CHAPTER VI

SIMULATION OF AN EXISTING TOPPING COLUMN

The configuration of an existing topping column from which the plant-operating conditions are obtained is shown in Fig. 28. The topper has four sidestrippers, two pumparounds, a reflux-accumulator and a condenser. The sidedraw products are HSR naphtha, kerosene, diesel and atmospheric gas oil from plates no.7,16,25 and 30, respectively. LPG and LSR naphtha come out the condenser, and the reduced crude come out the column bottom. The main column consists of thirty-seven plates. Other column specifications are noted in the figure.

As for the theoretical analogue, the stages are numbered downward, starting from the top of main column through the bottom of the last sidestripper. The reflux-accumulator is no. 1, the top plate no. 2, and so on, the bottom plate of the last sidestripper being no. N.

Light-component analysis and assay for the crude oil feed are given in Table 11 and Fig. 29 respectively.

6.1 Crude and Sidestream Products Models

Based on the pseudocomponent concept discussed in section 4.1, the crude was divided into 39 normal boiling fractions (pseudocomponents), as shown in Fig. 30. The API gravity at mid-percent-volume of each fraction is used to represent the fraction gravity, and its average boiling point (ABP) is used to estimate the

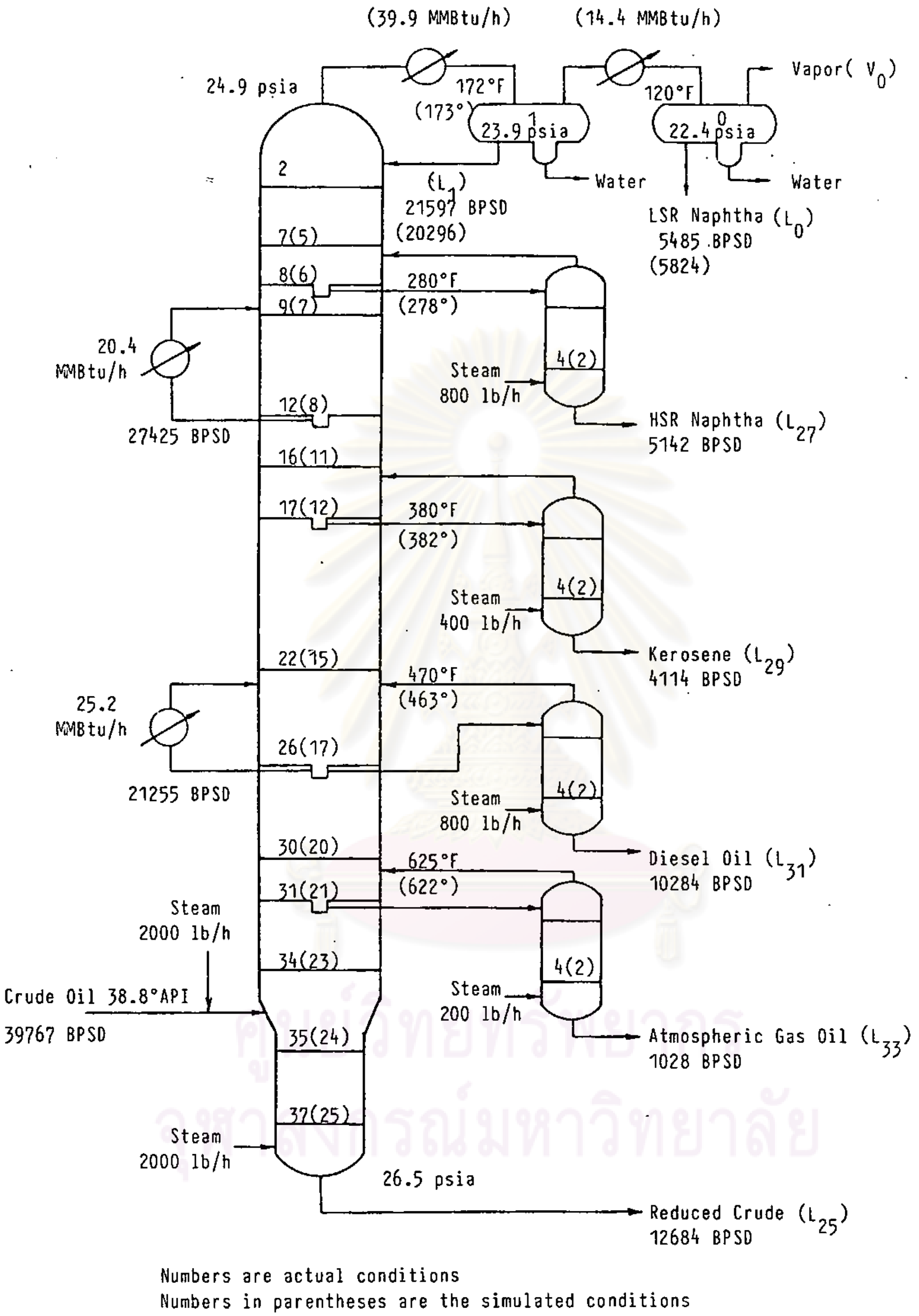

Fig. 28 Schematic diagram and conditions for the simulation of and existing topping column.

Table 11 Light-Component Analysis for the Crude Oil Feed

Component	Volume percent
Methane	0.09
Ethane	0.50
Propane	0.77
n-Butane	1.04
n-Pentane	2.60

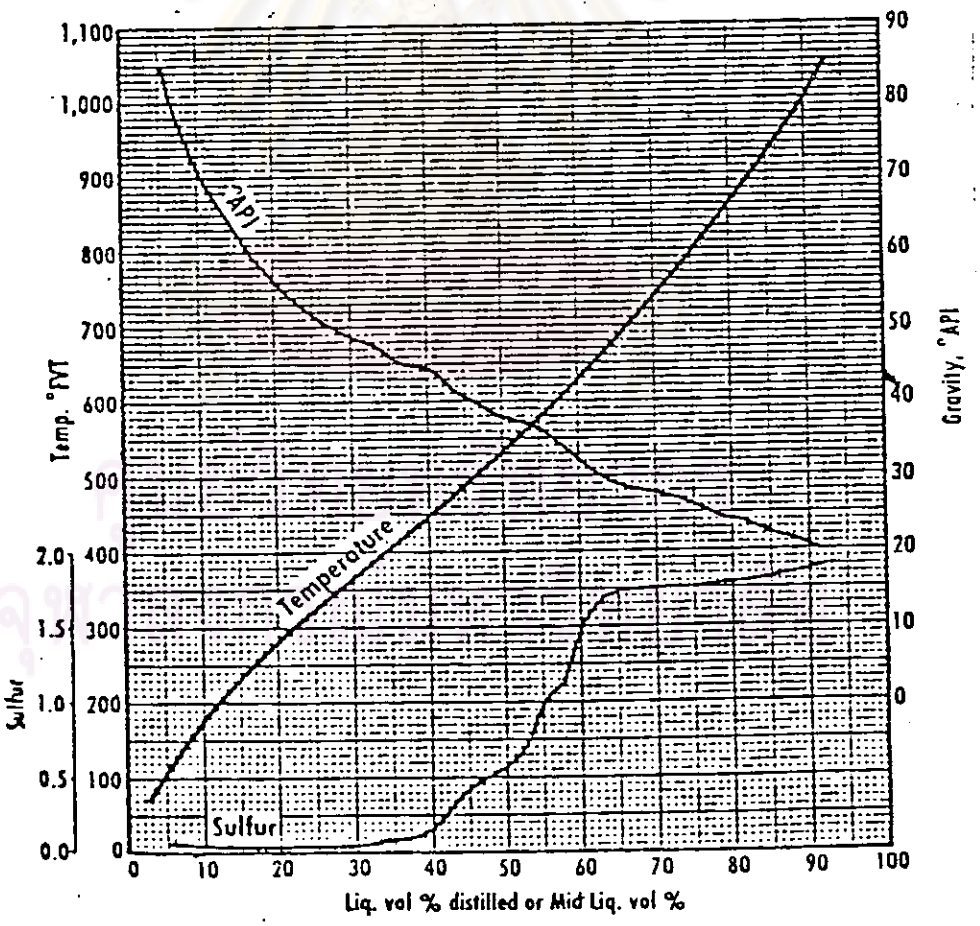

Fig. 29 Crude Assay for the Topping Column of Fig. 28.

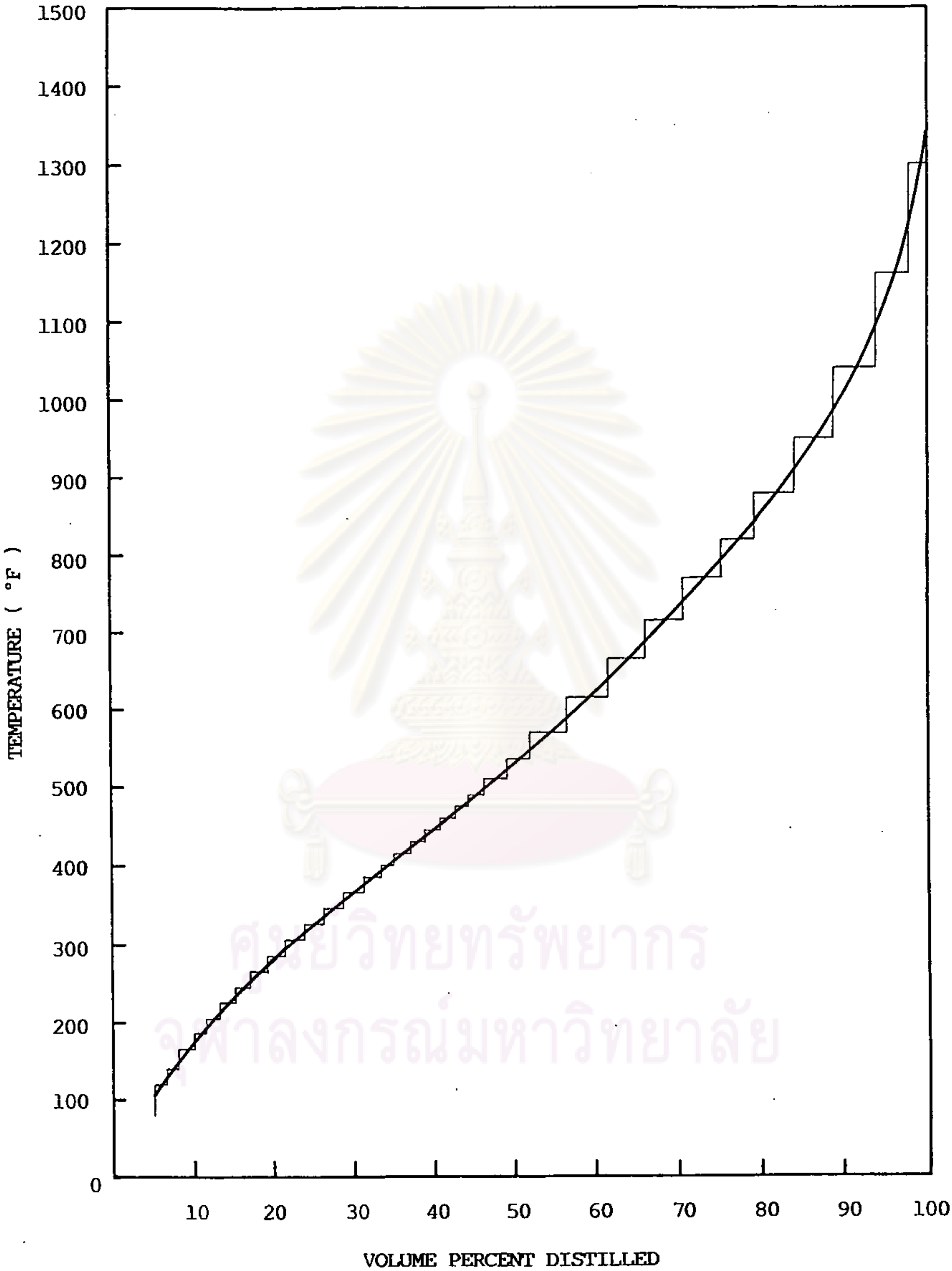

Fig. 30 The representive crude oil feed was divided into 39 normal boiling point fractions (pseudocomponents).

molecular weight of each fraction from Eq.(13) that fits Maxwell's correlation (Fig. 10). Thus the representation of this crude feed by pseudocomponents has been obtained, as given in Table 12.

The K-values of the pseudocomponents and the vapor and liquid enthalpies were obtained from Esso 53-12 chart (Fig. 20) and Johnson and Grayson enthalpy chart (Fig. 22), as discussed in 4.1, respectively. The partial pressure of water in the vapor phase above the two liquid phases in the condenser and reflux-accumulator was taken equal to its vapor pressure as given in Ref.41. The enthalpies of water in the vapor and liquid phases were taken from Ref.14. Curve-fitting results of the data on K-values and the vapor and liquid enthalpies are given in Tables 13-15.

The ASTM distillations and gravity in °API of the end-product streams are given on Table 16. The average molecular weights of these streams were obtained from their average boiling points and °API by using Eq.(13). Based on these data, the flow rates in lb.mol/h of these end-product streams was calculated and also shown in Table 16. The TBP distillations of these end-products streams were obtained by fitting the ASTM distillations and using the procedure discussed in section 3.1.4 for conversion.

6.2 Topping Column Model

The existing topping column in Fig. 28 has a slightly differrent column configuration from the model column in Fig. 23, i.e. one condenser and one reflux-accumulator which are separated from each other. To make use of the available computer program, the condenser may be solved later by using only one theoretical stage or

Table 12. Pseudocomponents Representation of Crude Oil Feed.

Component	ABP(°F)	Sp.Gr.	MW	lb.mol/h
1	-258.7	0.3005	16.04	9.76
2	-127.5	0.3561	30.07	36.03
3	-43.1	0.5072	44.09	51.43
4	31.1	0.5840	58.12	60.52
5	96.9	0.6308	72.15	131.65
6	120	0.6506	81.31	69.56
7	140	0.6574	84.97	69.11
8	165	0.6919	90.81	88.33
9	187	0.7040	96.31	63.55
10	205	0.7128	101.02	69.53
11	225	0.7275	105.75	79.75
12	245	0.7389	110.99	69.46
13	265	0.7447	117.14	84.76
14	285	0.7547	122.89	78.31
15	305	0.7669	128.42	86.54
16	325	0.7732	135.06	79.64
17	345	0.7796	141.90	76.43
18	365	0.7861	148.94	76.48
19	385	0.7892	156.86	67.07
20	400	0.7949	162.30	42.58
21	415	0.8017	167.66	60.98
22	430	0.8026	174.35	48.03
23	445	0.8054	180.83	46.67
24	460	0.8100	187.05	50.20
25	475	0.8179	192.63	36.92
26	490	0.8236	198.84	48.02
27	510	0.8299	207.64	64.87
28	535	0.8373	219.10	66.45
29	570	0.8408	237.67	92.27
30	615	0.8591	258.90	96.17
31	665	0.8772	284.42	80.45
32	715	0.8871	314.02	73.69
33	760	0.8927	343.29	67.83
34	820	0.9042	382.90	54.75
35	880	0.9111	426.54	61.91
36	950	0.9230	478.08	52.60
37	1040	0.9371	547.49	49.60
38	1160	0.9415	652.43	34.90
39	1300	0.9433	779.32	14.03
40	212	1.0000	18.00	111.11
Total feed				2601.94

Note: kg.mol/h = lb.mol/h x 0.454

Table 13 Vapor-liquid equilibrium data for the pseudocomponents in Table 12.

$$(K_i/T)^{\frac{1}{3}} = A1(I) + A2(I)*T + A3(I)*T^2 + A4(I)*T^3$$

T = temperature in °F/400 ; Range 100 °F $\leq$ Temp. °F $\leq$ 700 °F

COMPONENT	A1(I)	A2(I)	A3(I)	A4(I)
1	0.35808358D+01	-0.20090727D+01	-0.74604981D+00	0.44371119D+00
2	0.38047433D+01	0.45538158D+01	-0.54889519D+01	0.16213948D+01
3	0.23215305D+01	0.37621479D+01	-0.33305123D+01	0.87041357D+00
4	0.14682751D+01	0.28216935D+01	-0.14694561D+01	0.23918829D+00
5	0.76315602D+00	0.29636085D+01	-0.13303089D+01	0.18633146D+00
6	0.62974611D+00	0.27785270D+01	-0.11674380D+01	0.16767847D+00
7	0.49408073D+00	0.26658735D+01	-0.10413676D+01	0.14704787D+00
8	0.34873100D+00	0.24780226D+01	-0.82128337D+00	0.94436431D-01
9	0.26339774D+00	0.22190410D+01	-0.53752106D+00	0.17750824D-01
10	0.22162428D+00	0.19498953D+01	-0.25590436D+00	-0.60609659D-01
11	0.19739359D+00	0.16143953D+01	0.83084295D-01	-0.15540655D+00
12	0.18799920D+00	0.12676613D+01	0.42139389D+00	-0.24925402D+00
13	0.18571545D+00	0.93462319D+00	0.73346545D+00	-0.33401817D+00
14	0.18477464D+00	0.63429347D+00	0.99959719D+00	-0.40358362D+00
15	0.18157596D+00	0.37866981D+00	0.12089200D+01	-0.45417308D+00
16	0.17450051D+00	0.17290431D+00	0.13554556D+01	-0.48435561D+00
17	0.16348398D+00	0.16261444D-01	0.14412415D+01	-0.49478783D+00
18	0.14947361D+00	-0.96335150D-01	0.14728422D+01	-0.48775541D+00
19	0.13389294D+00	-0.17256690D+00	0.14599740D+01	-0.46661309D+00
20	0.12206852D+00	-0.21110918D+00	0.14278368D+01	-0.44381830D+00
21	0.11073553D+00	-0.23772929D+00	0.13817174D+01	-0.41692387D+00
22	0.10032471D+00	-0.25577374D+00	0.13261001D+01	-0.38750676D+00
23	0.91142061D-01	-0.26816322D+00	0.12650011D+01	-0.35698820D+00
24	0.83368549D-01	-0.27729921D+00	0.12018223D+01	-0.32657865D+00
25	0.77068219D-01	-0.28501033D+00	0.11392533D+01	-0.29723921D+00
26	0.72199613D-01	-0.29252677D+00	0.10792122D+01	-0.26965738D+00
27	0.67694380D-01	-0.30326549D+00	0.10049358D+01	-0.23627732D+00
28	0.64489622D-01	-0.31753476D+00	0.92184016D+00	-0.20016604D+00
29	0.62075301D-01	-0.33294263D+00	0.81713297D+00	-0.15765974D+00
30	0.57173953D-01	-0.32538611D+00	0.67796572D+00	-0.10741111D+00
31	0.45178706D-01	-0.26448201D+00	0.49141436D+00	-0.46413393D-01
32	0.31331120D-01	-0.17824675D+00	0.29948483D+00	0.12684700D-01
33	0.29493377D-01	-0.14485701D+00	0.19571783D+00	0.40646440D-01
34	0.13221718D-01	-0.42944774D-01	0.13265009D-01	0.93085634D-01
35	-0.19209542D-02	0.43064104D-01	-0.12033596D+00	0.12555197D+00
36	-0.12937661D-01	0.99766271D-01	-0.19523332D+00	0.13298242D+00
37	-0.15738211D-01	0.10672280D+00	-0.18761986D+00	0.10712978D+00
38	-0.92507900D-02	0.61498269D-01	-0.10338784D+00	0.54987143D-01
39	-0.20442187D-02	0.15276498D-01	-0.26361308D-01	0.15023930D-01
40	0.52376370D+01	0.84259994D-01	-0.10816656D+01	0.28167153D+00
*** FOR WATER IN THE CONDENSER/ACCUMULATOR				
	0.28333518D+00	0.70081415D+00	0.11937639D+01	0.87699291D+00

Table 14 Liquid enthalpies for the pseudocomponents in Table 12.

$(h_i/10^5)^{\frac{1}{2}}$ = B1(I) + B2(I)*T + B3(I)*T²

T = temperature in °F/400

h_i = liquid enthalpy, Btu/lb mol

COMPONENT	B1(I)	B2(I)	B3(I)
1	0.16852671D+00	0.13185405D+00	-0.17392434D-01
2	0.18921665D+00	0.17881551D+00	-0.19871128D-01
3	0.22863145D+00	0.18596551D+00	-0.11429565D-01
4	0.24269822D+00	0.24522686D+00	-0.27301188D-01
5	0.26534290D+00	0.26857005D+00	-0.28230318D-01
6	0.28940864D+00	0.26959597D+00	-0.20789476D-01
7	0.28964032D+00	0.26777067D+00	-0.18145001D-01
8	0.29440650D+00	0.27416013D+00	-0.18296091D-01
9	0.30017967D+00	0.28081532D+00	-0.18693101D-01
10	0.30559906D+00	0.28654284D+00	-0.19050643D-01
11	0.31018273D+00	0.29142108D+00	-0.19274212D-01
12	0.31609348D+00	0.29714053D+00	-0.19520020D-01
13	0.32388247D+00	0.30451010D+00	-0.19920233D-01
14	0.33023078D+00	0.31057235D+00	-0.20156645D-01
15	0.33553872D+00	0.31580682D+00	-0.20284659D-01
16	0.34294440D+00	0.32299038D+00	-0.20636242D-01
17	0.35024367D+00	0.33015814D+00	-0.20983377D-01
18	0.35742297D+00	0.33730784D+00	-0.21327374D-01
19	0.36609738D+00	0.34570641D+00	-0.21806810D-01
20	0.37100263D+00	0.35078846D+00	-0.22032406D-01
21	0.37536322D+00	0.35551545D+00	-0.22221652D-01
22	0.38253883D+00	0.36239978D+00	-0.22637561D-01
23	0.38884025D+00	0.36864654D+00	-0.22984135D-01
24	0.39418333D+00	0.37420603D+00	-0.23257577D-01
25	0.39772324D+00	0.37847751D+00	-0.23397500D-01
26	0.40232013D+00	0.38384186D+00	-0.23775571D-01
27	0.40928600D+00	0.39096036D+00	-0.23970417D-01
28	0.41813032D+00	0.40034006D+00	-0.24411744D-01
29	0.43436278D+00	0.41633234D+00	-0.25317123D-01
30	0.44723178D+00	0.43096175D+00	-0.25758595D-01
31	0.46251716D+00	0.44773249D+00	-0.26143348D-01
32	0.48230368D+00	0.46799935D+00	-0.26888444D-01
33	0.50201012D+00	0.48780716D+00	-0.27738923D-01
34	0.52491615D+00	0.51174391D+00	-0.28418391D-01
35	0.55023265D+00	0.53777281D+00	-0.29382266D-01
36	0.57463959D+00	0.56487434D+00	-0.29938479D-01
37	0.60229232D+00	0.59845436D+00	-0.30495347D-01
38	0.65234457D+00	0.65116934D+00	-0.32767131D-01
39	0.71037759D+00	0.71066688D+00	-0.35567633D-01
40	0.50942051D-01	0.24548845D+00	-0.67540262D-01

Table 15 Vapor enthalpies for the pseudocomponents in Table 12.

$(H_i/10^5)^{\frac{1}{2}}$ = C1(I) + C2(I)*T +C3(I)*T²

T = temperature in °F/400

H_i = vapor enthalpy, Btu/lb mol

COMPONENT	C1(I)	C2(I)	C3(I)
1	0.21983716D+00	0.74948894D-01	-0.67785510D-04
2	0.29833282D+00	0.76319279D-01	0.82131019D-02
3	0.34742411D+00	0.98454002D-01	0.71569776D-02
4	0.39110834D+00	0.11631621D+00	0.66587499D-02
5	0.43247089D+00	0.13029787D+00	0.73242350D-02
6	0.46977035D+00	0.13995877D+00	0.78724440D-02
7	0.47341756D+00	0.14071894D+00	0.86605097D-02
8	0.48430950D+00	0.14300238D+00	0.93620696D-02
9	0.49612865D+00	0.14541971D+00	0.98928908D-02
10	0.50672850D+00	0.14763733D+00	0.10286995D-01
11	0.51692229D+00	0.14913552D+00	0.10727092D-01
12	0.52840284D+00	0.15152818D+00	0.11106099D-01
13	0.54225367D+00	0.15510324D+00	0.11458530D-01
14	0.55421422D+00	0.15802153D+00	0.11805837D-01
15	0.56463229D+00	0.16071297D+00	0.12134005D-01
16	0.57782590D+00	0.16447863D+00	0.12470274D-01
17	0.59084811D+00	0.16830485D+00	0.12804986D-01
18	0.60367581D+00	0.17219370D+00	0.13137847D-01
19	0.61866160D+00	0.17662037D+00	0.13490211D-01
20	0.62756853D+00	0.17951793D+00	0.13733700D-01
21	0.63564357D+00	0.18235372D+00	0.13967382D-01
22	0.64788780D+00	0.18594698D+00	0.14244088D-01
23	0.65884082D+00	0.18934969D+00	0.14508067D-01
24	0.66835704D+00	0.19256725D+00	0.14756013D-01
25	0.67511683D+00	0.19547285D+00	0.14968027D-01
26	0.68354392D+00	0.19869784D+00	0.15196332D-01
27	0.69578010D+00	0.20321843D+00	0.15509756D-01
28	0.71136528D+00	0.20904258D+00	0.15898885D-01
29	0.73921997D+00	0.21789947D+00	0.16538448D-01
30	0.76200411D+00	0.22882717D+00	0.17097711D-01
31	0.78808570D+00	0.24214262D+00	0.17654091D-01
32	0.82136209D+00	0.25621583D+00	0.18348753D-01
33	0.85449528D+00	0.26912415D+00	0.19048675D-01
34	0.89214165D+00	0.28736789D+00	0.19779641D-01
35	0.93398075D+00	0.30572157D+00	0.20622936D-01
36	0.97263214D+00	0.32888798D+00	0.21298730D-01
37	0.10146780D+01	0.36044056D+00	0.21935229D-01
38	0.10970304D+01	0.39690811D+00	0.23595781D-01
39	0.11936301D+01	0.43551713D+00	0.25611737D-01
40	0.40730043D+00	0.84736299D-01	-0.18868246D-01

Table 16 ASTM distillation analysis and molal flow rate of the sidestream products.

	Sidestream Product				
	LN	HN	KS	DO	AGO
ASTM distillation					
IBP	86	220	314	422	566
5%	108	242	335	450	602
10%	120	254	347	471	624
50%	168	291	387	547	680
90%	216	334	430	626	757
95%	232	347	444	643	780
EP	254	370	473	660	823
API gravity	75.5	56.3	46.8	37.2	30.0
Molecular weight	93.0	121	162	220	300
Flow rate,					
GPM	160	150	120	300	30
lb mol/h	587.2	465.8	293.6	517.2	43.78

NOTE : LN = Light naphtha
HN = Heavy naphtha
KS = Kerosene
DO = Diesel oil
AGO = Atmospheric gas oil
IBP = Initial boiling point
EP = End point
GPM = Gallon per minute

by doing only equilibrium flash calculation at the specified temperature and pressure. The condenser duty may be obtained from the enthalpy difference of the input and output streams around the condenser. Therefore, there is no need to modify the available computer program when applied to the topping column of interest, except including a subroutine for the condenser calculation.

6.3 The Theoretical Analogue Column

In order to determine the theoretical analogue column, the original number of plates between the sidestream withdrawal positions possessed by the actual column in Fig. 28 was revised by trial and error to get the assumed theoretical analogue column. The predicted data obtained from computer simulation of the assumed theoretical analogue column was compared with the plant data to come up with the best analogue column Some of these simulation results are shown in Table 17.

The theoretical analogue column which was found to give satisfactory match between the simulated data and plant data is shown in Fig. 28. The computed values of temperatures, flow rates and compositions obtained by the computer program for the chosen analogue column are presented in Tables 18-20.

The agreement between the simulation and plant data of selected variables is reasonably good as shown in Figs. 31-32. The simulated and actual stage temperatures are compared in Fig. 31. Figure 32 compares the simulated TBP distillation curves of the sidestream products and their counterparts, which are obtained from plant ASTM distillation curves. It may be concluded that the present

Table 17 Some of the simulation results on various stage number

Stage Variable	Column Number 5213-C	3276-C	6172-D	4972-E*	5213-E	Actual
NW(1)	5	6	7	6	6	8
NW(2)	10	11	13	12	13	17
NW(3)	16	17	19	17	19	26
NW(4)	21	22	24	21	24	31
NV(1)	4	5	6	5	5	7
NV(2)	9	10	12	11	12	16
NV(3)	15	16	18	16	18	23
NV(4)	20	21	23	20	23	30
NQ(1)	6	7	8	7	7	9
NQ(2)	15	16	18	16	18	23
NP(1)	7	8	9	8	8	12
NP(2)	16	17	19	17	19	26
NF	24	25	27	24	26	35
NT	25	26	28	25	27	38
Resulted temp.(°F)						
Ov'hd Reflux	172	173	174	173	175	172
Sidedraw no.1	275	277	280	278	280	280
no.2	377	380	383	382	383	380
no.3	463	463	465	463	465	470
no.4	622	623	625	622	624	625
Bottom stream	649	650	654	650	654	650

* used as the theoretical analogue column.

Table 18 Initial and final values compared

Plate no.	Temperature (°F)		Liquid (lb mol/h)		Vapor (lb mol/h)	
	Initial	Final	Initial	Final	Initial	Final
1	160.00	172.90	1000.0000	2170.5092	470.0000	1020.1393
2	220.00	228.45	2000.0000	2322.7129	4000.0000	3248.3466
3	240.00	243.10	2000.0000	2280.0959	3900.0000	3400.5503
4	260.00	262.83	2000.0000	2193.9577	3800.0000	3357.9333
5	280.00	278.18	2000.0000	2073.4069	3700.0000	3271.7951
6	300.00	297.19	1500.0000	1399.4917	3600.0000	3026.2602
7	320.00	319.32	4000.0000	4489.7447	3500.0000	2898.7491
8	340.00	337.43	1300.0000	2351.3425	3400.0000	3310.5021
9	360.00	355.64	1300.0000	2238.3003	3300.0000	3350.5099
10	380.00	369.42	1300.0000	2209.8183	3200.0000	3738.0577
11	400.00	381.87	1300.0000	2115.7189	3100.0000	3709.0757
12	420.00	394.79	1500.0000	1669.2578	2900.0000	3546.9132
13	440.00	409.09	1500.0000	1561.4733	2800.0000	3439.9552
14	460.00	423.14	1500.0000	1437.1541	2700.0000	3332.1707
15	480.00	438.77	1000.0000	1226.3481	2500.0000	3207.8516
16	500.00	463.03	2400.0000	2905.5530	2500.0000	2997.5455
17	520.00	500.83	300.0000	579.6780	2400.0000	3402.7460
18	540.00	572.16	500.0000	476.5553	2300.0000	2977.1754
19	560.00	607.48	400.0000	407.3621	2200.0000	2774.0527
20	580.00	622.27	400.0000	356.4372	2100.0000	2704.8595
21	600.00	630.45	400.0000	248.2940	2000.0000	2635.7046
22	620.00	637.82	400.0000	179.3576	1900.0000	2578.4714
23	640.00	646.27	200.0000	80.2108	1800.0000	2510.0351
24	660.00	654.47	500.0000	408.2796	300.0000	162.9097
25	660.00	649.76	500.0000	382.6859	300.0000	136.7037
26	280.00	284.03	500.0000	509.9795	200.0000	124.9840
27	260.00	271.24	500.0000	455.3200	150.0000	88.6595
28	400.00	384.92	400.0000	318.9163	100.0000	68.0631
29	380.00	373.54	400.0000	293.6400	60.0000	47.4763
30	500.00	494.72	500.0000	515.2579	200.0000	123.0044
31	480.00	486.57	600.0000	571.2000	150.0000	88.4579
32	580.00	624.97	100.0000	47.6242	100.0000	18.2301
33	560.00	616.76	100.0000	43.7800	60.0000	14.9442

Table 19 Product distribution within distillate and bottoms

Component No.	LSR naphtha (lb mol/h)	Vapor (lb mol/h)	Reduced crude (lb mol/h)
1	0.44444070D+00	0.93158372D+01	0.15693[illegible]89D-05
2	0.66309502D+01	0.29398915D+02	0.14114586D-03
3	0.21904993D+02	0.29516486D+02	0.41805406D-03
4	0.41915499D+02	0.18529063D+02	0.78651170D-03
5	0.11349244D+03	0.17385814D+02	0.44693545D-02
6	0.62205951D+02	0.60349735D+01	0.30412888D-02
7	0.63274234D+02	0.46553370D+01	0.38043136D-02
8	0.81888239D+02	0.36707557D+01	0.65972563D-02
9	0.58389054D+02	0.16839172D+01	0.63130900D-02
10	0.61798399D+02	0.12451562D+01	0.38260965D-02
11	0.62644152D+02	0.84857134D+00	0.13457142D-01
12	0.34377337D+02	0.31215506D+00	0.15775503D-01
13	0.12398749D+02	0.74795022D-01	0.26215513D-01
14	0.18340752D+01	0.72411520D-02	0.33351061D-01
15	0.25615191D+00	0.64890226D-03	0.51260177D-01
16	0.26364337D-01	0.41880150D-04	0.56209902D-01
17	0.24204353D-02	0.23543525D-05	0.39901527D-01
18	0.16895311D-03	0.98337541D-07	0.12617477D+00
19	0.62189201D-05	0.21259089D-08	0.16104848D+00
20	0.26933472D-06	0.61104492D-10	0.13428293D+00
21	0.22055537D-07	0.32975943D-11	0.25291463D+00
22	0.85388547D-09	0.84151309D-13	0.26226116D+00
23	0.34578200D-10	0.22108589D-14	0.33399833D+00
24	0.12440623D-11	0.51687352D-16	0.47447271D+00
25	0.23832557D-13	0.64049007D-18	0.45737411D+00
26	0.64892133D-15	0.11213192D-19	0.77894555D+00
27	0.38908645D-17	0.36813338D-22	0.14945575D+01
28	0.32843832D-20	0.14181947D-25	0.23387992D+01
29	0.12849383D-24	0.16897546D-30	0.56744871D+01
30	0.87731815D-31	0.20416340D-37	0.11313006D+02
31	0.60278535D-38	0.17351331D-45	0.17816482D+02
32	0.30398920D-45	0.17532381D-53	0.29246345D+02
33	0.28549808D-53	0.12831722D-61	0.44919972D+02
34	0.84036155D-65	0.23443424D-73	0.49972383D+02
35	0.00000000D+00	0.00000000D+00	0.51140154D+02
36	0.00000000D+00	0.00000000D+00	0.52551552D+02
37	0.00000000D+00	0.00000000D+00	0.49604402D+02
38	0.00000000D+00	0.00000000D+00	0.34904581D+02
39	0.00000000D+00	0.00000000D+00	0.14032314D+02
40	0.00000000D+00	0.23720962D+01	0.4350841[illegible]D+01
TOTAL			0.38258452D+03

Table 20 Product distribution among sidestrippers

Component No.	HSR naphtha (lb mol/h)	Kerosene (lb mol/h)	Diesel oil (lb mol/h)	Gas oil (lb mol/h)
1	0.39588446D-05	0.26303107D-05	0.65346242D-05	0.17781088D-06
2	0.34924308D-03	0.18725749D-03	0.50445745D-03	0.16577254D-04
3	0.61712336D-02	0.18775324D-02	0.27150835D-02	0.51515350D-04
4	0.5699753[illegible]D-01	0.99460753D-02	0.30977218D-02	0.10016274D-03
5	0.62517812D+00	0.86542121D-01	0.56847484D-01	0.59223431D-03
6	0.59567645D+00	0.73503557D-01	0.47001771D-01	0.42175928D-03
7	0.98596034D+00	0.12314237D+00	0.58108227D-01	0.54541392D-02
8	0.23560491D+01	0.27087584D+00	0.13669543D+00	0.97553412D-03
9	0.30190157D+01	0.30831050D+00	0.14457266D+00	0.95148635D-03
10	0.57756646D+01	0.48596635D+00	0.21583953D+00	0.13456164D-02
11	0.15063924D+02	0.82978303D+00	0.34908595D+00	0.20724023D-02
12	0.33249414D+02	0.10725021D+01	0.42390529D+00	0.24509059D-02
13	0.69595454D+02	0.19573293D+01	0.73981344D+00	0.41097221D-02
14	0.72692200D+02	0.27775504D+01	0.96921391D+00	0.52618671D-02
15	0.70676622D+02	0.50221293D+01	0.15250652D+01	0.82179335D-02
16	0.63988359D+02	0.85395451D+01	0.20101572D+01	0.10769393D-01
17	0.55148266D+02	0.17379869D+02	0.27937503D+01	0.14867170D-01
18	0.36201000D+02	0.35970558D+02	0.41610390D+01	0.21562716D-01
19	0.12717233D+02	0.48422599D+02	0.57437589D+01	0.27627649D-01
20	0.30469505D+01	0.34010159D+02	0.53704972D+01	0.23552292D-01
21	0.14022031D+01	0.47500193D+02	0.11775577D+02	0.44547257D-01
22	0.31226332D+00	0.32385476D+02	0.14522398D+02	0.46723104D-01
23	0.73433954D-01	0.24515134D+02	0.21483500D+02	0.60079034D-01
24	0.15351624D-01	0.17032407D+02	0.32559193D+02	0.85995944D-01
25	0.13651191D-02	0.65804265D+01	0.29693477D+02	0.83442578D-01
26	0.33247737D-03	0.39516340D+01	0.43145243D+02	0.14244236D+00
27	0.25116554D-04	0.16107024D+01	0.61488585D+02	0.27590399D+00
28	0.6437193[illegible]D-06	0.32908045D+00	0.63253596D+02	0.42927[illegible]3D+00
29	0.39588685D-08	0.43541706D-01	0.95500232D+02	0.10517186D+01
30	0.29633557D-11	0.19986393D-02	0.32629091D+02	0.22283704D+01
31	0.57506873D-15	0.43816359D-04	0.58195046D+02	0.44381254D+01
32	0.58367608D-19	0.54672345D-06	0.32567774D+02	0.11874534D+02
33	0.19291173D-23	0.34478551D-08	0.59654506D+01	0.16945519D+02
34	0.81663107D-31	0.23163370D-12	0.67886942D-01	0.47075330D+01
35	0.44914009D-39	0.39733441D-17	0.31562006D-03	0.76730362D+00
36	0.84478097D-50	0.16519543D-23	0.15116923D-06	0.35514607D-01
37	0.00000000D+00	0.16313635D-32	0.19994702D-11	0.34849442D-03
38	0.00000000D+00	0.22591735D-45	0.35869232D-19	0.15288580D-06
39	0.00000000D+00	0.00000000D+00	0.15523797D-29	0.28093867D-11
40	0.22623509D+01	0.16910497D+01	0.35003009D+01	0.43882985D+01
TOTAL	0.46581955D+03	0.29365763D+03	0.57119920D+03	0.45779687D+02

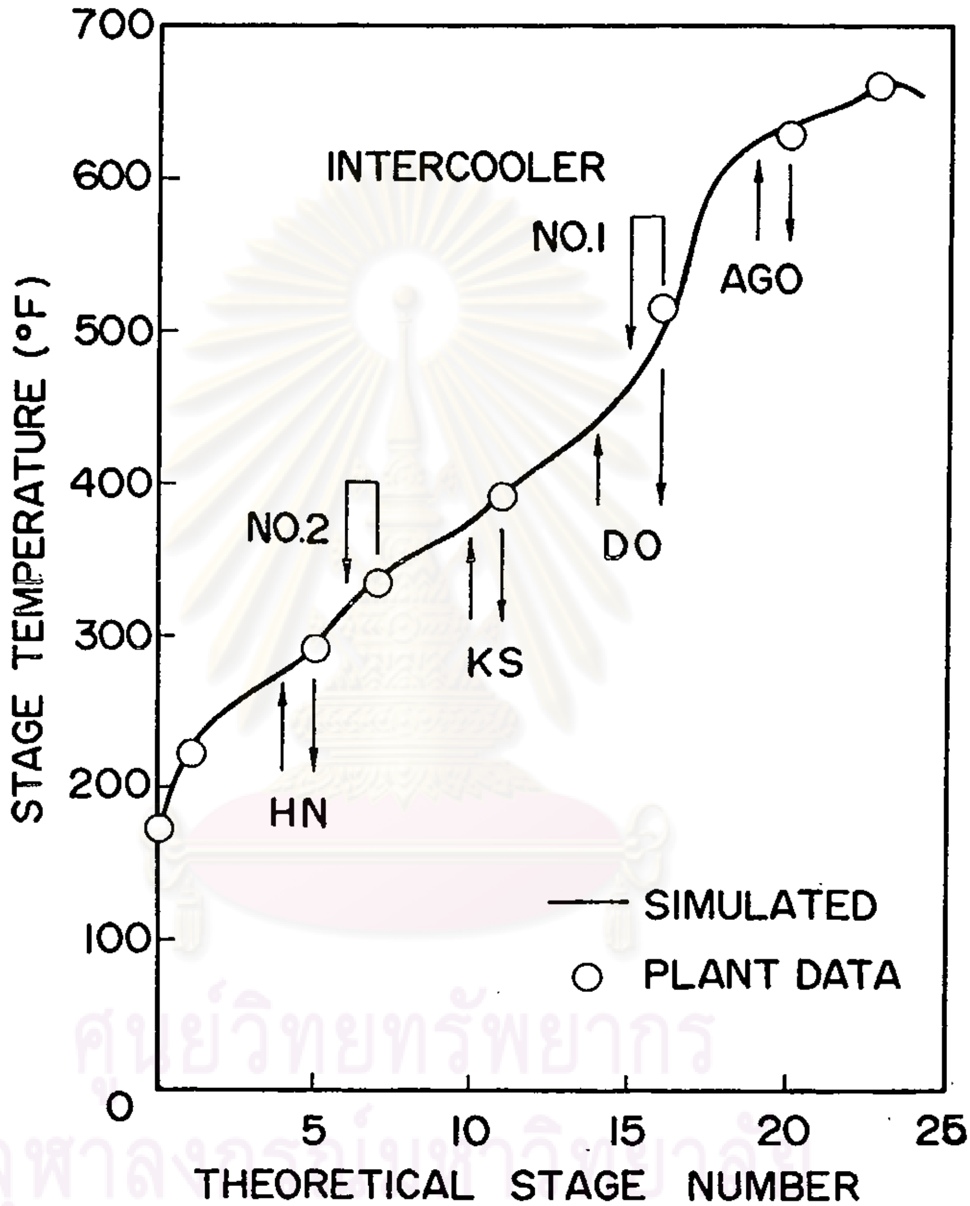

Fig. 31 Comparison of simulated stage temperature with plant data.

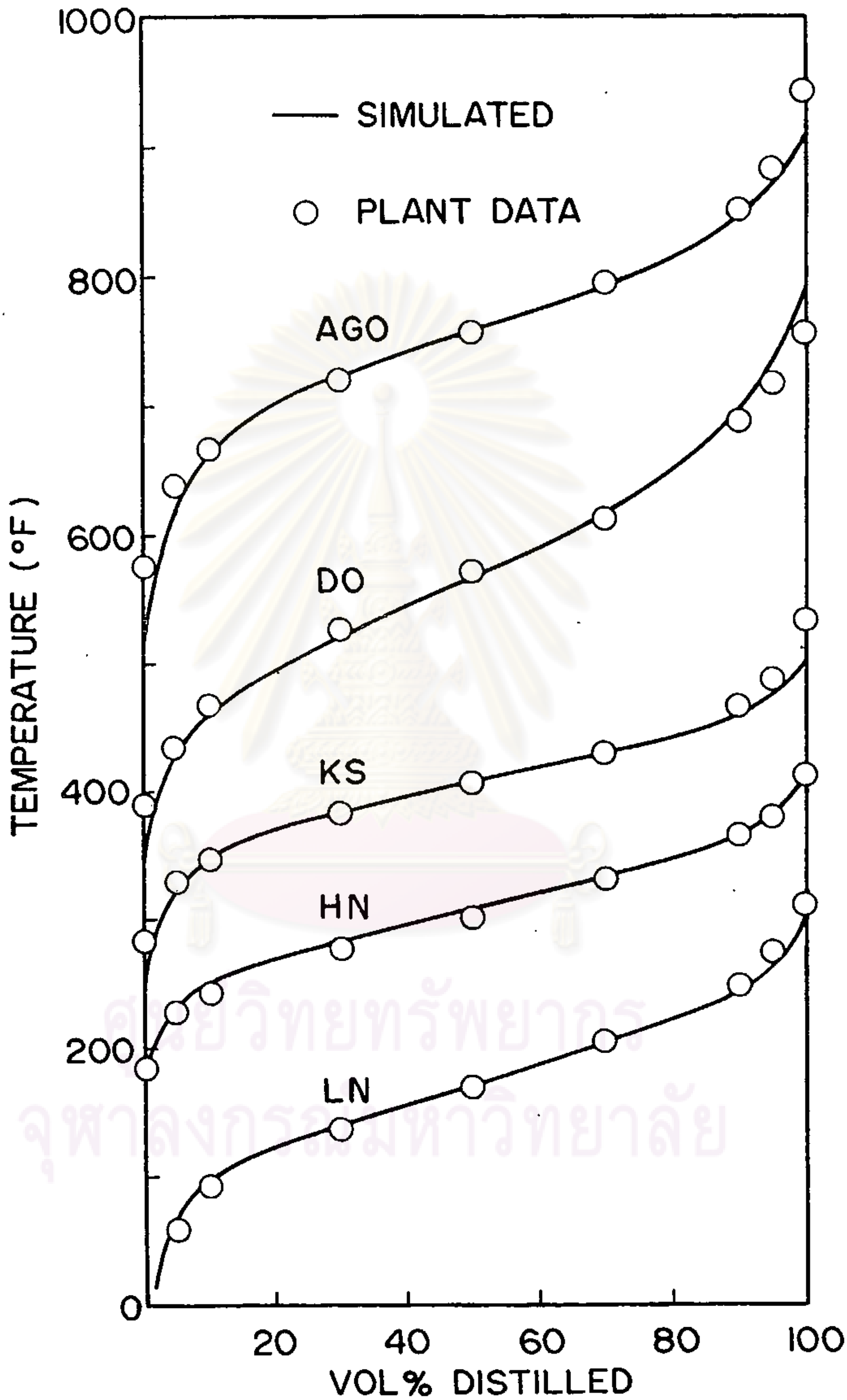

Fig. 32 Comparison of simulated TBP distillation curves with plant data.