CHAPTER 4

EXPERIMENTAL APPARATUS AND PROCEDURE

EXPERIMENTAL APPARATUS

Fig. 4.1 is a photograph of the experimental apparatus. The heat transfer plates and frames were made by Fischer Company (Austria) and the apparatus was installed by Processing Machinery and Equipment Co. Ltd. (Thailand). What follows is a technical description (specification) of the apparatus and a description of the experimental procedure.

4.1 Plate Heat Exchanger

4.1.1 Description

Type	:	chevron corrugation angle= 50 degrees; Eurocal 5, as presented in Fig. 4.2
Plate Material	:	AISI 304
Gasket	:	nitrile rubber
Surface per plate	:	0.05 m^2
Width	:	0.1125 m
Length	:	0.445 m
Thickness	:	0.0006 m
Plate gap	:	0.00313 m

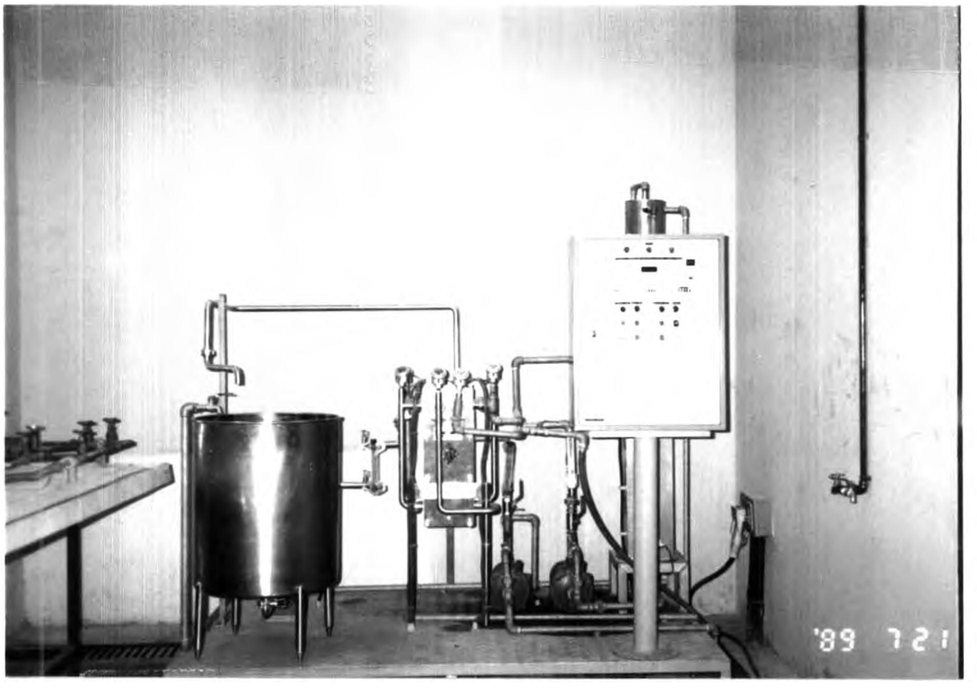

Figure 4.1 Photograph of Plate Heat Exchanger Investigated.

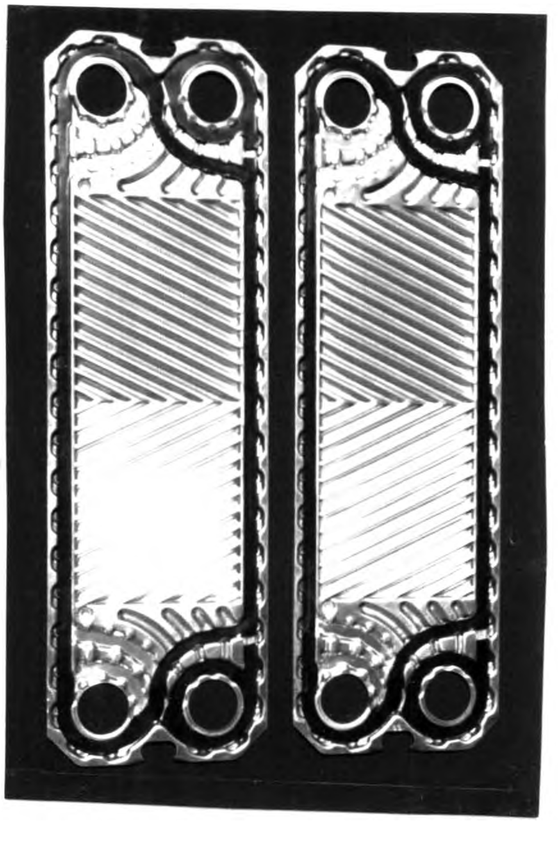

Figure 4.2 Type Eurocal 5; Chevron Corrugation (angle = 50 degrees).

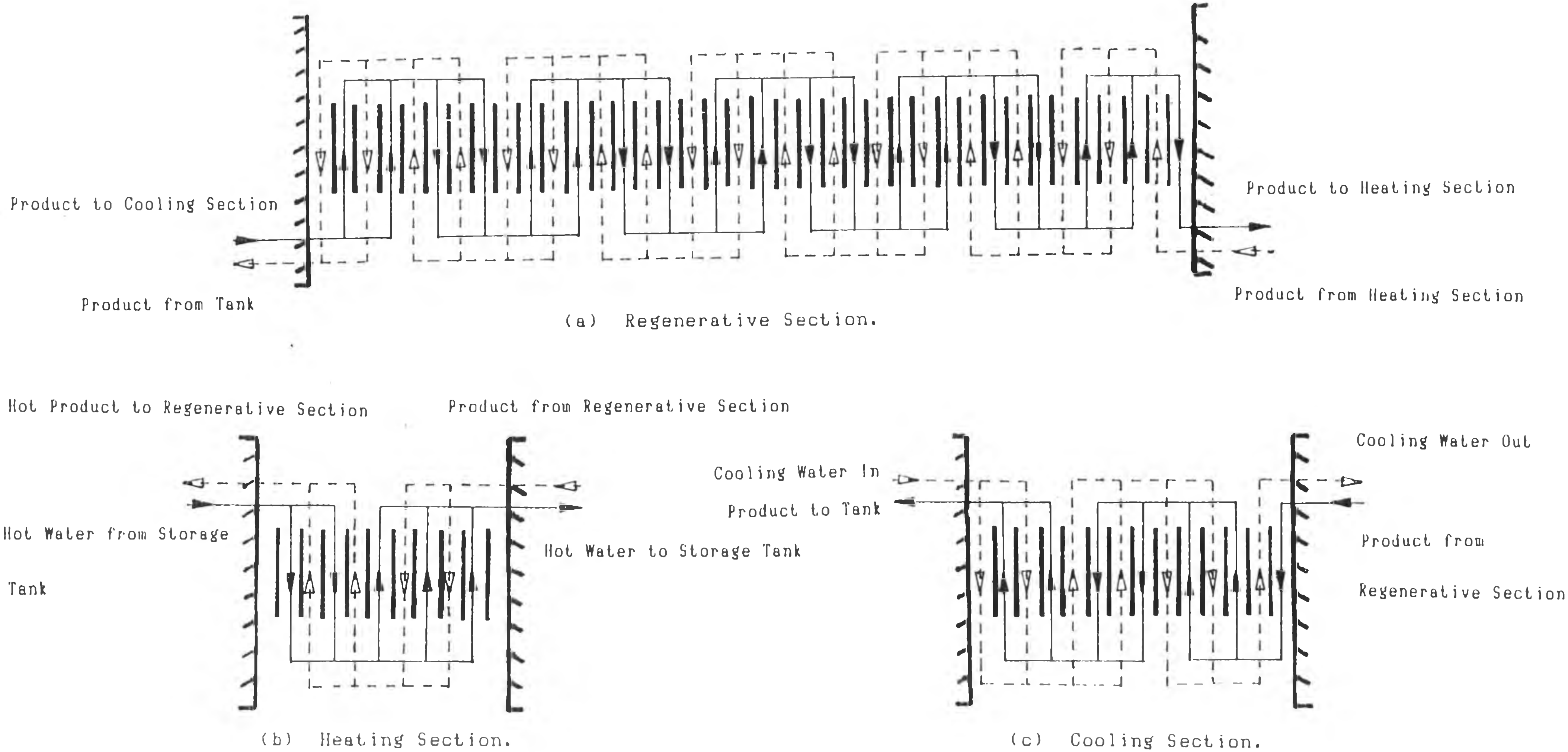

Figure 4.3 Flow Arrangement in Each Section of the Plate Heat Exchanger

The plate heat exchanger used in this work investigation has three sections, as shown in Fig. 4.3.

1. Regenerative Section (Section 1)

This section preheats the incoming product stream by transferring heat from the hot product stream from the heating section to the same stream from the unheated product tank. It has 37 plates, and a heat transfer area of na = 0.75 m^2, and the flow arrangement is multipass with nine pass/nine pass.

2. Heating Section (Section 2)

The section heats up the product stream by transferring heat from the hot water stream from the hot water tank, which is controlled to have a set temperature, to the pre-heated product stream from the regenerative section. It has 10 plates and a heat transfer area of na = 0.04 m^2. The flow arrangement is multipass with two pass/two pass.

3. Cooling Section (Section 3)

The section finally cools down the product stream by transferring heat from the product stream from the regenerative section to cooling water from the cooling water tank. It has 13 plates, with a heat transfer of area na = 0.05 m^2 and the flow arrangement is multipass with three pass/three pass.

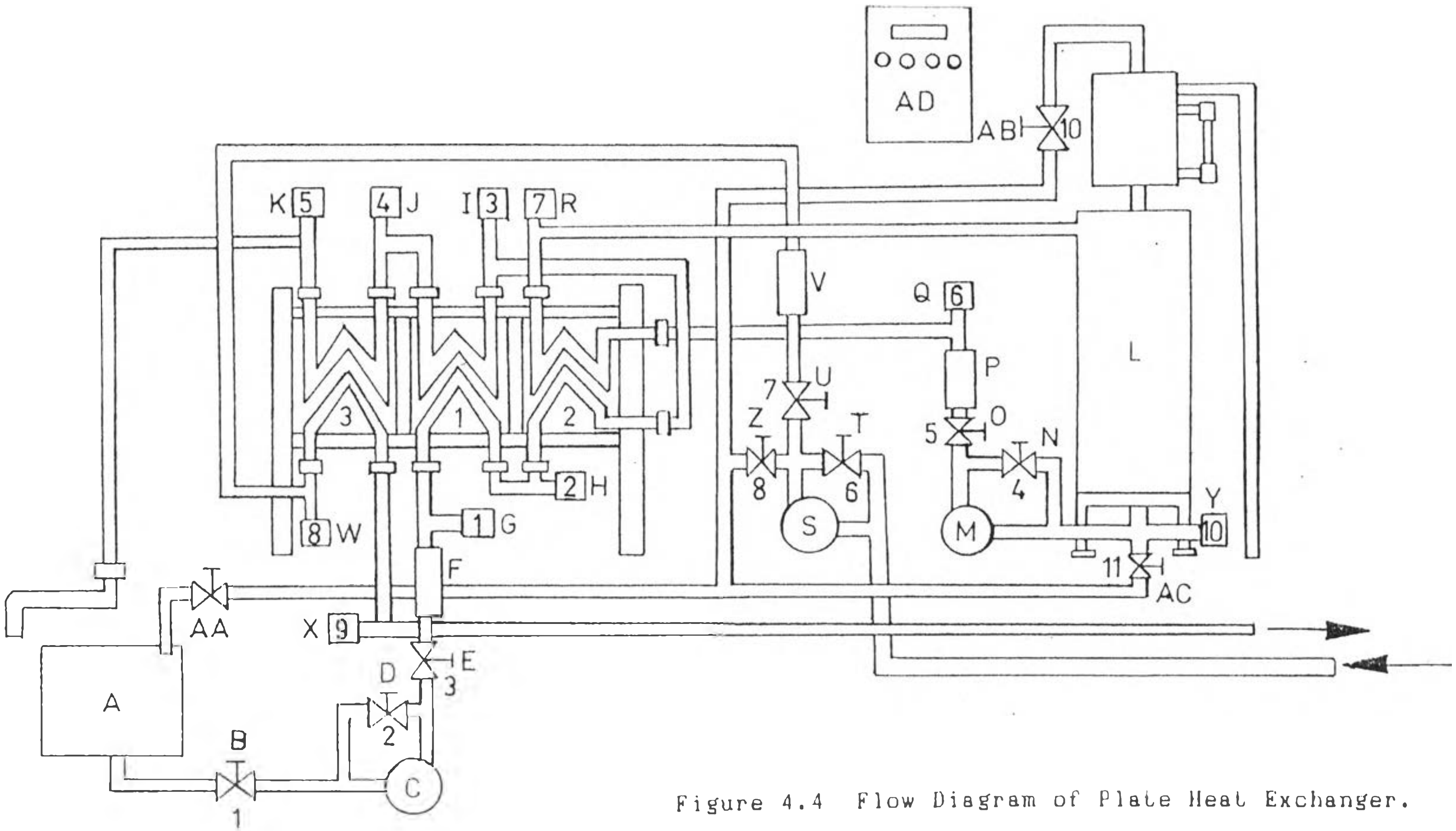

Figure 4.4 Flow Diagram of Plate Heat Exchanger.

4.1.2 Flow Diagram of Plate Heat Exchanger

Fig. 4.4 is the flow diagram of the experimental apparatus. The meanings of the symbols shown the Figure are explained in the following list.

1. Regenerative section(Section 1).
2. Heating section(Section 2).
3. Cooling section(Section 3).

A. Product tank, 1 m^3.

B. Shut-off valve (no.1) for unheated product storage tank.

C. Stainless steel pump, 1 HP, for product stream.

D. Recirculation valve (no.2) for product stream.

E. Flow regulating valve (no.3) for product stream into regenerative section.

F. Product flow meter(rotameter), scale 1-7.5 LPM.

G. Thermocouple set no.1 for product temperature measurement at inlet of the regenerative section.

H. Thermocouple set no.2 for product temperature measurement at outlet of the regenerative section (inlet of heating section).

I. Thermocouple set no.3 for product temperature measurement at outlet of heating section (inlet of regenerative section).

J. Thermocouple set no. 4 for product temperature measurement at outlet of regenerative section (inlet of cooling section).

K. Thermocouple set no. 5 for product temperature measurement at outlet of cooling section.

L. Electric heater, 12 KW , with temperature controller to produce hot water in the storage tank.

M. Hot water pump, 0.6 HP.

N. Recirculation valve (no. 4) for hot water stream.

O. Flow regulating valve (no.5) for hot water stream into heating section.

P. Flow meter (rotameter) for hot water, scale 0.18-0.96 m^3/hr.

Q. Thermocouple set no. 6 for hot water temperature measurement at inlet of heating section.

R. Thermocouple set no. 7 for hot water measurement at outlet of heating section.

S. Pump for cooling water (tap water), 0.6 HP.

T. Recirculation valve (no.6) for cooling water stream.

U. Flow regulating valve (no. 7) for cooling water into cooling section.

V. Cooling water flow meter (rotameter), scale 1.8-18 LPM.

W. Thermocouple set no. 8 for cooling water temperature measurement at inlet of cooling section.

X. Thermocouple set no. 9 for cooling water temperature measurement at outlet cooling section.

Y. Thermocouple set no. 10 for hot water temperature temperature measurement in storage tank.

Z. Shut-off valve (no. 8) for water supply to product tank and/or hot water tank.

AA. Shut-off valve (no. 9) for water supply to product tank.

AB. Shut-off valve (no. 10) for water supply to hot water tank.

AC. Drain valve (no. 11) for hot water tank.

AD. Electical panel (switchboard) of plate heat exchanger.

Experimental Procedure

4.2 General Experimental Procedure

1. Open the main breaker.
2. Check level of water in the hot water tank to make sure that it is full. If not, it can be filled by closing valve (no. 7) and opening valve (no. 8) and valve (no. 10).
3. Fill product into the product tank.
4. Open valve(no.1) and switch on the product pump. Adjust the flow rate of the product by manipulating valves (no. 2 and no. 3), and read the flow rate with the flow meter F.
5. Switch on the hot water pump and adjust the flow rate of hot water by manipulating valves(no. 4 and no. 5). Set the desired temperature of the hot water on the temperature controller and switch on the heater.
6. Temperature of the hot water will increase until it reaches the set temperature. The temperature controller will turn the heater on or off to keep the hot water temperature at the set value.
7. Switch on the cooling water pump and adjust its flow rate by manipulating valves (no. 6 and no. 7).
8. Read and record the temperatures indicated by thermocouple set no. 1 to no. 9 after they has reached steady-state values.
9. Switch off and pumps and main the breaker when the experiment has ended.

At first, the rotameters used to measure the flow rates of the product, hot water and cooling water streams were calibrated for each type of liquid at room temperature.

4.3 Experimental Conditions Investigated

Three types of products(water, sucrose solution and glycerine solution) have been investigated under similar experimental conditions; the temperatures of the heating water is varied to be 75, 85, and 98 °C and the flow rates of the products, heating water and cooling water streams are as follows.

4.3.1 Case I: Product is water

In this case water is taken to be the product to be preheated, heated and cooled by the respective sections of the plate heat exchanger.

4.3.1.1 Case I-1: Equal flow rates

In case I-1, the flow rates of the product(water), heating water and cooling water streams are always essentially the same.

4.3.1.1.1 Case I-1(a): Hot water at 75 °C

The experimental procedure is as follows:

(i). Adjust the flow rates of the product stream, hot water stream and cooling water stream to be 2 LPM.

(ii). Record the temperatures indicated by thermocouples no. 1- no. 9 at steady state.

(iii). Repeat steps (i) and (ii), but change the flow rates of the product, the hot water and the cooling water streams to be 3, 4, 5, 6, 7 and 7.5 LPM, respectively.

4.3.1.1.2 <u>Case I-1(b): Hot water at 85 $^{\circ}$C</u>

4.3.1.1.3 <u>Case I-1(c): Hot water at 98 $^{\circ}$C</u>

The experimental procedure of cases I-1(b) and I-1(c) are the same as that of case I-1(a).

4.3.1.2 <u>Case I-2: Unequal flow rates</u>.

4.3.1.2.1 <u>Case I-2(a): Hot water at 75 $^{\circ}$C</u>

(i). Set the flow rates of both the hot water and cooling water streams to 3 LPM, but set the flow rate of the product stream to 2 LPM.

(ii). Read and record the temperature data at steady state.

(iii).Keep constant the hot water and the cooling water flow rates while varying the flow rate of the product stream to 4, 5, 6, 7, and 7.5 LPM, respectively. Repeat step (ii) for each product flow rate mentioned here.

(iv). Next repeat steps (i)-(iii) by varying the flow rates of both the hot water and the cooling water streams to 4, 5, 6, 7, 7.5, 9, and 12 LPM,respectively. For each condition of equal flow rates, the product flow rate is adjusted from 2 to 7.5 LPM. as mentioned above.

4.3.1.2.2 <u>Case I-2(b): Hot water at 85 $^{\circ}$C</u>

4.3.1.2.3 <u>Case I-2(c): Hot water at 98 $^{\circ}$C</u>

The experimental procedure for cases I-2(b) and (c) is the same as that of case I-1(a).

4.3.2 Case II: Product is syrup (sucrose solution)

In case II, the product is a syrup of various fixed concentrations while the other two streams are water.

4.3.2.1 Case II-1: 20 wt% syrup

4.3.2.2 Case II-2: 30 wt% syrup

4.3.2.3 Case II-3: 40 wt% syrup

Cases II-1, II-2 and II-3 all have the same experimental procedure as that of Case I-1. Of course, the flow rates of all streams are essentially the same during each run.

4.3.3 Case III: Product is glycerine (in water)

In case III, the product is glycerine while the remaining streams are water.

4.3.3.1 Case III-1: 40 vol% glycerine

4.3.3.2 Case III-2: 50 vol% glycerine

4.3.3.3 Case III-3: 60 vol% glycerine

Cases III-1, III-2 and III-3 all have the same experimental procedure as that of Case I-1. In addition, all flow rates are essentially equal during each run.

4.4 Summary of Experimental Conditions

Tables 4.1 and 4.2 summarize the experimental conditions

Table 4.1 Summary of experiments for equal flow rates.

Hot water flow rate (H) = Cool water flow rate (C) = Product water flow rate (P), LPM.

Each run number consists of three cases, namely, T10 = 98, 85, and 75 °C, respectively.

Type of Product	Water	Syrup(wt%)			Glycerine(vol%)		
Concentration	-	20	30	40	40	50	60
Run No.	H=C=P	H=C=P	H=C=P	H=C=P	H=C=P	H=C=P	H=C=P
1	2	2	2	2	2	2	2
2	3	3	3	3	3	3	3
3	4	4	4	4	4	4	4
4	5	5	5	5	5	5	5
5	6	6	6	-	6	6	-
6	7	-	-	-	-	-	-
7	7.5	-	-	-	-	-	-

Table 4.2 Summary of experimental conditions for unequal water/water flow rates (LPM).

Each run number consists of three cases, namely, T10 = 98, 85, and 75 °C, respectively.

Set No.	1			2			3			4			5			6			7			8		
Run No.	H	C	P	H	C	P	H	C	P	H	C	P	H	C	P	H	C	P	H	C	P	H	C	P
1	3	3	7.5	4	4	7.5	5	5	7.5	6	6	7.5	7	7	7.5	7.5	7.5	7	9	9	7	12	12	7
2	3	3	7	4	4	7	5	5	7	6	6	7	7	7	6	7.5	7.5	6	9	9	6	12	12	6
3	3	3	6	4	4	6	5	5	6	6	6	5	7	7	5	7.5	7.5	5	9	9	5	12	12	5
4	3	3	5	4	4	5	5	5	4	6	6	4	7	7	4	7.5	7.5	4	9	9	4	12	12	4
5	3	3	4	4	4	3	5	5	3	6	6	3	7	7	3	7.5	7.5	3	9	9	3	12	12	3
6	3	3	2	4	4	2	5	5	2	6	6	2	7	7	2	7.5	7.5	2	9	9	2	12	12	2

used in the present study.

Table 4.1 summarizes the experimental conditions for the cases of equal liquid/liquid flow rates. Table 4.2 summarizes the experimental conditions for the cases of unequal water/water flow rates.

The corresponding experimental values of the Reynolds and Prandtl numbers of each stream in each section of the plate exchanger are presented in Tables 4.3-4.17. The pilot-scale plate heat exchanger studied has chevron corrugations and the transition regime ranges from Re approximately 10 to 150. More specifically, Table 4.3 lists the values of Re and Pr used in the experiments for the case of equal water/water flow rates. Here the Re ranges between 379 and 3,184 (turbulent region). Tables 4.4-4.11 list the values of Re and Pr used in the experiments for the cases of unequal water/water flow rates. Here the flow rates of the hot water(H) and cooling water(C) streams are both set at 3, 4, 5, 6, 7, 7.5, 9, and 12 LPM, respectively. For each set of condition for the hot and cooling water flow rates, the product flow rate is varied from 2 to 7.5 LPM. The corresponding value of product Re thus ranges between 584 and 4,961(turbulent region).

Tables 4.12-4.14 list the values of Re and Pr used in the experiments for the cases of equal syrup/syrup flow rates with syrup concentration being 20, 30, and 40 wt%, respectively. Here the values of Re fall between 150 and 1,260 (turbulent region).

Tables 4.15-4.16 list the values of Re and Pr used in the experiments for the cases of equal glycerine/glycerine flow rates with glycerine concentration of 40, 50, and 60 vol%, respectively. Here the values of Re fall between 85 and 754. So the transition region occurs only in case of 60 vol% glycerine concentration and 2 LPM flow rate. The rest is in the turbulent flow region.

Table 4.3 Experimental conditions for equal water/water flow rates.

Product is water : T10 = 98°C												
Equal flow rates H = C = P (LPM)	Section											
	3				1				2			
	Water		Water		Water		Water		Water		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	406	4.93	412	4.85	613	3.13	663	2.87	904	2.04	789	1.95
3	597	5.04	609	4.93	906	3.18	984	2.90	1341	2.07	1170	1.97
4	788	5.09	804	4.97	1189	3.24	1293	2.94	1766	2.09	1551	1.98
5	975	5.15	1000	5.01	1474	3.27	1616	2.94	2195	2.11	1922	2.00
6	1182	5.09	1206	4.99	1755	3.30	1910	2.99	2587	2.14	2274	2.03
7	1350	5.21	1378	5.09	1999	3.38	2963	3.04	2963	2.18	2622	2.06
7.5	1425	5.31	1462	5.15	2151	3.37	2352	3.04	3185	2.18	2818	2.05
Product is water : T10 = 85°C												
Equal flow rates H = C = P (LPM)	Section											
	3				1				2			
	Water		Water		Water		Water		Water		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	380	5.31	388	5.18	546	3.54	587	3.28	775	2.41	676	2.30
3	567	5.34	579	5.21	819	3.54	881	3.28	1170	2.39	1013	2.30
4	756	5.34	772	5.21	1088	3.56	1170	3.30	1550	2.41	1334	2.33
5	945	5.34	965	5.21	1348	3.59	1451	3.33	1912	2.44	1667	2.33
6	1128	5.38	1152	5.24	1604	3.62	1734	3.34	2279	2.46	1994	2.34
7	1295	5.48	1323	5.34	1848	3.66	1999	3.38	2633	2.48	2305	2.36
7.5	1388	5.48	1417	5.34	1972	3.68	2125	3.41	2792	2.51	2437	2.39
Product is water : T10 = 75°C												
Equal flow rates H = C = P (LPM)	Section											
	3				1				2			
	Water		Water		Water		Water		Water		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	410	4.88	414	4.82	539	3.59	567	3.41	715	2.64	616	2.53
3	612	4.92	621	4.82	802	3.62	850	3.41	1065	2.66	928	2.52
4	812	4.93	824	4.85	1065	3.63	1129	3.43	1410	2.68	1220	2.56
5	1025	4.88	1035	4.82	1314	3.68	1405	3.44	1750	2.70	1530	2.55
6	1194	5.04	1218	4.93	1564	3.72	1659	3.50	2071	2.75	1812	2.59
7	1393	5.04	1414	4.96	1825	3.72	1927	3.51	2407	2.76	2092	2.62
7.5	1484	5.07	1507	4.99	1922	3.81	2048	3.54	2533	2.81	2218	2.66

Table 4.4 Experimental conditions for unequal water/water (H = C = 3 and vary P (LPM)).

H=C=3 (LPM)	Product is water : T10 = 98°C											
	Section											
	3				1				2			
P	C		P		P		P		P		H	
(LPM)	Water		Water		Water		Water		Water		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	597	5.04	406	4.93	618	3.10	671	2.83	915	2.02	1197	1.92
4	597	5.04	816	4.90	1179	3.27	1293	2.94	1740	2.12	.150	2.01
5	597	5.04	1020	4.90	1451	3.33	1586	3.00	2117	2.18	1131	2.04
6	591	5.09	1224	4.90	1700	3.41	1854	3.10	2462	2.26	.111	2.08
7	579	5.21	1407	4.99	1935	3.50	2105	3.20	2783	2.35	1088	2.12
7.5	585	5.15	1507	4.99	2056	3.53	2229	3.24	2944	2.38	1081	2.14

H=C=3 (LPM)	Product is water : T10 = 85°C											
	Section											
	3				1				2			
P	C		P		P		P		P		H	
(LPM)	Water		Water		Water		Water		Water		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	597	5.04	400	5.01	562	3.44	604	3.18	795	2.35	1059	2.23
3	600	5.01	812	4.93	1088	3.56	1179	3.27	1529	2.44	1007	2.31
4	588	5.12	1010	4.96	1348	3.59	1445	3.34	1862	2.51	997	2.34
6	585	5.15	1206	4.99	1577	3.68	1693	3.43	2166	2.60	975	2.39
7	585	5.15	1407	4.99	1817	3.74	1951	3.47	1975	3.43	959	2.43
7.5	585	5.15	1507	4.99	1922	3.81	2065	3.51	2597	2.73	956	2.44

H=C=3 (LPM)	Product is water : T10 = 75°C											
	Section											
	3				1				2			
P	C		P		P		P		P		H	
(LPM)	Water		Water		Water		Water		Water		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	585	5.15	396	5.07	535	3.62	564	3.43	720	2.61	931	2.51
4	582	5.18	792	5.07	1020	3.83	1092	3.54	1375	2.76	903	2.60
5	573	5.28	985	5.09	1254	3.91	1337	3.62	1670	2.85	887	2.66
6	579	5.21	1182	5.09	1471	4.01	1577	3.68	1954	2.92	875	2.70
7	585	5.15	1378	5.09	1593	4.08	1817	3.74	2229	2.99	860	2.76
7.5	567	5.34	1447	5.21	1798	4.12	1905	3.85	2343	3.05	850	2.79

Table 4.5 Experimental conditions for unequal water/water (H = C = 4 and vary P (LPM)).

H=C=4 (LPM)	Product is water : T10 = 98°C											
	Section											
	3				1				2			
P	C		P		P		P		P		H	
(LPM)	Water		Water		Water		Water		Water		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	780	5.15	400	5.01	611	3.14	668	2.03	912	2.03	1596	1.92
3	784	5.12	600	5.01	902	3.20	977	2.92	1341	2.07	1560	1.97
5	788	5.09	1015	4.93	1451	3.33	1580	3.01	2130	2.17	1516	2.03
6	780	5.15	1218	4.93	1714	3.38	1868	3.07	2493	2.23	1481	2.08
7	780	5.15	1421	4.93	1983	3.41	2163	3.10	2873	2.26	1472	2.09
7.5	800	5.01	1553	4.82	2116	3.43	2299	3.13	3021	2.31	1446	2.13
H=C=4 (LPM)	Product is water : T10 = 85°C											
	Section											
	3				1				2			
P	C		P		P		P		P		H	
(LPM)	Water		Water		Water		Water		Water		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	780	5.15	398	5.04	567	3.41	608	3.15	805	2.31	1398	2.21
3	776	5.18	591	5.09	833	3.49	892	3.24	1181	2.37	1377	2.25
5	780	5.15	995	5.04	1337	3.62	1451	3.33	1887	2.48	1334	2.33
6	772	5.21	1188	5.07	1577	3.68	1707	3.40	2204	2.55	1308	2.38
7	764	5.28	1378	5.09	1809	3.77	1951	3.47	2502	2.64	1283	2.43
7.5	764	5.28	1477	5.09	1922	3.81	2073	3.50	2643	2.68	1279	2.43
H=C=4 (LPM)	Product is water : T10 = 75°C											
	Section											
	3				1				2			
P	C		P		P		P		P		H	
(LPM)	Water		Water		Water		Water		Water		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	760	5.31	386	5.21	526	3.68	557	3.47	720	2.61	1250	2.49
3	764	5.28	579	5.21	775	3.77	829	3.50	1065	2.66	1229	2.54
5	756	5.34	965	5.21	1248	3.93	1337	3.62	1695	2.80	1187	2.65
6	748	5.41	1158	5.21	1484	3.97	1577	3.68	1983	2.88	1171	2.69
7	756	5.34	1350	5.21	1701	4.06	1825	3.72	2279	2.92	1158	2.72
7.5	756	5.34	1447	5.21	1806	4.10	1938	3.77	2406	2.97	1154	2.73

Table 4.6 Experimental conditions for unequal water/water (H = C = 5 and vary P (LPM)).

H=C=5 (LPM)	Product is water : T10 = 98°C											
	Section											
	3				1				2			
P	C		P		P		P		P		H	
(LPM)	Water		Water		Water		Water		Water		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	975	5.15	402	4.99	618	3.10	680	2.79	931	1.98	1917	2.01
3	970	5.18	597	5.04	923	3.11	1002	2.85	1380	2.01	2000	1.92
4	985	5.09	800	5.01	1217	3.15	1312	2.90	1804	2.05	1972	1.95
6	985	5.09	1206	4.99	1776	3.26	1925	2.97	2618	2.12	1917	2.01
7	985	5.09	1407	4.99	2040	3.31	2229	2.99	3009	2.15	1900	2.03
7.5	980	5.12	1507	4.99	2185	3.31	2379	3.00	3214	2.15	1895	2.03

H=C=5 (LPM)	Product is water : T10 = 85°C											
	Section											
	3				1				2			
P	C		P		P		P		P		H	
(LPM)	Water		Water		Water		Water		Water		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	965	5.21	402	4.99	571	3.38	618	3.10	811	2.30	1764	2.18
3	975	5.15	597	5.04	367	3.34	909	3.17	1227	2.27	1732	2.23
4	975	5.15	796	5.04	1101	3.51	1198	3.21	1570	2.38	1710	2.26
6	965	5.21	1194	5.04	1625	3.57	1741	3.33	2264	2.48	1657	2.35
7	975	5.15	1393	5.04	1348	3.66	1999	3.38	2571	2.55	1646	2.36
7.5	975	5.15	1492	5.04	1955	3.72	2125	3.41	2717	2.59	1614	2.41

H=C=5 (LPM)	Product is water : T10 = 75°C											
	Section											
	3				1				2			
P	C		P		P		P		P		H	
(LPM)	Water		Water		Water		Water		Water		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	955	5.28	390	5.15	530	3.64	567	3.41	725	2.59	1572	2.48
3	955	5.28	582	5.18	792	3.66	836	3.47	1072	2.64	1551	2.51
4	955	5.28	776	5.18	1020	3.83	1097	3.53	1395	2.71	1530	2.55
6	945	5.34	1152	5.24	1491	3.95	1597	3.63	2012	2.83	1479	2.66
7	940	5.38	1336	5.28	1709	4.03	1840	3.68	2305	2.89	1458	2.70
7.5	935	5.41	1432	5.28	1822	4.06	1955	3.72	2442	2.92	1443	2.73

Table 4.7 Experimental conditions for unequal water/water (H = C = 6 and vary P (LPM)).

H=C=6 (LPM)	Product is water : T10 = 98°C											
	Section											
	3				1				2			
P	C		P		P		P		P		H	
(LPM)	Water		Water		Water		Water		Water		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	1146	5.28	398	5.04	613	3.13	671	2.00	920	2.01	2434	1.89
3	1158	5.21	591	5.09	906	3.18	991	2.88	1364	2.03	2387	1.93
4	1158	5.21	792	5.07	1198	3.21	1302	2.92	1788	2.07	2353	1.96
5	1163	5.18	990	5.07	1457	3.31	1598	2.98	2175	2.12	2300	2.01
7	1169	5.15	1393	5.04	1999	3.38	2195	3.04	2945	2.20	2241	2.06
7.5	1169	5.15	1507	4.99	2125	3.41	2343	3.05	3126	2.22	2235	2.07

H=C=6 (LPM)	Product is water : T10 = 85°C											
	Section											
	3				1				2			
P	C		P		P		P		P		H	
(LPM)	Water		Water		Water		Water		Water		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	1182	5.09	402	4.99	569	3.40	613	3.13	803	2.32	2104	2.20
3	1194	5.04	609	4.93	840	3.46	913	3.15	1189	2.35	2078	2.23
4	1188	5.07	804	4.99	1106	3.50	1198	3.21	1570	2.38	2058	2.26
5	1188	5.07	1015	4.93	1382	3.50	1486	3.24	1937	2.41	2027	2.30
6	1188	5.07	1421	4.93	1903	3.56	2040	3.31	2633	2.48	1988	2.35
7	1194	5.04	1522	4.93	1997	3.63	2177	3.33	2783	2.52	1975	2.36

H=C=6 (LPM)	Product is water : T10 = 75°C											
	Section											
	3				1				2			
P	C		P		P		P		P		H	
(LPM)	Water		Water		Water		Water		Water		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	1110	5.48	380	5.31	524	3.70	557	3.47	720	2.61	1899	2.46
3	1098	5.54	558	5.44	775	3.77	819	3.54	1065	2.66	1862	2.51
4	1116	5.44	752	5.38	1016	3.85	1097	3.53	1410	2.68	1855	2.52
5	1098	5.54	940	5.38	1242	3.95	1343	3.60	1719	2.76	1818	2.58
6	1075	5.68	1302	5.44	1701	4.06	1817	3.74	2313	2.88	1768	2.67
7	1098	5.54	1402	5.41	1822	4.06	1955	3.72	2478	2.88	1762	2.68

Table 4.8 Experimental conditions for unequal water/water (H = C = 7 and vary P (LPM)).

H=C=7 (LPM)	Product is water : T10 = 98°C											
	Section											
	3				1				2			
P	C		P		P		P		P		H	
(LPM)	Water		Water		Water		Water		Water		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	1393	5.04	412	4.85	625	3.05	683	2.78	928	1.99	2855	1.88
3	1400	5.01	618	4.85	927	3.10	1013	2.81	1376	2.01	2824	1.90
4	1407	4.99	820	4.88	1222	3.14	1336	2.85	1814	2.04	2777	1.93
5	1407	4.99	1046	4.77	1515	3.17	1652	2.88	2235	2.07	2738	1.97
4	1421	4.93	1255	4.77	1797	3.21	1961	2.91	2634	2.11	2699	2.00
7.5	1421	4.93	1576	4.74	2211	3.27	2406	2.97	3195	2.17	2653	2.03
H=C=7 (LPM)	Product is water : T10 = 85°C											
	Section											
	3				1				2			
P	C		P		P		P		P		H	
(LPM)	Water		Water		Water		Water		Water		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	1350	5.21	400	5.01	571	3.38	616	3.11	811	2.30	2485	2.17
3	1350	5.21	597	5.04	857	3.38	909	3.17	1204	2.32	2439	2.22
4	1357	5.18	796	5.04	1119	3.46	1208	3.18	1590	2.35	2416	2.24
5	1364	5.15	990	5.07	1382	3.50	1492	3.23	1962	2.38	2386	2.27
6	1371	5.12	1200	5.01	1645	3.53	1776	3.26	2302	2.43	2349	2.31
7.5	1371	5.12	1484	5.07	2005	3.62	2168	3.34	2792	2.51	2275	2.39
H=C=7 (LPM)	Product is water : T10 = 75°C											
	Section											
	3				1				2			
P	C		P		P		P		P		H	
(LPM)	Water		Water		Water		Water		Water		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	1378	5.09	1378	4.93	544	3.56	576	3.36	730	2.57	2216	2.46
3	1378	5.09	603	4.99	802	3.62	853	3.40	1083	2.60	2194	2.48
4	1385	5.07	804	4.99	1060	3.64	1124	3.44	1425	2.65	2165	2.52
5	1378	5.09	1005	4.99	1303	3.72	1399	3.46	1756	2.69	2150	2.54
6	1385	5.07	1200	5.01	1551	3.77	1659	3.50	2078	2.73	2106	2.60
7.5	1336	5.28	1454	5.18	1872	3.93	1997	3.63	2497	2.86	2042	2.70

Table 4.9 Experimental conditions for unequal water/water (H = C = 7.5 and vary P (LPM)).

H=C=7.5(LPM)	Product is water : T10 = 98°C											
	Section											
	3				1				2			
P	C		P		P		P		P		H	
(LPM)	Water		Water		Water		Water		Water		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	1425	5.31	396	5.07	620	3.08	675	2.81	936	1.97	3051	1.88
3	1425	5.31	591	5.09	920	3.13	1002	2.85	1384	2.00	3017	1.90
4	1432	5.28	780	5.15	1208	3.18	1317	2.89	1814	2.04	2992	1.92
5	1447	5.21	1000	5.01	1486	3.24	1628	2.92	2221	2.08	2942	1.96
6	1439	5.24	1194	5.04	1762	3.28	1925	2.97	2618	2.12	2883	2.00
7	1462	5.15	1393	5.04	2040	3.31	2237	2.98	3018	2.14	2842	2.03

H=C=7.5(LPM)	Product is water : T10 = 85°C											
	Section											
	3				1				2			
P	C		P		P		P		P		H	
(LPM)	Water		Water		Water		Water		Water		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	1462	5.15	404	4.96	576	3.36	620	3.08	816	2.28	2662	2.17
3	1454	5.18	597	5.04	850	3.41	920	3.13	1208	2.31	2622	2.21
4	1462	5.09	788	5.09	1124	3.44	1208	3.18	1590	2.35	2581	2.25
5	1447	5.21	995	5.04	1376	3.51	1492	3.23	1950	2.39	2533	2.30
6	1425	5.31	1169	5.15	1611	3.60	1755	3.30	2294	2.44	2509	2.32
7	1417	5.34	1350	5.21	1872	3.62	2023	3.34	2650	2.47	2469	2.36

H=C=7.5(LPM)	Product is water : T10 = 75°C											
	Section											
	3				1				2			
P	C		P		P		P		P		H	
(LPM)	Water		Water		Water		Water		Water		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	1462	5.15	420	4.74	576	3.36	620	3.08	816	2.28	2662	2.17
3	1462	5.15	600	5.01	850	3.41	916	3.14	1201	2.33	2613	2.22
4	1462	5.15	788	5.09	1124	3.44	1208	3.18	1590	2.35	2581	2.25
5	1462	5.15	990	5.07	1376	3.51	1492	3.23	1950	2.39	2549	2.28
6	1417	5.18	1163	5.18	1611	3.60	1748	3.31	2294	2.44	2501	2.33
7	1484	5.07	1407	4.99	1825	3.72	1935	3.50	2416	2.75	2257	2.60

Table 4.10 Experimental conditions for unequal water/water (H = C = 9 and vary P (LPM)).

H=C=9 (LPM)	Product is water : T10 = 98°C											
	Section											
	3				1				2			
P	C		P		P		P		P		H	
(LPM)	Water		Water		Water		Water		Water		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	1718	5.28	402	4.99	623	3.07	683	2.78	939	1.97	3691	1.87
3	1736	5.21	600	5.01	927	3.10	1010	2.82	1388	2.00	3651	1.89
4	1754	5.15	800	5.01	1222	3.14	1332	2.86	1830	2.02	1830	1.92
5	1754	5.15	1010	4.96	1515	3.17	1658	2.87	2261	2.04	3570	1.93
6	1772	5.09	1212	4.96	1797	3.21	1968	2.90	2665	2.08	3530	1.96
7	1754	5.15	1400	5.15	2080	3.24	2271	2.93	3073	2.11	3470	2.00

H=C=9 (LPM)	Product is water : T10 = 85°C											
	Section											
	3				1				2			
P	C		P		P		P		P		H	
(LPM)	Water		Water		Water		Water		Water		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	1674	5.15	390	5.15	569	3.40	616	3.11	821	2.26	3204	2.16
3	1683	5.41	579	5.21	846	3.43	909	3.17	1216	2.30	3175	2.18
4	1701	5.34	768	5.24	1198	3.21	1198	3.21	1596	2.34	3136	2.22
5	1718	5.28	980	5.12	1388	3.49	1492	3.23	1975	2.36	3097	2.25
6	1736	5.21	1182	5.09	1652	3.51	1783	3.24	2340	2.39	3059	2.28
7	1727	5.24	1364	5.15	1919	3.53	2056	3.28	2694	2.43	3021	2.31

H=C=9 (LPM)	Product is water : T10 = 75°C											
	Section											
	3				1				2			
P	C		P		P		P		P		H	
(LPM)	Water		Water		Water		Water		Water		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	1665	5.48	382	5.28	530	3.64	562	3.44	730	2.57	2849	2.46
3	1665	5.48	570	5.31	785	3.70	829	3.50	1072	2.64	2812	2.49
4	1709	5.31	772	5.21	1025	3.72	1110	3.49	1425	2.65	2792	2.51
5	1701	5.34	970	5.18	1292	3.77	1388	3.49	1768	2.67	2774	2.53
6	1709	5.31	1158	5.21	1537	3.81	1645	3.53	2092	2.71	2727	2.58
7	1683	5.41	1350	5.21	1786	3.83	1895	3.57	2398	2.77	2699	2.61

Table 4.11 Experimental conditions for unequal water/water (H = C = 12 and vary P (LPM)).

H=C=12(LPM)	Product is water : T10 = 98°C											
	Section											
	3				1				2			
P	C		P		P		P		P		H	
(LPM)	Water		Water		Water		Water		Water		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	2303	5.24	412	4.85	630	3.02	690	2.75	941	1.96	4961	1.85
3	2303	5.24	612	4.90	934	3.07	1021	2.79	1392	1.99	4881	1.88
4	2315	5.21	804	4.99	1217	3.15	1332	2.86	1824	2.03	4800	1.92
5	2291	5.28	995	5.04	1510	3.18	1652	2.88	2248	2.06	4760	1.93
6	2315	5.21	1206	4.99	1797	3.21	1983	2.88	2665	2.08	4681	1.97
7	2315	5.21	1414	4.96	2105	3.20	2279	2.92	3073	2.11	4627	2.00

H=C=12(LPM)	Product is water : T10 = 85°C											
	Section											
	3				1				2			
P	C		P		P		P		P		H	
(LPM)	Water		Water		Water		Water		Water		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	2279	5.31	398	5.04	573	3.37	618	3.10	818	2.27	4272	2.16
3	2315	5.21	594	5.07	850	3.41	916	3.14	1208	2.31	4233	2.18
4	2315	5.21	800	5.01	1133	3.41	1231	3.11	1611	2.31	4208	2.20
5	2327	5.18	1000	5.01	1411	3.43	1510	3.18	1975	2.36	4143	2.24
6	2327	5.18	1206	4.99	1679	3.46	1804	3.20	2340	2.39	4091	2.27
7	2351	5.12	1407	4.99	1943	3.49	2088	3.23	2694	2.43	4066	2.29

H=C=12(LPM)	Product is water : T10 = 75°C											
	Section											
	3				1				2			
P	C		P		P		P		P		H	
(LPM)	Water		Water		Water		Water		Water		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	2208	5.51	376	5.38	521	3.72	560	3.46	725	2.59	3811	2.45
3	2208	5.51	570	5.31	772	3.79	833	3.49	1076	2.62	3749	2.49
4	2232	5.44	768	5.24	1043	3.72	1119	3.46	1429	2.64	3736	2.50
5	2268	5.34	970	5.18	1303	3.70	1399	3.47	1775	2.66	3698	2.53
6	2256	5.38	1163	5.18	1557	3.74	1659	3.50	2100	2.70	3660	2.56
7	2268	5.34	1357	5.18	1801	3.79	1927	3.51	2424	2.73	3623	2.59

Table 4.12 Experimental conditions for equal syrup/syrup flow rates. (20 wt% concentration).

Equal flow rates H = C = P (LPM)	Section											
Product is sugar solution 20 wt% : T10 = 93°C												
	3				1				2			
	Water		Syrup		Syrup		Syrup		Syrup		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	386	5.21	235	9.41	392	5.36	428	4.88	651	3.12	778	1.93
3	585	5.15	359	9.23	582	5.42	649	4.82	969	3.15	1163	1.98
4	776	5.18	478	9.23	761	5.54	857	4.88	1264	3.22	1542	2.00
5	965	5.21	594	9.29	936	5.63	1050	4.98	1546	3.29	1895	2.03
6	1158	5.21	713	9.29	1118	5.67	1260	4.98	1848	3.31	2274	2.31
Product is sugar solution 20 wt% : T10 = 85°C												
	3				1				2			
	Water		Syrup		Syrup		Syrup		Syrup		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	388	5.18	236	9.35	360	5.89	388	5.42	549	3.74	690	2.24
3	579	5.21	350	9.47	531	5.99	576	5.48	816	3.77	1023	2.27
4	768	5.24	467	9.47	694	6.12	761	5.54	1064	3.37	1355	2.29
5	960	5.24	587	9.41	854	6.23	941	5.60	1306	3.74	1683	2.31
6	1140	5.31	701	9.47	1019	6.26	1124	5.63	1552	3.78	1988	2.35
Product is sugar solution 20 wt% : T10 = 75°C												
	3				1				2			
	Water		Syrup		Syrup		Syrup		Syrup		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	386	5.21	228	9.73	321	6.67	343	6.67	467	4.44	610	2.56
3	579	5.21	348	9.54	489	6.55	489	6.26	697	4.47	918	2.55
4	768	5.24	467	9.47	648	6.59	694	6.12	921	4.51	1212	2.58
5	955	5.28	584	9.47	801	6.67	858	6.19	1129	4.50	1499	2.61
6	1146	5.28	692	9.60	957	6.71	1035	6.16	1355	4.60	1799	2.61

Table 4.13 Experimental conditions for equal syrup/syrup flow rates.(30 wt% concentration).

Product is sugar solution 30 wt% : T10 = 98°C												
Equal flow rates H = C = P (LPM)	Section											
	3				1				2			
	Water		Syrup		Syrup		Syrup		Syrup		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	396	5.07	149	15.36	257	8.49	287	7.54	452	4.67	778	1.98
3	585	5.15	223	15.36	379	8.65	426	7.63	665	4.76	1153	2.00
4	780	5.15	298	15.36	491	8.92	559	7.76	856	4.93	1516	2.03
5	975	5.15	372	15.36	607	9.03	695	7.81	1055	5.01	1884	2.04
6	1163	5.18	444	15.47	724	9.08	824	7.90	1247	5.09	2248	2.06

Product is sugar solution 30 wt% : T10 = 85°C												
Equal flow rates H = C = P (LPM)	Section											
	3				1				2			
	Water		Syrup		Syrup		Syrup		Syrup		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	390	5.15	145	15.81	230	9.54	251	8.70	370	5.75	682	2.27
3	585	5.15	218	15.81	340	9.73	377	8.70	550	5.82	1020	2.28
4	776	5.18	292	15.69	445	9.91	491	8.92	707	6.04	1342	2.31
5	975	5.15	367	15.58	550	10.04	610	8.97	870	6.14	1662	2.34
6	1163	5.18	435	15.81	652	10.16	728	9.03	1033	6.21	1988	2.35

Product is sugar solution 30 wt% : T10 = 75°C												
Equal flow rates H = C = P (LPM)	Section											
	3				1				2			
	Water		Syrup		Syrup		Syrup		Syrup		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	390	5.15	144	15.92	211	10.49	230	9.54	320	6.72	612	2.55
3	576	5.24	215	16.04	303	10.98	338	9.79	462	6.99	912	2.57
4	760	5.31	281	16.40	405	10.98	445	9.91	613	7.03	1208	2.59
5	945	5.34	353	16.28	497	11.20	545	10.10	738	7.32	1494	2.62
6	1128	5.38	418	16.52	596	11.20	648	10.23	881	7.37	1781	2.65

Table 4.14 Experimental conditions for equal syrup/syrup flow rates.(40 wt% concentration).

Product is sugar solution 40 wt% : T10 = 98°C												
Equal flow rates H = C = P (LPM)	Section											
	3				1				2			
	Water		Syrup		Syrup		Syrup		Syrup		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	400	5.01	95	24.86	169	13.42	193	11.69	310	7.10	776	1.98
3	597	5.04	142	25.06	252	13.51	293	11.54	470	7.02	1167	1.98
4	788	5.09	188	25.26	326	13.98	381	11.84	599	7.35	1520	2.03
5	980	5.12	237	25.06	402	14.17	468	12.07	733	7.52	1895	2.03

Product is sugar solution 40 wt% : T10 = 85°C												
Equal flow rates H = C = P (LPM)	Section											
	3				1				2			
	Water		Syrup		Syrup		Syrup		Syrup		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	398	5.04	92	25.88	150	15.28	167	13.61	253	8.77	684	2.26
3	588	5.12	138	25.88	219	15.71	251	13.61	371	8.96	1010	2.31
4	780	5.15	187	25.46	286	16.05	326	13.98	476	9.37	1342	2.31
5	975	5.15	230	25.87	353	16.27	400	13.27	581	9.60	1651	2.35

Product is sugar solution 40 wt% : T10 = 75°C												
Equal flow rates H = C = P (LPM)	Section											
	3				1				2			
	Water		Syrup		Syrup		Syrup		Syrup		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	396	5.07	89	26.72	133	17.34	147	15.60	211	10.62	612	2.55
3	582	5.18	131	27.38	193	17.98	215	16.05	304	11.10	909	2.58
4	772	5.21	177	26.94	252	18.38	288	15.93	395	11.39	1199	2.61
5	960	5.24	219	27.38	313	18.51	351	16.39	482	11.69	1479	2.66

Table 4.15 Experimental conditions for equal glycerine/glycerine flow rates.(40 vol% concentration).

Product is glycerine solution 40 vol% : T10 = 98°C												
Equal flow rates H = C = P (LPM)	Section											
	3				1				2			
	Water		Glycerine		Glycerine		Glycerine		Glycerine		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	416	4.79	135	19.87	232	11.56	265	10.10	416	6.43	787	1.95
3	618	4.85	201	20.01	341	11.77	391	10.28	612	6.57	1170	1.97
4	824	4.85	268	20.01	447	11.98	515	10.40	799	6.70	1547	1.99
5	1015	4.93	328	20.43	545	12.28	629	10.64	963	6.95	1906	2.02
6	1212	4.96	396	20.29	643	12.50	755	10.64	1137	7.06	2287	2.06

Product is glycerine solution 40 vol% : T10 = 85°C												
Equal flow rates H = C = P (LPM)	Section											
	3				1				2			
	Water		Glycerine		Glycerine		Glycerine		Glycerine		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	406	4.93	131	20.43	205	13.05	230	11.63	337	7.74	693	2.23
3	609	4.93	195	20.57	304	13.21	343	11.70	500	8.03	1026	2.26
4	804	4.99	259	20.71	398	13.46	444	12.05	642	8.34	1359	2.23
5	1010	4.96	328	20.43	488	13.71	552	12.13	781	8.57	1678	2.31
6	1218	4.93	383	21.00	575	13.97	654	12.28	927	8.57	2001	2.06

Product is glycerine solution 40 vol% : T10 = 75°C												
Equal flow rates H = C = P (LPM)	Section											
	3				1				2			
	Water		Glycerine		Glycerine		Glycerine		Glycerine		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	406	4.93	128	20.85	188	14.24	203	13.21	286	9.38	621	2.51
3	597	5.04	187	21.44	272	14.79	297	13.54	414	9.70	918	2.55
4	796	5.04	250	21.44	349	15.36	391	13.71	533	10.04	1216	2.57
5	975	5.15	304	22.04	473	15.76	473	14.15	648	10.34	1499	2.61
6	1169	5.15	359	22.25	497	16.17	564	14.24	764	10.52	1775	2.66

Table 4.16 Experimental conditions for equal glycerine/glycerine flow rates.(50 vol% concentration).

Product is glycerine solution 50 vol% : T10 = 98°C												
Equal flow rates H = C = P (LPM)	Section											
	3				1				2			
	Water		Glycerine		Glycerine		Glycerine		Glycerine		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	406	4.93	91	31.66	176	16.45	205	14.16	348	8.32	784	1.96
3	606	4.96	136	31.92	251	17.28	299	14.54	498	8.73	1167	1.98
4	804	4.99	183	31.66	328	17.64	398	14.54	648	8.94	1542	2.00
5	1010	4.96	229	31.66	396	18.28	488	14.84	785	9.22	1906	2.02
6	1194	5.04	272	31.92	475	18.28	577	15.04	931	9.33	2287	2.06

Product is glycerine solution 50 vol% : T10 = 85°C												
Equal flow rates H = C = P (LPM)	Section											
	3				1				2			
	Water		Glycerine		Glycerine		Glycerine		Glycerine		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	404	4.96	89	32.43	153	18.94	174	16.68	271	10.70	695	2.22
3	606	4.96	134	32.43	221	19.64	255	17.04	391	11.11	1023	2.27
4	800	5.01	176	32.95	289	20.07	330	17.52	505	11.47	1355	2.29
5	995	5.04	221	32.69	348	20.81	407	17.77	607	11.92	1678	2.31
6	1138	5.07	259	33.49	417	20.81	482	18.02	724	12.00	1994	2.34

Product is glycerine solution 50 vol% : T10 = 75°C												
Equal flow rates H = C = P (LPM)	Section											
	3				1				2			
	Water		Glycerine		Glycerine		Glycerine		Glycerine		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	404	4.96	86	33.49	133	21.75	149	19.50	220	13.15	621	2.51
3	594	5.07	128	34.03	195	22.24	220	19.78	319	13.60	918	2.55
4	792	5.07	172	33.76	255	22.74	291	19.92	412	14.06	1216	2.57
5	985	5.09	214	33.76	316	22.91	358	20.21	505	14.35	1504	2.60
6	1175	5.12	255	34.03	368	23.60	427	20.36	589	14.74	1799	2.66

Table 4.17 Experimental conditions for equal glycerine/glycerine flow rates. (60 vol% concentration).

Product is glycerine solution 60 vol% : T10 = 98°C												
Equal flow rates H = C = P (LPM)	Section											
	3				1				2			
	Water		Glycerine		Glycerine		Glycerine		Glycerine		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	414	4.82	56	56.27	106	30.03	126	25.18	213	14.93	780	1.97
3	606	4.96	83	57.20	152	31.36	187	25.53	310	15.40	1170	1.97
4	804	4.99	111	57.20	200	31.82	244	26.07	398	15.98	1533	2.01
5	1005	4.99	139	57.20	239	33.24	296	26.81	467	17.02	1895	2.03

Product is glycerine solution 60 vol% : T10 = 85°C												
Equal flow rates H = C = P (LPM)	Section											
	3				1				2			
	Water		Glycerine		Glycerine		Glycerine		Glycerine		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	392	5.12	50	63.16	84	37.72	100	31.82	159	20.01	678	2.29
3	588	5.12	77	61.60	127	37.44	152	31.36	235	20.28	1061	2.29
4	780	5.15	104	61.09	167	38.01	200	31.82	303	20.96	1342	2.31
5	970	5.18	130	61.09	203	39.18	244	32.52	362	21.97	1641	2.37

Product is glycerine solution 60 vol% : T10 = 75°C												
Equal flow rates H = C = P (LPM)	Section											
	3				1				2			
	Water		Glycerine		Glycerine		Glycerine		Glycerine		Water	
	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr	Re	Pr
2	408	4.90	54	59.11	81	39.48	91	34.75	131	24.32	608	2.57
3	600	5.01	79	60.09	121	39.48	136	35.01	195	24.49	918	2.55
4	800	5.01	106	60.09	154	41.33	178	35.80	247	25.71	1199	2.61
5	960	5.24	126	63.16	185	42.95	215	36.88	301	26.43	1484	2.65