CHAPTER V

RESULT

5.1 Introduction

In this chapter, the resilient heat exchanger network design method provided by Wongsri (1990) is used to design the resilient heat exchanger networks for Hydrodealkylation process (HDA Process). The design procedures and definitions from previous chapters will be an accessory to design and compare with the alternatives in conceptual design. The Problem Table Method is applied to find pinch temperature and reach maximum energy recovery (MER). The Network Resiliency, stream resiliency and cost estimated will be consequence to compare and choose the best network that more optimum for the Hydrodealkylation process (HDA Process). The information for used in design is shown in the following table.

Table 5.1 The Information of HDA Process

Stream Name	Tin (°C)	Tout (°C)	W	Duty (KW)
H1: Reactor Product Stream (RPS)	621	45	33	19008
H2: Recycle Column Condenser (RCC)	183	181	200	400
C1: Reactor Feed Stream (RFS)	65	621	32.24	17925.44
C2: Product Column Reboiler (PCR)	145	193	91	4368
C3: Stabilizer Column Reboiler (SCR)	190	215	59	1475
C4: Recycle Column Reboiler (RCR)	349.5	350.7	456	547.2

5.2 The Alternative 1

From previous chapter the Alternative 1 can be write a simply heat exchanger network as following: See Figure 5.1

There are only two streams in the network. So we can find Pinch temperature by using Problem Table Method as following: See Table 5.2

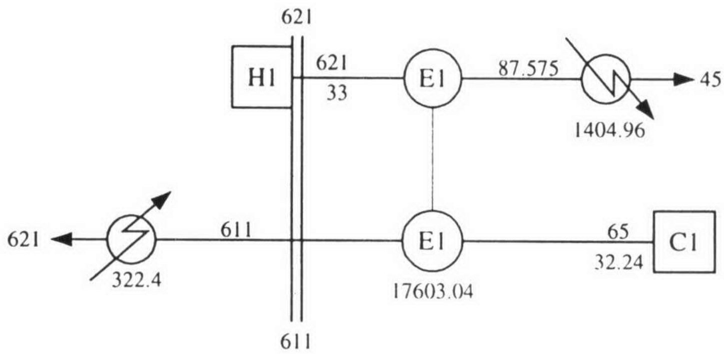

Figure 5.1 Heat Exchanger Network of Alternative 1

Table 5.2 Problem Table for Alternative 1 and 2

W		T hot	T cold	ΔT	Sum W	Require	Interval (H)	Cascade	Sum Interval
H1	C1								
0	0	631	621			Qh			
0	32.24	621	611	10	-32.24	322.4	-322.4	0	-322.4
33	32.24	75	65	546	0.76	0	414.96	414.96	92.56
33	0	45	35	30	33	414.96	990	1404.96	1082.56
								Qc	

By using Synthesis procedure that provided by Wongsri (1990), we can receive the resilient network from the synthesis tables in Chapter V as following: See Table 5.3-5.4

Table 5.3 Synthesis Table for cold end of Alternative 1 and 2

Synthesis Table For Cold End Of Alternative 1							
Stream	Load	W	T1	T2	D1	D2	Action
a) State 1							
H1	18678	33	611	45	330	0	Selected BC
C1	16958.24	32.24	75	601	322.4	322.4	Selected
b) State 2							
H1	1719.76	33	97.11393939	45	330	0	To Cooler
C1							Matched To H1

Table 5.4 Synthesis Table for hot end of Alternative 1 and 2

Synthesis Table For Hot End Of Alternative 1							
Stream	Load	W	T1	T2	D1	D2	Action
a) State 1							
H1	0	33	621	621	330	330	Selected AH
C1	322.4	32.24	611	621	0	322.4	Selected
b) State 2							
H1							Matched To C1
C1	322.4	32.24	611	621	0	322.4	To Heater

So, the resilient network for Alternative 1 is show in Figure 5.2.

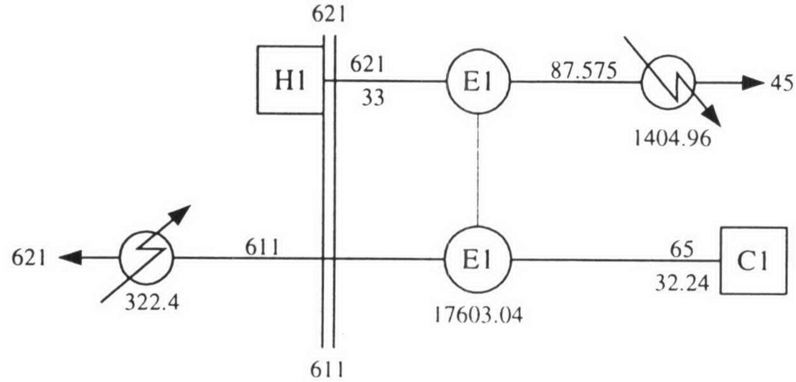

Figure 5.2 Resilient Heat Exchanger Network of Alternative 1

We can see that the network is about the same. So the Alternative 1 that design in Conceptual Design is not only optimum heat exchanger network but also resilient heat exchanger network. The Resiliency and cost estimation to compare with these two methods is also about the same and not need to calculated for comparison.

5.3 The Alternative 2

From previous chapter the Alternative 2 can be write a simply heat exchanger network into two subnetworks as following: See Figure 5.3.

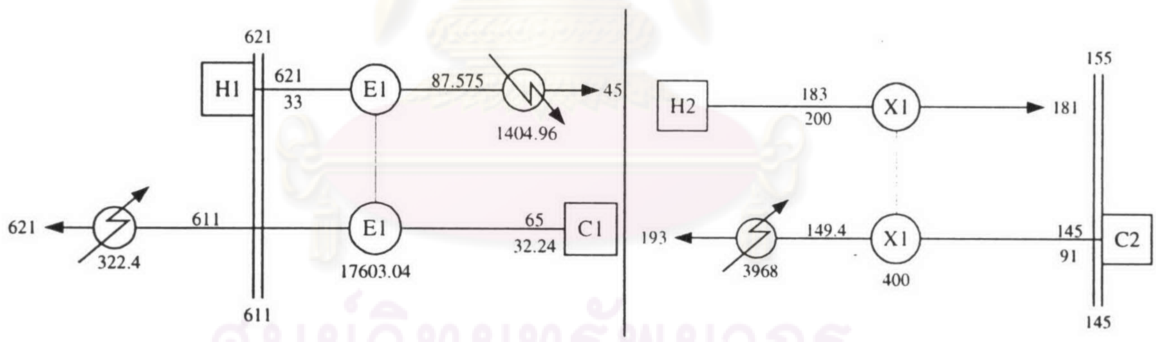

Figure 5.3 Heat Exchanger Network of Alternative 2

There are two streams in both subnetworks. So we can find Pinch temperature by using Problem Table Method as follow: See Table 5.2 and 5.5.

Table 5.5 Problem Table for Alternative 2 and 3

W		T hot	T cold	ΔT	Sum W	Require	Interval (H)	Cascade	Sum Interval
H2	C2								
0	0	203	193			Qh			
0	91	183	173	20	-91	3968	-1820	2148	-1820
200	91	181	171	2	109	2148	218	2366	-1602
0	91	155	145	26	-91	2366	-2366	0	-3968
								Qc	

For Alternative 2, the synthesis table is follow: See Table 5.3-5.4 and 5.6 (There are only hot side for stream H2 and C2).

Table 5.6 Synthesis Table for hot end of Alternative 2 and 3

Synthesis Table For Hot End Of Alternative 2							
Stream	Load	W	T1	T2	D1	D2	Action
a) State 1							
H2	200	200	182	181	200	0	Selected AH
C2	3458	91	155	193	0	910	Selected
b) State 2							
H2							Matched To C1
C2	3258	91	157.1978022	193	0	1110	To Heater

So, the resilient networks for Alternative 2 are show in Figure 5.4

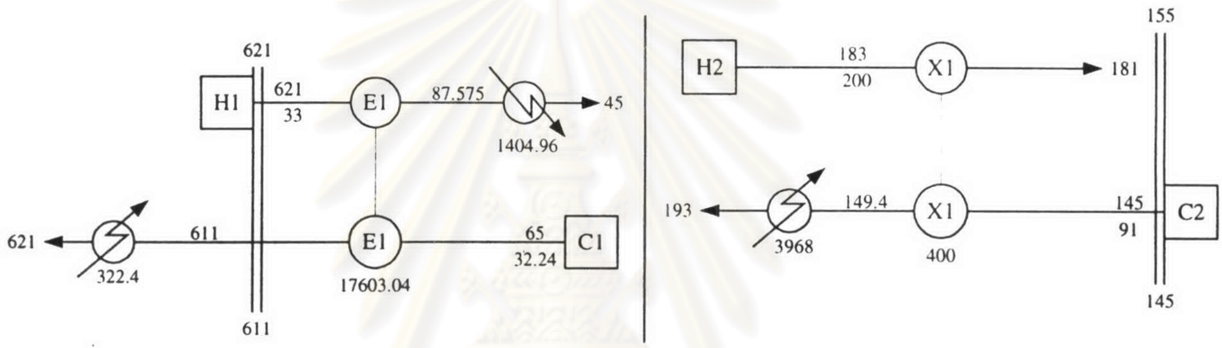

Figure 5.4 Resilient Heat Exchanger Network of Alternative 2

We can see that all the subnetworks are about the same. So the Alternative 2 that design in Conceptual Design is not only optimum heat exchanger network but also resilient heat exchanger network for each subnetworks. The Resiliency and cost estimation to compare with the new network not need to calculate for any comparison. However, this alternative does not reach MER because the alternative did not integrated all the streams.

5.4 The Alternative 3

From previous chapter the Alternative 3 can be write a simply heat exchanger network into two subnetworks as following: See Figure 5.5.

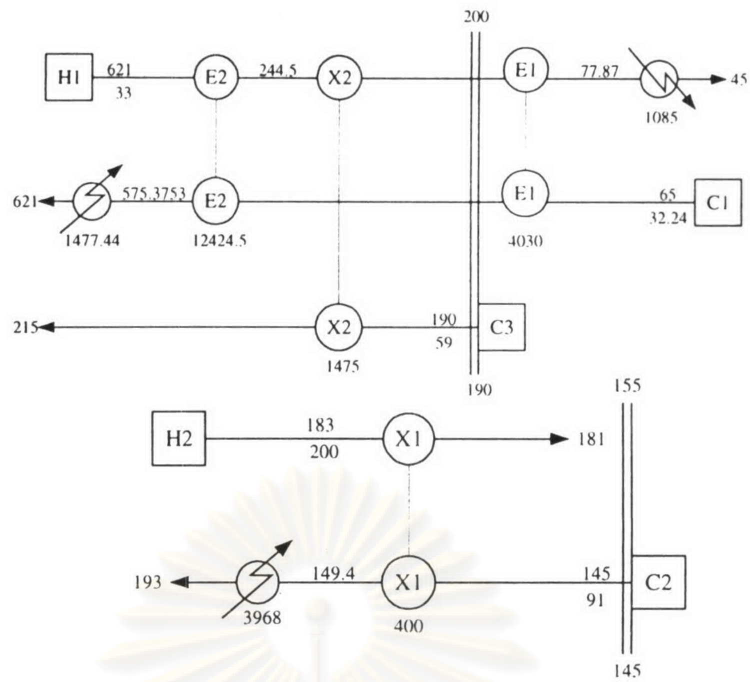

Figure 5.5 Heat Exchanger Network of Alternative 3

There are two streams and three streams in each subnetworks. So we can find Pinch temperature by using Problem Table Method as follow: See Table 5.5 and 5.7.

Table 5.7 Problem Table for Alternative 3

W			T hot	T cold	Δ T	Sum W	Require	Interval (H)	Cascade	Sum Interval
h1	c1	c3								
0	0	0	631	621			Qh			
0	32.24	0	621	611	10	-32.24	1477.44	-322.4	1155.04	-322.4
33	32.24	0	225	215	396	0.76	1155.04	300.96	1456	-21.44
33	32.24	59	200	190	25	-58.24	1456	-1456	0	-1477.44
33	32.24	0	75	65	125	0.76	0	95	95	-1382.44
33	0	0	45	35	30	33	95	990	1085	-392.44
									Qc	

For Alternative 3, the synthesis tables are follow: See Table 5.6 (There are only hot side for stream H2 and C2) and 5.8-5.9

Table 5.8 Synthesis Table for cold end of Alternative 3

Synthesis Table For Cold End Of Alternative 3							
Stream	Load	W	T1	T2	D1	D2	Action
a) State 1							
H1	5445	33	210	45	330	0	Selected BC
C1	4030	32.24	75	200	322.4	322.4	Selected
b) State 2							
H1	1415	33	87.87878788	45	330	0	To Cooler
C1							Matched To H1

Table 5.9 Synthesis Table for hot end of Alternative 3

Synthesis Table For Hot End Of Alternative 3							
Stream	Load	W	T1	T2	D1	D2	Action
a) State 1							
H1	13233	33	611	210	330	330	Selected C[H]
C1	13573.04	32.24	200	621	0	322.4	
C3	885	59	200	215	0	590	Selected
b) State 2							
H1	12348	33	611	236.8181818	330	0	Selected AH
C1	13573.04	32.24	200	621	0	322.4	Selected
C3					0	260	To Heater
c) State 3							
H1							Matched To C1
C1	1225.04	32.24	583.0024814	621	0	652.4	To Heater

We can see that the subnetwork which form by H2 and C2 streams is about the same but another isn't. It needs auxiliary reboiler unit to be installed at the end of stream C3 to be resilient networks. So the Alternative 3 that design in Conceptual Design is only optimum heat exchanger network. The Resiliency and cost estimation to compare with the new network not need to calculate for comparison of choosing the best resilient network. However, this alternative does not reach MER because the alternative did not integrated all the streams.

The resilient networks for Alternative 3 are show in Figure 5.6

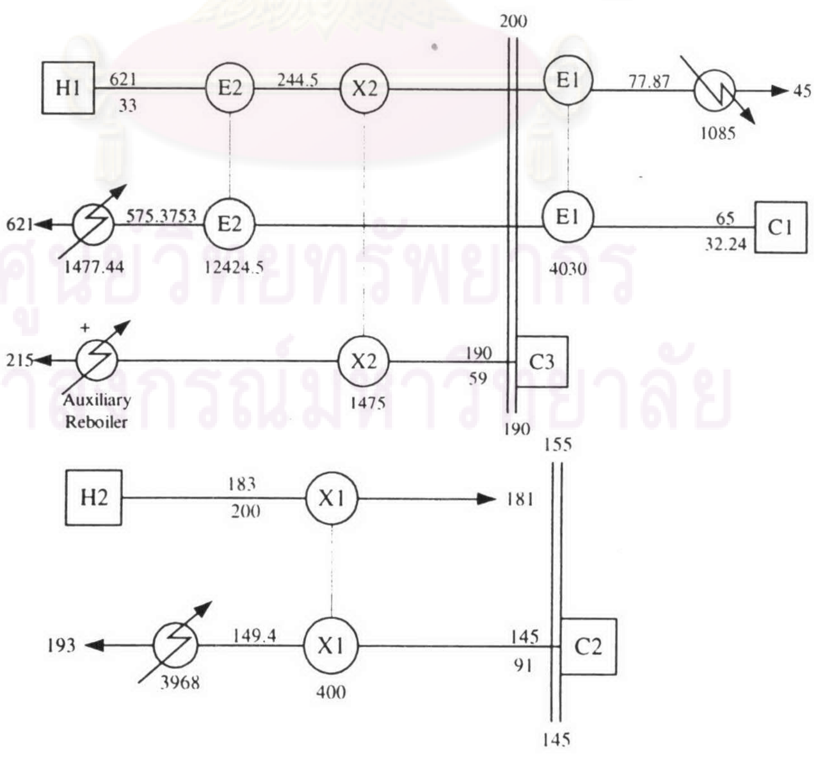

Figure 5.6 Resilient Heat Exchanger Network of Alternative 3

5.5 The Alternative 4

From previous chapter the Alternative 4 can be write a simply heat exchanger network as following: See Figure 5.7.

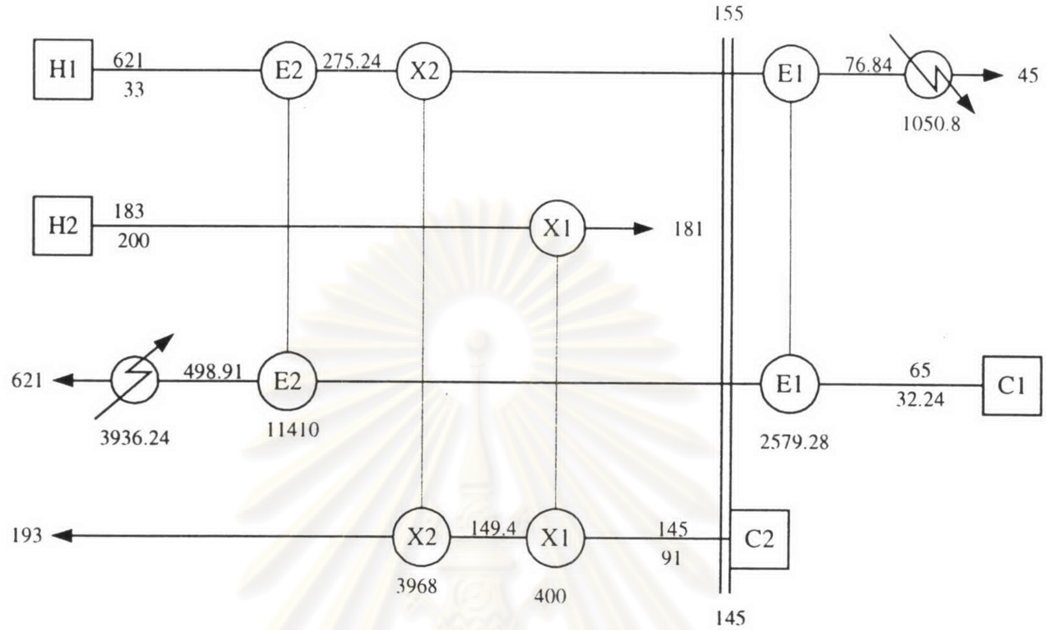

Figure 5.7 Heat Exchanger Network of Alternative 4

There are four streams in the network same as alternative 2. But this alternative did not separate into two subnetworks. So, the network could reach MER and we can find Pinch temperature by using Problem Table Method as following: See Table 5.10

Table 5.10 Problem Table for Alternative 4

W				T hot	T cold	Δ T	sum W	Require	Interval (H)	Cascade	Sum Interval
h1	h2	c1	c2								
0	0	0	0	631	621			Qh			
0	0	32.24	0	621	611	10	-32.24	3936.24	-322.4	3613.84	-322.4
33	0	32.24	0	203	193	418	0.76	3613.84	317.68	3931.52	-4.72
33	0	32.24	91	183	173	20	-90.24	3931.52	-1804.8	2126.72	-1809.52
33	200	32.24	91	181	171	2	109.76	2126.72	219.52	2346.24	-1590
33	0	32.24	91	155	145	26	-90.24	2346.24	-2346.24	0	-3936.24
33	0	32.24	0	75	65	80	0.76	0	60.8	60.8	-3875.44
33	0	0	0	45	35	30	33	60.8	990	1050.8	-2885.44
										Qc	

For Alternative 4, the synthesis tables are follow: See Table 5.11-5.13.

Table 5.11 Synthesis Table for cold end of Alternative 4, 5 and 6

Synthesis Table For Cold End Of Alternative 4,5,6							
Stream	Load	W	T1	T2	D1	D2	Action
a) State 1							
H1	3960	33	165	45	330	0	Selected BC
C1	2579.2	32.24	75	155	322.4	322.4	Selected
b) State 2							
H1	1380.8	33	86.84242424	45	330	0	To Cooler
C1							Matched To H1

Table 5.12 Synthesis Table 1 for hot end of Alternative 4

Synthesis Table 1 For Hot End Of Alternative 4							
Stream	Load	W	T1	T2	D1	D2	Action
a) State 1							
H1	14718	33	611	165	330	330	Selected C[H]
H2	200	200	182	181	200	0	
C1	15023.84	32.24	155	621	0	322.4	
C2	3458	91	155	193	0	910	Selected
b) State 2							
H1	11260	33	611	269.7878788	330	0	
H2	200	200	182	181	200	0	Selected A[H]
C1	15023.84	32.24	155	621	0	322.4	Selected
C2					0	580	To Heater
c) State 3							
H1	11260	33	611	269.7878788	330	0	Selected AH
H2							Matched To C1
C1	14823.84	32.24	161.2034739	621	0	522.4	Selected
d) State 4							
H1							Matched To C1
C1	3563.84	32.24	510.4590571	621	0	852.4	To Heater

Table 5.13 Synthesis Table 2 for hot end of Alternative 4

Synthesis Table 2 For Hot End Of Alternative 4							
Stream	Load	W	T1	T2	D1	D2	Action
a) State 1							
H1	14718	33	611	165	330	330	
H2	200	200	182	181	200	0	Selected A[H]
C1	15023.84	32.24	155	621	0	322.4	
C2	3458	91	155	193	0	910	Selected
b) State 2							
H1	14718	33	611	165	330	330	Selected C[H]
H2							Matched To C2
C1	15023.84	32.24	155	621	0	322.4	
C2	3258	91	157.1978022	193	0	1110	Selected
c) State 3							
H1	11460	33	611	263.7272727	330	0	Selected AH
C1	15023.84	32.24	155	621	0	322.4	Selected
C2					0	780	To Heater
d) State 4							
H1							Matched To C1
C1	3563.84	32.24	510.4590571	621	0	652.4	To Heater

The resilient networks for Alternative 4 is show in Figure 5.8-5.9

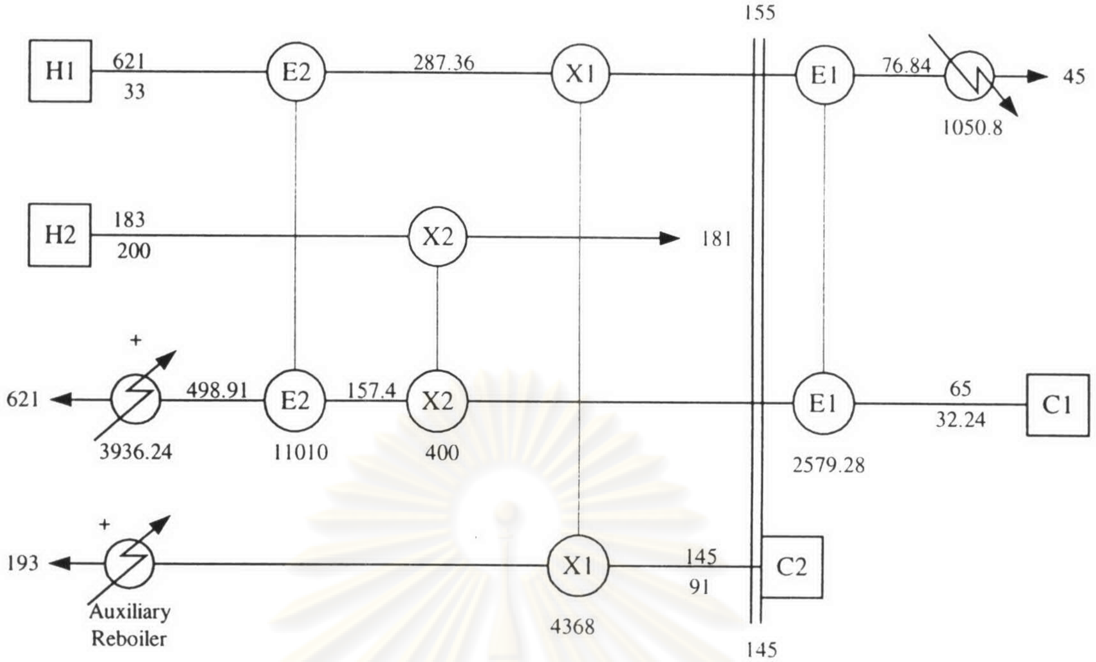

Figure 5.8 Resilient Heat Exchanger Network 4.1 of Alternative 4

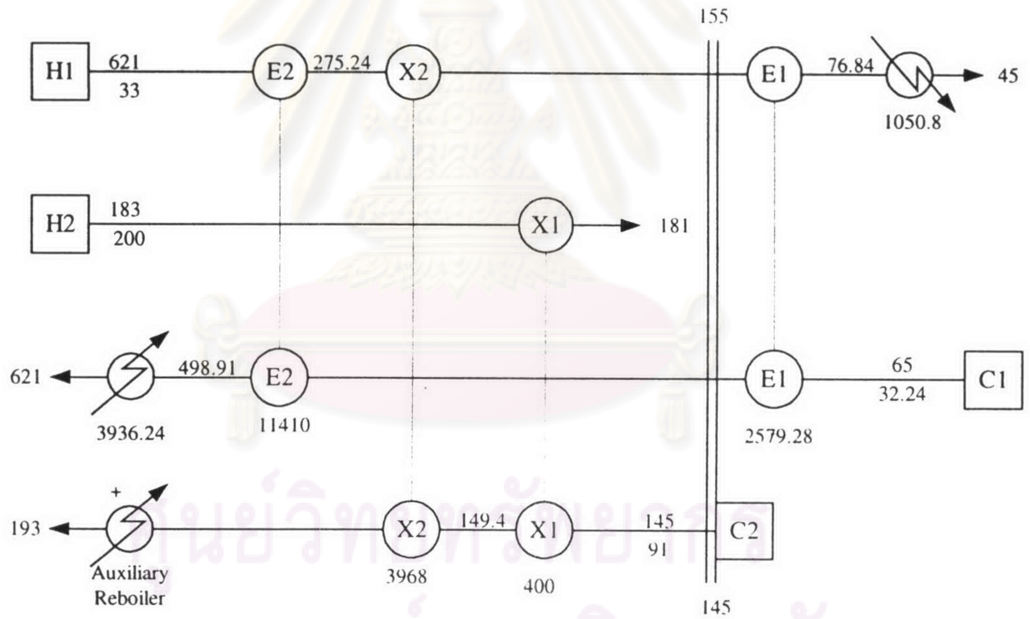

Figure 5.9 Resilient Heat Exchanger Network 4.2 of Alternative 4

We can see that the networks that show above are need auxiliary reboiler unit to be installed at the end of stream C2 to be resilient networks. So the Alternative 4 that design in Conceptual Design is only optimum heat exchanger network. The Resiliency and cost estimation to compare with these networks is also needed to calculate for comparison. However, the cost estimation can point out that the resilient network 4.1 is needed a smaller size of auxiliary reboiler at the same variations.

5.6 The Alternative 5

From previous chapter the Alternative 5 can be write a simply heat exchanger network as following: See Figure 5.10.

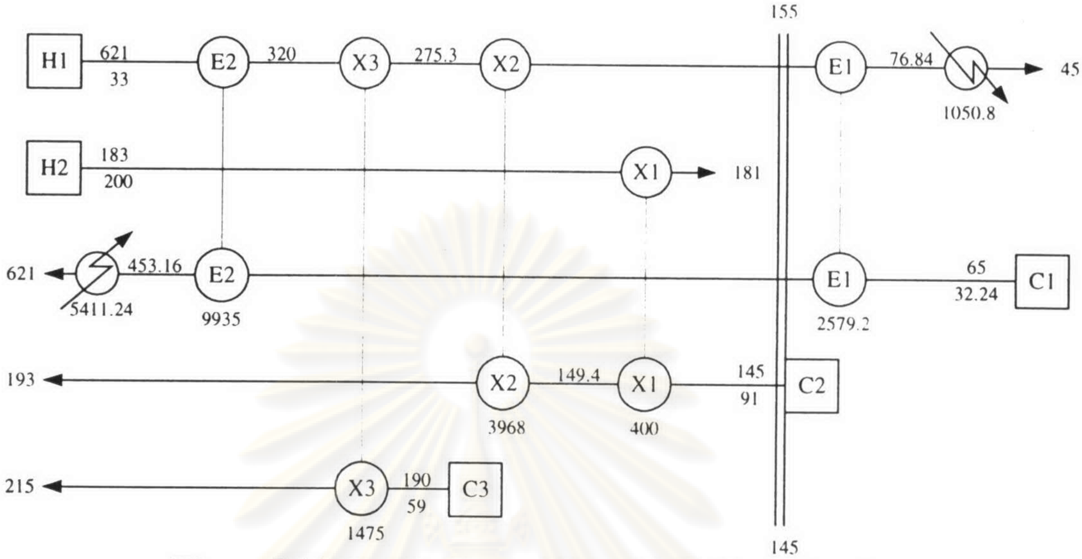

Figure 5.10 Heat Exchanger Network of Alternative 5

There are five streams in the network same as alternative 3. But this alternative did not separate into two subnetworks. So, the network could reach MER and we can find Pinch temperature by using Problem Table Method as following: See Table 5.14.

From the table 5.14, the cold end will be the same. So there is only one kind of the network at the cold end and the synthesis will be the same as in table 5.10.

Table 5.14 Problem Table for Alternative 5

W					T hot	T cold	Δ T	Sum W	Require	Interval (H)	Cascade	Sum Interval
h1	h2	c1	c2	c3								
0	0	0	0	0	631	621			Qh			
0	0	32.24	0	0	621	611	10	-32.24	5411.24	-322.4	5088.84	-322.4
33	0	32.24	0	0	225	215	396	0.76	5088.84	300.96	5389.8	-21.44
33	0	32.24	0	59	203	193	22	-58.24	5389.8	-1281.28	4108.52	-1302.72
33	0	32.24	91	59	200	190	3	-149.2	4108.52	-447.72	3660.8	-1750.44
33	0	32.24	91	0	183	173	17	-90.24	3660.8	-1534.08	2126.72	-3284.52
33	200	32.24	91	0	181	171	2	109.76	2126.72	219.52	2346.24	-3065
33	0	32.24	91	0	155	145	26	-90.24	2346.24	-2346.24	0	-5411.24
33	0	32.24	0	0	75	65	80	0.76	0	60.8	60.8	-5350.44
33	0	0	0	0	45	35	30	33	60.8	990	1050.8	-4360.44
											Qc	

For Alternative 5, the synthesis tables are follow: See Table 5.15-5.18.

Table 5.15 Synthesis Table 1 for hot end of Alternative 5

Synthesis Table 1 For Hot End Of Alternative 5							
Stream	Load	W	T1	T2	D1	D2	Action
a) State 1							
H1	14718	33	611	165	330	330	Selected C[H]
H2	200	200	182	181	200	0	
C1	15023.84	32.24	155	621	0	322.4	
C2	3458	91	155	193	0	910	Selected
C3	885	59	200	215	0	590	
b) State 2							
H1	11260	33	611	269.7878788	330	0	
H2	200	200	182	181	200	0	Selected A[H]
C1	15023.84	32.24	155	621	0	322.4	Selected
C2					0	580	To Heater
C3	885	59	200	215	0	590	
c) State 3							
H1	11260	33	611	269.7878788	330	0	Selected B[C]
H2							Matched To C1
C1	14823.84	32.24	161.2034739	621	0	522.4	
C3	885	59	200	215	0	590	Selected
d) State 4							
H1	10375	33	584.1818182	269.7878788	920	0	Selected AH
C1	14823.84	32.24	161.2034739	621	0	522.4	Selected
C3							Matched To H1
e) State 5							
H1							Matched To C1
C1	4448.84	32.24	483.0086849	621	0	1442.4	To Heater

Table 5.16 Synthesis Table 2 for hot end of Alternative 5

Synthesis Table 2 For Hot End Of Alternative 5							
Stream	Load	W	T1	T2	D1	D2	Action
a) State 1							
H1	14718	33	611	165	330	330	
H2	200	200	182	181	200	0	Selected A[H]
C1	15023.84	32.24	155	621	0	322.4	
C2	3458	91	155	193	0	910	Selected
C3	885	59	200	215	0	590	
b) State 2							
H1	14718	33	611	165	330	330	Selected C[H]
H2							Matched To C2
C1	15023.84	32.24	155	621	0	322.4	
C2	3258	91	157.1978022	193	0	1110	Selected
C3	885	59	200	215	0	590	
c) State 3							
H1	11460	33	611	263.7272727	330	0	Selected B[C]
C1	15023.84	32.24	155	621	0	322.4	
C2					0	780	To Heater
C3	885	59	200	215	0	590	Selected
d) State 4							
H1	10575	33	584.1818182	263.7272727	920	0	Selected AH

C1	15023.84	32.24	155	621	0	322.4	Selected
C3							Matched To H1
e) State 5							
H1							Matched To C1
C1	4448.84	32.24	483.0086849	621	0	1242.4	To Heater

Table 5.17 Synthesis Table 3 for hot end of Alternative 5

Synthesis Table 3 For Hot End Of Alternative 5							
Stream	Load	W	T1	T2	D1	D2	Action
a) State 1							
H1	14718	33	611	165	330	330	Selected C[H]
H2	200	200	182	181	200	0	
C1	15023.84	32.24	155	621	0	322.4	
C2	3458	91	155	193	0	910	Selected
C3	885	59	200	215	0	590	
b) State 2							
H1	11260	33	611	269.7878788	330	0	
H2	200	200	182	181	200	0	Selected A[H]
C1	15023.84	32.24	155	621	0	322.4	Selected
C2					0	580	To Heater
C3	885	59	200	215	0	590	
c) State 3							
H1	11260	33	611	269.7878788	330	0	Selected C[H]
H2							Matched To C1
C1	14823.84	32.24	161.2034739	621	0	522.4	
C3	885	59	200	215	0	590	Selected
d) State 4							
H1	10375	33	611	296.6060606	330	0	Selected AH
C1	14823.84	32.24	161.2034739	621	0	522.4	Selected
C3					0	590	To Heater
e) State 5							
H1							Matched To C1
C1	4448.84	32.24	483.0086849	621	0	852.4	To Heater

Table 5.18 Synthesis Table 4 for hot end of Alternative 5

Synthesis Table 4 For Hot End Of Alternative 5							
Stream	Load	W	T1	T2	D1	D2	Action
a) State 1							
H1	14718	33	611	165	330	330	
H2	200	200	182	181	200	0	Selected A[H]
C1	15023.84	32.24	155	621	0	322.4	
C2	3458	91	155	193	0	910	Selected
C3	885	59	200	215	0	590	
b) State 2							
H1	14718	33	611	165	330	330	Selected C[H]
H2							Matched To C2
C1	15023.84	32.24	155	621	0	322.4	
C2	3258	91	157.1978022	193	0	1110	Selected
C3	885	59	200	215	0	590	
c) State 3							
H1	11460	33	611	263.7272727	330	0	Selected C[H]

C1	15023.84	32.24	155	621	0	322.4	
C2					0	780	To Heater
C3	885	59	200	215	0	590	Selected
d) State 4							
H1	10575	33	611	290.5454545	330	0	Selected AH
C1	15023.84	32.24	155	621	0	322.4	Selected
C3					0	590	To Heater
e) State 5							
H1							Matched To C1
C1	4448.84	32.24	483.0086849	621	0	652.4	To Heater

The resilient networks for Alternative 5 is show in Figure 5.11-5.14

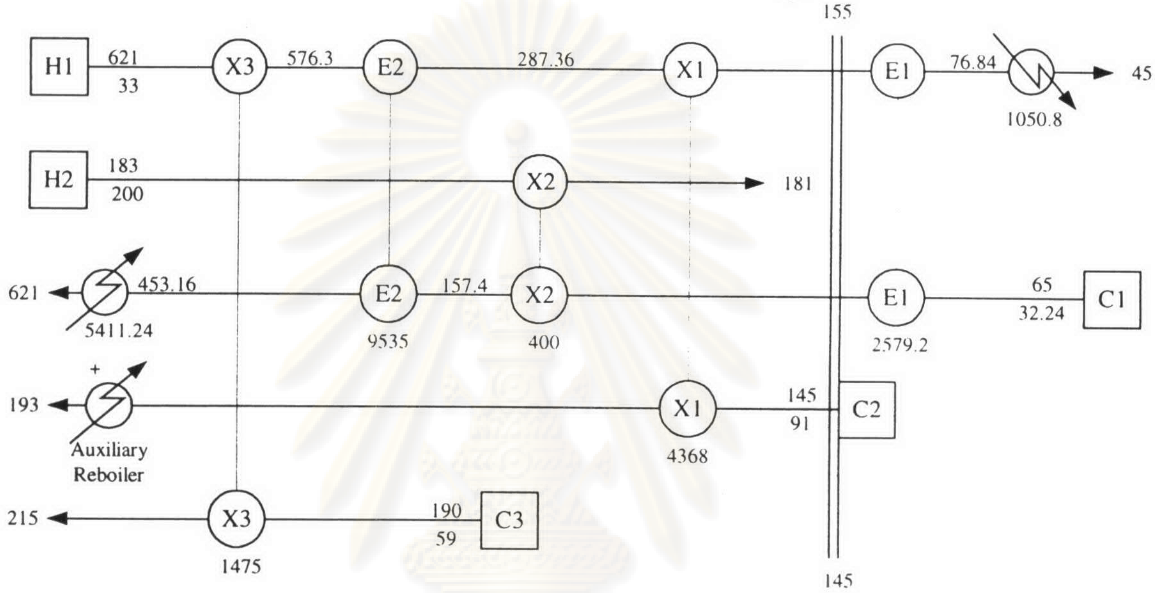

Figure 5.11 Resilient Heat Exchanger Network 5.1 of Alternative 5

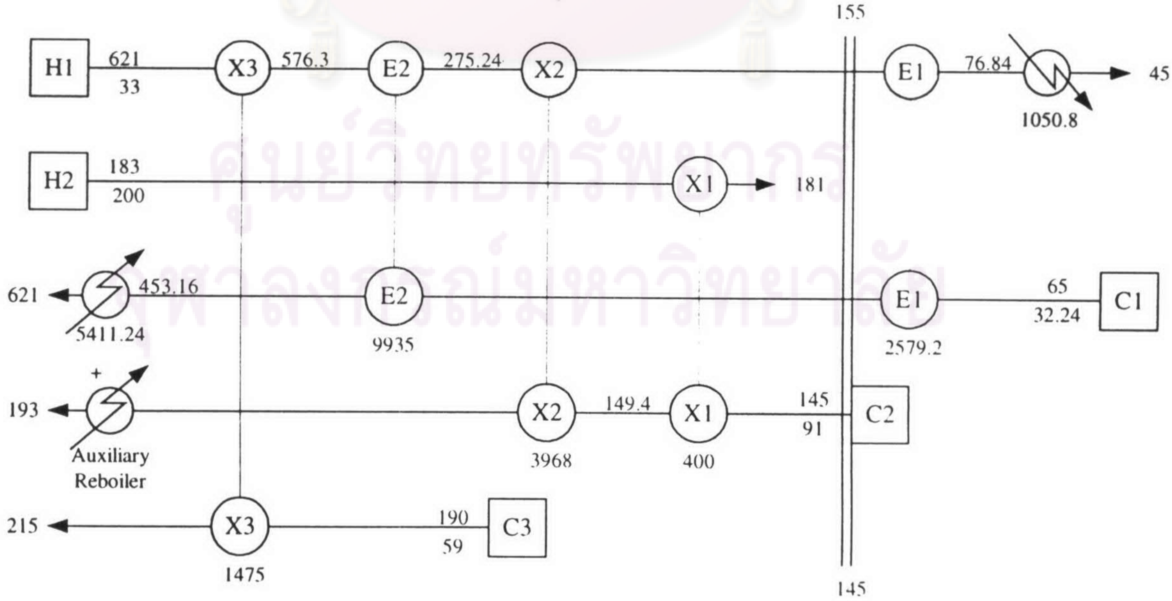

Figure 5.12 Resilient Heat Exchanger Network 5.2 of Alternative 5

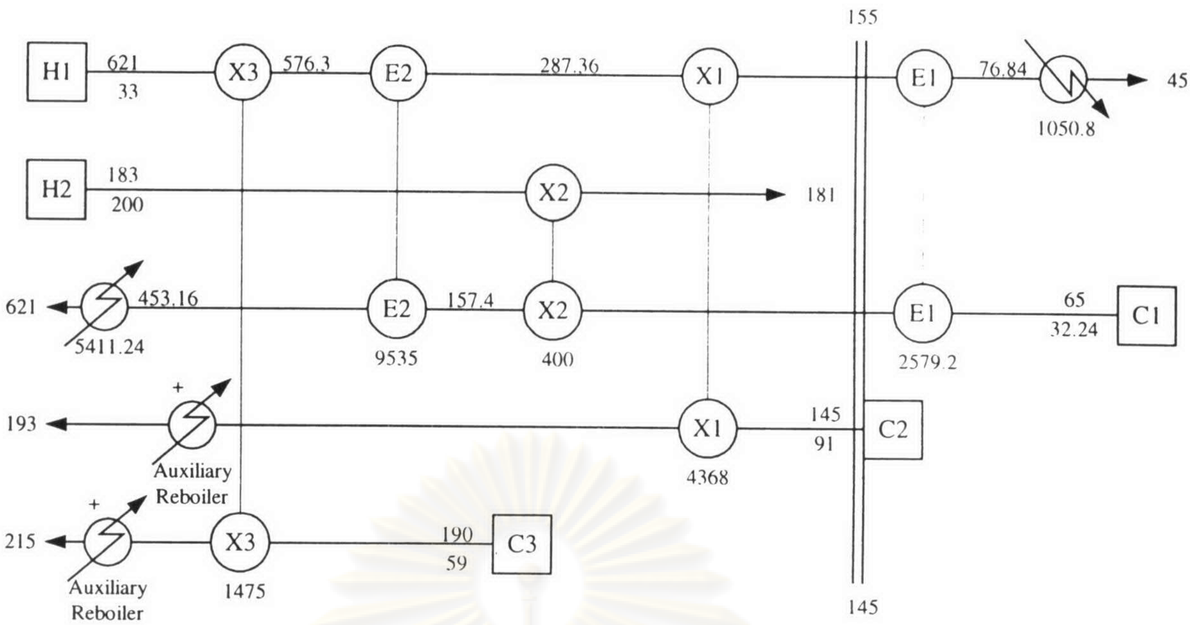

Figure 5.13 Resilient Heat Exchanger Network 5.3 of Alternative 5

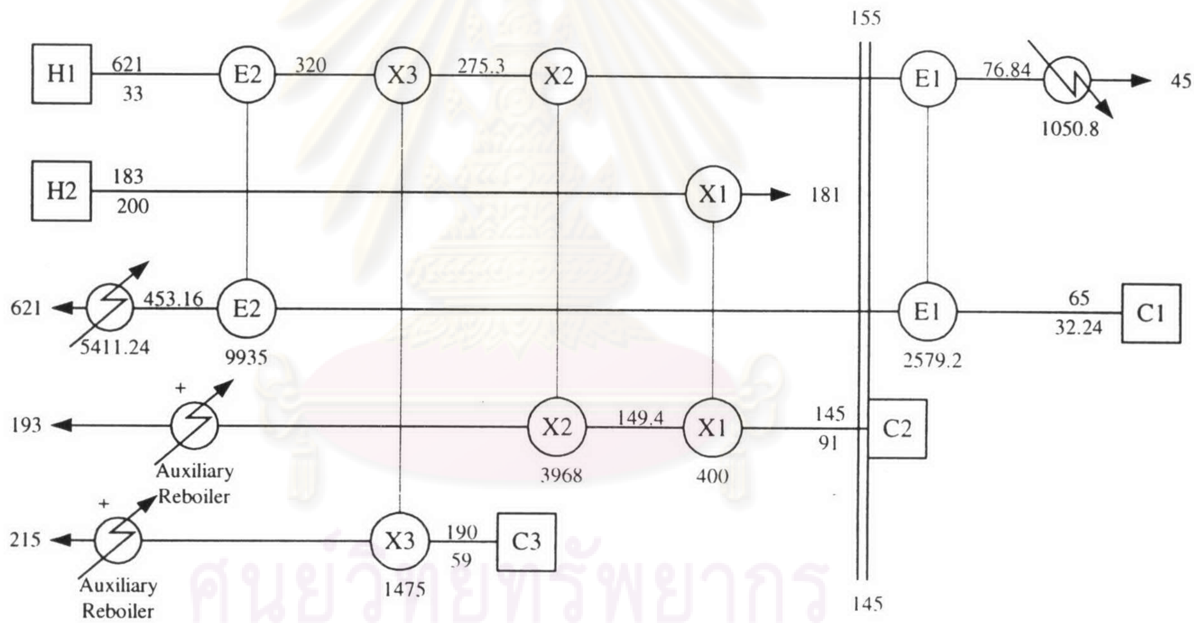

Figure 5.14 Resilient Heat Exchanger Network 5.4 of Alternative 5

We can see that the networks that show above are need auxiliary reboiler unit to be installed at the end of stream C2 or C3 to be resilient networks. So the Alternative 5 that design in Conceptual Design is only optimum heat exchanger network. The Resiliency and cost estimation to compare with these networks is also needed to calculate for comparison. However, the cost estimation can point out that the resilient network 5.1 is needed a smaller size of auxiliary reboiler at the same variations.

5.7 The Alternative 6

From previous chapter the Alternative 6 can be write a simply heat exchanger network as following: See Figure 5.15.

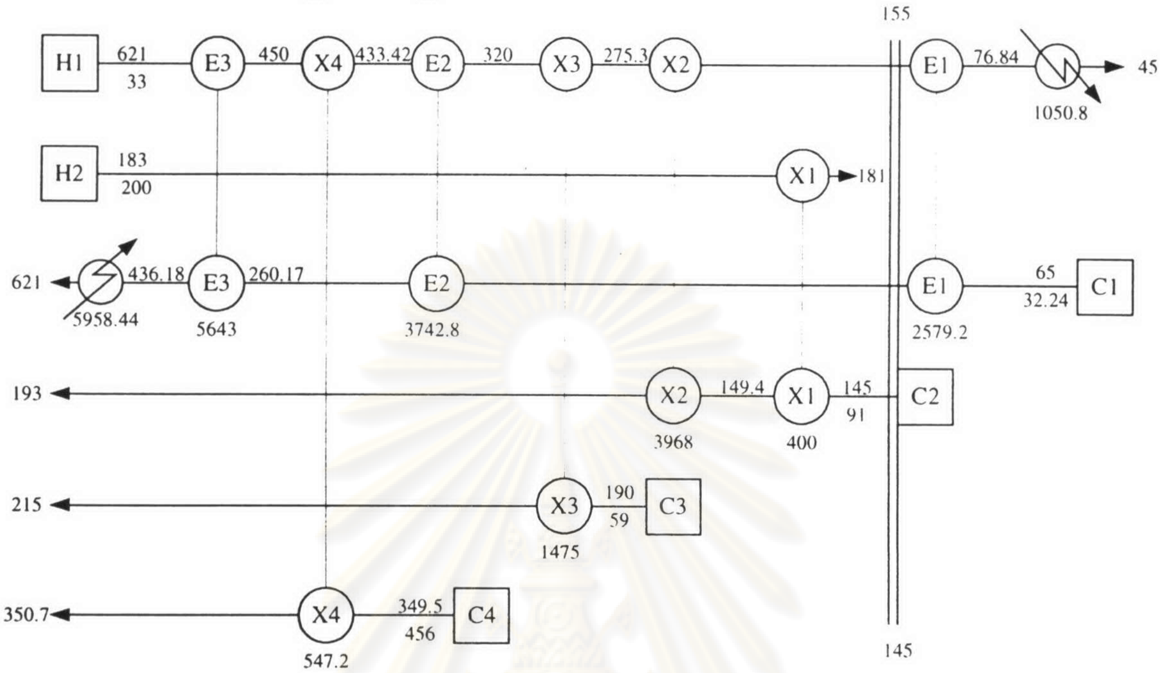

Figure 5.15 Heat Exchanger Network of Alternative 6

We can see that there are six streams in the network. The network could reach MER and we can find Pinch temperature by using Problem Table Method as following: See Table 5.19

Table 5.19 Problem Table for Alternative 6

W						T hot	T cold	ΔT	Sum W	Require	Interval (H)	Cascade	Sum Interval
h1	h2	c1	c2	c3	c4								
0	0	0	0	0	0	631	621			Qh			
0	0	32.24	0	0	0	621	611	10	-32.24	5958.44	-322.4	5636.04	-322.4
33	0	32.24	0	0	0	360.7	350.7	260.3	0.76	5636.04	197.828	5833.87	-124.572
33	0	32.24	0	0	456	359.5	349.5	1.2	-455.2	5833.868	-546.288	5287.58	-670.86
33	0	32.24	0	0	0	225	215	134.5	0.76	5287.58	102.22	5389.8	-568.64
33	0	32.24	0	59	0	203	193	22	-58.24	5389.8	-1281.28	4108.52	-1849.92
33	0	32.24	91	59	0	200	190	3	-149.2	4108.52	-447.72	3660.8	-2297.64
33	0	32.24	91	0	0	183	173	17	-90.24	3660.8	-1534.08	2126.72	-3831.72
33	200	32.24	91	0	0	181	171	2	109.76	2126.72	219.52	2346.24	-3612.2
33	0	32.24	91	0	0	155	145	26	-90.24	2346.24	-2346.24	0	-5958.44
33	0	32.24	0	0	0	75	65	80	0.76	0	60.8	60.8	-5897.64
33	0	0	0	0	0	45	35	30	33	60.8	990	1050.8	-4907.64
												Qc	

From the table 5.19, the cold end will be the same. So there is only one kind of the network at the cold end and the synthesis will be the same as in table 5.10.

For Alternative 6, the synthesis tables are follow: See Table 5.20-5.25.

Table 5.20 Synthesis Table 1 for hot end of Alternative 6

Synthesis Table 1 For Hot End Of Alternative 6							
Stream	Load	W	T1	T2	D1	D2	Action
a) State 1							
H1	14718	33	611	165	330	330	Selected C[H]
H2	200	200	182	181	200	0	
C1	15023.84	32.24	155	621	0	322.4	
C2	3458	91	155	193	0	910	Selected
C3	885	59	200	215	0	590	
C4	319.2	456	350	350.7	0	228	
b) State 2							
H1	11260	33	611	269.7878788	330	0	
H2	200	200	182	181	200	0	Selected A[H]
C1	15023.84	32.24	155	621	0	322.4	Selected
C2					0	580	To Heater
C3	885	59	200	215	0	590	
C4	319.2	456	350	350.7	0	228	
c) State 3							
H1	11260	33	611	269.7878788	330	0	Selected B[C]
H2							Matched To C1
C1	14823.84	32.24	161.2034739	621	0	522.4	
C3	885	59	200	215	0	590	Selected
C4	319.2	456	350	350.7	0	228	
d) State 4							
H1	10375	33	584.1818182	269.7878788	920	0	Selected B[C]
C1	14823.84	32.24	161.2034739	621	0	522.4	
C3							Matched To H1
C4	319.2	456	350	350.7	0	228	Selected
e) State 5							
H1	10055.8	33	574.5090909	269.7878788	1148	0	Selected AH
C1	14823.84	32.24	161.2034739	621	0	522.4	Selected
C4							Matched To H1
e) State 5							
H1							Matched To C1
C1	4768.04	32.24	473.1079404	621	0	1670.4	To Heater

Table 5.21 Synthesis Table 2 for hot end of Alternative 6

Synthesis Table 2 For Hot End Of Alternative 6							
Stream	Load	W	T1	T2	D1	D2	Action
a) State 1							
H1	14718	33	611	165	330	330	
H2	200	200	182	181	200	0	Selected A[H]
C1	15023.84	32.24	155	621	0	322.4	
C2	3458	91	155	193	0	910	Selected
C3	885	59	200	215	0	590	
C4	319.2	456	350	350.7	0	228	

b) State 2							
H1	14718	33	611	165	330	330	Selected C[H]
H2							Matched To C2
C1	15023.84	32.24	155	621	0	322.4	
C2	3258	91	157.1978022	193	0	1110	Selected
C3	885	59	200	215	0	590	
C4	319.2	456	350	350.7	0	228	
c) State 3							
H1	11460	33	611	263.7272727	330	0	Selected B[C]
C1	15023.84	32.24	155	621	0	322.4	
C2					0	780	To Heater
C3	885	59	200	215	0	590	Selected
C4	319.2	456	350	350.7	0	228	
d) State 4							
H1	10575	33	584.1818182	263.7272727	920	0	Selected B[C]
C1	15023.84	32.24	155	621	0	322.4	
C3							Matched To H1
C4	319.2	456	350	350.7	0	228	Selected
e) State 5							
H1	10255.8	33	574.5090909	263.7272727	1148	0	Selected AH
C1	15023.84	32.24	155	621	0	322.4	Selected
C4							Matched To H1
d) State 6							
H1							Matched To C1
C1	4768.04	32.24	473.1079404	621	0	1470.4	To Heater

Table 5.22 Synthesis Table 3 for hot end of Alternative 6

Synthesis Table 3 For Hot End Of Alternative 6							
Stream	Load	W	T1	T2	D1	D2	Action
a) State 1							
H1	14718	33	611	165	330	330	Selected C[H]
H2	200	200	182	181	200	0	
C1	15023.84	32.24	155	621	0	322.4	
C2	3458	91	155	193	0	910	Selected
C3	885	59	200	215	0	590	
C4	319.2	456	350	350.7	0	228	
b) State 2							
H1	11260	33	611	269.7878788	330	0	
H2	200	200	182	181	200	0	Selected A[H]
C1	15023.84	32.24	155	621	0	322.4	Selected
C2					0	580	To Heater
C3	885	59	200	215	0	590	
C4	319.2	456	350	350.7	0	228	
c) State 3							
H1	11260	33	611	269.7878788	330	0	Selected B[C]
H2							Matched To C1
C1	14823.84	32.24	161.2034739	621	0	522.4	
C3	885	59	200	215	0	590	
C4	319.2	456	350	350.7	0	228	Selected
d) State 4							
H1	10940.8	33	601.3272727	269.7878788	558	0	Selected B[C]
C1	14823.84	32.24	161.2034739	621	0	522.4	
C3	885	59	200	215	0	590	Selected
C4							Matched To H1

e) State 5							
H1	10055.8	33	574.5090909	269.7878788	1148	0	Selected AH
C1	14823.84	32.24	161.2034739	621	0	522.4	Selected
C4							Matched To H1
e) State 5							
H1							Matched To C1
C1	4768.04	32.24	473.1079404	621	0	1670.4	To Heater

Table 5.23 Synthesis Table 4 for hot end of Alternative 6

Synthesis Table 4 For Hot End Of Alternative 6							
Stream	Load	W	T1	T2	D1	D2	Action
a) State 1							
H1	14718	33	611	165	330	330	
H2	200	200	182	181	200	0	Selected A[H]
C1	15023.84	32.24	155	621	0	322.4	
C2	3458	91	155	193	0	910	Selected
C3	885	59	200	215	0	590	
C4	319.2	456	350	350.7	0	228	
b) State 2							
H1	14718	33	611	165	330	330	Selected C[H]
H2							Matched To C2
C1	15023.84	32.24	155	621	0	322.4	
C2	3258	91	157.1978022	193	0	1110	Selected
C3	885	59	200	215	0	590	
C4	319.2	456	350	350.7	0	228	
c) State 3							
H1	11460	33	611	263.7272727	330	0	Selected B[C]
C1	15023.84	32.24	155	621	0	322.4	
C2					0	780	To Heater
C3	885	59	200	215	0	590	
C4	319.2	456	350	350.7	0	228	Selected
d) State 4							
H1	11140.8	33	601.3272727	263.7272727	558	0	Selected B[C]
C1	15023.84	32.24	155	621	0	322.4	
C3	885	59	200	215	0	590	Selected
C4							Matched To H1
e) State 5							
H1	10255.8	33	574.5090909	263.7272727	1148	0	Selected AH
C1	15023.84	32.24	155	621	0	322.4	Selected
C3							Matched To H1
d) State 6							
H1							Matched To C1
C1	4768.04	32.24	473.1079404	621	0	1470.4	To Heater

Table 5.24 Synthesis Table 5 for hot end of Alternative 6

Synthesis Table 5 For Hot End Of Alternative 6							
Stream	Load	W	T1	T2	D1	D2	Action
a) State 1							
H1	14718	33	611	165	330	330	Selected C[H]
H2	200	200	182	181	200	0	
C1	15023.84	32.24	155	621	0	322.4	
C2	3458	91	155	193	0	910	Selected

C3	885	59	200	215	0	590	
C4	319.2	456	350	350.7	0	228	
b) State 2							
H1	11260	33	611	269.7878788	330	0	
H2	200	200	182	181	200	0	Selected A[H]
C1	15023.84	32.24	155	621	0	322.4	Selected
C2					0	580	To Heater
C3	885	59	200	215	0	590	
C4	319.2	456	350	350.7	0	228	
c) State 3							
H1	11260	33	611	269.7878788	330	0	Selected C[H]
H2							Matched To C1
C1	14823.84	32.24	161.2034739	621	0	522.4	
C3	885	59	200	215	0	590	Selected
C4	319.2	456	350	350.7	0	228	
d) State 4							
H1	10375	33	611	296.6060606	330	0	Selected B[C]
C1	14823.84	32.24	161.2034739	621	0	522.4	
C3					0	590	To Heater
C4	319.2	456	350	350.7	0	228	Selected
e) State 5							
H1	10055.8	33	601.3272727	296.6060606	558	0	Selected AH
C1	14823.84	32.24	161.2034739	621	0	522.4	Selected
C4							Matched To H1
e) State 5							
H1							Matched To C1
C1	4768.04	32.24	473.1079404	621	0	1080.4	To Heater

Table 5.25 Synthesis Table 6 for hot end of Alternative 6

Synthesis Table 6 For Hot End Of Alternative 6							
Stream	Load	W	T1	T2	D1	D2	Action
a) State 1							
H1	14718	33	611	165	330	330	
H2	200	200	182	181	200	0	Selected A[H]
C1	15023.84	32.24	155	621	0	322.4	
C2	3458	91	155	193	0	910	Selected
C3	885	59	200	215	0	590	
C4	319.2	456	350	350.7	0	228	
b) State 2							
H1	14718	33	611	165	330	330	Selected C[H]
H2							Matched To C2
C1	15023.84	32.24	155	621	0	322.4	
C2	3258	91	157.1978022	193	0	1110	Selected
C3	885	59	200	215	0	590	
C4	319.2	456	350	350.7	0	228	
c) State 3							
H1	11460	33	611	263.7272727	330	0	Selected C[H]
C1	15023.84	32.24	155	621	0	322.4	
C2					0	780	To Heater
C3	885	59	200	215	0	590	Selected
C4	319.2	456	350	350.7	0	228	
d) State 4							
H1	10575	33	611	290.5454545	920	0	Selected B[C]
C1	15023.84	32.24	155	621	0	322.4	

C3					0	590	To Heater
C4	319.2	456	350	350.7	0	228	Selected
e) State 5							
H1	10255.8	33	601.3272727	290.5454545	1148	0	Selected AH
C1	15023.84	32.24	155	621	0	322.4	Selected
C4							Matched To H1
d) State 6							
H1							Matched To C1
C1	4768.04	32.24	473.1079404	621	0	1470.4	To Heater

The resilient networks for Alternative 6 is show in Figure 5.16-5.21

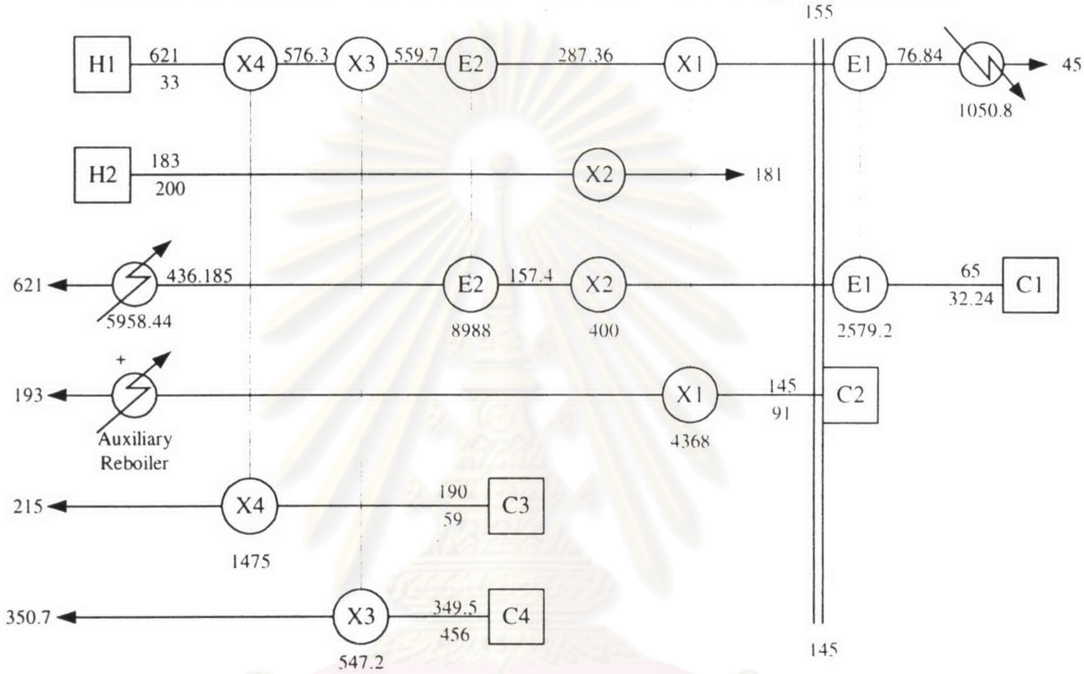

Figure 5.16 Resilient Heat Exchanger Network 6.1 of Alternative 6

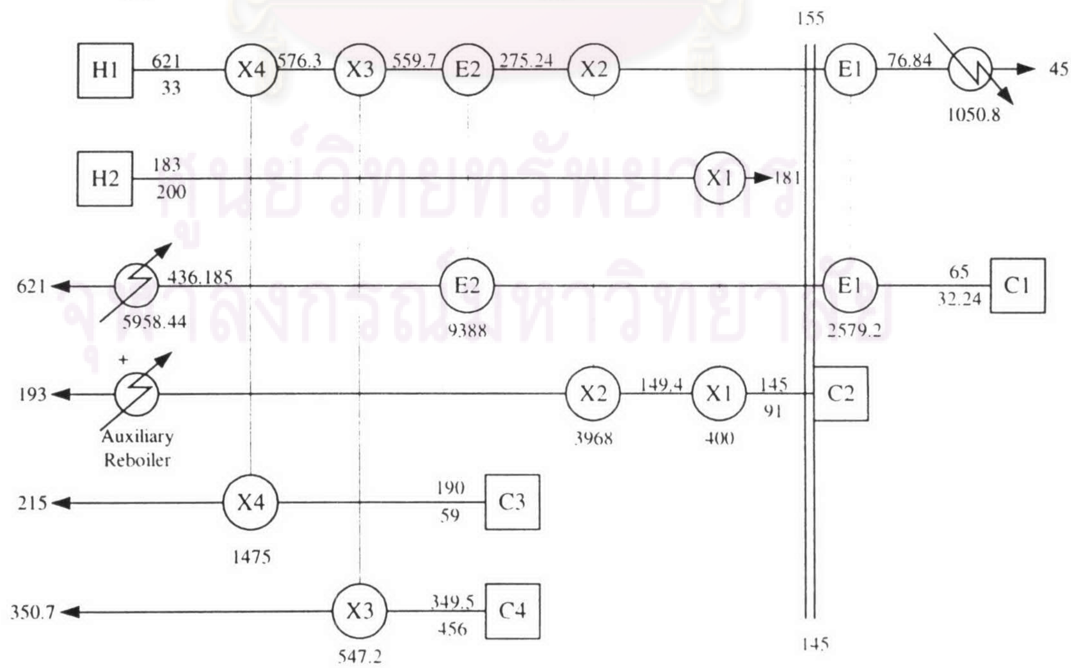

Figure 5.17 Resilient Heat Exchanger Network 6.2 of Alternative 6

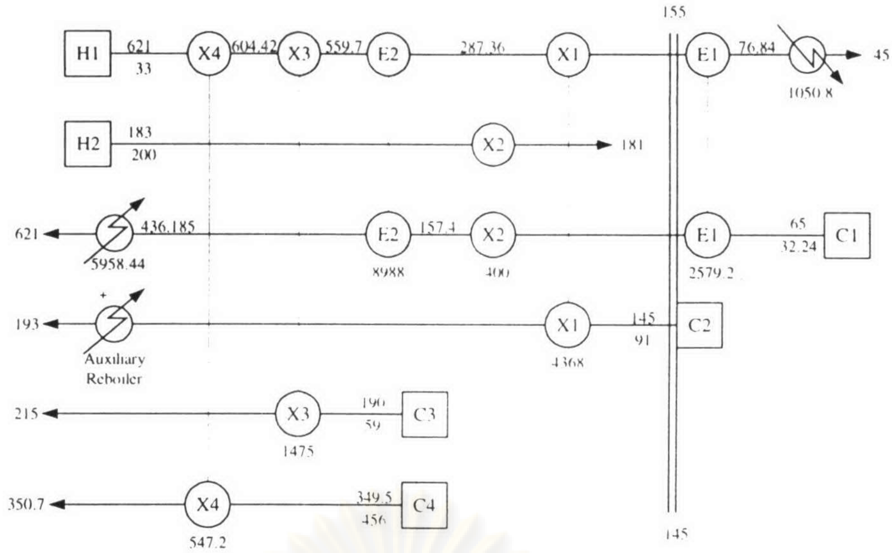

Figure 5.18 Resilient Heat Exchanger Network 6.3 of Alternative 6

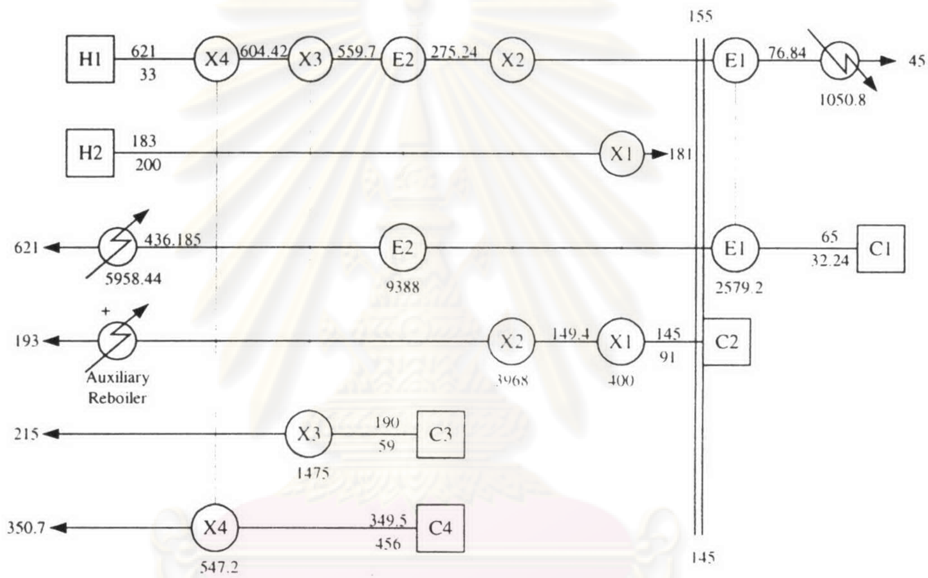

Figure 5.19 Resilient Heat Exchanger Network 6.4 of Alternative 6

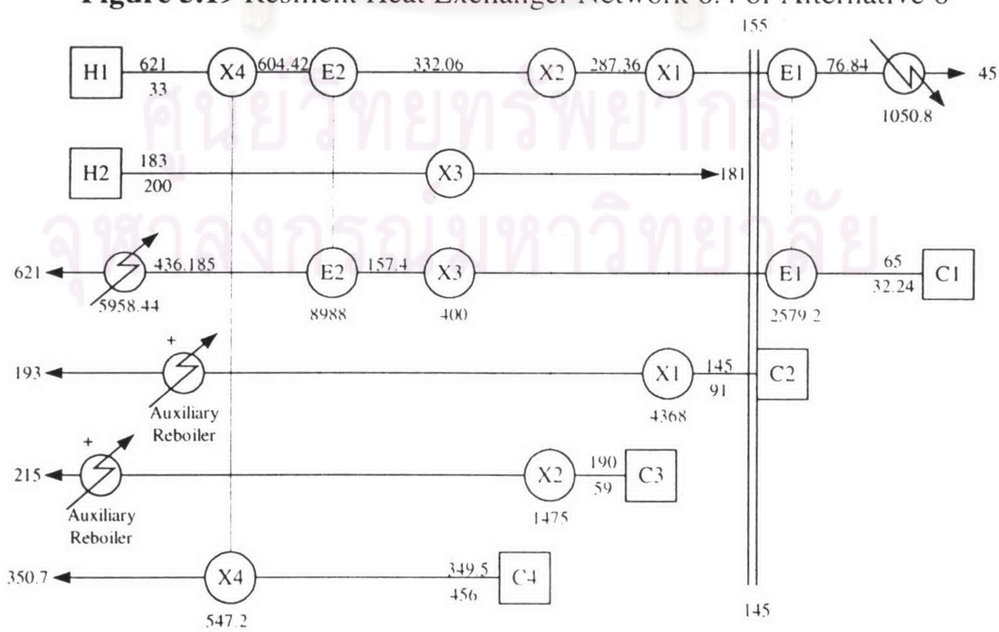

Figure 5.20 Resilient Heat Exchanger Network 6.5 of Alternative 6

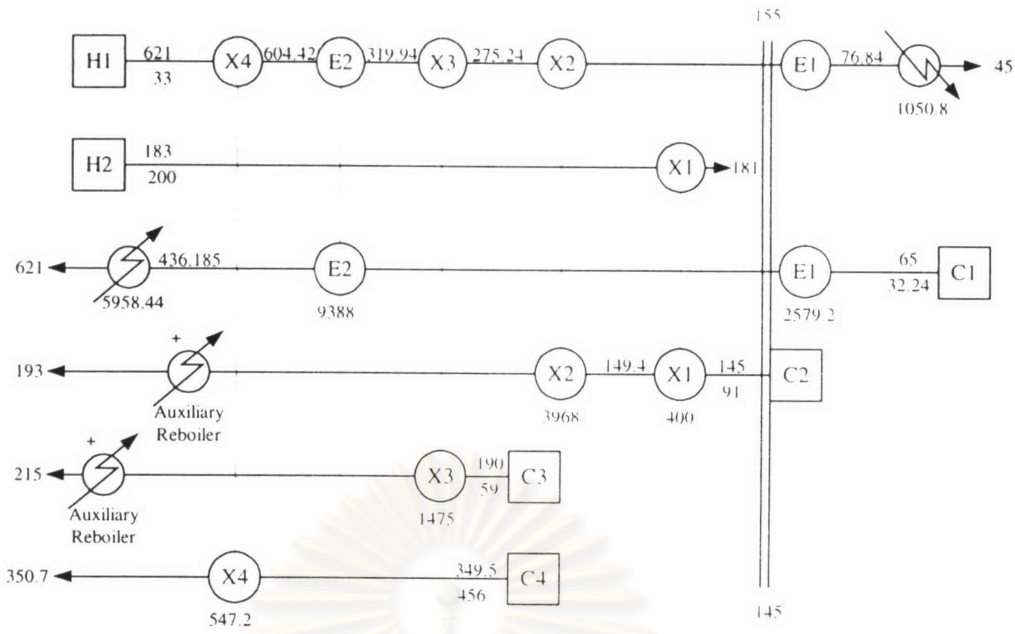

Figure 5.21 Resilient Heat Exchanger Network 6.6 of Alternative 6

We can see that the networks that show above are need auxiliary reboiler unit to be installed at the end of stream C2 or C3 to be resilient networks. So the Alternative 5 that design in Conceptual Design is only optimum heat exchanger network. The Resiliency and cost estimation to compare with these networks is also needed to calculate for comparison. However, the cost estimation can point out that the resilient networks 6.1 and 6.3 are needed a smaller size of auxiliary reboiler.

In case of Alternative 6, there are two networks that look about the same to be the best resilient network. For appropriate, we would like to choose the resilient one of the network 6.3 because of the higher temperature inlet of stream C4.

5.8 Testing the Networks

From the above result, we receive the resilient networks with the various structures. For comparison to choose the best resilient network, we are not considered only the resilience of the network but also combined with cost estimation. The most resilience network is not necessary to be the best network. Because of more auxiliary utilities installed is more resiliency to the networks. Therefore, we must considered the networks at the same disturbance to received the information about the size of auxiliary utilities that installed and to find the lowest cost in used of the auxiliary utilities.

In case of considering variations, all the networks has different necessity in size of the auxiliary reboiler(s). For inconvenient that would not to explained about the Alternative 1 in this part because of not being installed auxiliary utilities in the network to receive the resilient network. But the alternative 2 must to compared with Alternative 4 because of use the same four stream in the network.

Table 5.26 will explained that the usage of all networks and resiliency for all stream in all networks. We find that the best network in Alternative 4, 5 and 6 are 4.1, 5.1 and 6.3 respectively because of lowest cost in using auxiliary utility and still be the resilient network.

For testing the networks, the simulations for control is not need. Therefore, we need the disturbance propagation technique to design the path of tolerates disturbance and used the control structure design method (Kunlawaniteewat, 2002) to installed the control loops into the networks for eradicated the variations. Because of eradicated the variations into utilities is more powerful and take less effected in temperatures of the streams that exchanged. The Figure 5.22-5.33 will show the process flowchart, the disturbance load propagation and the path of the variation into utilities for all resilient networks by using by-pass controlled.

Table 5.26 The Resiliency and Utilities usage for the resilient networks

		Resilient Network No.					
	Base case	2	4.1	4.2			
Utilities usage,KW		5695.36	4987.04	4987.04			
Resiliency of Stream H1		1727.36	5368.64	5368.64			
Resiliency of Stream H2		400	400	400			
Resiliency of Stream C1		1727.36	1380.8	1380.8			
Resiliency of Stream C2		3968	580	780			
Sum of the Resiliency		7822.72	7729.44	7929.44			
Network Resiliency		400	400	400			
Resilience Index		-	400	400			
Modify Resilience Index		-	580	780			
Auxiliary Utilities usages for Condition 1		0	580	780			
Auxiliary Utilities Cost Estimated	108m	+0%	+2.9%	+3.9%			
Auxiliary Utilities usages for Condition 2		0	680	880			
Auxiliary Utilities Cost Estimated	108m	+0%	+3.4%	+4.4%			
		Resilient Network No.					
	Base case	3	5.1	5.2	5.3	5.4	
Utilities usage,KW		6530.44	6462.04	6462.04	6462.04	6462.04	
Resiliency of Stream H1		1737.44	5991.24	6191.24	7433.64	7433.64	
Resiliency of Stream H2		400	400	400	400	400	
Resiliency of Stream C1		1415	1380.8	1380.8	1380.8	1380.8	
Resiliency of Stream C2		3968	580	780	580	780	
Resiliency of Stream C3		260	1475	1475	2065	1370	
Sum of the Resiliency		7780.44	9827.04	10227.04	11859.44	11364.44	
Network Resiliency		400	400	400	400	400	
Resilience Index		-	400	400	400	400	
Modify Resilience Index		-	580	780	580	780	
Auxiliary Utilities usages for Condition 1		260	580	780	1170	1370	
Auxiliary Utilities Cost Estimated	108m	+1.3%	+2.9 %	+3.9%	+5.85%	+6.85%	
Auxiliary Utilities usages for Condition 2		360	680	880	1270	1470	
Auxiliary Utilities Cost Estimated	108m	+1.8%	+3.4%	+4.4%	+6.35%	+7.35%	
		Resilient Network No.					
	Base case	6.1	6.2	6.3	6.4	6.5	6.6
Utilities usage,KW		7009.24	7009.24	7009.24	7009.24	7009.24	7009.24
Resiliency of Stream H1		8141.24	8208.88	7561.24	7428.84	8212.84	8798.84
Resiliency of Stream H2		400	400	400	400	400	400
Resiliency of Stream C1		1380.8	1380.8	1380.8	1380.8	1380.8	1380.8
Resiliency of Stream C2		580	780	580	780	580	780
Resiliency of Stream C3		0	1475	1475	1475	1170	1370
Resiliency of Stream C4		547.2	547.2	547.2	547.2	547.2	547.2
Sum of the Resiliency		11049.24	12791.88	11944.24	12011.84	12290.84	13276.84
Network Resiliency		400	400	400	400	400	400
Resilience Index		400	400	400	400	400	400
Modify Resilience Index		580	780	580	780	580	780
Auxiliary Utilities usages for Condition 1		580	780	580	780	1170	1370
Auxiliary Utilities Cost Estimated	108m	+2.9%	+3.9%	+2.9%	+3.9%	+5.85%	+6.85%
Auxiliary Utilities usages for Condition 2		680	780	680	880	1270	1470
Auxiliary Utilities Cost Estimated	108m	+3.4%	+4.4%	+3.4%	+4.4%	+6.35%	+7.35%

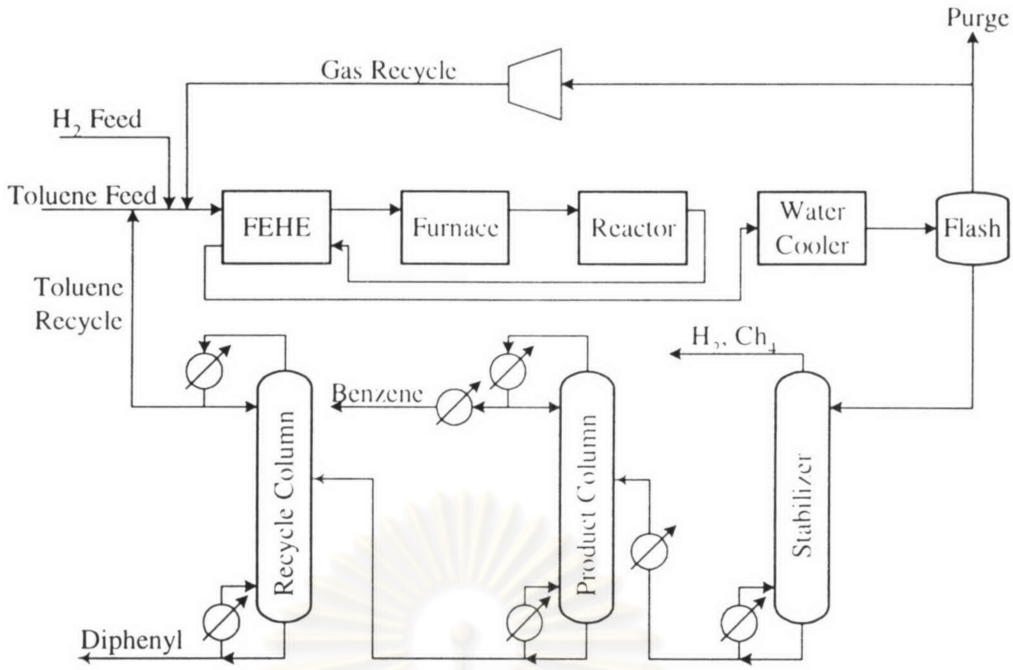

Figure 5.22 The Process Flowchart for Alternative 1

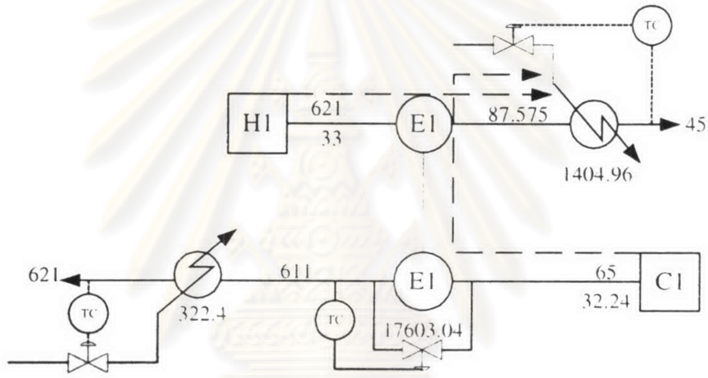

Figure 5.23 The disturbance load propagation for the best resilient network of Alternative 1

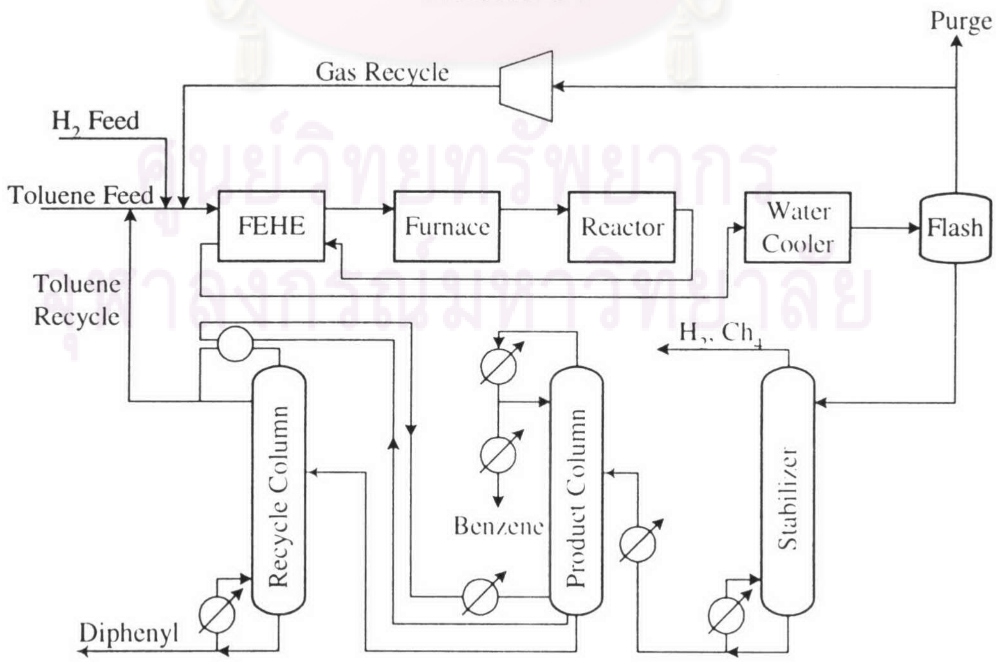

Figure 5.24 The Process Flowchart for Alternative 2

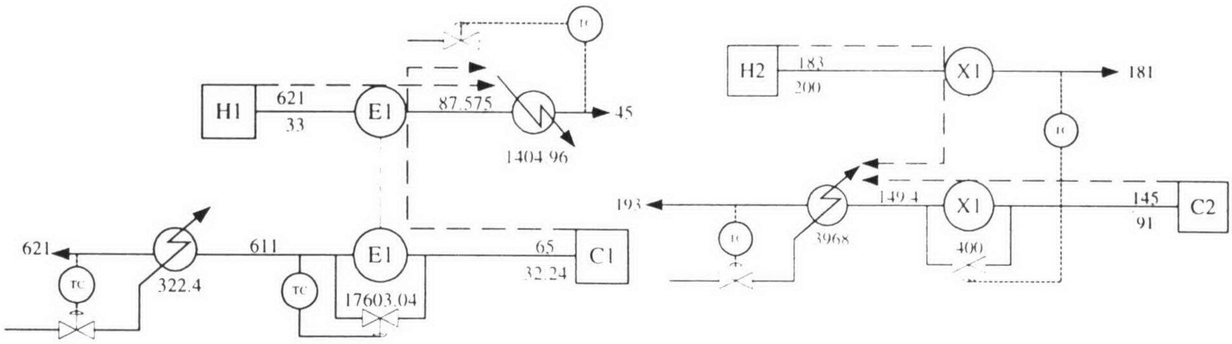

Figure 5.25 The disturbance load propagation for the best resilient network of Alternative 2

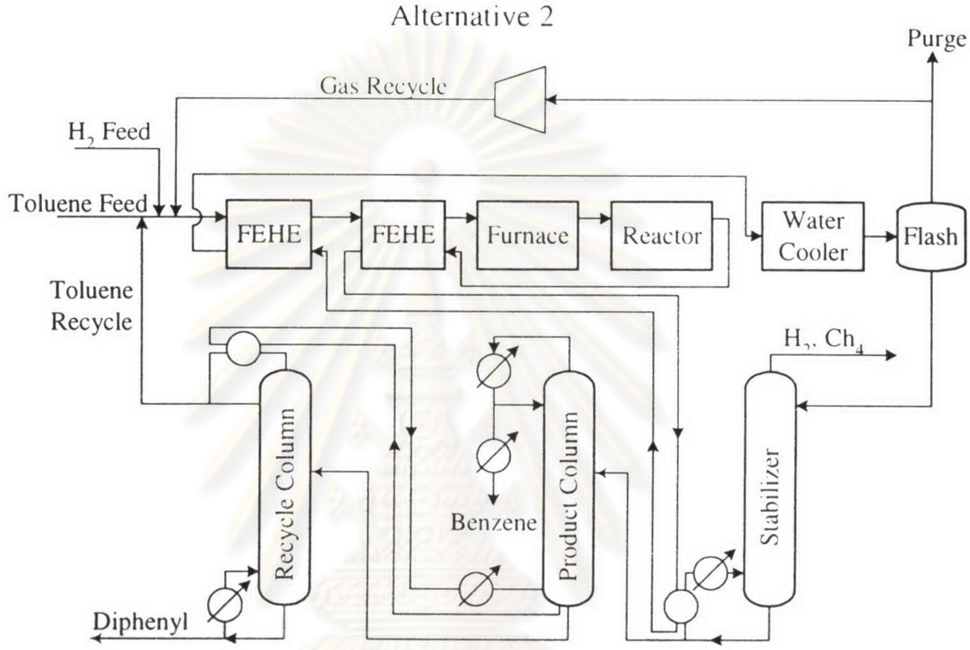

Figure 5.26 The Process Flowchart for Alternative 3

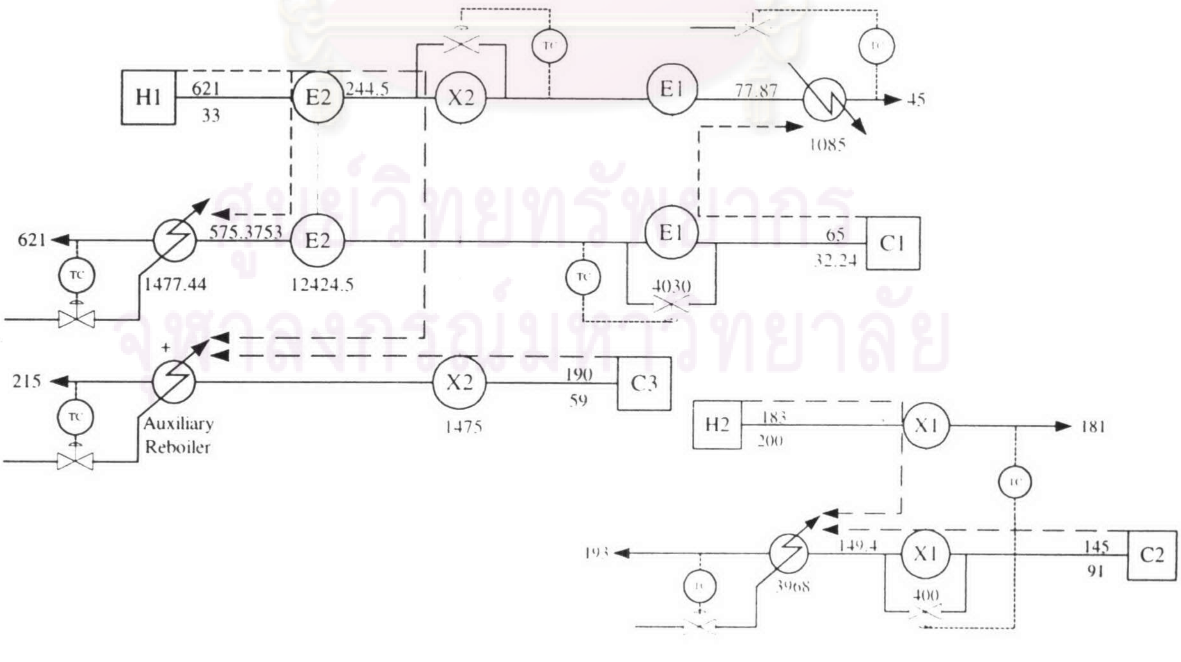

Figure 5.27 The disturbance load propagation for the best resilient network of Alternative 3

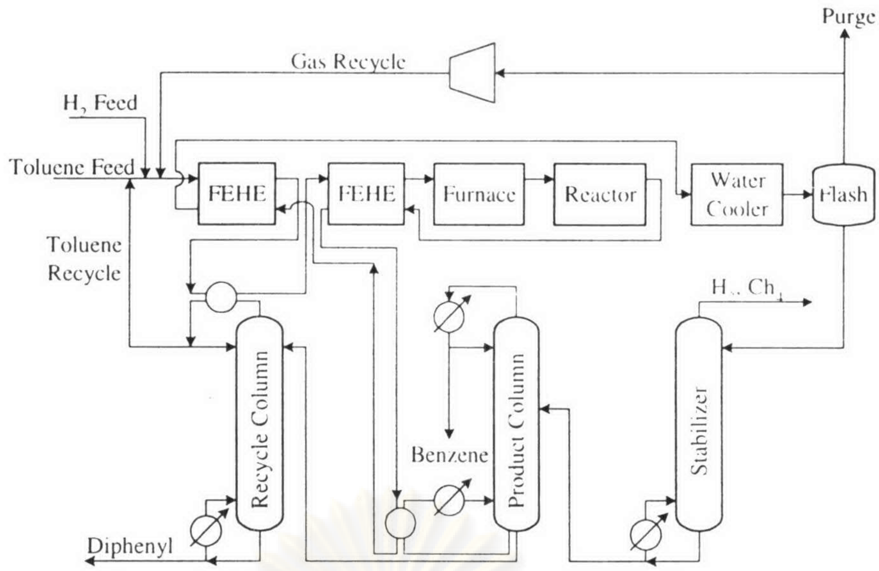

Figure 5.28 The Process Flowchart for Alternative 4

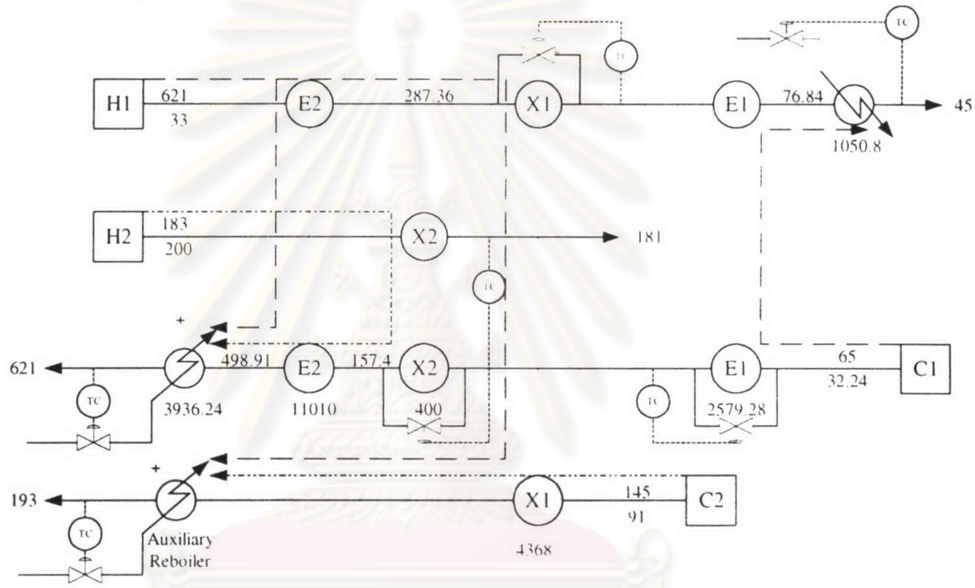

Figure 5.29 The disturbance load propagation for the best resilient network of Alternative 4

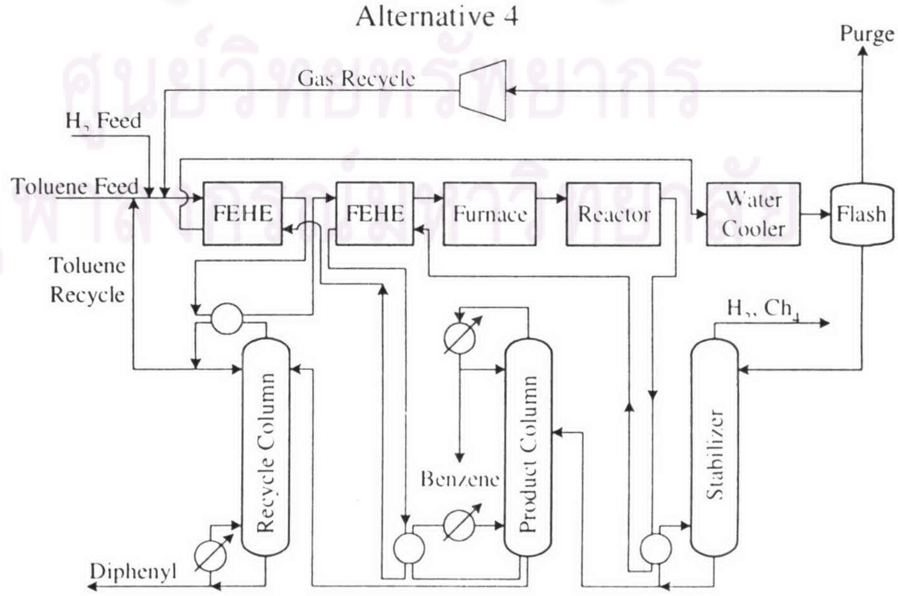

Figure 5.30 The Process Flowchart for Alternative 5

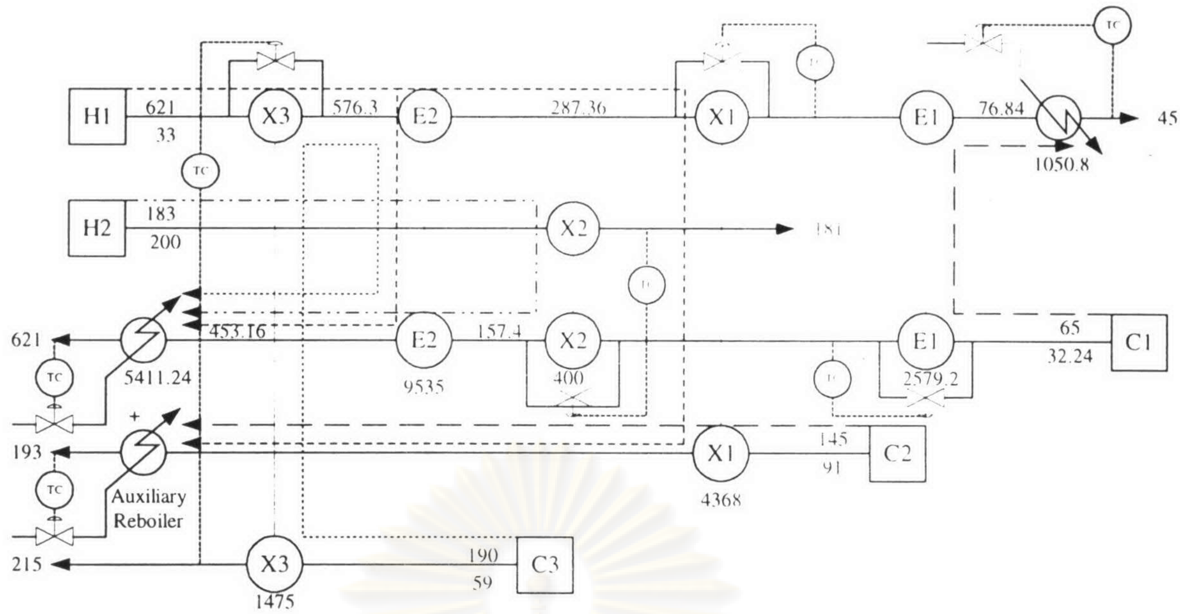

Figure 5.31 The disturbance load propagation for the best resilient network of Alternative 5

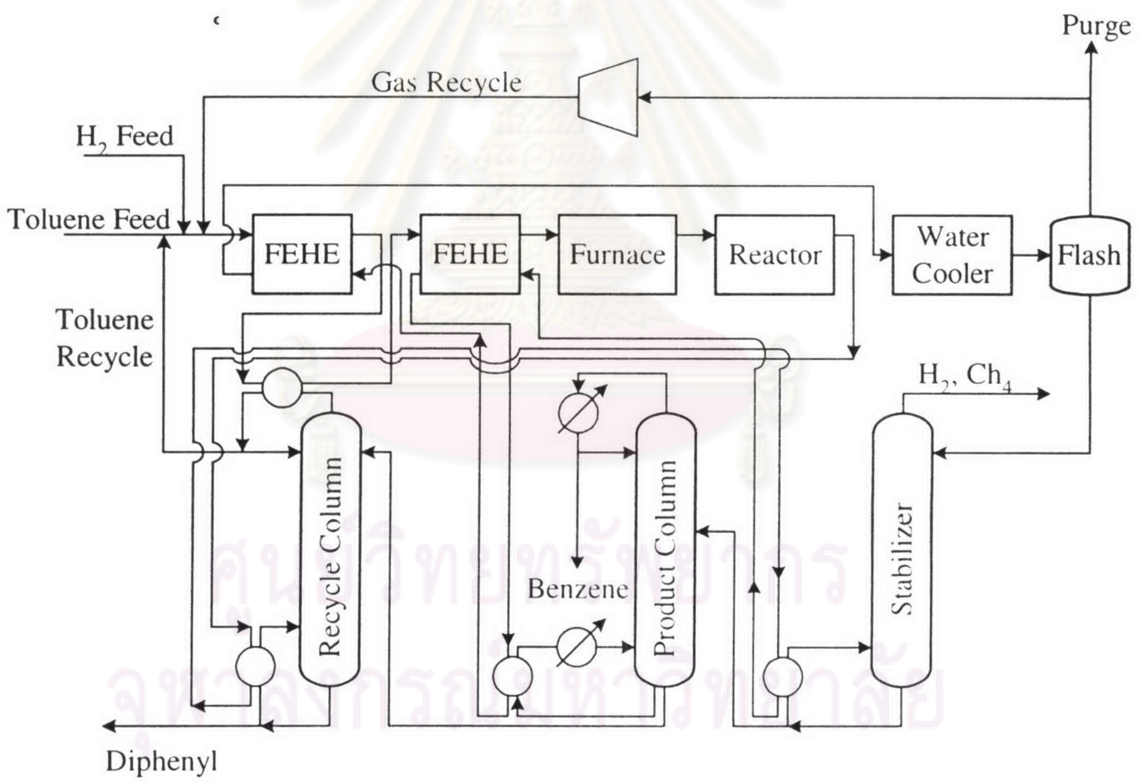

Figure 5.32 The Process Flowchart for Alternative 6

From Figure 5.32, if we are not installed an auxiliary reboiler at the bottom of Product Column, it will caused the target temperature changed of the stream that re-input at the bottom of column. So the effect to the quality of product will occur and reduced the profit of operation.

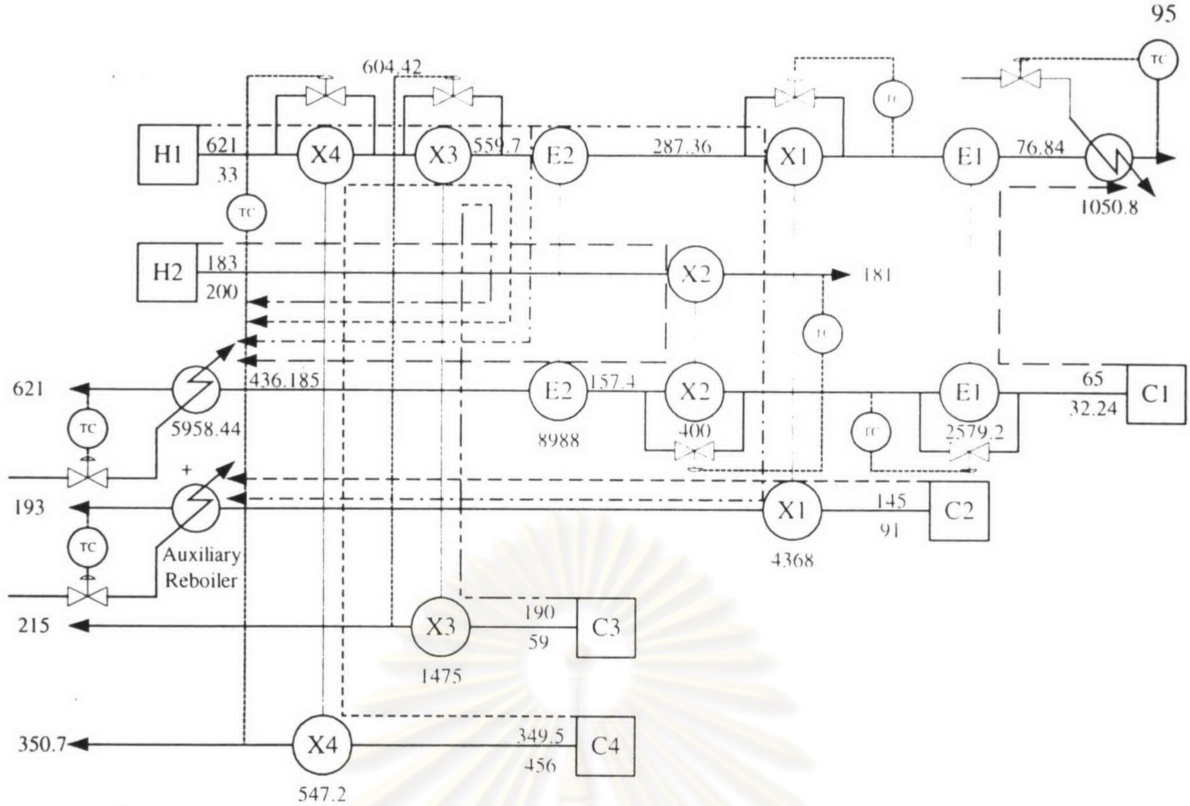

Figure 5.33 The disturbance load propagation for the best resilient network of Alternative 6