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ศูนย์วิทยทรัพยากร  
จุฬาลงกรณ์มหาวิทยาลัย

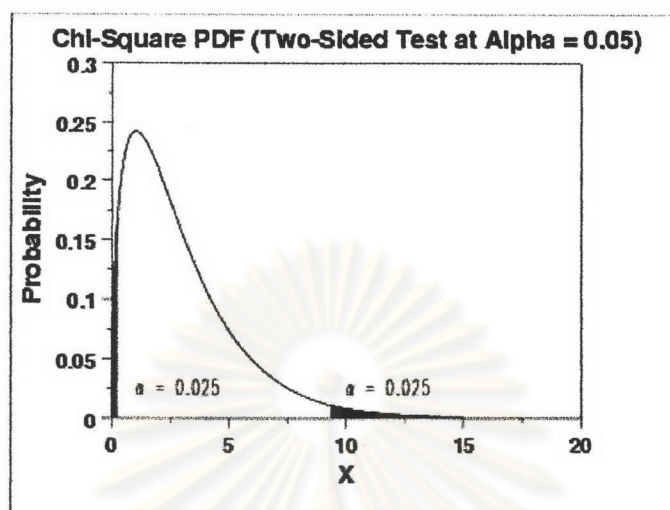


**APPENDICES**

ศูนย์วิทยทรัพยากร  
จุฬาลงกรณ์มหาวิทยาลัย

## APPENDIX A

Table A.1 Table of Chi-Square Distribution



df	Pr	0.1	0.05	0.025	0.01	0.001
1		2.706	3.841	5.024	6.635	10.828
2		4.605	5.991	7.378	9.210	13.816
3		6.251	7.815	9.348	11.345	16.266
4		7.779	9.488	11.143	13.277	18.467
5		9.236	11.070	12.833	15.086	20.515
6		10.645	12.592	14.449	16.812	22.458
7		12.017	14.067	16.013	18.475	24.322
8		13.362	15.507	17.535	20.090	26.125
9		14.684	16.919	19.023	21.666	27.877
10		15.987	18.307	20.483	23.209	29.588
11		17.275	19.675	21.920	24.725	31.264
12		18.549	21.026	23.337	26.217	32.910
13		19.812	22.362	24.736	27.688	34.528
14		21.064	23.685	26.119	29.141	36.123
15		22.307	24.996	27.488	30.578	37.697
16		23.542	26.296	28.845	32.000	39.252
17		24.769	27.587	30.191	33.409	40.790
18		25.989	28.869	31.526	34.805	42.312
19		27.204	30.144	32.852	36.191	43.820
20		28.412	31.410	34.170	37.566	45.315
21		29.615	32.671	35.479	38.932	46.797
22		30.813	33.924	36.781	40.289	48.268
23		32.007	35.172	38.076	41.638	49.728

Table A.1 Table of Chi-Square Distribution (cont.)

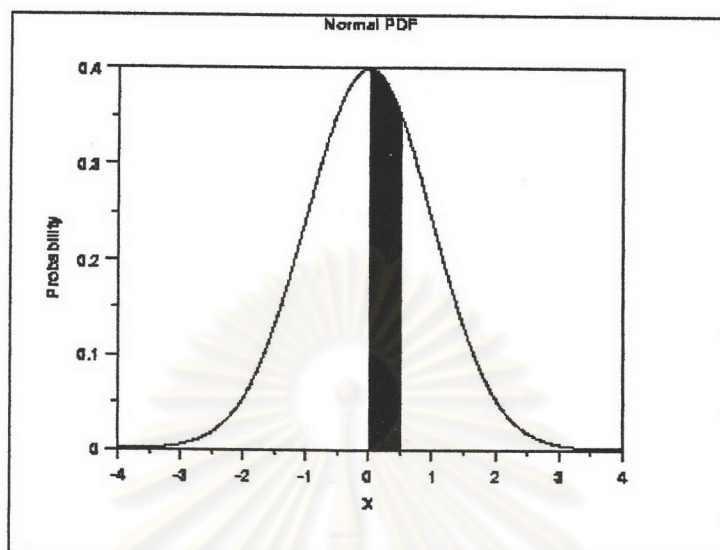
df	Pr	0.1	0.05	0.025	0.01	0.001
24		33.196	36.415	39.364	42.980	51.179
25		34.382	37.652	40.646	44.314	52.620
26		35.563	38.885	41.923	45.642	54.052
27		36.741	40.113	43.195	46.963	55.476
28		37.916	41.337	44.461	48.278	56.892
29		39.087	42.557	45.722	49.588	58.301
30		40.256	43.773	46.979	50.892	59.703
31		41.422	44.985	48.232	52.191	61.098
32		42.585	46.194	49.480	53.486	62.487
33		43.745	47.400	50.725	54.776	63.870
34		44.903	48.602	51.966	56.061	65.247
35		46.059	49.802	53.203	57.342	66.619
36		47.212	50.998	54.437	58.619	67.985
37		48.363	52.192	55.668	59.893	69.347
38		49.513	53.384	56.896	61.162	70.703
39		50.660	54.572	58.120	62.428	72.055
40		51.805	55.758	59.342	63.691	73.402
41		52.949	56.942	60.561	64.950	74.745
42		54.090	58.124	61.777	66.206	76.084
43		55.230	59.304	62.990	67.459	77.419
44		56.369	60.481	64.201	68.710	78.750
45		57.505	61.656	65.410	69.957	80.077
46		58.641	62.830	66.617	71.201	81.400
47		59.774	64.001	67.821	72.443	82.720
48		60.907	65.171	69.023	73.683	84.037
49		62.038	66.339	70.222	74.919	85.351
50		63.167	67.505	71.420	76.154	86.661
51		64.295	68.669	72.616	77.386	87.968
52		65.422	69.832	73.810	78.616	89.272
53		66.548	70.993	75.002	79.843	90.573
54		67.673	72.153	76.192	81.069	91.872
55		68.796	73.311	77.380	82.292	93.168
56		69.919	74.468	78.567	83.513	94.461
57		71.040	75.624	79.752	84.733	95.751
58		72.160	76.778	80.936	85.950	97.039
59		73.279	77.931	82.117	87.166	98.324
60		74.397	79.082	83.298	88.379	99.607
61		75.514	80.232	84.476	89.591	100.888
62		76.630	81.381	85.654	90.802	102.166

Table A.1 Table of Chi-Square Distribution (cont.)

df	Pr	0.1	0.05	0.025	0.01	0.001
63		77.745	82.529	86.830	92.010	103.442
64		78.860	83.675	88.004	93.217	104.716
65		79.973	84.821	89.177	94.422	105.988
66		81.085	85.965	90.349	95.626	107.258
67		82.197	87.108	91.519	96.828	108.526
68		83.308	88.250	92.689	98.028	109.791
69		84.418	89.391	93.856	99.228	111.055
70		85.527	90.531	95.023	100.425	112.317
71		86.635	91.670	96.189	101.621	113.577
72		87.743	92.808	97.353	102.816	114.835
73		88.850	93.945	98.516	104.010	116.092
74		89.956	95.081	99.678	105.202	117.346
75		91.061	96.217	100.839	106.393	118.599
76		92.166	97.351	101.999	107.583	119.850
77		93.270	98.484	103.158	108.771	121.100
78		94.374	99.617	104.316	109.958	122.348
79		95.476	100.749	105.473	111.144	123.594
80		96.578	101.879	106.629	112.329	124.839
81		97.680	103.010	107.783	113.512	126.083
82		98.780	104.139	108.937	114.695	127.324
83		99.880	105.267	110.090	115.876	128.565
84		100.980	106.395	111.242	117.057	129.804
85		102.079	107.522	112.393	118.236	131.041
86		103.177	108.648	113.544	119.414	132.277
87		104.275	109.773	114.693	120.591	133.512
88		105.372	110.898	115.841	121.767	134.746
89		106.469	112.022	116.989	122.942	135.978
90		107.565	113.145	118.136	124.116	137.208
91		108.661	114.268	119.282	125.289	138.438
92		109.756	115.390	120.427	126.462	139.666
93		110.850	116.511	121.571	127.633	140.893
94		111.944	117.632	122.715	128.803	142.119
95		113.038	118.752	123.858	129.973	143.344
96		114.131	119.871	125.000	131.141	144.567
97		115.223	120.990	126.141	132.309	145.789
98		116.315	122.108	127.282	133.476	147.010
99		117.407	123.225	128.422	134.642	148.230
100		118.498	124.342	129.561	135.807	149.449

## APPENDIX B

Table B.1 Table of Normal Distribution



z	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.0000	0.0040	0.0080	0.0120	0.0160	0.0199	0.0239	0.0279	0.0319	0.0359
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714	0.0754
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103	0.1141
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480	0.1517
0.4	0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1808	0.1844	0.1879
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190	0.2224
0.6	0.2258	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2518	0.2549
0.7	0.2580	0.2612	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.2852
0.8	0.2881	0.2910	0.2939	0.2967	0.2996	0.3023	0.3051	0.3079	0.3106	0.3133
0.9	0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3340	0.3365	0.3389
1.0	0.3413	0.3438	0.3461	0.3485	0.3508	0.3531	0.3554	0.3577	0.3599	0.3621
1.1	0.3643	0.3665	0.3686	0.3708	0.3729	0.3749	0.3770	0.3790	0.3810	0.3830
1.2	0.3849	0.3869	0.3888	0.3907	0.3925	0.3944	0.3962	0.3980	0.3997	0.4015
1.3	0.4032	0.4049	0.4066	0.4082	0.4099	0.4115	0.4131	0.4147	0.4162	0.4177
1.4	0.4192	0.4207	0.4222	0.4236	0.4251	0.4265	0.4279	0.4292	0.4306	0.4319
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4430	0.4441
1.6	0.4452	0.4463	0.4474	0.4485	0.4495	0.4505	0.4515	0.4525	0.4535	0.4545
1.7	0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625	0.4633
1.8	0.4641	0.4649	0.4656	0.4664	0.4671	0.4678	0.4686	0.4693	0.4700	0.4706
1.9	0.4713	0.4719	0.4726	0.4732	0.4738	0.4744	0.4750	0.4756	0.4762	0.4767
2.0	0.4773	0.4778	0.4783	0.4788	0.4793	0.4798	0.4803	0.4808	0.4812	0.4817
2.1	0.4821	0.4826	0.4830	0.4834	0.4838	0.4842	0.4846	0.4850	0.4854	0.4857
2.2	0.4861	0.4865	0.4868	0.4871	0.4875	0.4878	0.4881	0.4884	0.4887	0.4890

Table B.1 Table of Normal Distribution (cont.)

z	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
2.2	0.4893	0.4896	0.4898	0.4901	0.4904	0.4906	0.4909	0.4911	0.4913	0.4916
2.4	0.4918	0.4920	0.4922	0.4925	0.4927	0.4929	0.4931	0.4932	0.4934	0.4936
2.5	0.4938	0.4940	0.4941	0.4943	0.4945	0.4946	0.4948	0.4949	0.4951	0.4952
2.6	0.4953	0.4955	0.4956	0.4957	0.4959	0.4960	0.4961	0.4962	0.4963	0.4964
2.7	0.4965	0.4966	0.4967	0.4968	0.4969	0.4970	0.4971	0.4972	0.4973	0.4974
2.8	0.4974	0.4975	0.4976	0.4977	0.4977	0.4978	0.4979	0.4980	0.4980	0.4981
2.9	0.4981	0.4982	0.4983	0.4983	0.4984	0.4984	0.4985	0.4985	0.4986	0.4986
3.0	0.4987	0.4987	0.4987	0.4988	0.4988	0.4989	0.4989	0.4989	0.4990	0.4990
3.1	0.4990	0.4991	0.4991	0.4991	0.4992	0.4992	0.4992	0.4992	0.4993	0.4993
3.2	0.4993	0.4993	0.4994	0.4994	0.4994	0.4994	0.4994	0.4995	0.4995	0.4995
3.3	0.4995	0.4995	0.4996	0.4996	0.4996	0.4996	0.4996	0.4996	0.4996	0.4997
3.4	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4998	0.4998
3.5	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998
3.6	0.4998	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999
3.7	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999
3.8	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.5000	0.5000	0.5000
3.9	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
4.0	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000



## APPENDIX C

## Example for Principal Component Calculation

Table C.1 Observation data

Batch no.	Interval time	Pressure	Flow	Platen Forward	Coil Forward	Platen Load	Platen Turn	Coil Load	Coil Turn	Peak	Bias	APC Angle
1	200	12	2.5	250	90	70.2	78.4	32.7	25.4	340	564	60.8
2	200	12	2.4	250	90	70	78.6	32.7	25.4	335	564	61.1
3	200	12.1	2.6	250	90	70.2	78.5	32.7	25.4	325	558	60.6
4	200	12	2.5	250	90	70.8	78.3	32.7	25.4	340	560	60.6
5	200	12.1	2.5	250	89	70	78.8	32.8	25.5	340	558	61.9
6	200	12	2.4	250	88	71.1	77	31.4	26.1	390	552	60.2
7	200	12	2.4	252	89	71.3	77	31.2	26.1	390	554	60.6
8	200	12	2.4	253	90	70.8	77	31.3	26.1	380	550	60.5
9	200	12	2.4	251	89	70.9	77	31.4	26.1	390	549	60.7
10	200	12.1	2.6	250	89	71	77	31.3	26.1	380	552	60.6
11	200	12.1	2.4	251	89	71	77.1	31.4	26.1	385	554	60.8
12	200	12	2.4	251	89	71.7	77.1	31.3	26.1	350	555	60.6
13	200	12	2.4	252	88	71	77	31.2	26.1	380	548	60
14	200	12.2	2.6	251	89	71.2	77.1	31.3	26.1	390	558	60.3
15	200	12	2.4	252	89	71.4	76.9	31.4	26.1	385	562	60.8
16	200	12	2.5	255	89	71.5	77.1	32.5	25.2	400	564	60.8
17	200	11.9	2.4	250	91	71.5	77.1	32.4	25.2	410	561	60.2
18	200	12	2.5	252	88	71.4	77	32.4	25.3	400	555	60.6
19	200	12.1	2.4	251	89	71.9	76.9	32.5	25.2	410	558	59.3
20	200	12	2.6	252	88	71.3	77	32.5	25.3	385	552	60.5
Mean		12.03	2.47	251.15	89.15	71.01	77.40	31.96	25.72	375.25	556.40	60.58
Sigma		0.07	0.08	1.31	0.81	0.55	0.67	0.66	0.40	26.53	5.07	0.49

Table C.2 Standardized (Scaling) data

Batch no.	Interval time	Pressure	Flow	Platen Forward	Coil Forward	Platen Load	Platen Turn	Coil Load	Coil Turn	Peak	Bias	APC Angle
1	200	-0.457	0.431	-0.879	1.046	-1.477	1.490	1.127	-0.784	-1.329	1.498	0.458
2	200	-0.457	-0.800	-0.879	1.046	-1.841	1.786	1.127	-0.784	-1.517	1.498	1.070
3	200	1.066	1.661	-0.879	1.046	-1.477	1.638	1.127	-0.784	-1.894	0.315	0.051
4	200	-0.457	0.431	-0.879	1.046	-0.383	1.341	1.127	-0.784	-1.329	0.710	0.051
5	200	1.066	0.431	-0.879	-0.185	-1.841	2.082	1.278	-0.535	-1.329	0.315	2.699
6	200	-0.457	-0.800	-0.879	-1.415	0.164	-0.585	-0.839	0.958	0.556	-0.867	-0.784
7	200	-0.457	-0.800	0.649	-0.185	0.529	-0.585	-1.142	0.958	0.556	-0.473	0.051
8	200	-0.457	-0.800	1.413	1.046	-0.383	-0.585	-0.990	0.958	0.179	-1.262	-0.153
9	200	-0.457	-0.800	-0.115	-0.185	-0.201	-0.585	-0.839	0.958	0.556	-1.459	0.255
10	200	1.066	1.661	-0.879	-0.185	-0.018	-0.585	-0.990	0.958	0.179	-0.867	0.051
11	200	1.066	-0.800	-0.115	-0.185	-0.018	-0.437	-0.839	0.958	0.367	-0.473	0.458
12	200	-0.457	-0.800	-0.115	-0.185	1.258	-0.437	-0.990	0.958	-0.952	-0.276	0.051
13	200	-0.457	-0.800	0.649	-1.415	-0.018	-0.585	-1.142	0.958	0.179	-1.656	-1.171
14	200	2.588	1.661	-0.115	-0.185	0.346	-0.437	-0.990	0.958	0.556	0.315	-0.560
15	200	-0.457	-0.800	0.649	-0.185	0.711	-0.734	-0.839	0.958	0.367	1.104	0.458
16	200	-0.457	0.431	2.941	-0.185	0.893	-0.437	0.824	-1.282	0.933	1.498	0.458
17	200	-1.979	-0.800	-0.879	2.276	0.893	-0.437	0.673	-1.282	1.310	0.907	-0.764
18	200	-0.457	0.431	0.649	-1.415	0.711	-0.585	0.673	-1.033	0.833	-0.276	0.051
19	200	1.066	-0.800	-0.115	-0.185	1.622	-0.734	0.824	-1.282	1.310	0.315	-2.598
20	200	-0.457	1.661	0.649	-1.415	0.529	-0.585	0.824	-1.033	0.367	-0.867	-0.153



**Table C.3 Covariance Matrix (Correlation Matrix)**

	Pressure	Flow	Platen Forward	Coil Forward	Platen Load	Platen Tune	Coil Load	Coil Tune	Peak	Bias	APC Angle
Pressure	1.000	0.503	-0.178	-0.187	-0.155	0.122	-0.101	0.201	-0.125	-0.054	0.024
Flow	0.503	1.000	-0.096	-0.076	-0.216	0.256	0.322	-0.273	-0.240	0.100	0.162
Platen Forward	-0.178	-0.096	1.000	-0.319	0.452	-0.512	-0.199	0.026	0.476	-0.089	-0.084
Coil Forward	-0.187	-0.076	-0.319	1.000	-0.334	0.462	0.346	-0.297	-0.344	0.534	0.129
Platen Load	-0.155	-0.216	0.452	-0.334	1.000	-0.853	-0.364	0.088	0.786	-0.174	-0.638
Platen Tune	0.122	0.256	-0.512	0.462	-0.853	1.000	0.679	-0.425	-0.873	0.508	0.588
Coil Load	-0.101	0.322	-0.199	0.346	-0.364	0.679	1.000	-0.944	-0.380	0.635	0.235
Coil Tune	0.201	-0.273	0.026	-0.297	0.088	-0.425	-0.944	1.000	0.106	-0.595	-0.009
Peak	-0.125	-0.240	0.476	-0.344	0.786	-0.873	-0.380	0.106	1.000	-0.282	-0.551
Bias	-0.054	0.100	-0.089	0.534	-0.174	0.508	0.635	-0.595	-0.282	1.000	0.260
APC Angle	0.024	0.162	-0.084	0.129	-0.638	0.588	0.235	-0.009	-0.551	0.260	1.000

Due to different unit of original process variables, correlation matrix are brought instead of covariance matrix.

**Table C.4 Eigenvalue and %Explained Variance**

Eigenvalue	4.507	2.065	1.489	1.022	0.707	0.439	0.342	0.277	0.133	0.014	0.005
% Explained Variance	40.974	18.776	13.532	9.290	6.427	3.991	3.113	2.514	1.212	0.129	0.043

Each column of eigenvalue are represent each principal component that can explain variation in process.

**Table C.5 Eigenvector**

Pressure	0.039	-0.371	0.532	-0.237	0.408	-0.351	-0.286	0.284	0.239	-0.101	-0.038
Flow	0.163	-0.119	0.662	0.022	0.021	0.581	0.311	-0.212	-0.175	0.098	0.031
Platen Forward	-0.233	0.229	0.116	0.655	0.304	0.211	-0.553	-0.042	0.001	0.074	0.041
Coil Forward	0.261	0.187	-0.336	-0.360	0.481	0.545	-0.074	0.245	0.241	-0.011	0.040
Platen Load	-0.371	0.314	0.131	-0.116	0.128	-0.119	0.273	-0.362	0.639	0.292	0.057
Platen Tune	0.456	-0.100	-0.053	0.019	-0.083	-0.126	-0.203	-0.035	0.008	0.843	-0.056
Coil Load	0.362	0.364	0.202	0.046	-0.271	-0.114	-0.076	0.163	0.161	-0.150	0.725
Coil Tune	-0.258	-0.513	-0.246	-0.014	0.263	0.025	0.066	-0.188	-0.160	0.148	0.673
Peak	-0.380	0.273	0.121	-0.038	0.088	-0.051	0.285	0.660	-0.330	0.352	0.074
Bias	0.294	0.356	0.010	0.000	0.552	-0.381	0.196	-0.334	-0.424	-0.082	-0.009
APC Angle	0.273	-0.235	-0.127	0.606	0.176	-0.075	0.514	0.266	0.327	-0.064	-0.059

Each column of eigenvector are represented a principal component that contain of eleven original process variables.

## BIOGRAPHY

Mr. Peerapol Boonyuen was born on 14 January 1975 at Phang-Nga province. I was graduated in bachelor degree in industrial chemistry science from King Mongkut Institute Technology Ladkrabang (KMITL) in 1996.

I work at Western Digital Bangpa-in (Thailand) Co., Ltd. At Bangpa-in Industrial Real Estate in charge of process engineer.



ศูนย์วิทยทรัพยากร  
จุฬาลงกรณ์มหาวิทยาลัย