           FX = 0
         ENDIF
        ENDIF
       ENDIF
        SUMP = SUMP + FX
   10 CONTINUE
       TOR51 = SUMP/N
       RETURN
       END
C*****-------------------------*********-------------------------******C
C                            SUBROUTINE TOR 6                          C
C*****-------------------------*********-------------------------******C
      SUBROUTINE TMEAN6(FCOE,SDEGB,FVL,CDEGVL,FMB,SCB,PLB,BRB,TRB,VL
     $           ,RADC,TOR6,PI)
           N = 360
          D1 = SDEGB
          D2 = CDEGVL
          D3 = 180-CDEGVL
          D4 = 180-SDEGB
        DEG0 = 0.
        DEGN = 360.
        DDEG = (DEGN-DEG0)/N
        SUMP = 0.
      DO 10 I = 0,N,1
           X = I*DDEG
      IF ((X.GE.D1).AND.(X.LT.D2)) THEN
        S  = (FVL-BRB)*(1-COS( (X-D1)*PI/180 ))/1000
        V  = (FVL-BRB)*RADC*SIN( (X-D1)*PI/180 )/1000
        A  = (FVL-BRB)*(RADC**2)*COS( (X-D1)*PI/180 )/1000
        FX = -1*(SCB*S+PLB+FMB*A)*(FCOE*(BRB/1000+S)+V/RADC)
      ELSE
       IF ((X.GE.D2).AND.(X.LE.D3)) THEN
          S  = ((BRB+VL-TRB)*SIN( X*PI/180 )+TRB-BRB)/1000
          V  = (BRB+VL-TRB)*RADC*COS( X*PI/180 )/1000
          A  = -1*(BRB+VL-TRB)*(RADC**2)*SIN( X*PI/180 )/1000
          FX = -1*(SCB*S+PLB+FMB*A)*(FCOE*(BRB/1000+S)+V/RADC)
       ELSE
        IF ((X.GT.D3).AND.(X.LE.D4)) THEN
           S  = (FVL-BRB)*(1+COS( (X+D1)*PI/180 ))/1000
           V  = -1*(FVL-BRB)*RADC*SIN( (X+D1)*PI/180 )/1000
           A  = -1*(FVL-BRB)*(RADC**2)*COS( (X+D1)*PI/180 )/1000
           FX = -1*(SCB*S+PLB+FMB*A)*(FCOE*(BRB/1000+S)+V/RADC)
        ELSE
           FX = 0
         ENDIF
       ENDIF
      ENDIF
       SUMP = SUMP + FX
   10 CONTINUE
       TOR6 = SUMP/N
       RETURN
       END
C*****-------------------------*********-------------------------******C
C                            SUBROUTINE TOR 7                          C
C*****-------------------------*********-------------------------******C
      SUBROUTINE TMEAN7(FCOE,SDEGB,FB,CDEGB,FMB,SCB,PLB,BRB,TRB,VLB,RADC
     $,TOR7,PI)
           N = 360
          D1 = SDEGB
          D2 = CDEGB
          D3 = 180-CDEGB
          D4 = 180-SDEGB
        DEG0 = 0.
        DEGN = 360.
        DDEG = (DEGN-DEG0)/N
        SUMP = 0.
      DO 10 I = 0,N,1
           X = I*DDEG
```

```
      IF ((X.GE.D1).AND.(X.LT.D2)) THEN
       S  = (FB-BRB)*(1-COS( (X-D1)*PI/180 ))/1000
       V  = (FB-BRB)*RADC*SIN( (X-D1)*PI/180 )/1000
       A  = (FB-BRB)*(RADC**2)*COS( (X-D1)*PI/180 )/1000
       FX = -1*(SCB*S+PLB+FMB*A)*(FCOE*(BRB/1000+S)+V/RADC)
      ELSE
       IF ((X.GE.D2).AND.(X.LE.D3)) THEN
          S  = ((BRB+VLB-TRB)*SIN( X*PI/180 )+TRB-BRB)/1000
          V  = (BRB+VLB-TRB)*RADC*COS( X*PI/180 )/1000
          A  = -1*(BRB+VLB-TRB)*(RADC**2)*SIN( X*PI/180 )/1000
          FX = -1*(SCB*S+PLB+FMB*A)*(FCOE*(BRB/1000+S)+V/RADC)
       ELSE
        IF ((X.GT.D3).AND.(X.LE.D4)) THEN
           S  = (FB-BRB)*(1+COS( (X+D1)*PI/180 ))/1000
           V  = -1*(FB-BRB)*RADC*SIN( (X+D1)*PI/180 )/1000
           A  = -1*(FB-BRB)*(RADC**2)*COS( (X+D1)*PI/180 )/1000
           FX = -1*(SCB*S+PLB+FMB*A)*(FCOE*(BRB/1000+S)+V/RADC)
        ELSE
           FX = 0
        ENDIF
       ENDIF
      ENDIF
       SUMP = SUMP + FX
   10 CONTINUE
       TOR7 = SUMP/N
       RETURN
      END
C*****-------------------------********-------------------------------******C
C                          SUBROUTINE TOR 71                                 C
C*****-------------------------********-------------------------------******C
      SUBROUTINE TMEAN71(FCOE,SDEGB,FBM,CDEGM,XMIN19,XMIN20,XMIN21,
     $                   XMIN22,XMIN23,XMIN24,RADC,TOR71,PI)
          FB = FBM
          FM = XMIN19
          SC = XMIN20
          PL = XMIN21
          BR = XMIN22
          TR = XMIN23
          VL = XMIN24
           N = 360
          D1 = SDEGB
          D2 = CDEGM
          D3 = 180-CDEGM
          D4 = 180-SDEGB
        DEG0 = 0.
        DEGN = 360.
        DDEG = (DEGN-DEG0)/N
        SUMP = 0.
      DO 10 I = 0,N,1
           X = I*DDEG
      IF ((X.GE.D1).AND.(X.LT.D2)) THEN
       S  = (FB-BR)*(1-COS( (X-D1)*PI/180 ))/1000
       V  = (FB-BR)*RADC*SIN( (X-D1)*PI/180 )/1000
       A  = (FB-BR)*(RADC**2)*COS( (X-D1)*PI/180 )/1000
       FX = -1*(SC*S+PL+FM*A)*(FCOE*(BR/1000+S)+V/RADC)
      ELSE
       IF ((X.GE.D2).AND.(X.LE.D3)) THEN
          S  = ((BR+VL-TR)*SIN( X*PI/180 )+TR-BR)/1000
          V  = (BR+VL-TR)*RADC*COS( X*PI/180 )/1000
          A  = -1*(BR+VL-TR)*(RADC**2)*SIN( X*PI/180 )/1000
          FX = -1*(SC*S+PL+FM*A)*(FCOE*(BR/1000+S)+V/RADC)
       ELSE
        IF ((X.GT.D3).AND.(X.LE.D4)) THEN
           S  = (FB-BR)*(1+COS( (X+D1)*PI/180 ))/1000
           V  = -1*(FB-BR)*RADC*SIN( (X+D1)*PI/180 )/1000
           A  = -1*(FB-BR)*(RADC**2)*COS( (X+D1)*PI/180 )/1000
           FX = -1*(SC*S+PL+FM*A)*(FCOE*(BR/1000+S)+V/RADC)
        ELSE
           FX = 0
```

```
        ENDIF
       ENDIF
       ENDIF
        SUMP = SUMP + FX
   10 CONTINUE
       TOR71 = SUMP/N
       RETURN
       END
C*****-------------------------*********-------------------------******C
C                  (SEL1) SUBROUTINE FOR CALCULATION                   C
C*****-------------------------*********-------------------------******C
       SUBROUTINE SEL1(RPM,GN,G1,G2,G3,G4,G5,GD,TEFF,GT)
       IF (RPM.LE.1200.) THEN
           GN = 1.
       ELSE
        IF (RPM.LE.1800.) THEN
             GN = 2.
        ELSE
          IF (RPM.LE.2000.) THEN
               GN = 3.
          ELSE
            IF (RPM.LE.2200.) THEN
                GN = 4.
            ELSE
                GN = 5.
            ENDIF
          ENDIF
        ENDIF
       ENDIF

       IF ( GN.EQ.1 ) THEN
           GT = G1*GD
         TEFF = 0.8
       ELSE
        IF ( GN.EQ.2 ) THEN
             GT = G2*GD
           TEFF = 0.8
        ELSE
          IF ( GN.EQ.3 ) THEN
              GT = G3*GD
            TEFF = 0.85
          ELSE
            IF ( GN.EQ.4 ) THEN
               GT = G4*GD
             TEFF = 0.9
            ELSE
              IF ( GN.EQ.5 ) THEN
                GT = G5*GD
               TEFF = 0.9
              ELSE
       WRITE(6,*) ' ENTER NEW GEAR NUMBER '
         ENDIF
        ENDIF
       ENDIF
        ENDIF
       ENDIF
       RETURN
       END
```

ประวัติผู้วิจัย

นาย ไพรัช เลิศอารยะพงษ์ เกิดเมื่อวันที่ 13 เดือน กันยายน พุทธศักราช 2514 ที่ เขตยานนาวา จังหวัดกรุงเทพมหานคร สำเร็จการศึกษาปริญญาวิศวกรรมศาสตรบัณฑิต ภาควิชาวิศวกรรมเครื่องกล คณะวิศวกรรมศาสตร์ จากสถาบันเทคโนโลยีพระจอมเกล้าธนบุรี เมื่อปีการศึกษา 2536 เข้าศึกษาต่อในหลักสูตรวิศวกรรมมหาบัณฑิต ภาควิชาวิศวกรรมเครื่องกล คณะวิศวกรรมศาสตร์จุฬาลงกรณ์มหาวิทยาลัยเมื่อปีการศึกษา 2539

สถาบันวิทยบริการ
จุฬาลงกรณ์มหาวิทยาลัย