CHAPTER IV

VERIFY SIMULATION MODEL AND OPTIMIZATION

In this section, the performance and effectiveness of the proposed simulation handling scheme compared between programming in Matlab and real process production are considered. The simulation is verified and corrected until it can be represented the real process. We apply DE with the proposed constraint handling schematic to be met optimization problems following objective function which is maximum production in time horizon. The problem is run 100 times with 10 different seeds for random number generator to check the consistency of the result obtained.

4.1 Verify simulation

AC1 is set to start prior. After that, AC2 is started. The time horizon in scope of interested is 1440 min (1 day). Time of starting batch from both reactors are recorded by absolute time by T_{11} is time of start 1st batch from AC1. It is always set at 1st minute and AC2 is started afterward. The process control is using distribution control system (DCS) commanded. Batches are fed following recipe as describe in section 3.

The first trial is performed FALSE function by random T_{11}, T_{12}, T_{13} and T_{21}, T_{22}, T_{23} which are absolute time of stating batch from AC1 and 2. It is for checking that model will be generated FALSE and production equal to zero when those times are prohibited in constrained function. The constrained function is limited maximum utilities supply in the same minute in time horizon. It means that group of time can not be occurred in the real process production. The result of simulation shown FALSE and production equaled to zero like made in model. It can conclude that the constrained function is valid.

The trial is performed 7 days with is around 42 batches for batch production simulation. Time of starting batch are recorded and checked in simulation model.

Trial description in real process (Tracked out from DCS) is here below.

- Black line: Conversion rate from AC1.
- Red line: Conversion rate of AC2.
- Violet line: Volume in degasser (m^3)
- Blue line: Production in one day (ton/day)

Trial 1

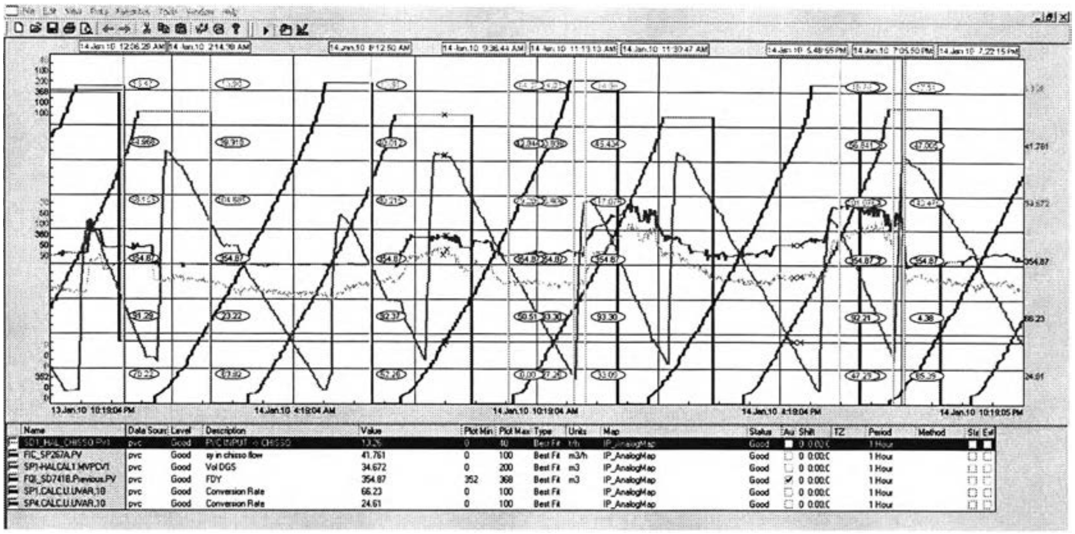

Figure 4.1 Real process operation in Trial 1

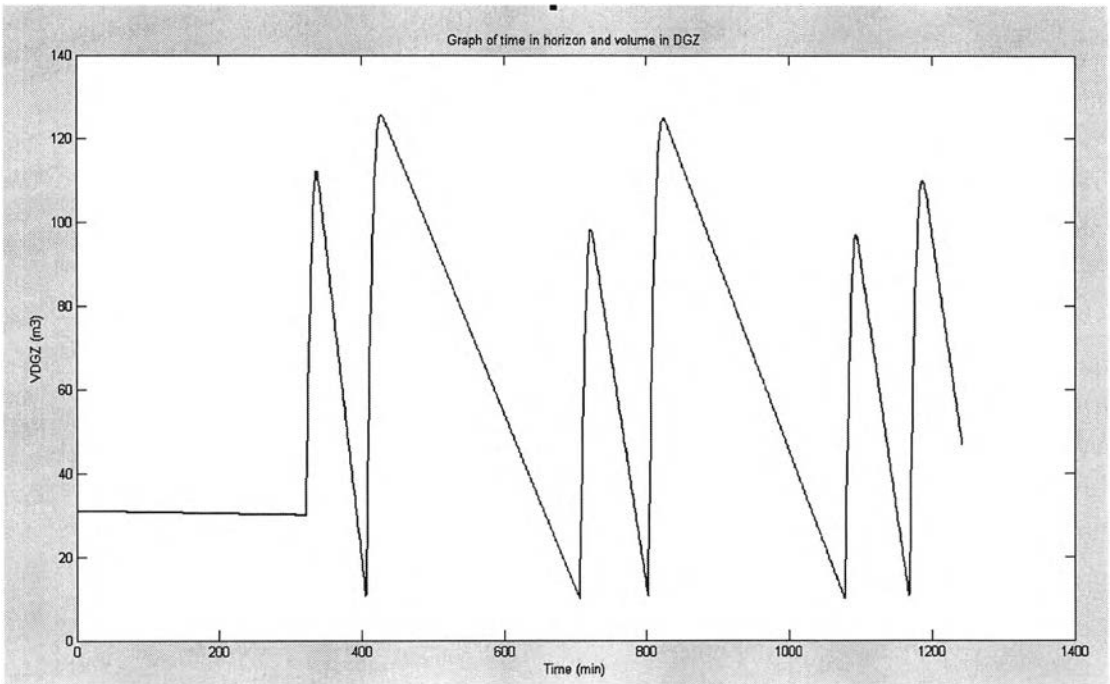

Figure 4.2 Graph of volume in DGZ from simulation in Trial 1

Table 4.1 Summary from Trial 1

Starting time AC1			Starting time AC2			Real production (ton/day)	Simulation production (ton/day)
T_{11}	T_{12}	T_{13}	T_{21}	T_{22}	T_{23}		
1	385	757	139	535	901	366.89	387.38

Trial 2

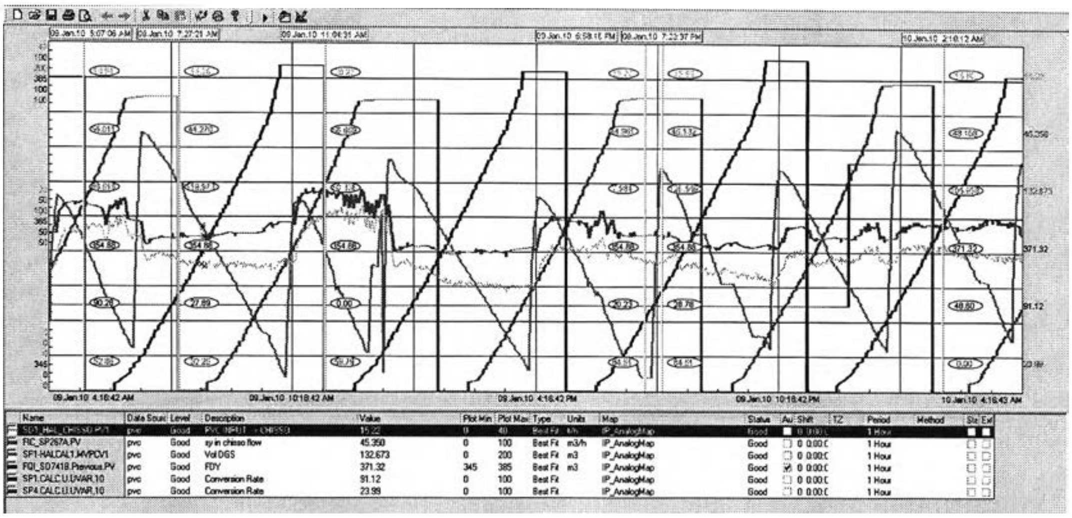

Figure 4.3 Real process operation in Trial 2

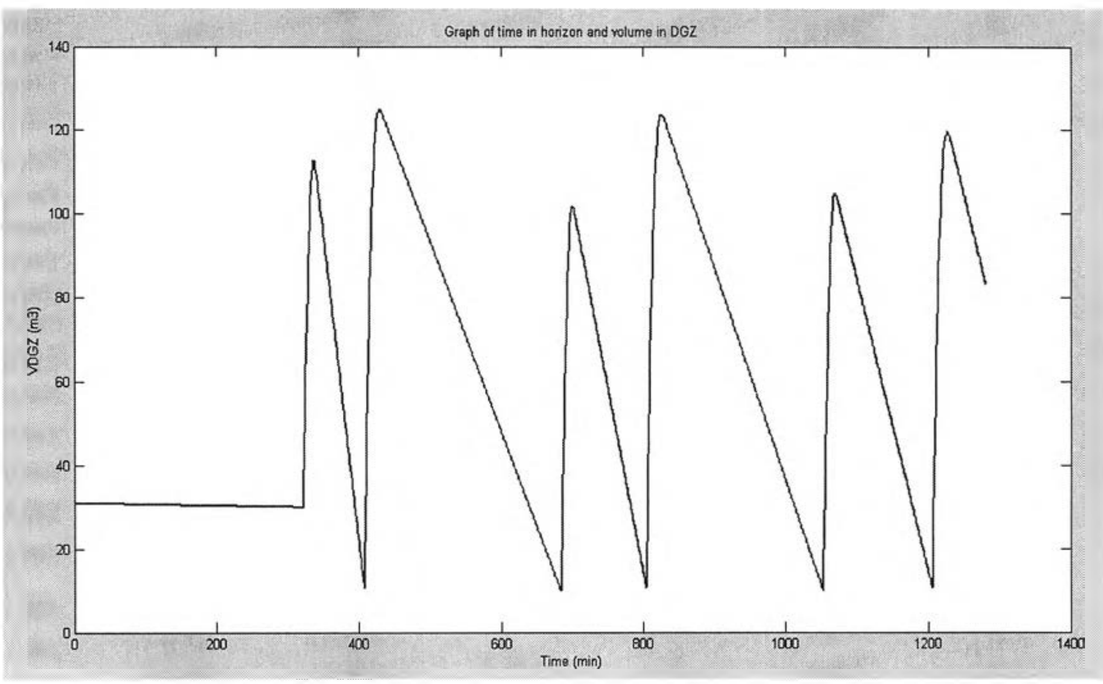

Figure 4.4 Graph of volume in DGZ from simulation in Trial 2

Table 4.2 Summary from Trial 2

Starting time AC1			Starting time AC2			Real production (ton/day)	Simulation production (ton/day)
T_{11}	T_{12}	T_{13}	T_{21}	T_{22}	T_{23}		
1	363	732	141	537	939	370.212	355.24

Trial 3

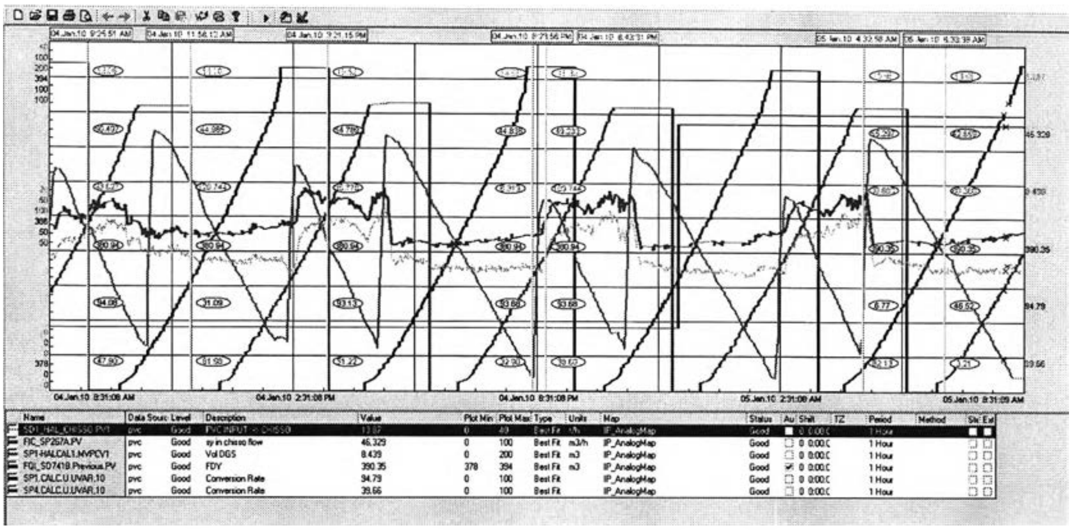

Figure 4.5 Real process operation in Trial 3

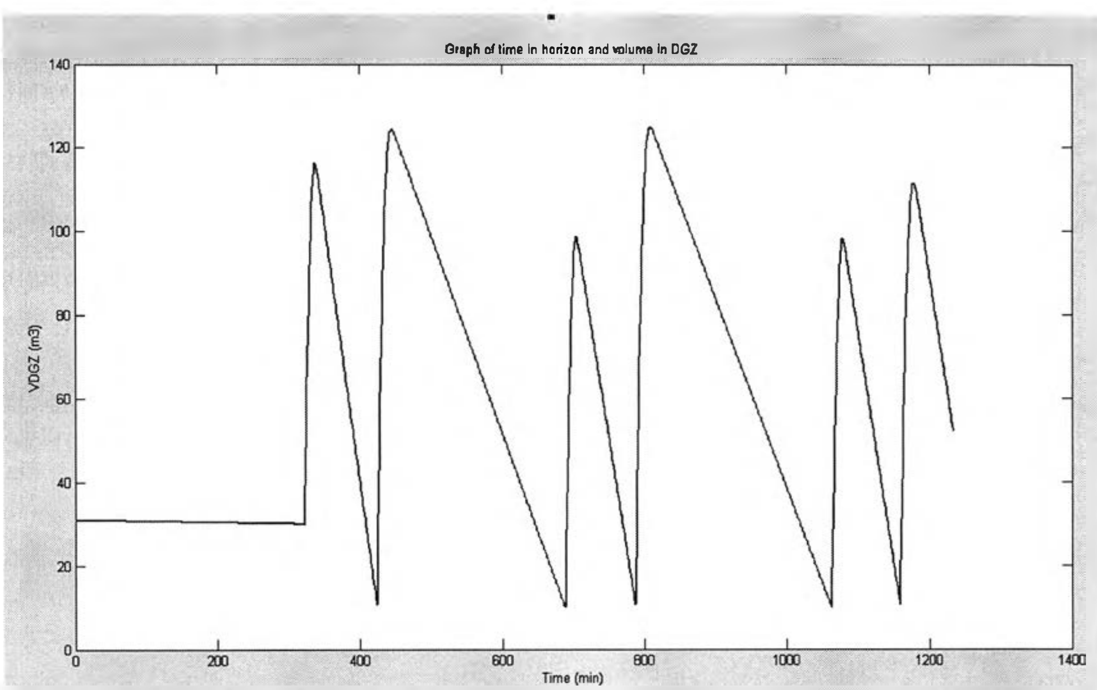

Figure 4.6 Graph of volume in DGZ from simulation in Trial 3

Table 4.3 Summary from Trial 3

Starting time AC1			Starting time AC2			Real production (ton/day)	Simulation production (ton/day)
T_{11}	T_{12}	T_{13}	T_{21}	T_{22}	T_{23}		
1	367	742	157	520	892	357.0	337.55

Trial 4

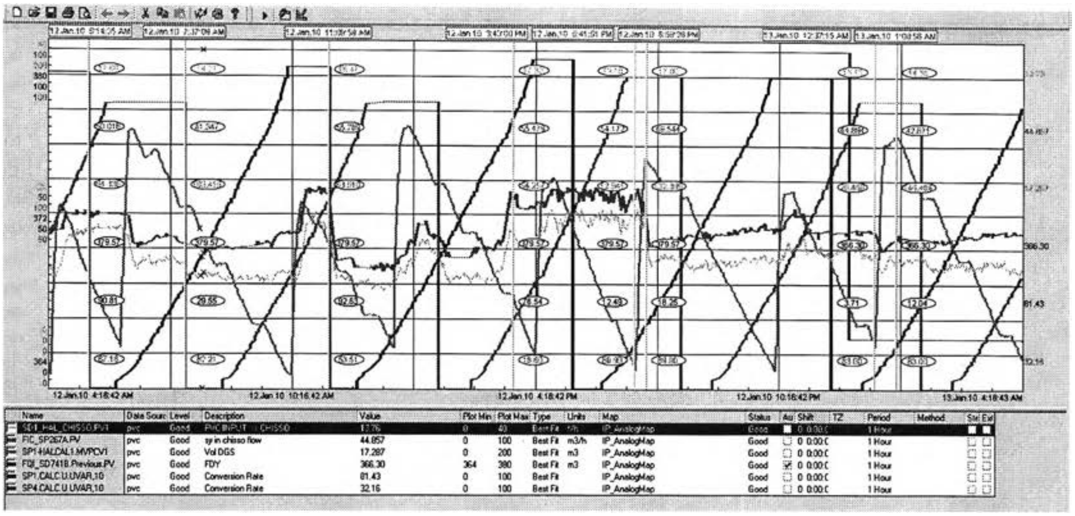

Figure 4.7 Real process operation in Trial 4

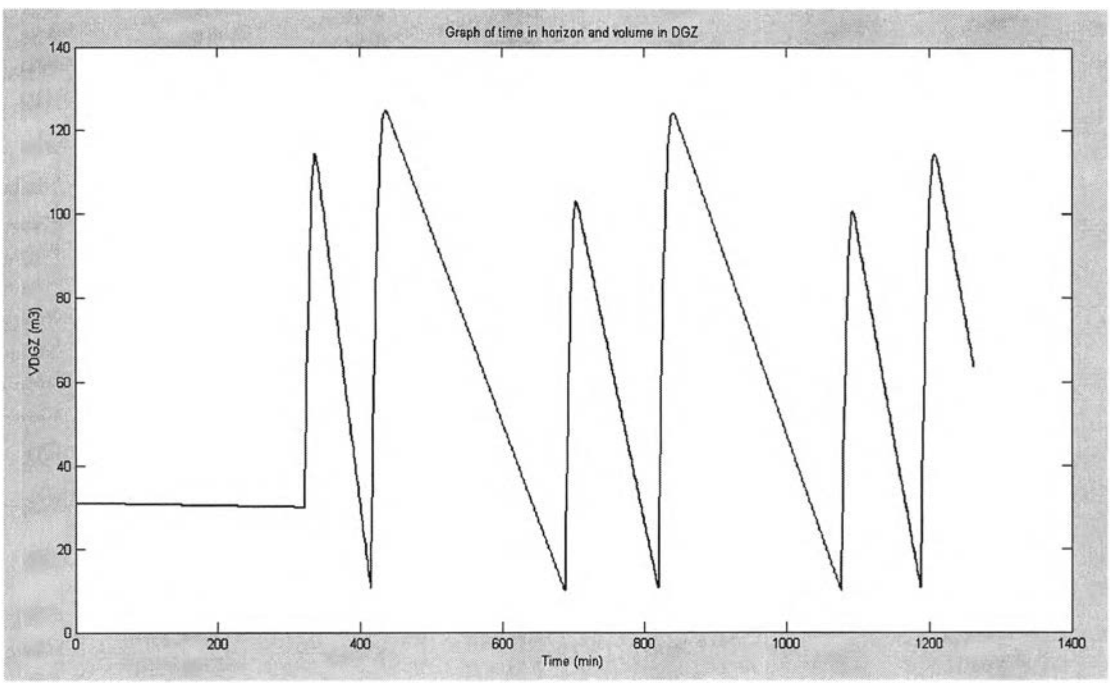

Figure 4.8 Graph of volume DGZ from simulation in Trial 4.

Table 4.4 Summary from Trial 4

Starting time AC1			Starting time AC2			Real production (ton/day)	Simulation production (ton/day)
T_{11}	T_{12}	T_{13}	T_{21}	T_{22}	T_{23}		
1	367	756	148	552	921	365.112	329.71

Trial 5

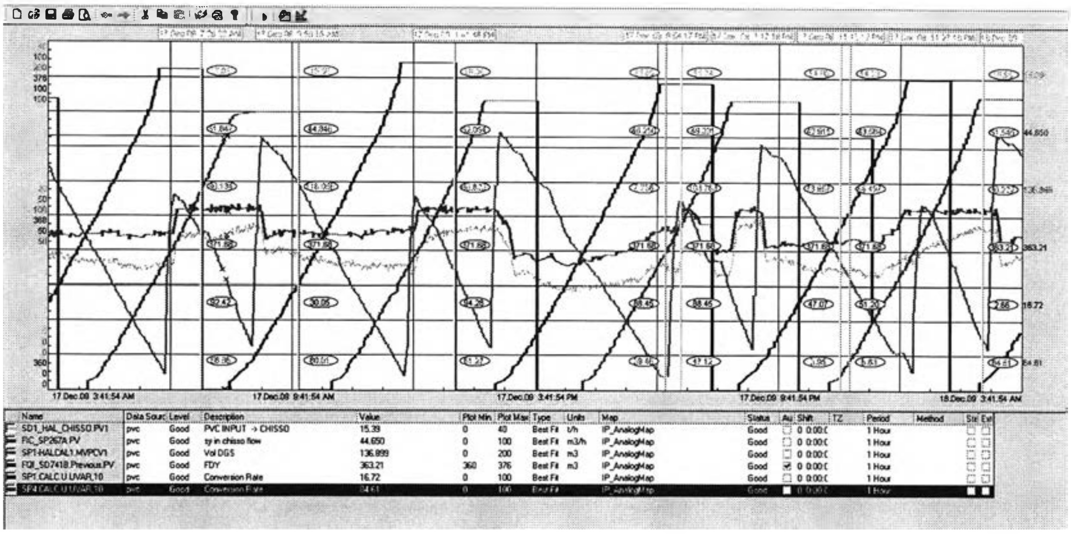

Figure 4.9 Real process operation in Trial 5

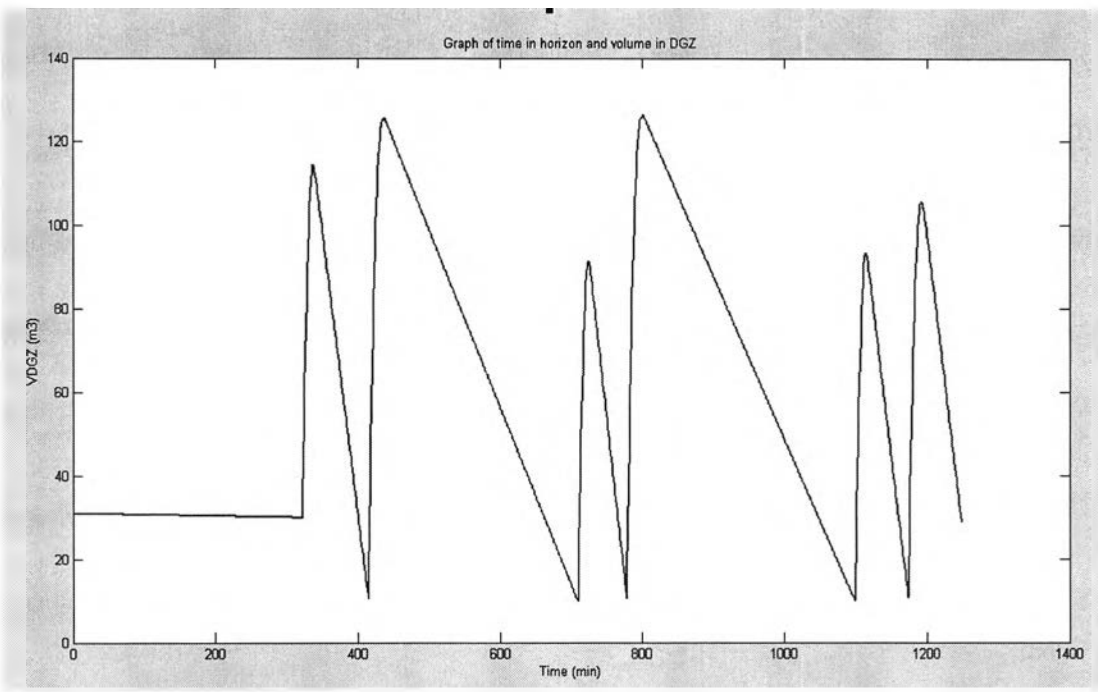

Figure 4.10 Graph of volume in DGZ from simulation in Trial 5

Table 4.5 Summary from Trial 5

Starting time AC1			Starting time AC2			Real production (ton/day)	Simulation production (ton/day)
T_{11}	T_{12}	T_{13}	T_{21}	T_{22}	T_{23}		
1	388	778	148	511	907	362.708	433.46

Trial 6

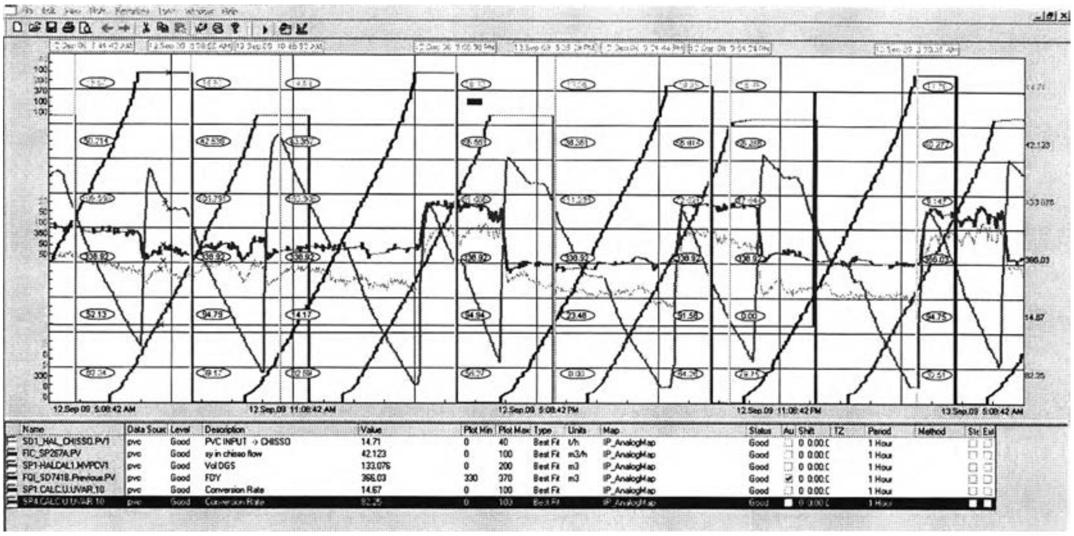

Figure 4.11 Real process operation in Trial 6

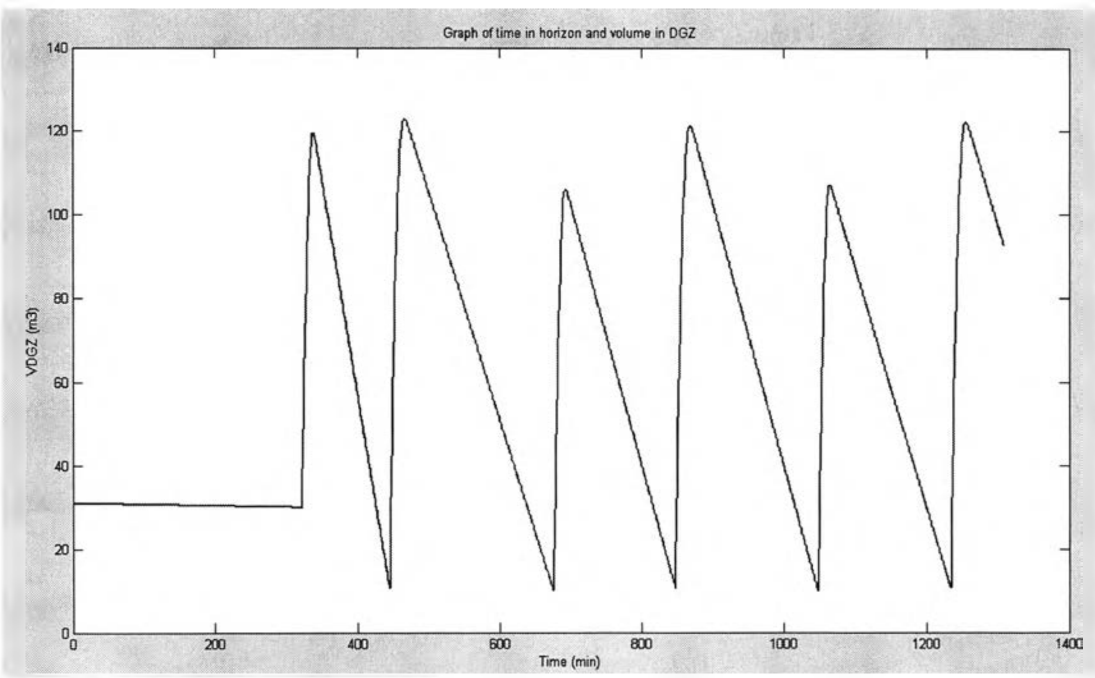

Figure 4.12 Graph of volume in DGZ from simulation in Trial 6

Table 4.6 Summary from Trial 6

Starting time AC1			Starting time AC2			Real production (ton/day)	Simulation production (ton/day)
T_{11}	T_{12}	T_{13}	T_{21}	T_{22}	T_{23}		
1	355	727	178	580	967	365.052	276.69

Trial 7

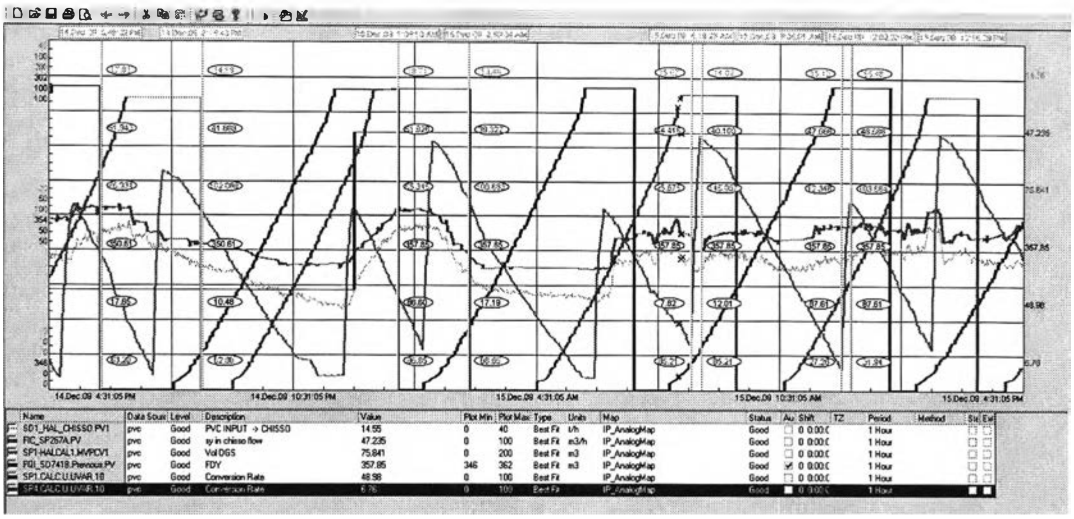

Figure 4.13 Real process operation in Trial 7

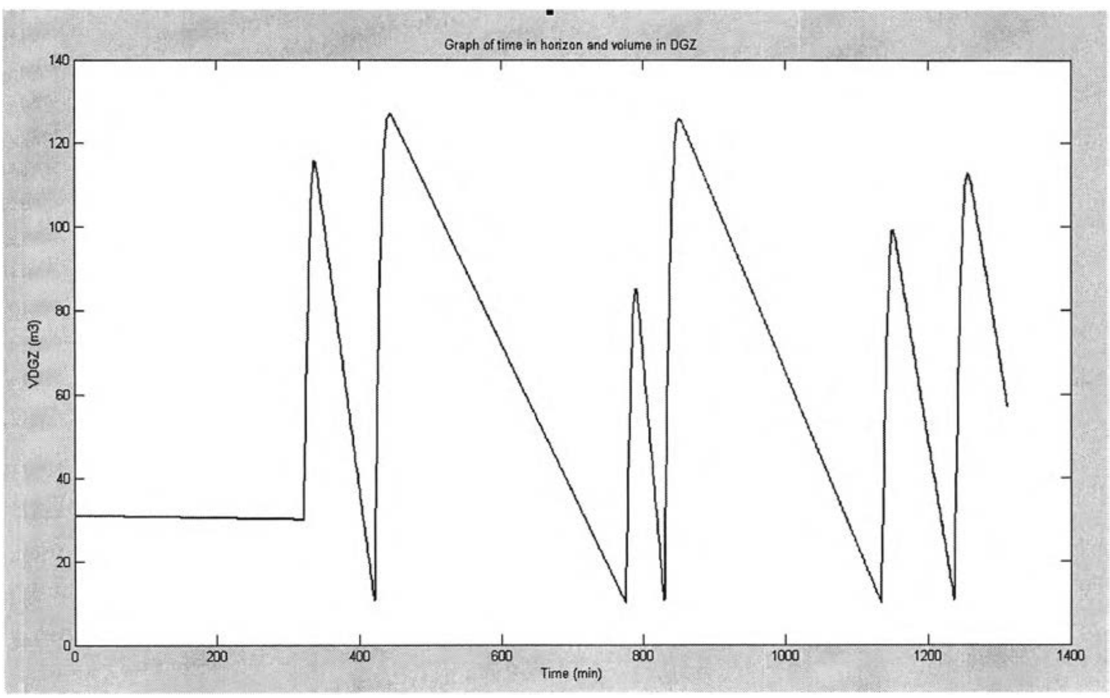

Figure 4.14 Graph of volume in DGZ from simulation in Trial 6.

Table 4.7 Summary from Trial 7

Starting time AC1			Starting time AC2			Real production (ton/day)	Simulation production (ton/day)
T_{11}	T_{12}	T_{13}	T_{21}	T_{22}	T_{23}		
1	454	814	154	562	970	355.0	300.60

The results production effectiveness from simulations is compared with production from real process production. These results came from production in 7 days 42 batches. The summary result comparison is here below in table 4.8.

Table 4.8 Production comparison between real process and simulation

Starting time AC1			Starting time AC2			Real production (ton/day)	Calculation production (ton/day)	Differentiation %
T_{11}	T_{12}	T_{13}	T_{21}	T_{22}	T_{23}			
1	385	757	139	535	901	366.89	387.38	-5.58
1	363	732	141	537	939	370.212	355.24	4.04
1	367	742	157	520	892	357.00	337.55	5.45
1	367	756	148	552	921	365.112	329.71	9.70
1	388	778	148	511	907	362.708	433.46	-19.51
1	355	727	178	580	967	365.052	276.69	24.21
1	454	814	154	562	970	355.00	300.60	15.32

Production deviation between simulation and real process is 4.8% in average, but range of deviation is during = -19.51% to 24.21%. It is too wide range until unacceptable. So, liner regression is used for finding the relation of both simulation and real process. Liner equation is used for correction production simulation. Result of plot is here below which is shown with equation in Fig 4.15.

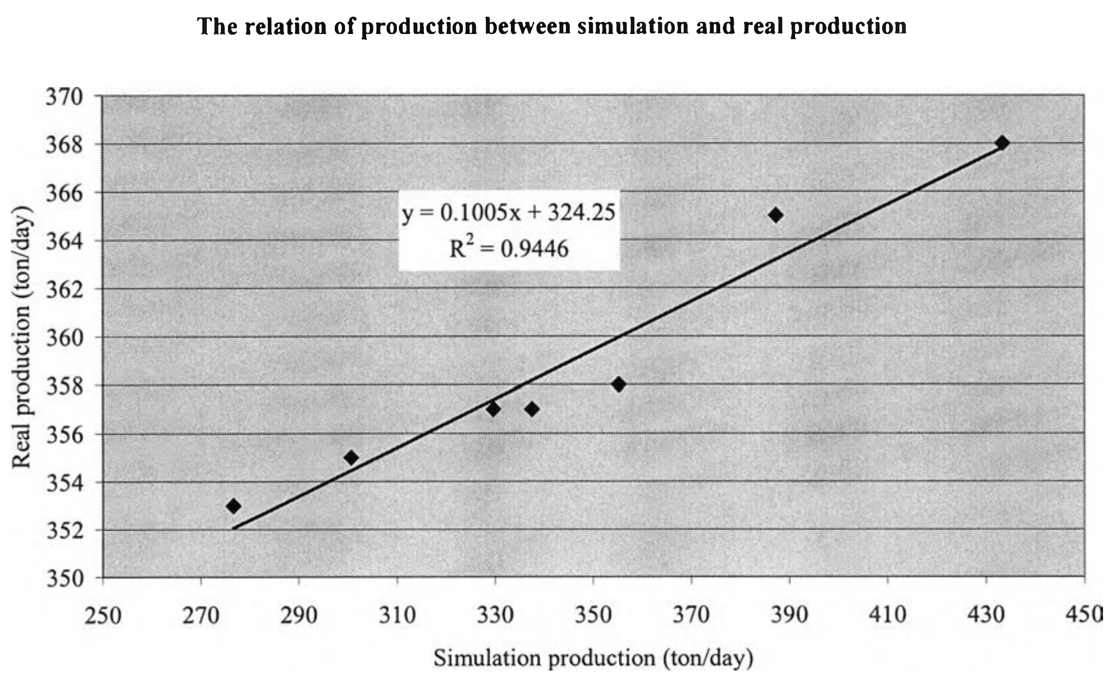

Figure 4.15 Linear regressions between real process and simulation

This linear equation is here below.

New simulation production (ton/day) = (Simulation production x *0.1005) + 324.25*

(4.1)

This formula is applied in Matlab simulation model in order to find result of production in simulation and compared them again with real production. The result is here below in table 4.9.

Table 4.9 Production comparison between real process and adjusted simulation

Starting time AC1			Starting time AC2			Real production (ton/day)	First simulation production (ton/day)	Adjust simulation production (ton/day)	Diff.
T_{11}	T_{12}	T_{13}	T_{21}	T_{22}	T_{23}				%
1	385	757	139	535	901	366.89	387.38	363.01	1.06
1	363	732	141	537	939	370.21	355.24	359.79	2.81
1	367	742	157	520	892	357.00	337.55	358.02	-0.29
1	367	756	148	552	921	365.11	329.71	357.24	2.16
1	388	778	148	511	907	362.71	433.46	367.62	-1.35
1	355	727	178	580	967	365.05	276.69	351.93	3.59
1	454	814	154	562	970	355.00	300.60	354.33	0.19

Production deviation between adjusted simulation and real process is decreased from 4.8% to 1.2% in average, and range of deviation is during = - 0.29% to 3.59%. By now on, simulation after adjusted is acceptable. So, this model can be used for optimization.

4.2 Optimization

In this problem, we consider linear program which is taken from section 3. The optimization problem is.

Max F = Max Production

Constrained

AC1 start up time = T_{11}, T_{21}, T_{31}
AC2 start up time = T_{21}, T_{22}, T_{23} *by* T_{23} + *Batch time* $\leq$ *1440 min*
$F\_DGZ\_MIN \leq F\_DGZ\_SP \leq F\_DGZ\_MAX$ (4.2)

The problem is run 100 generation rounds with 10 different seeds to random number generator to check the consistency of the result obtained. The detail of each seed is in appendix and summary table is here below.

Table 4.10 Maximum production from optimization and start batch time

Seed	Starting time AC1			Starting time AC2			Generation (round)	Max. Sim. production (ton/day)
	T_{11}	T_{12}	T_{13}	T_{21}	T_{22}	T_{23}		
10	1	373	765	125	445	899	82	442
30	1	360	799	102	431	928	63	465
70	1	374	784	104	445	983	95	465
150	1	356	761	126	426	902	90	456
300	1	375	755	113	449	894	45	436
700	1	398	778	122	471	905	77	438
1000	1	357	727	110	428	938	71	450
2000	1	354	736	121	423	966	94	453
9000	1	374	792	125	446	922	59	443
20000	1	381	757	124	452	959	74	446

We observed that result of optimization from seed 30 and 70 are shown maximum production at 465 ton/day while average production in real process without optimization is 390 ton/day. We apply stating time from seed 30 in real plant. The result shows production at 464 ton/day. So, the result of starting batch time for AC1 and AC2 from optimization at seed 30 and 70 can increase production 19.2% from normal production with out any changing equipment or de-bottle necking process production.

The studying by USAHA in 2007 was reported the unit price of suspension PVC resin in word market (CIF at Bangkok) was 880 US Dollar/ton and the gross profit margin was around 15%. So, the profit per tonnage of resin was 132 US Dollar/ton.

We take the production increase from optimal batch scheduling from average one is 465 – 390 = 75 ton/day. If we assume this production line in annual is serviced around 330 days, the gain estimation that optimal batch scheduling can make benefit is equal to 330 (day/year) x 75 (ton/day) x 132 (US Dollar/ton) = 3.267 Million US Dollar in annual with out any additional new equipment.