CHAPTER 4

EXPERIMENTAL RESULTS AND DISCUSSIONS

To study the individual effects of temperature, pressure and space velocity, each variable was studied while the remaining were kept constant. It was not easy to control exactly the feed rate of n-hexane in each of the experimental runs. On the other hand, the results shown in Table 4 and plotted in Figure 4a, Figure 4b and Figure 4c, which were summarized from Run Data No.11-1 to 11-5 and Run Data No.12-1 to 12-5 in Appendix A showed that the molar ratio of hydrogen to n-hexane in the feed did not noticeably affect the conversion of n-hexane. Therefore, the observed of n-hexane conversion and product selectivity could be discussed and compared among various experimental conditions.

4.1 EXPERIMENTAL RESULTS AND DISCUSSIONS FOR MORDENITE

a. Effect of Reaction Temperature

i) Effect of Temperature on Total Conversion of n-Hexane

Based on the experimental data of runs

Table 4. EFFECT OF REACTION TEMPERATURE ON n-HEXANE CONVERSION AND PRODUCT SELECTIVITIES

EXPERIMENTAL CONDITIONS :

P = 60 atg.

SV = 4000 hr^{-1}

TEMPERATURE	CONVERSION (%)		SELECTIVITY (%)			
			LPG		GASOLINE	
(°C)	H_2:N-C_6 = 38.04	H_2:N-C_6 = 57.94	H_2:N-C_6 = 38.04	H_2:N-C_6 = 57.94	H_2:N-C_6 = 38.04	H_2:N-C_6 = 57.94
260	3.42	4.12	10.50	13.28	89.89	84.83
280	14.56	11.28	17.02	17.86	79.71	78.94
300	49.06	43.02	30.78	22.04	65.53	75.27
320	94.97	93.53	74.99	69.28	20.85	27.05
340	98.70	98.69	88.23	87.62	6.79	7.45

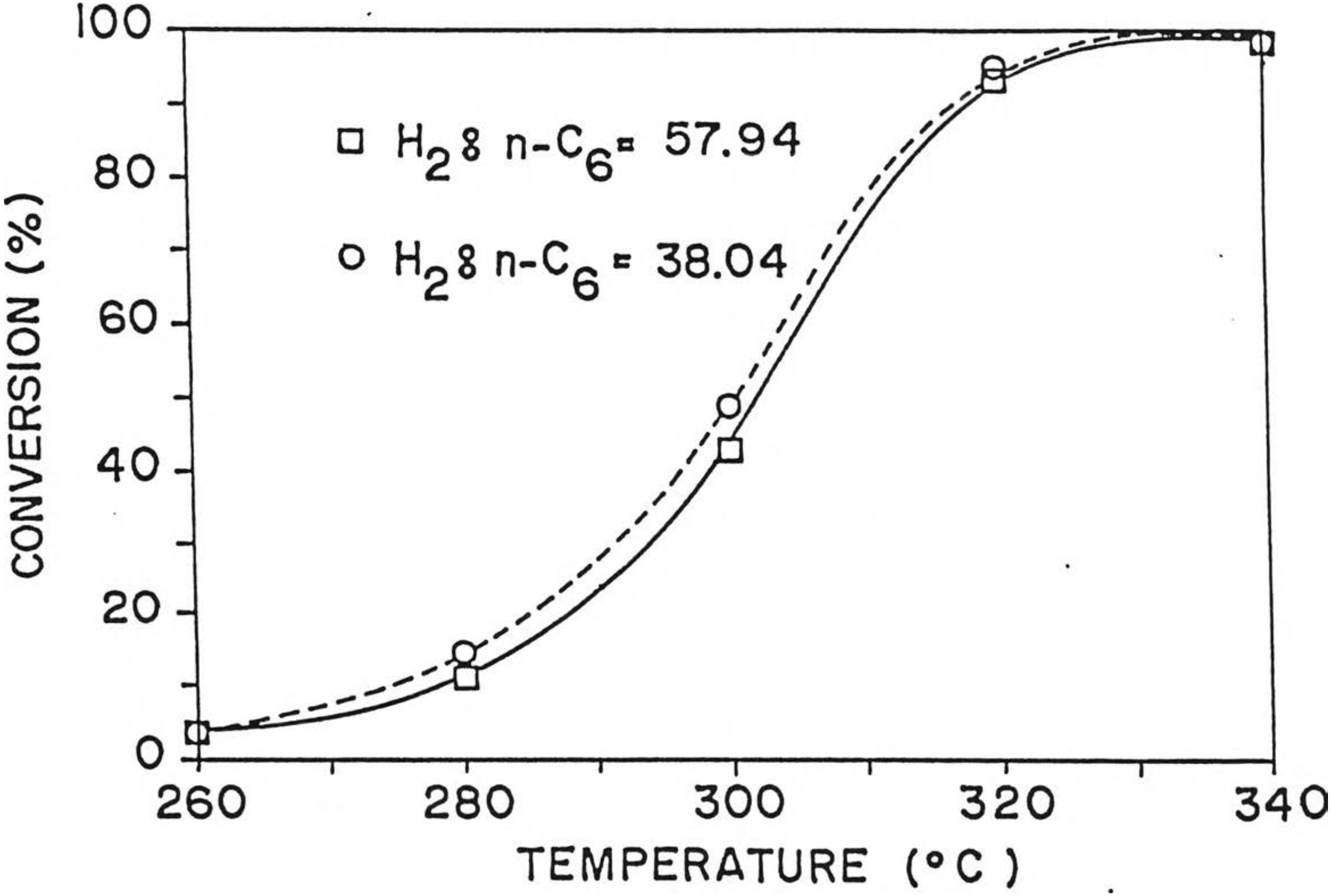

Figure 4a n-Hexane Conversion VS. Temperature of H-Mordenite Catalyst for P = 60 atg. ; Molar Ratio of H_2 : n-C_6 in Feed = 38.04, 57.94 ; SV. = 4000 hr^{-1}

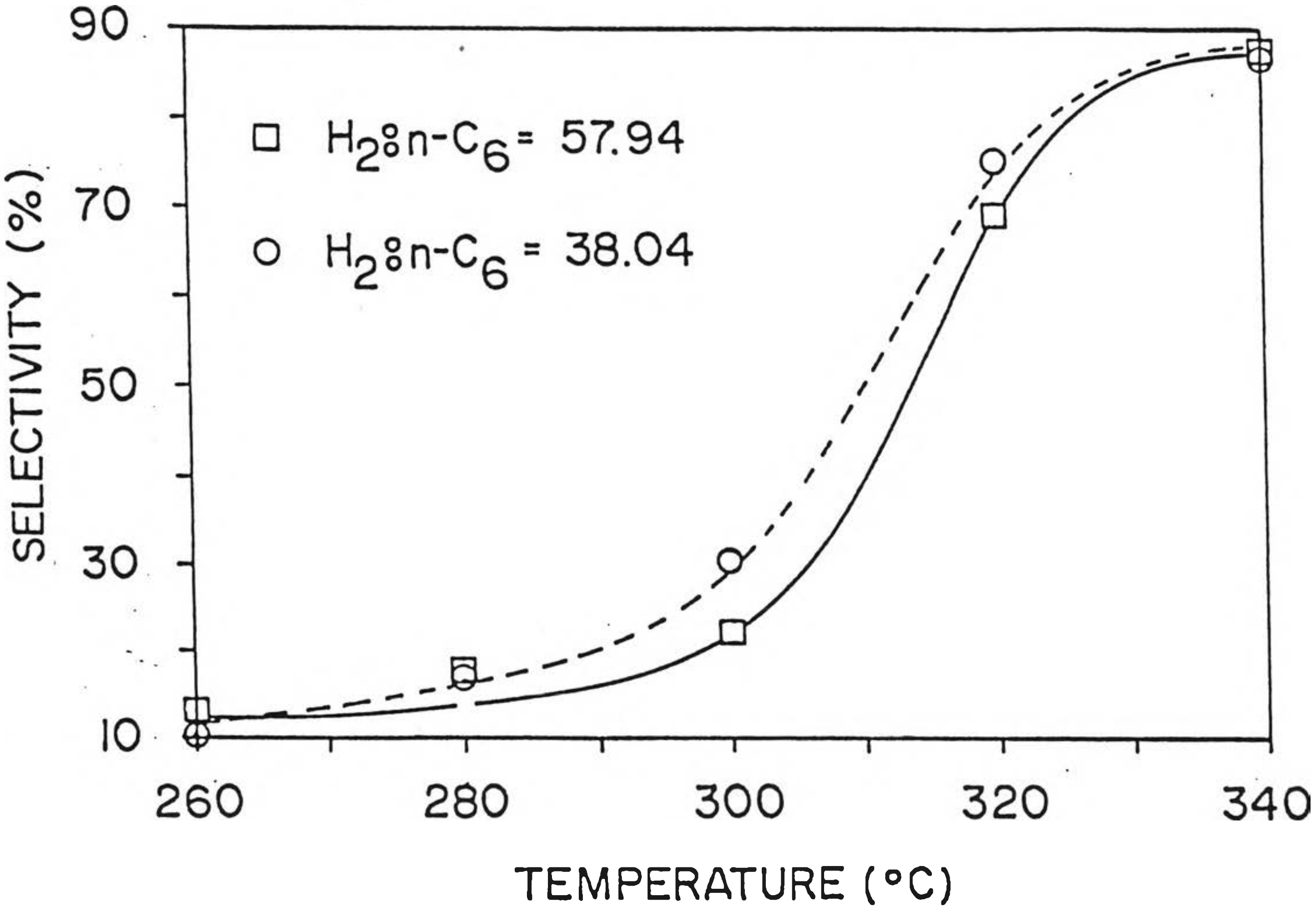

Figure 4b LPG Selectivity VS. Temperature of H-Mordenite Catalyst for P = 60 atg ; Molar Ratio of H_2 : n-C_6 in Feed = 38.04, 57.94 ; SV. = 4000 hr^{-1}

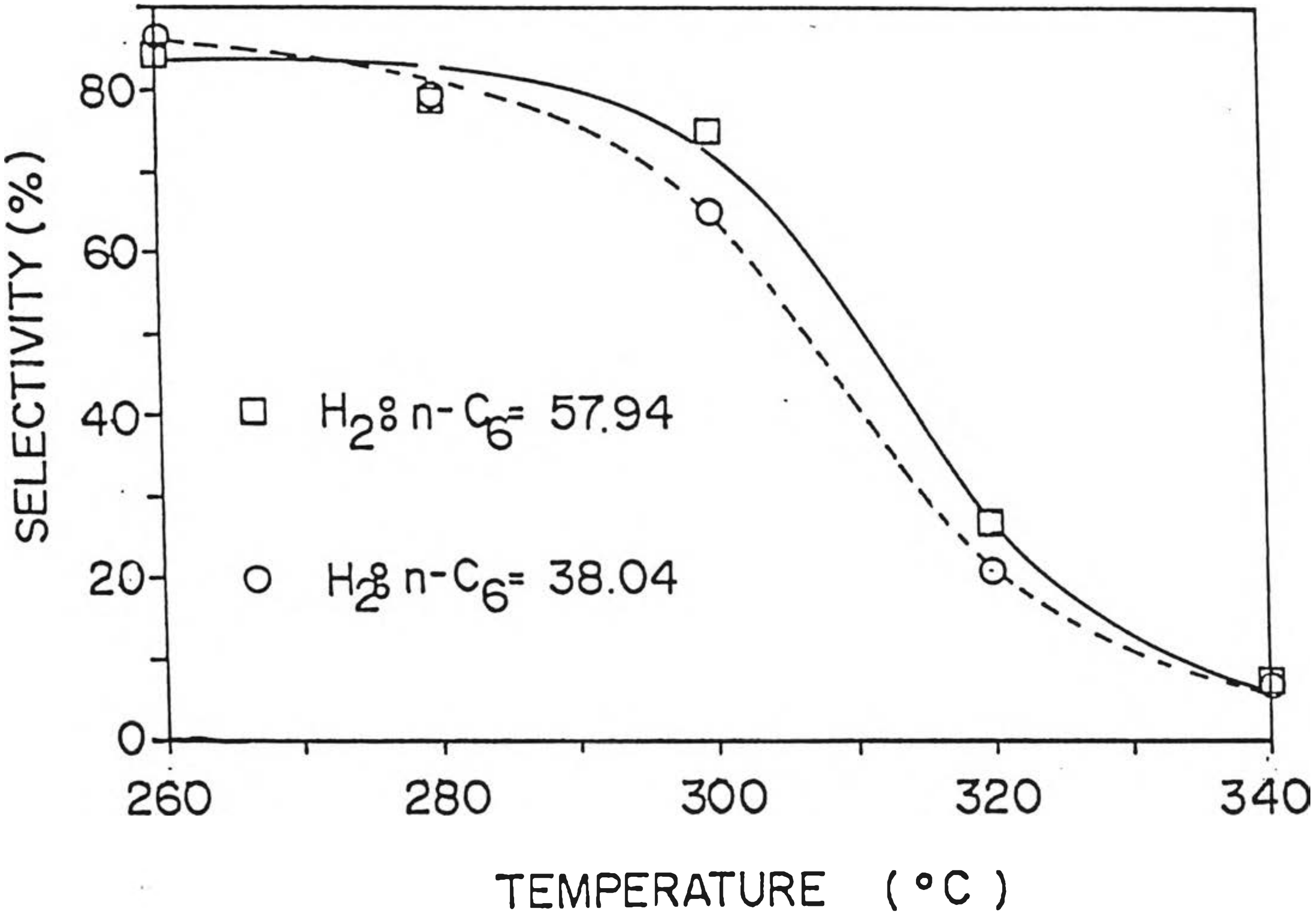

Figure 4c Gasoline Selectivity VS. Temperature of H-Mordenite Catalyst for P = 60 atg ; Molar Ratio H_2 : n-C_6 in Feed = 38.04, 57.94 ; SV. = 4000 hr^{-1}

Table 4-1 A Summary of the Effect of Temperature on the Total Conversion of n-Hexane

H-Mordenite Catalyst

Total Space Velocity = 4000 hr^{-1}

Temperature	Conversion (%)		
(°C)	p = 30 atg	P = 50 atg	P = 95 atg
260	16.40	5.61	6.19
280	75.36	27.56	19.22
300	93.22	79.68	45.80
320	97.47	97.03	81.78
340	98.22	98.90	98.22

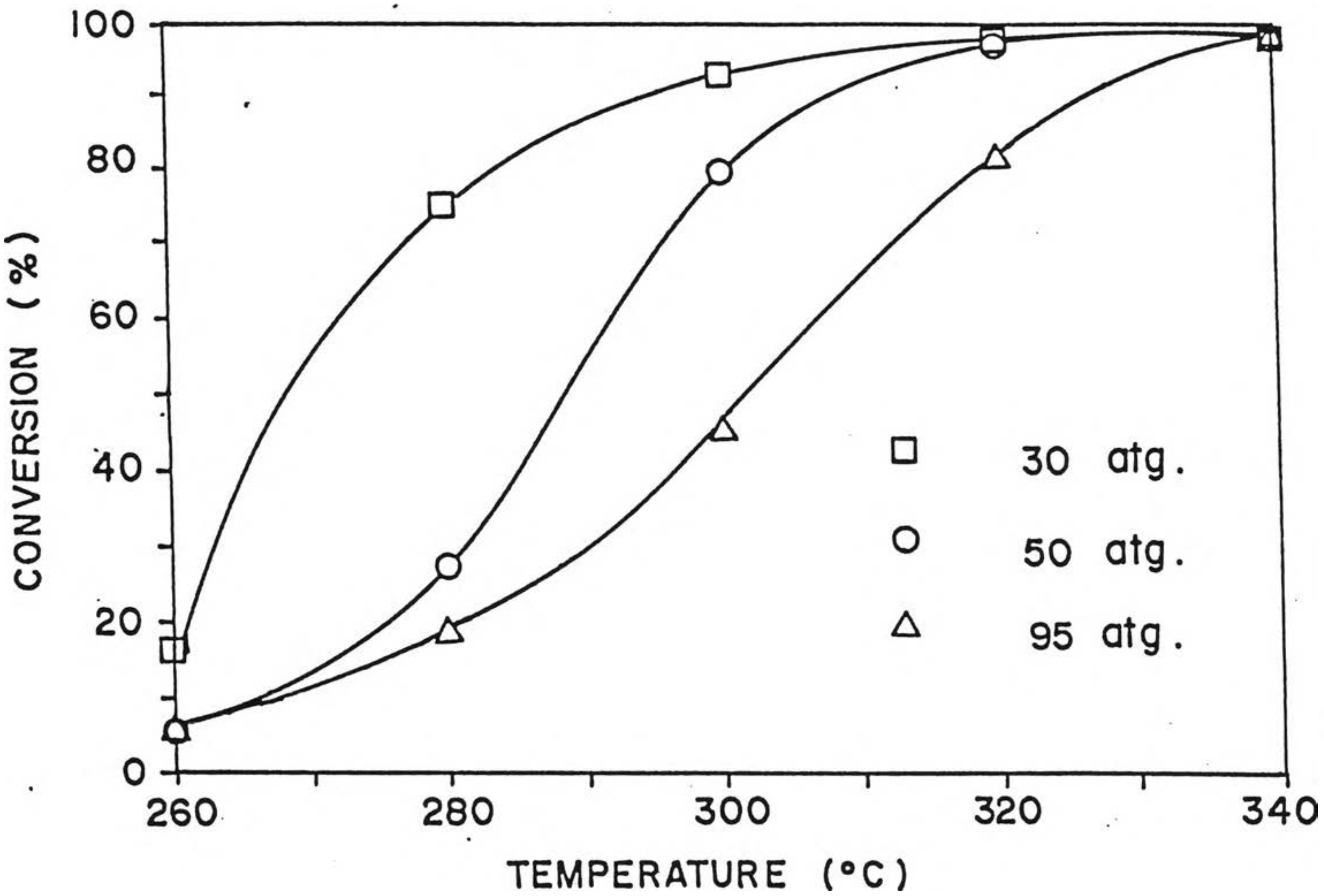

Figure 4-1 n-Hexane Conversion VS. Temperature of H-Mordenite Catalyst for

P = 30, 50, 95 atg ; SV. = 4000 hr^{-1}

no.1-1 to 1-5, 2-1 to 2-5 and 3-1 to 3-5 in Appendix A, a summary is made as shown in Table 4-1. A plot of total conversion, based on the n-hexane converted, versus temperature is shown in Figure 4-1. The obtained results show that at each fixed pressure, the conversion rose as temperature increased by 20 degrees celsius from 260°C to 340°C. On the other hand, the rate of increase of conversion slowed down as the temperature increased, as evident from the decreasing slope of the curves in Figure 4-1.

ii) Effect of Temperature on Product Selectivities

The product selectivities observed from the hydrocracking of n-hexane using H-mordenite catalyst can be divided into two product groups, namely, the selectivity for LPG (consisting of propane, n-butane and iso-butane) and the selectivity for gasoline (consisting of n-pentane, iso-pentane, 2,2-dimethylbutane (2,2-DMB), 2,3-dimethylbutane (2,3-DMB), 2-methylpentane (2-MP) and 3-methylpentane (3-MP)

To illuminate the effect of temperature on the above two types of selectivities, the observed selectivities at three fixed pressures are summarized in Table 4-2 and Table 4-3, and shown graphically in Figure 4-2 and Figure 4-3.

Table 4-2 reveals that as temperature rose, the selectivity for LPG also increased while selectivity

Table 4-2 **Effect of Temperature on LPG Selectivity**

H-Mordenite Catalyst

Total Space Velocity = 4000 hr^{-1}

Temperature (°C)	LPG Selectivity (%) P = 30 atg	P = 50 atg	P = 95 atg
260	6.12	6.22	11.08
280	55.08	11.60	10.65
300	77.90	67.35	16.59
320	87.15	81.48	48.91
340	92.02	89.79	92.10

Table 4-3 Effect of Temperature on Gasoline Selectivity

H-Mordenite Catalyst

Total Space Velocity = 4000 hr^{-1}

Temperature	Gasoline Selectivity (%)		
(°C)	P = 30 atg	P = 50 atg	P = 95 atg
260	93.18	92.86	87.85
280	43.91	87.06	87.31
300	20.53	41.26	80.63
320	10.68	15.63	46.59
340	5.02	6.15	4.93

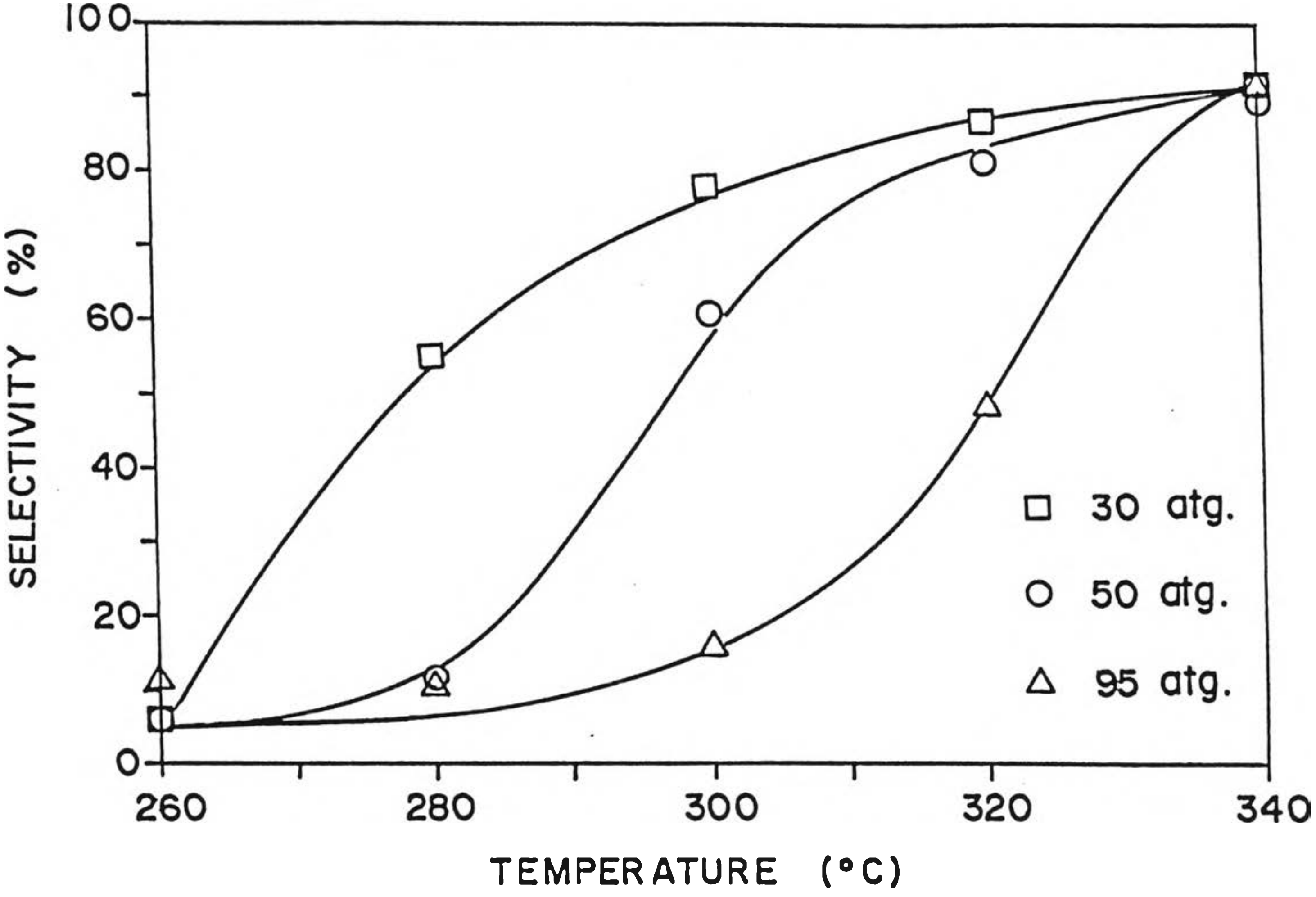

Figure 4-2 LPG Selectivity VS. Temperature of H-Mordenite Catalyst for P = 30, 50, 95 atg ; SV. = 4000 hr^{-1}

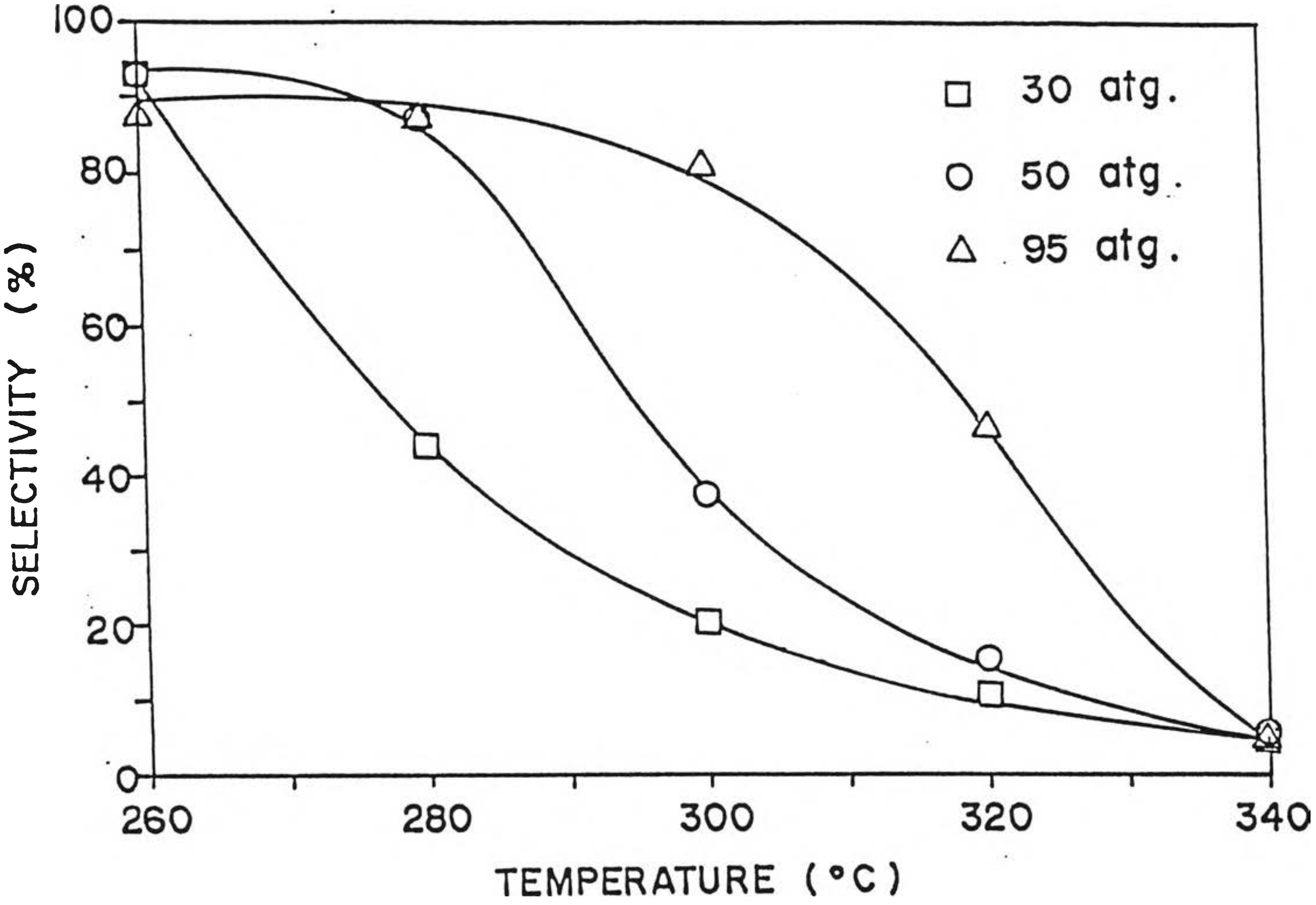

Figure 4-3 Gasoline Selectivity VS. Temperature of H-Mordenite Catalyst for P= 30, 50, 95 atg ; SV. = 4000 hr^{-1}

for gasoline dropped (see Table 4-3). This means that the hydrocracking of n-hexane occurred preferentially to the isomerization of n-hexane. Figure 4-4, Figure 4-5 and Figure 4-6 show the product distribution at 30, 50 and 95 atg, respectively. The figures show that the increase in lighter products, especially propane, at a high temperature was accompanied by a decrease in C_5paraffins and C_6 paraffins (excluding n-hexane).

iii) Effect of Temperature on Space Time Yield

As in the case of product selectivity, space time yield (STY) was based on two product groups. One was the STY of LPG and the other, the STY of gasoline.

A seen from Table 4-4 and the corresponding Figure 4-7, the STY of LPG increased as reaction temperature soared. Table 4-5 summarizes and Figure 4-8 shows graphically the STY of gasoline versus temperature. The observed STY of LPG and STY of gasoline revealed different temperature dependency. The STY of gasoline first increased but subsequently dropped after reaching a peak, which corresponds to the optimum point for the STY of gasoline. The above results also show that the optimum temperature shifted higher as the reaction pressure rose.

b. Effect of Reaction Pressure

i) Effect of Pressure on Total Conversion

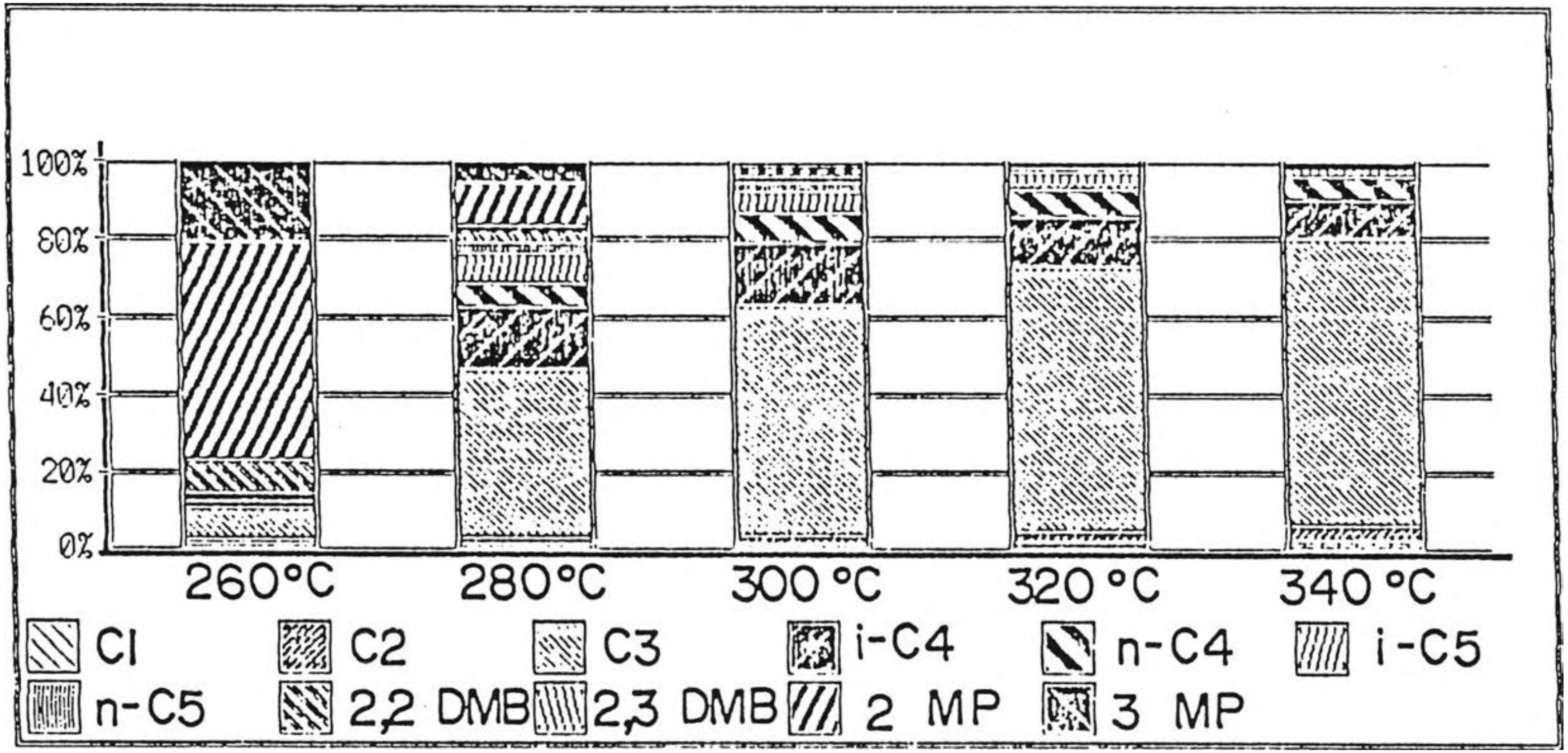

Figure 4-4 Product Distribution VS. Temperature of H-Mordenite Catalyst for $P = 30$ atg ; SV. = 4000 hr^{-1}

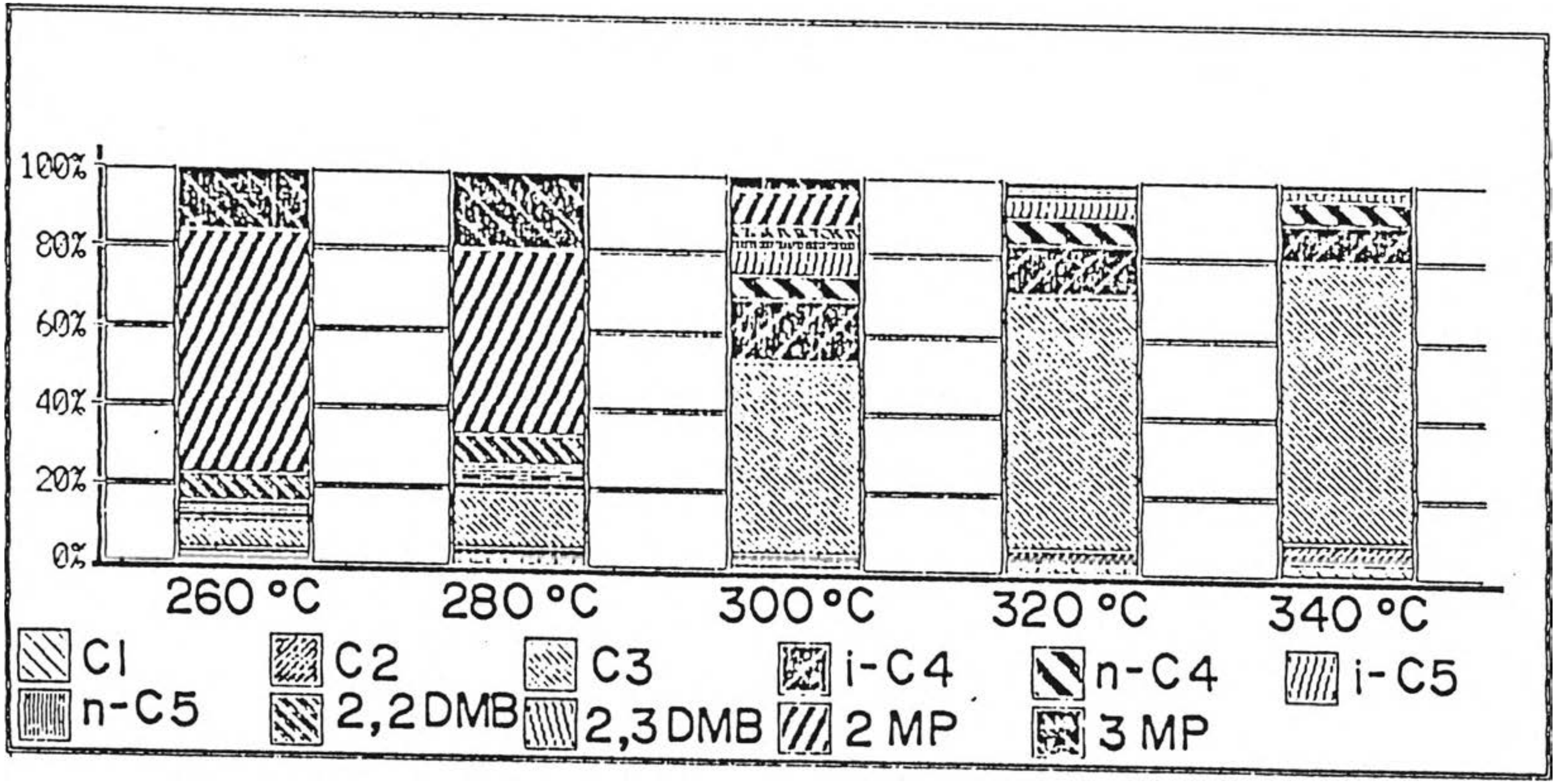

Figure 4-5 Product Distribution VS. Temperature of H-Mordenite Catalyst for $P = 50$ atg ; SV. = 4000 hr^{-1}

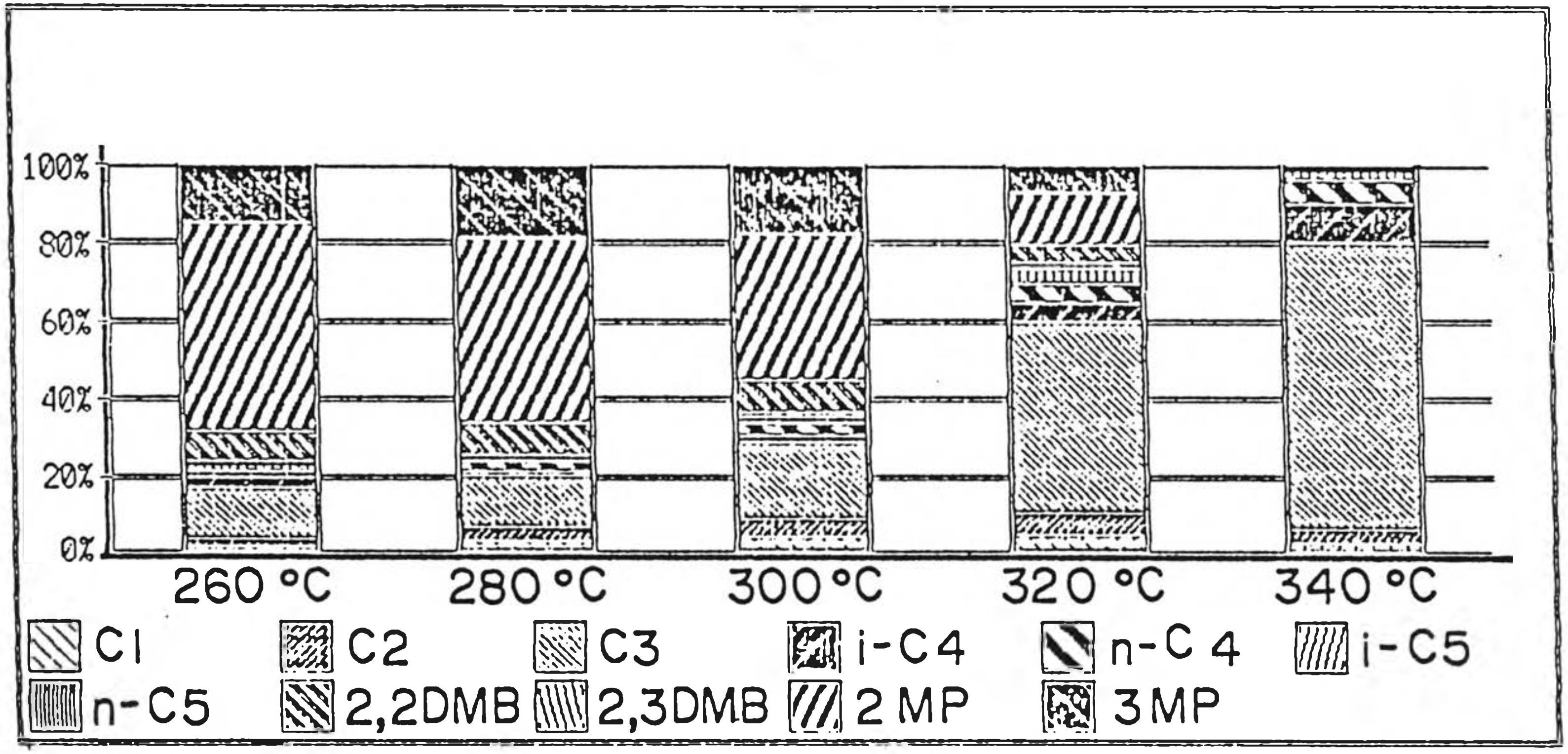

Figure 4-6 Product Distribution VS. Temperature of H-Mordenite Catalyst for P = 95 atg ; SV. = 4000 hr^{-1}

Table 4-4 Effect of Temperature on the STY of LPG

H-Mordenite Catalyst

Total Space Velocity = 4000 hr^{-1}

Temperature	STY of LPG (cm^3/cm^3hr)		
(°C)	P = 30 atg	P = 50 atg	P = 95 atg
260	0.87	0.36	0.86
280	36.11	3.32	2.55
300	63.18	55.70	9.47
320	73.90	82.06	49.86
340	78.63	92.10	112.78

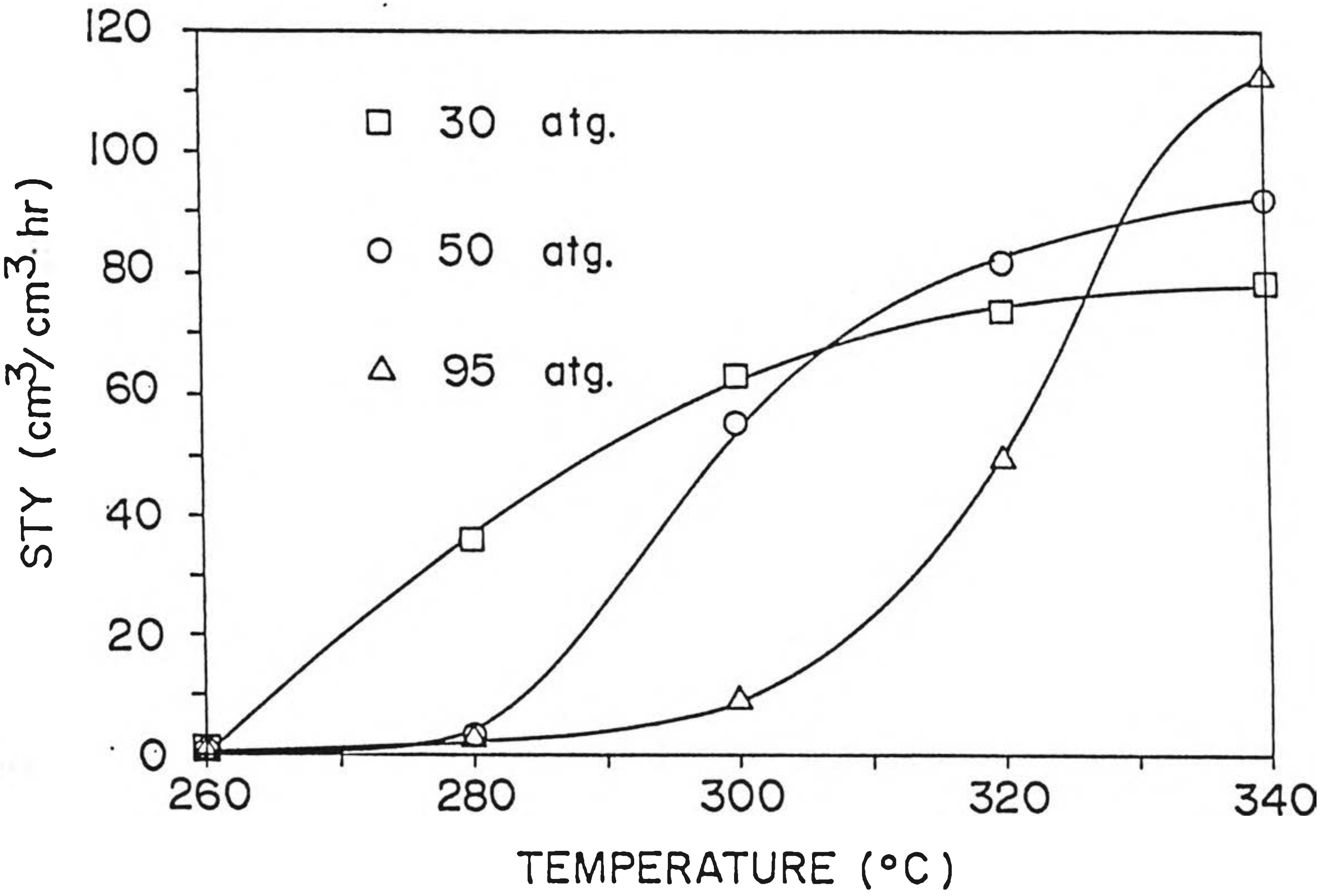

Figure 4-7 STY of LPG VS. Temperature of H-Mordenite Catalyst for P = 30, 50, 95 atg ; SV. = 4000 hr^{-1}

Table 4-5 Effect of Temperature on the STY of Gasoline

H-Mordenite Catalyst

Total Space Velocity = 4000 hr^{-1}

Temperature	STY of Gasoline (cm^3/cm^3hr)		
(°C)	P = 30 atg	P = 50 atg	P = 95 atg
260	13.29	5.40	6.78
280	28.78	24.91	20.92
300	16.65	34.12	46.03
320	9.06	15.74	47.50
340	4.29	6.31	6.04

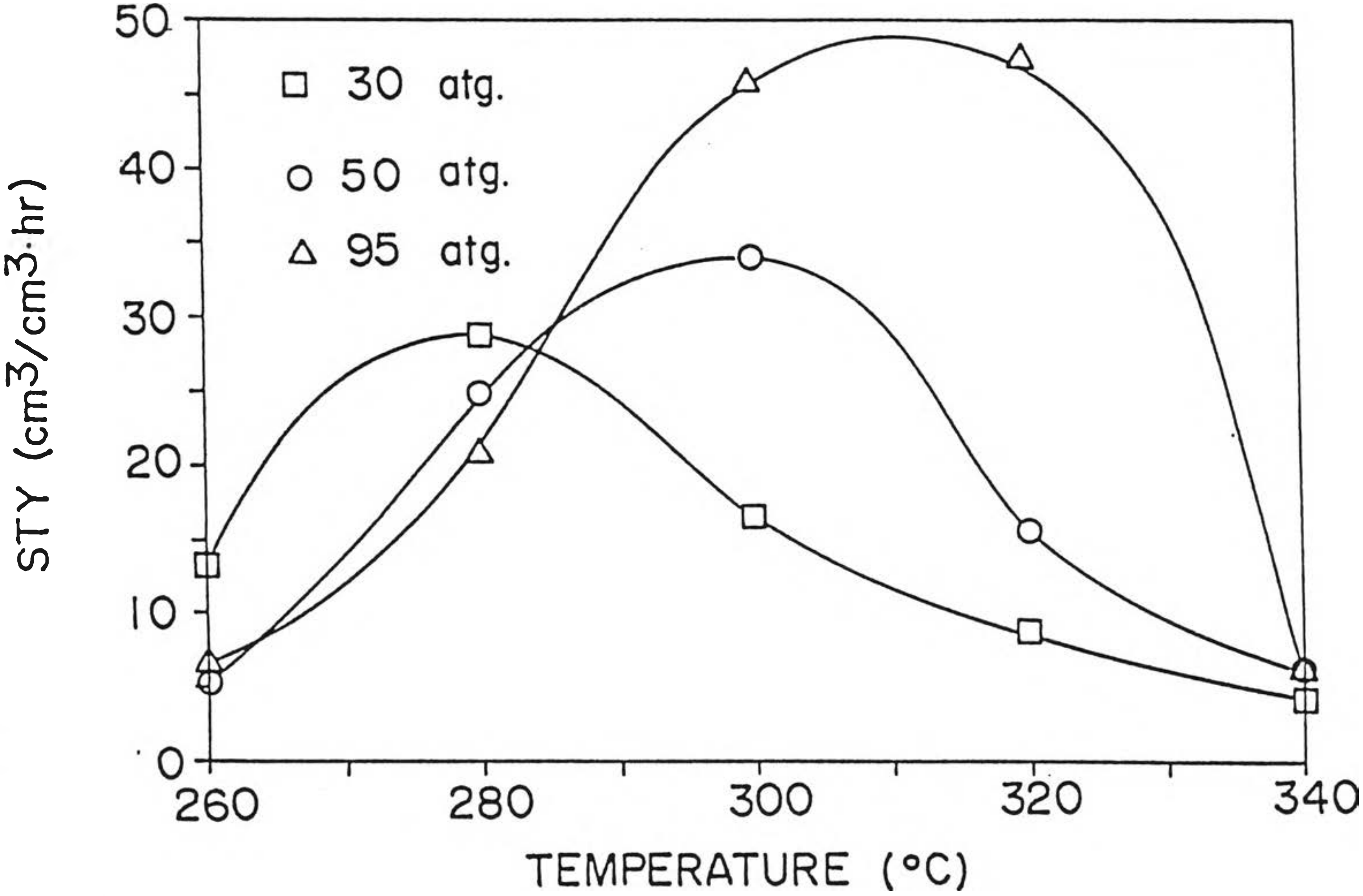

Figure 4-8 STY of Gasoline VS. Temperature of H-Mordenite Catalyst for P = 30, 50, 95 atg ; SV. 4000 hr^{-1}

of n-Hexane

Three pressures, i.e. 30, 50 and 95 atg, of n-hexane using H-mordenite catalyst because of the following reasons :

1) The pressure of 50 atg is the middle of the design pressure of the reactor set.

2) To investigate the effect of pressure on the hydrocracking reaction, therefore, a lower and a higher pressure should be chosen.

3) The pressure of 95 atg was reasonable in terms of safety as the maximum design pressure is 100 atg.

4) 30 atg was chosen to see how the hydrocracking reaction of n-hexane behaved at a relatively low pressure.

Table 4-1 shows the effect of pressure on the total conversion of n-hexane, which was shown graphically in Figure 4-1. When other conditions were kept constant, the effect of pressure on n-hexane conversion was remarkable at 280°C and 300°C but not so above 320°C. Especially at 340° C the effect of pressure was indistinguishable since almost all n-hexane was converted.

ii) Effect of Pressure on Product Selectivities

As seen from Table 4-2 and Figure 4-2, the selectivity for LPG dropped as pressure increased while the reaction temperature ranged from 280°C to 320°C.

On the contrary, within the above range of temperature, the selectivity for gasoline increased as the pressure increased (see Table 4-3 and Figure 4-3). At 260°C and 340°C, however, the pressure had little effect on the selectivity for gasoline.

iii) Effect of Pressure on Space Time Yield

Both the STY of LPG and STY of gasoline were affected by pressure, as revealed by Table 4-4 and Figure 4-7 for the effect of pressure on the STY of LPG, and by Table 4-5 and Figure 4-8 for the effect of pressure on the STY of gasoline. At a low reaction pressure, the optimum temperature was low and as the pressure rose, the optimum temperature tended to shift to a higher value.

c. Effect of Space Velocity

i) Effect of Space Velocity on Total Conversion of n-Hexane

The experimental data of Run No.2-1 to 2-5, 3-1 to 3-5 and 4-1 to 4-5 were summarized in Table 4-6 in order to illustrate the effect of space velocity on the total conversion of n-hexane.

Figure 4-9 then graphically shows the effect of space velocity on the total conversion. When other conditions were kept constant, the observed conversions at SV. 2,000 hr^{-1} and 4,000 hr^{-1} were not different, except at

Table 4-6 Effect of Space Velocity on Total Conversion of n-Hexane

Operating Pressure = 50 atg.

H-Mordenite Catalyst

Temperature	Conversion (%)		
(°C)	SV = 2000 hr^{-1}	SV = 4000 hr^{-1}	SV = 8000 hr^{-1}
260	3.79	5.61	3.98
280	54.82	27.56	17.89
300	88.04	79.68	52.82
320	97.04	97.03	54.10
340	99.28	98.90	57.11

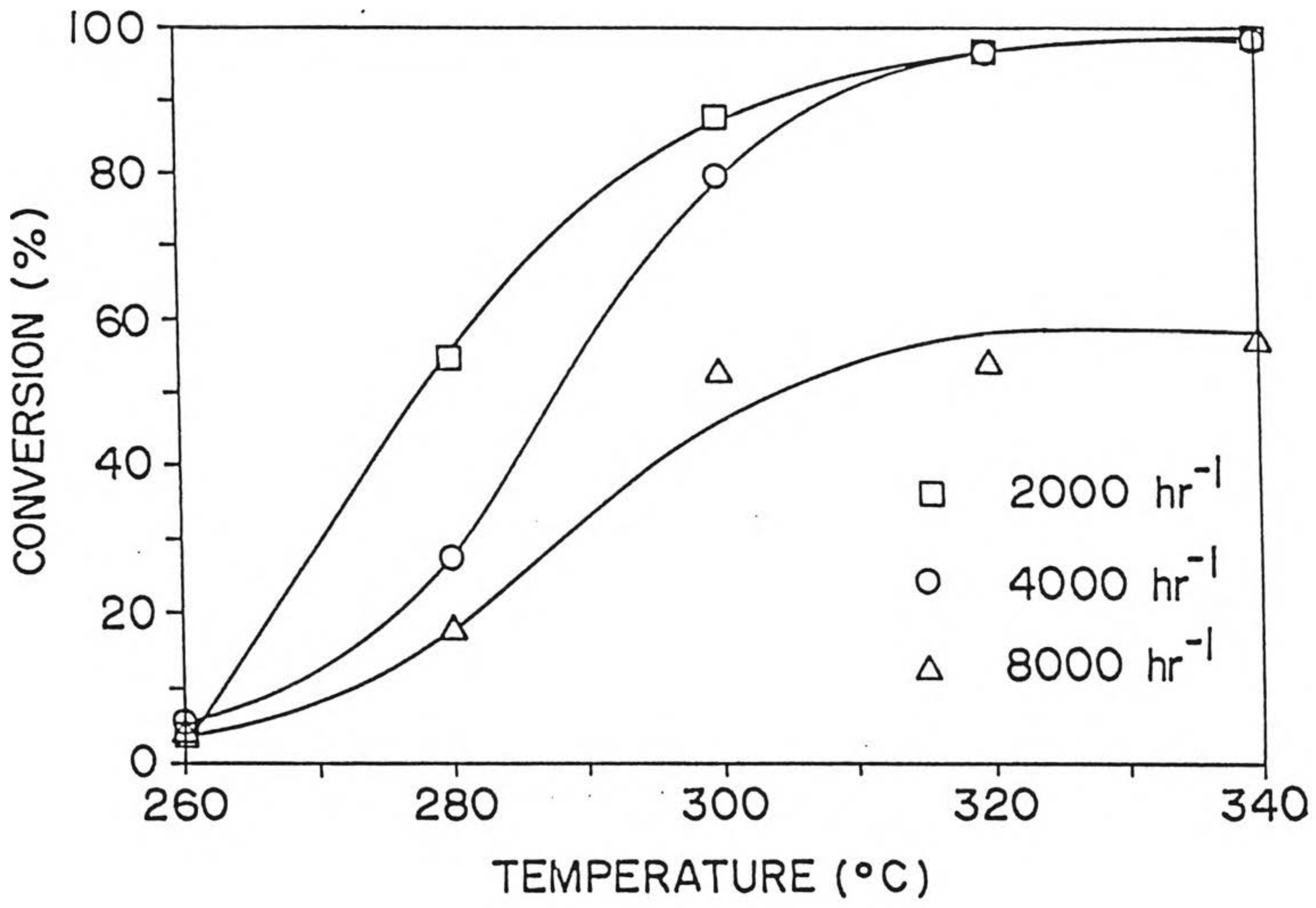

Figure 4-9 n-Hexane Conversion VS. Temperature of H-Mordenite Catalyst for P = 50 atg ; SV. = 2000, 4000, 8000 hr^{-1}

280° C.

Comparison of the results at SV 8,000 hr^{-1} with the other two SV's shows that the conversion at 8,000 hr^{-1} was lowest, except at 260° C

ii) Effect of Space Velocity on Product Selectivities

Based on the experimental data of Runs No.2-1 to 2-5, 3-1 to 3-5 and 4-1 to 4-5 in Appendix A, Table 4-7 and Table 4-8 summarize the selectivity for LPG and selectivity for gasoline at three different space velocities. The selectivity for LPG clearly depended upon the total conversion of n-hexane. In other words, the higher the n-hexane conversion, the more the LPG, especially propane. Figure 4-10 and Figure 4-11 show the product distribution for the cases of 50 atg and 2,000 hr^{-1}, and 50 atg and 8,000 hr^{-1}, respectively.

A comparison between Table 4-7 and Table 4-8 reveals an interesting correlation between LPG selectivity and gasoline selectivity. When LPG selectivity rose, gasoline selectivity dropped. Therefore, more LPG was found in the products when n-hexane conversion was high.

iii) Effect of Space Velocity on STY

Table 4-9 and Table 4-10 summarize the effect of space velocity on the STY of LPG and gasoline, respectively. Generally, a maximum STY of LPG was observed

Table 4-7 Effect of Space Velocity on LPG Selectivity

Operating Pressure = 50 atg.

H-Mordenite Catalyst

Temperature	LPG Selectivity (%)		
(°C)	SV = 2000 hr^{-1}	SV = 4000 hr^{-1}	SV = 8000 hr^{-1}
260	62.62	6.22	6.09
280	54.85	11.60	6.02
300	55.20	67.35	38.22
320	88.32	81.48	49.71
340	93.46	89.79	56.10

Table 4-8 Effect of Space Velocity on Gasoline Selectivity

Operating Pressure = 50 atg.

H-Mordenite Catalyst

Temperature	Gasoline Selectivity (%)		
(°C)	SV = 2000 hr^{-1}	SV = 4000 hr^{-1}	SV = 8000 hr^{-1}
260	35.28	92.86	93.37
280	44.08	87.06	93.28
300	33.84	41.26	60.84
320	8.13	15.63	48.86
340	1.31	6.15	42.48

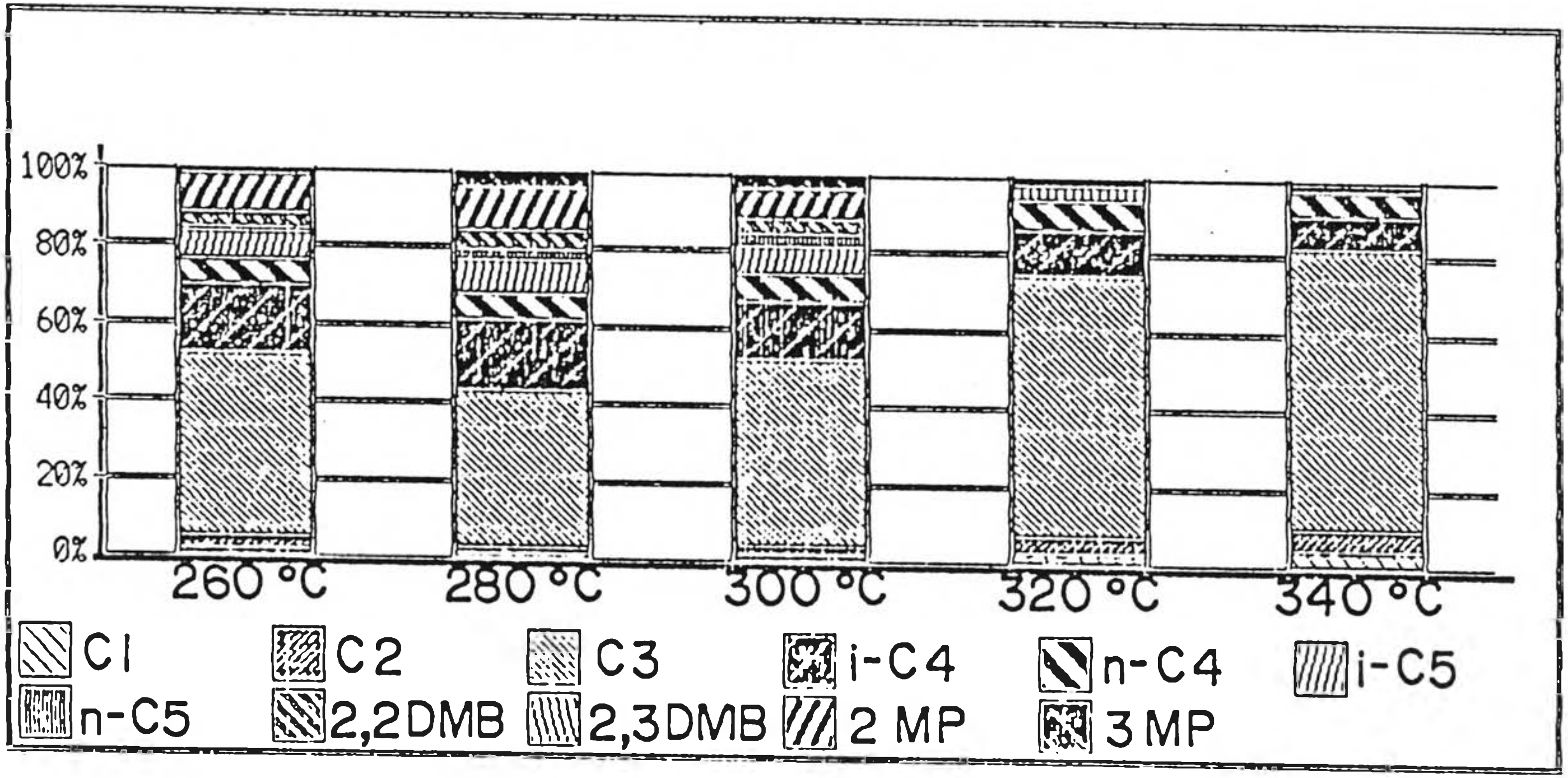

Figure 4-10 Product Distribution VS. Temperature of H-Mordenite Catalyst for $p = 50$ atg ; SV. = 2000 hr^{-1}

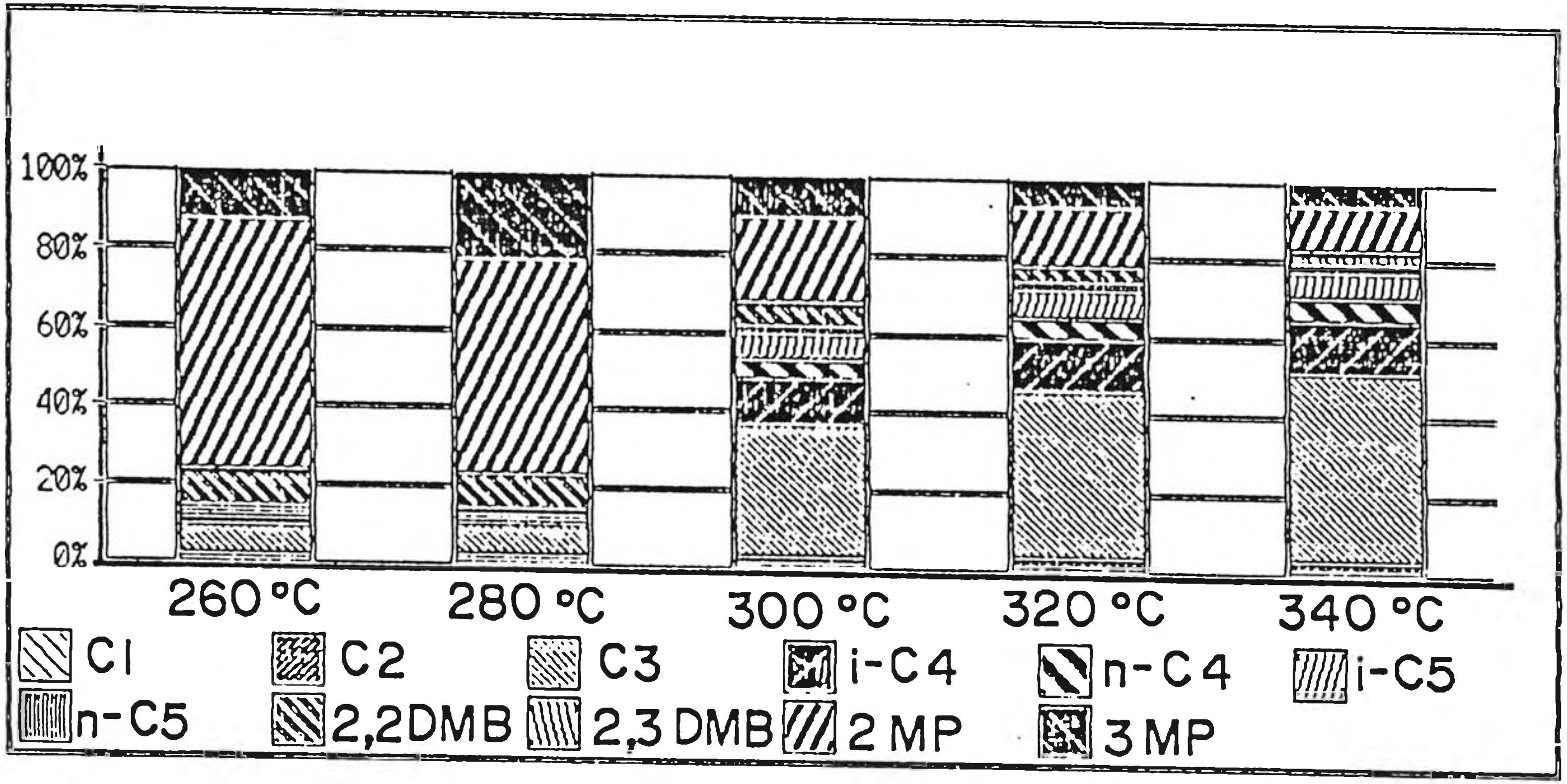

Figure 4-11 Product Distribution VS. Temperature of H-Mordenite Catalyst for $P = 50$ atg ; SV. = 8000 hr^{-1}

Table 4-9 Effect of Space Velocity on the STY of LPG

H-Mordenite Catalyst

Operating Pressure : 50 atg.

Space Velocity : 2000 4000 8000 hr^{-1}

N-Hexane Feed Rate : 207.58 116.82 488.55 cm^3/hr

Temperature (°C)	STY of LPG (cm^3/cm^3hr) SV = 2000 hr^{-1}	 SV = 4000 hr^{-1}	 SV = 8000 hr^{-1}
260	1.39	0.36	0.59
280	17.56	3.32	2.63
300	28.39	55.70	49.31
320	50.06	82.06	65.69
340	54.20	92.10	78.26

Table 4-10 Effect of Space Velocity on the STY of Gasoline.

H-Mordenite Catalyst

Operating Pressure : 50 atg.

Space Velocity : 2000 4000 8000 hr^{-1}

N-Hexane Feed Rate : 207.58 116.82 488.55 cm^3/hr

Temperature	STY of Gasoline (cm^3/cm^3hr)		
(°C)	SV = 2000 hr^{-1}	SV = 4000 hr^{-1}	SV = 8000 hr^{-1}
260	0.70	5.40	9.07
280	14.11	24.91	40.75
300	17.40	34.12	78.49
320	4.61	15.74	64.57
340	0.76	6.31	59.26

at 340° C, the upper temperature limit in the experiment. A moderate SV, around 4,000 hr^{-1} appeared to give the global maximum STY of LPG. As for the STY of gasoline, moderate temperature around 300° C and the highest SV gave the global maximum.

d. Deactivation of the Mordenite Catalyst

To see how the activity of the H-mordenite catalyst in the hydrocracking of n-hexane drop with time, after the whole series of experimental runs had been completed, a final run under the same experimental conditions as the first run was repeated. Table 4-11 and Figure 4-12 compared the observed n-hexane conversion between the fresh and used catalysts. Obviously the n-hexane conversion of the used H-mordenite catalyst after about ninety hours in operation was less than half that of the fresh one. By the way the product distribution belonging to the used catalyst was shown in Figure 4-13 based on detailed data obtained in Run data No. 6-1 to 6-5 in Appendix A. Table 4-11 also showed the different in Selectivity for both LPG and gasoline between the fresh and used H-mordenite catalysts. LPG selectivity of used catalyst was less than half of the fresh one, while selectivity for gasoline using used catalyst was greater than using the fresh one. Similar to LPG selectivity, the result for STY of LPG was obtained. But the reverse was resulted for STY of gasoline.

Table 4-11 Effect of Reaction Temperature on n-Hexane Conversion, Product Selectivities and STY of Fresh and Used H-Mordenite Catalysts

Experimental Conditions :

P = 30 atg

SV = 4000 hr^{-1}

TEMPERATURE	CONVERSION (%)		SELECTIVITY (%)				STY (cm^3/cm^3hr)			
(°C)	FRESH	USED	LPG		GASOLINE		LPG		GASOLINE	
	CATALYST	CATALYST	FRESH	USED	FRESH	USED	FRESH	USED	FRESH	USED
260	16.40	3.65	6.12	13.36	93.18	86.16	0.87	0.86	13.29	5.54
280	75.36	15.40	55.08	27.57	43.91	71.76	36.11	7.47	28.78	19.44
300	93.22	28.44	77.90	41.10	20.53	58.10	63.18	26.56	16.65	29.07
320	97.47	32.10	87.15	49.30	10.68	49.58	73.90	27.84	9.06	28.00
340	98.22	39.58	92.02	58.64	5.02	39.64	78.63	40.83	4.29	27.61

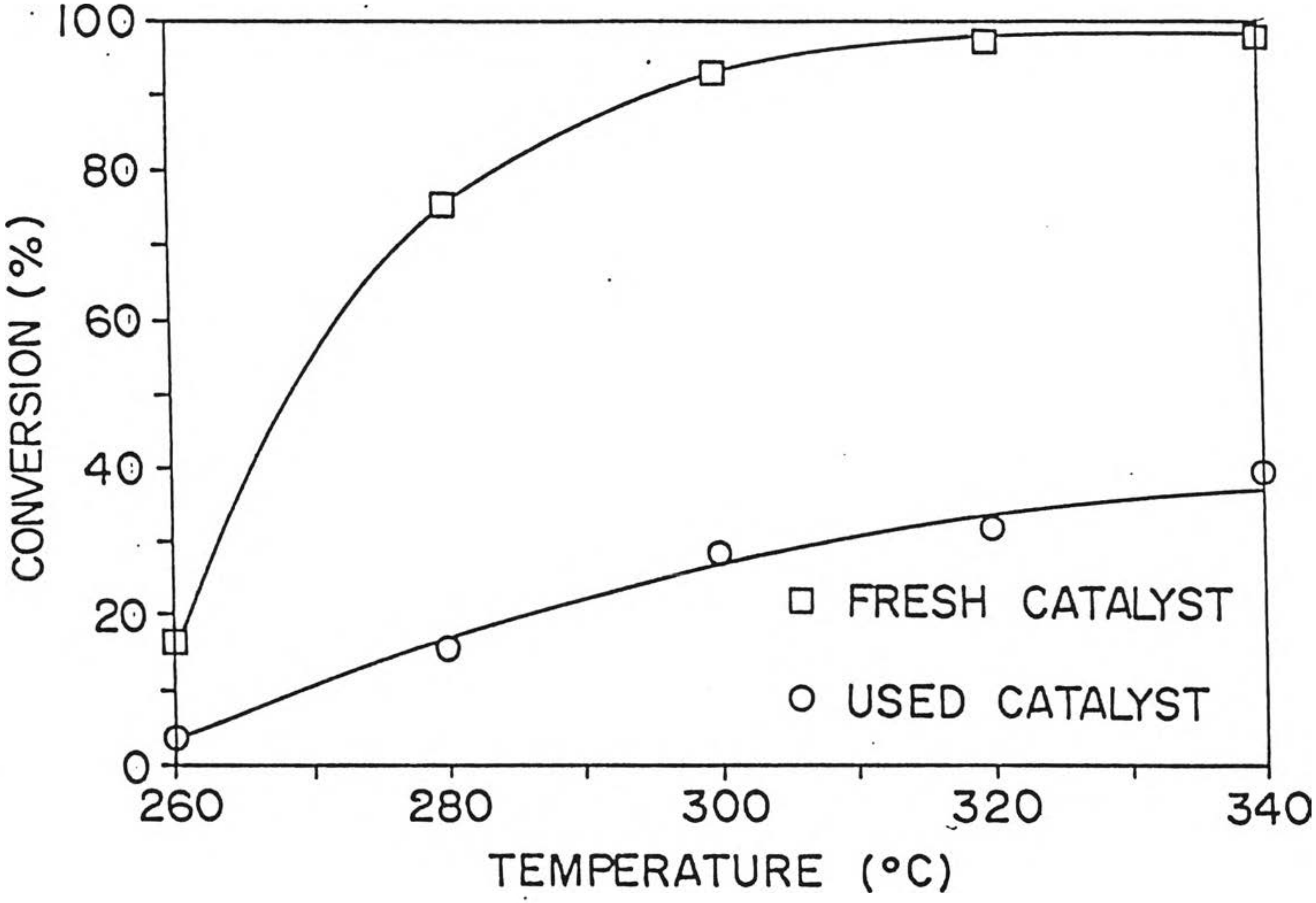

Figure 4-12 n-Hexane Conversion VS. Temperature of H-Mordenite Catalyst for P = 30 atg ; SV. = 4000 hr^{-1} (Comparison between Fresh and Used)

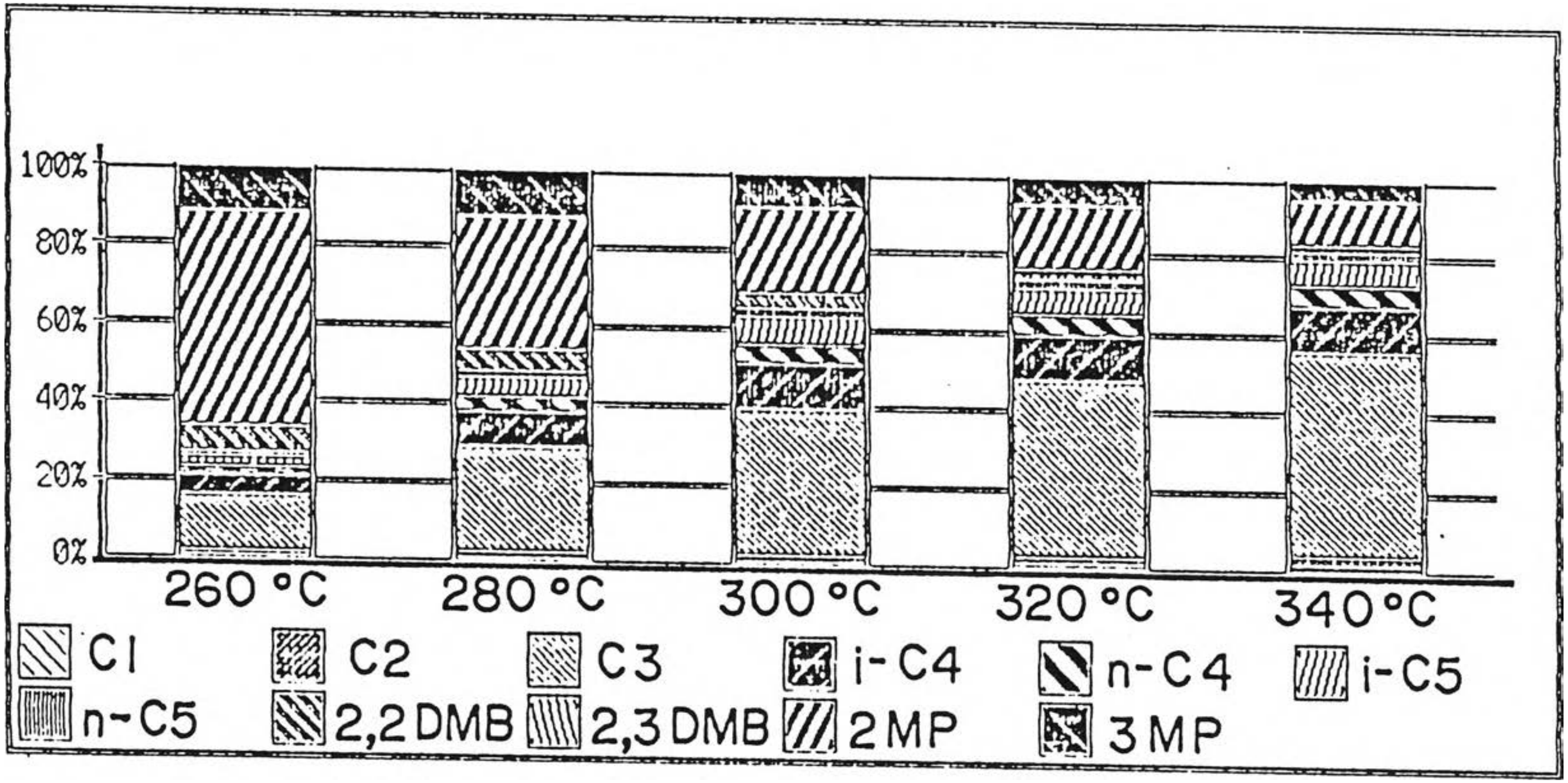

Figure 4-13 Product Distribution VS. Temperature of Used-H-Mordenite Catalyst for P = 30 atg ; SV. = 4000 hr^{-1}

4.2 EXPERIMENTAL RESULTS AND DISCUSSIONS FOR H-Y CATALYST

So far the investigation was concentrated on the H-mordenite catalyst and the effects of pressure, temperature and space velocity on the n-hexane hydrocracking reaction. Three different pressures, namely 30 atg, 50 atg and 95 atg, were used in the investigation and its effects were mentioned in section 4.1. The next catalyst under investigation was the Na-Y catalyst, which had been modified to the H-Y form. The objectives of investigation and the range of experimental conditions for the H-Y catalyst was the same as the H-mordenite.

a. Effect of Reaction Temperature

i) Effect of Temperature on the Total Conversion of n-Hexane

The detailed data of Runs No.7-1 to 7-5 and Runs No.9-1 to 9-5 in Appendix A were reorganized and tabulated in Table 4-12. From this table a plot of the total conversion vs. temperature was made as shown in Figure 4-14. The percentage of conversion depended remarkably on temperature at both operating pressures, namely 50 atg and 70 atg. As the temperature rose, more n-hexane was converted but the effect of temperature became less significant above 260° C

Table 4-12 Total Conversion of n-Hexane versus Temperature for the H-Y Catalyst. SV. = 4000 hr^{-1}

TEMPERATURE	CONVERSION (%)	
(°C)	P = 50 atg	P = 70 atg
260	1.24	1.10
280	3.54	3.03
300	14.89	6.99
320	31.17	26.77
340	57.01	49.94

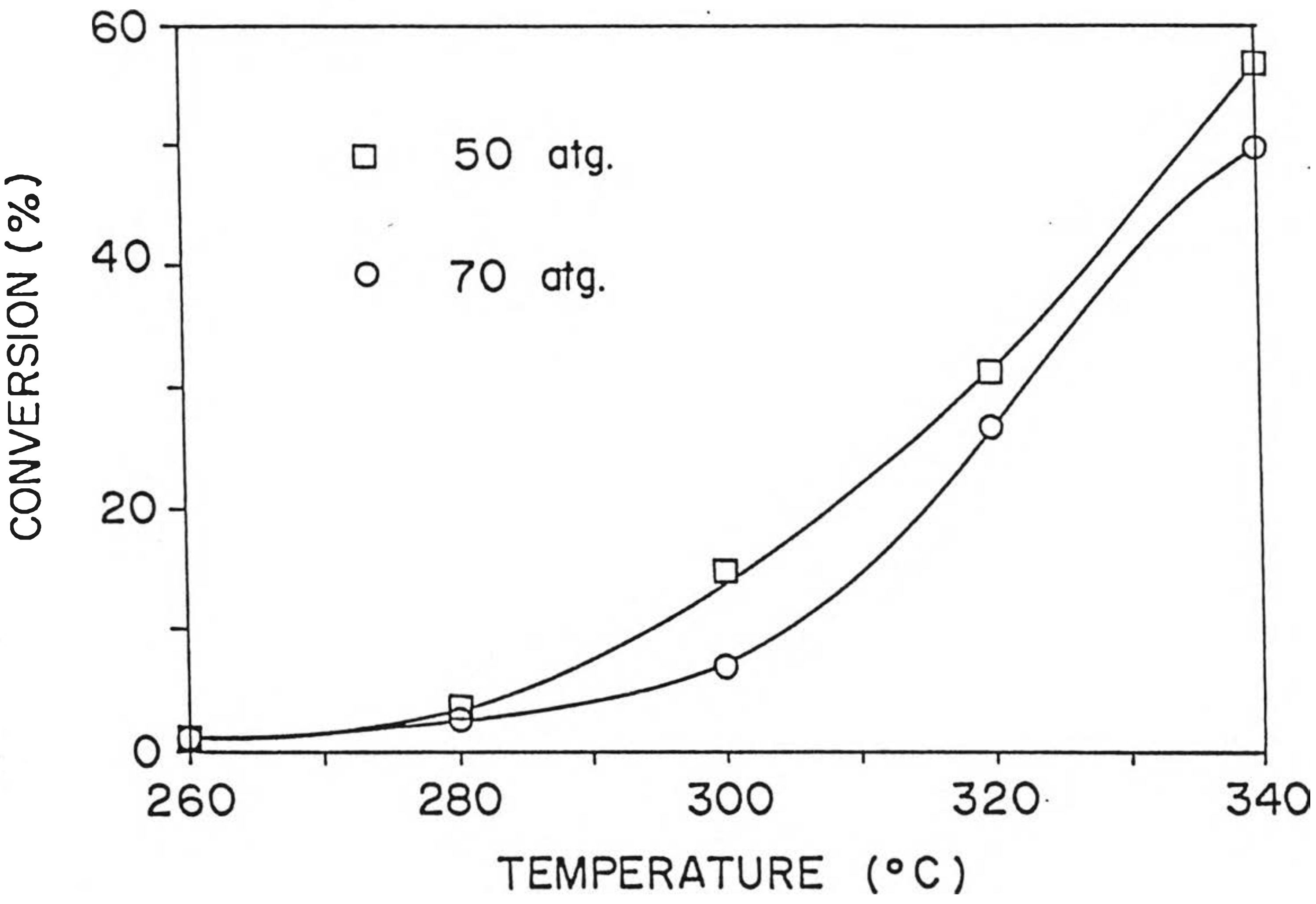

Figure 4-14 n-Hexane Conversion VS. Temperature of H-Y Catalyst for P = 50, 70 atg ; SV. = 4000 hr^{-1}

ii) Effect of Temperature on Selectivity

Four figures, Figure 4-15, Figure 4-16, Figure 4-17 and Figure 4-18 were drawn using the experimental results of Runs No. 7-1 to 7-5 and Runs No. 9-1 to 9-5 in Appendix A. Table 4-13 and Table 4-14 also summarized the observed product selectivities in each run.

Prepared from the results tabulated in Table 4-13 and Table 4-14, Figure 4-15 and Figure 4-16 showed LPG selectivity and gasoline selectivity versus temperature, respectively. Raising the temperature resulted in more propane, i-butane and n-butane in the products at both pressures, 50 and 70 atg, (see Figure 4-15). On the other hand, while more LPG products were obtained as the temperature increased, gasoline products, composed of i-pentane, n-pentane, 2,2-DMB, 2,3-DMB, 2MP and 3 MP, tended to fall down, as seen in Figure 4-16. Thus, when the temperature was sufficiently high, say, 320° C and 340° C, the consumed n-hexane would mostly be cracked to LPG, especially propane, as evident from Figure 4-17 and Figure 4-18, which showed the product distribution observed at 50 atg and 70 atg, respectively.

iii) Effect of Temperature on STY

To illuminate the effects of temperature on the STY of LPG and STY of gasoline, the experimental results were tabulated in Table 4-15 and Table 4-16 as well as shown graphically in Figure 4-19 and Figure 4-20.

Table 4-13 LPG Selectivity versus Temperature
(SV. = 4000 hr^{-1}, P = 50 and 70 atg)

TEMPERATURE	LPG SELECTIVITY (%)	
(°C)	P = 50 atg	P = 70 atg
260	4.58	3.93
280	7.77	6.17
300	10.00	8.10
320	27.57	17.28
340	42.41	32.75

Table 4-14 Gasoline Selecvitity versus Temperature
(SV. = 4000 hr^{-1}, P = 50 and 70 atg)

TEMPERATURE (°C)	GASOLINE SELECTIVITY (%)	
	P = 50 atg	P = 70 atg
260	95.42	96.07
280	91.71	93.41
300	89.60	91.49
320	71.83	82.10
340	56.83	66.25

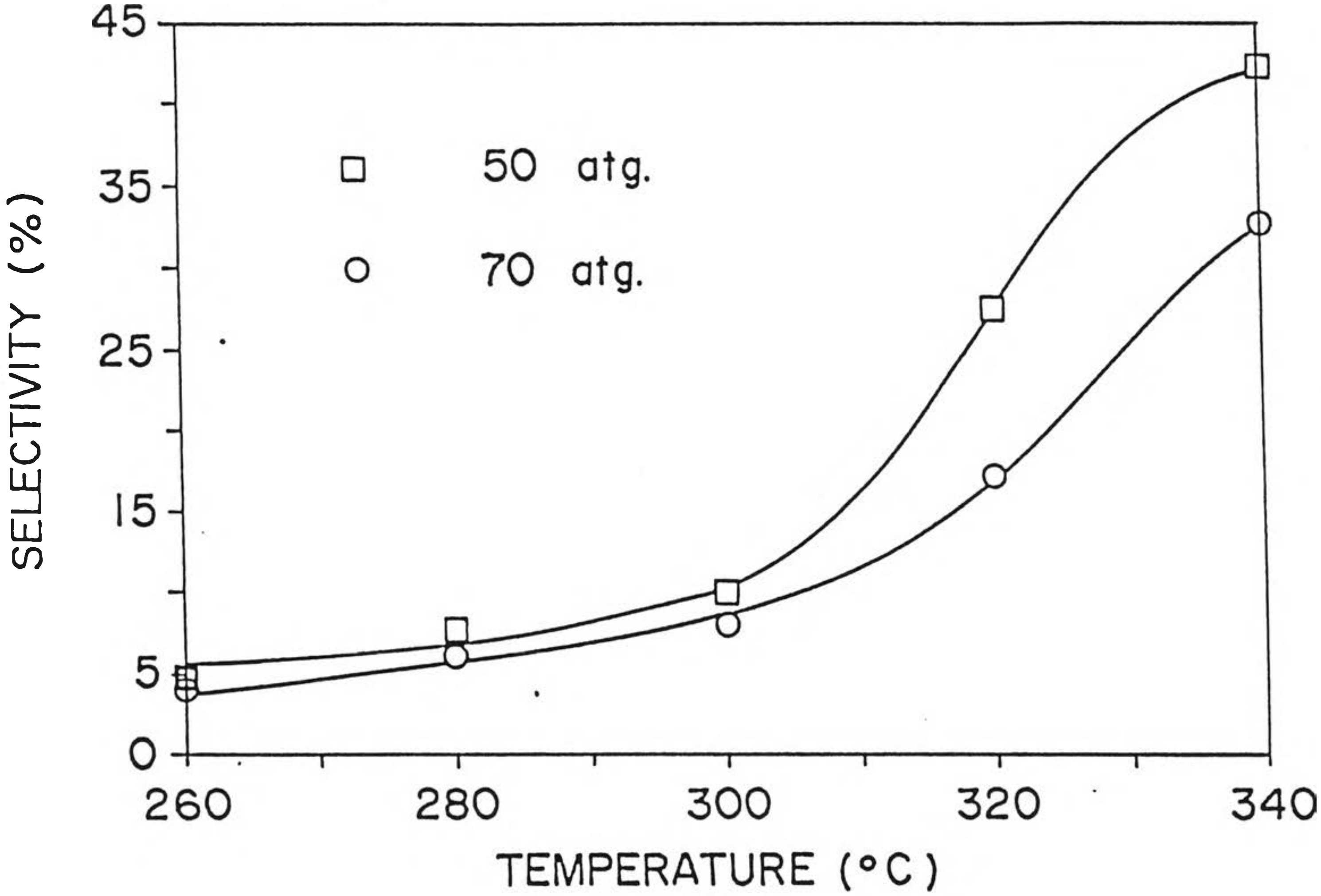

Figure 4-15 LPG Selectivity VS. Temperature of H-Y Catalyst for P = 50, 70 atg ; SV. = 4000 hr^{-1}

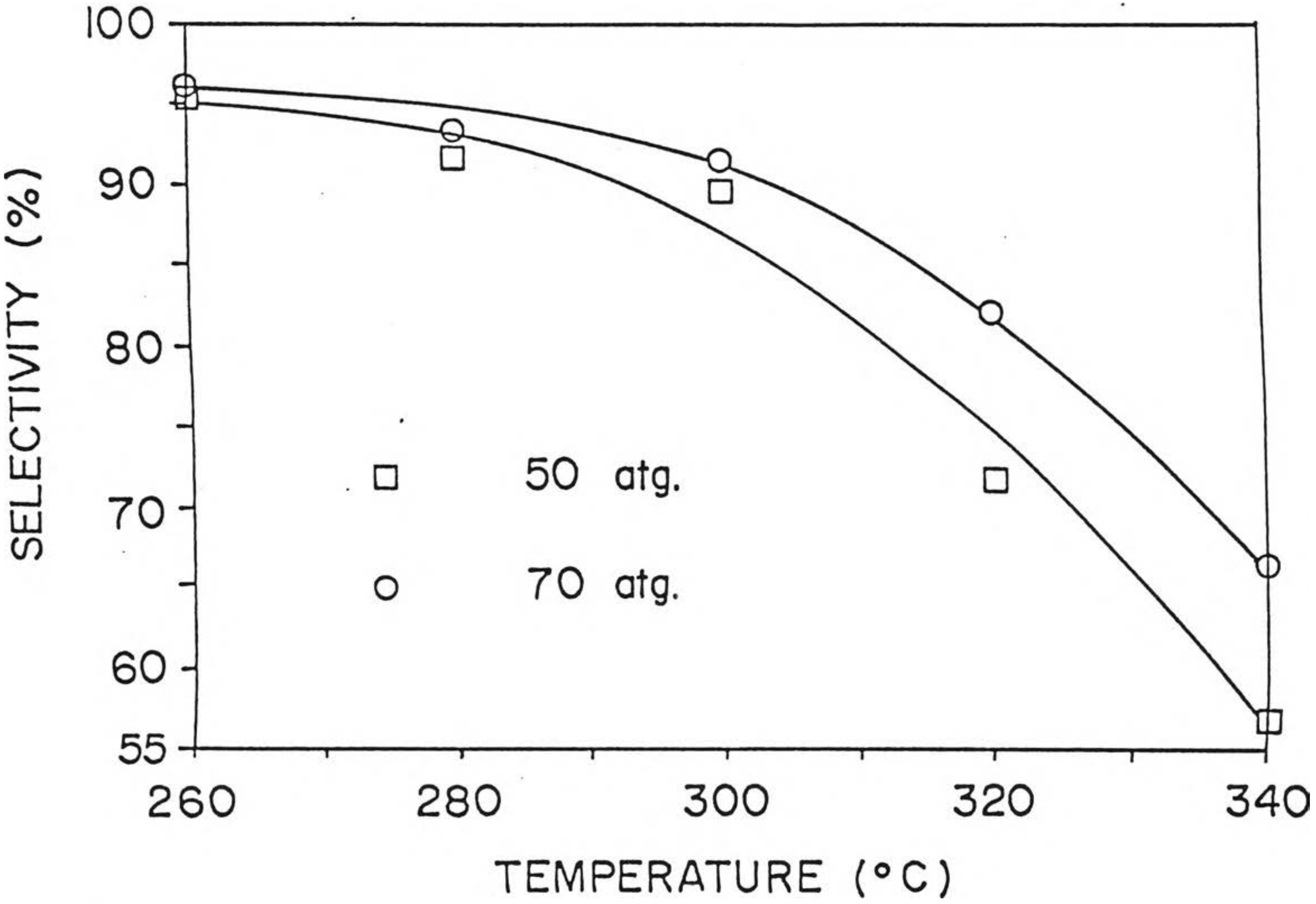

Figure 4-16 Gasoline Selectivity VS. Temperature of H-Y Catalyst for

P = 50, 70 atg ; SV. = 4000 hr^{-1}

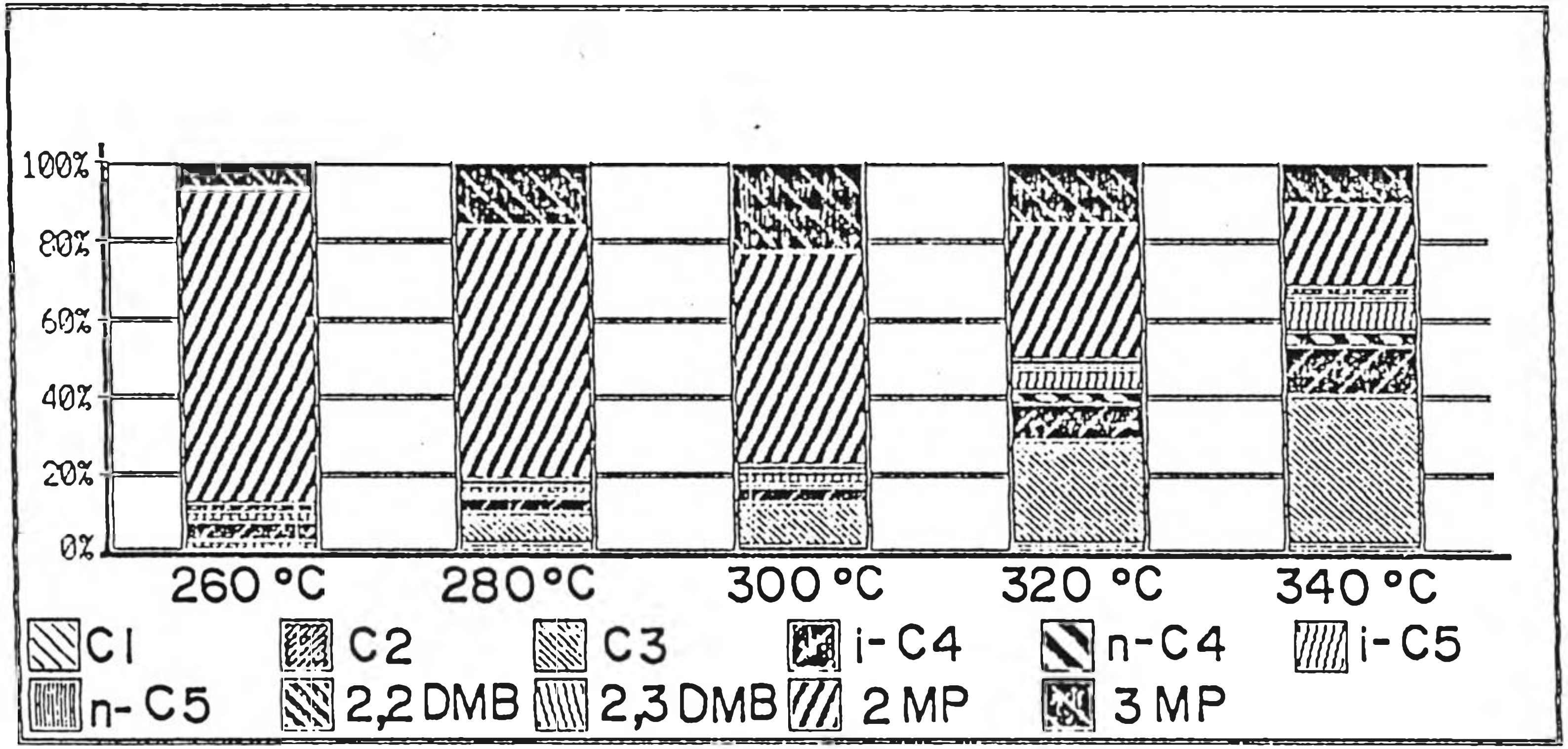

Figure 4-17 Product Distribution VS. Temperature of H-Y Catalyst for P = 50 atg ; SV. = 4000 hr^{-1}

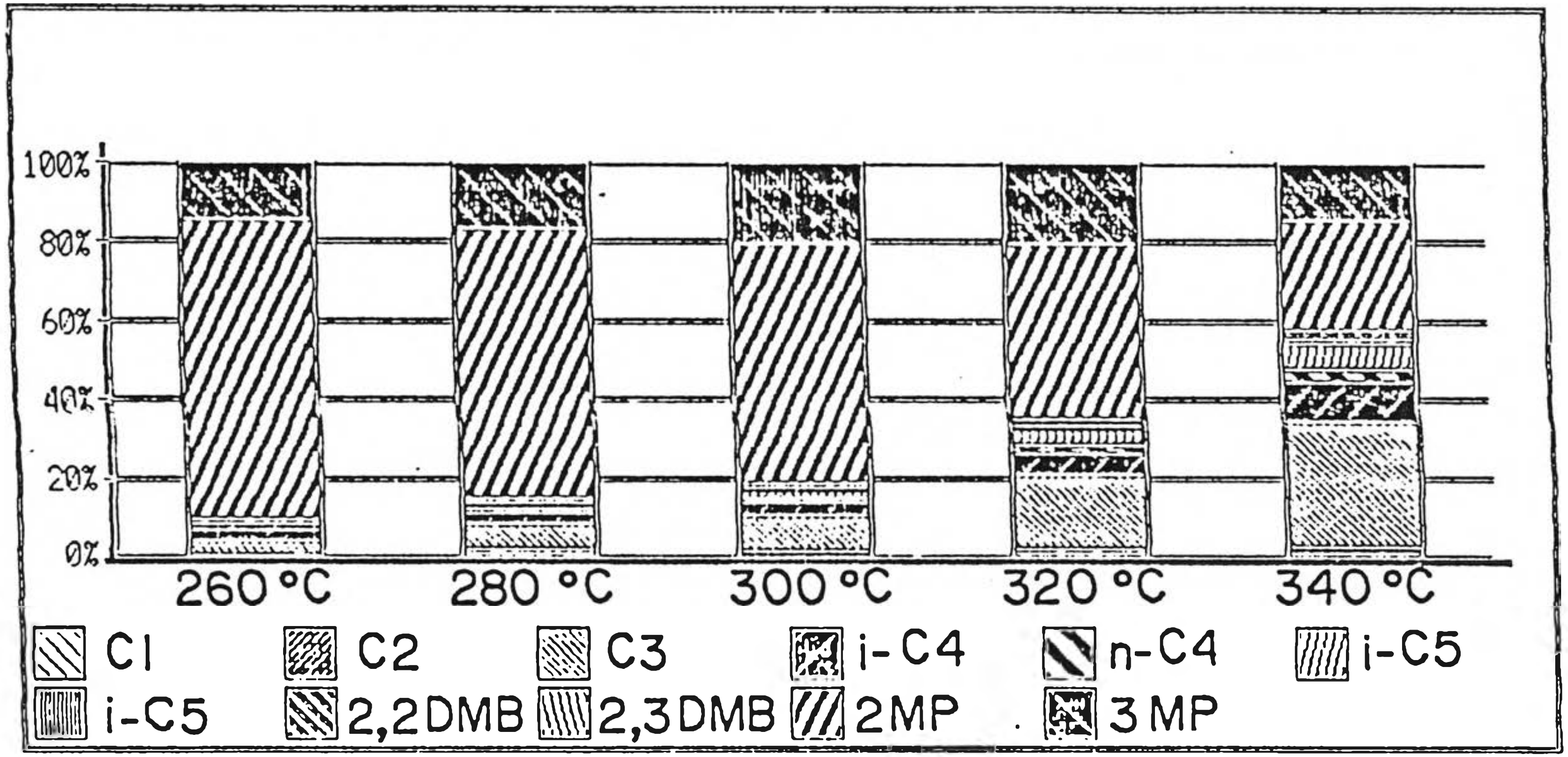

Figure 4-18 Product Distribution VS. Temperature of H-Y Catalyst for

P = 70 atg ; SV. = 4000 hr^{-1}

Figure 4-19 showed that the STY of LPG increased as the temperature increased at both experimental pressures, 50 and 70 atg. In fact the STY at 340° C was twelve times higher than that at 300° C of experimental pressure at 50 atg.

Similarly, Figure 4-20 showed that the STY of gasoline rose hand in hand with temperature.

b. Effect of Pressure

i) Effect of Pressure on the Total Conversion of n-Hexane

Figure 4-14 revealed that at the same temperature, the total conversion of n-hexane at 50 atg was slightly higher than that at 70 atg which is the result of equilibrium shifted. Equilibrium conversion is affected by pressure, for an increase in pressure in gas reactions, conversion rises when the number of moles decreases with reaction ; conversion drops when the number of moles increases with reaction. (30 : 215-216)

ii) Effect of Pressure on Product Selectivities

The effect of pressure on LPG selectivity was revealed in Figure 4-15. Its effect was insignificant at 260° C, 280° C and 300° C, but LPG selectivity at 50 atg was higher than that at 70 atg when the temperature was 320° C and 340° C

Table 4-15 Effect of Temperature on the STY of LPG

(SPACE VELOCITY = 4000 hr^{-1}, P 50 and 70 atg)

TEMPERATURE (°C)	STY OF LPG (cm^3/cm^3HR) P = 50 atg	 P = 70 atg
260	0.09	0.07
280	0.42	0.29
300	2.29	0.87
320	13.21	7.11
340	37.17	25.13

Table 4-16 Effect of Temperature on the STY of Gasoline (Space Velocity = 4000 hr^{-1}, P = 50 and 70 atg)

TEMPERATURE (°C)	STY OF GASOLINE (cm^3/cm^3HR)	
	P = 50 atg	P = 70 atg
260	1.81	1.62
280	4.99	4.35
300	20.51	9.83
320	34.41	33.80
340	49.80	51.80

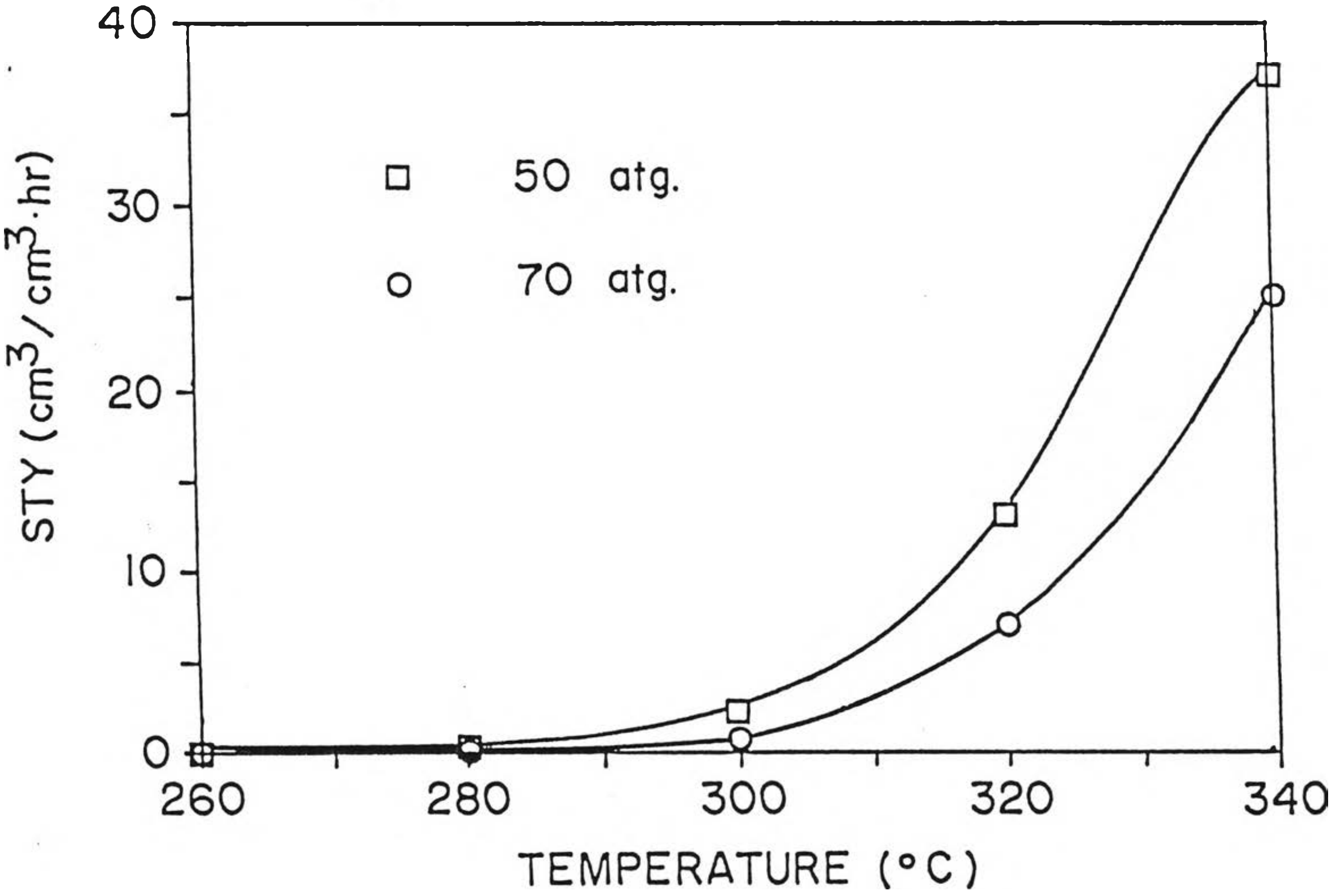

Figure 4-19 STY of LPG VS. Temperature of H-Y Catalyst for P = 50, 70 atg ; SV. = 4000 hr^{-1}

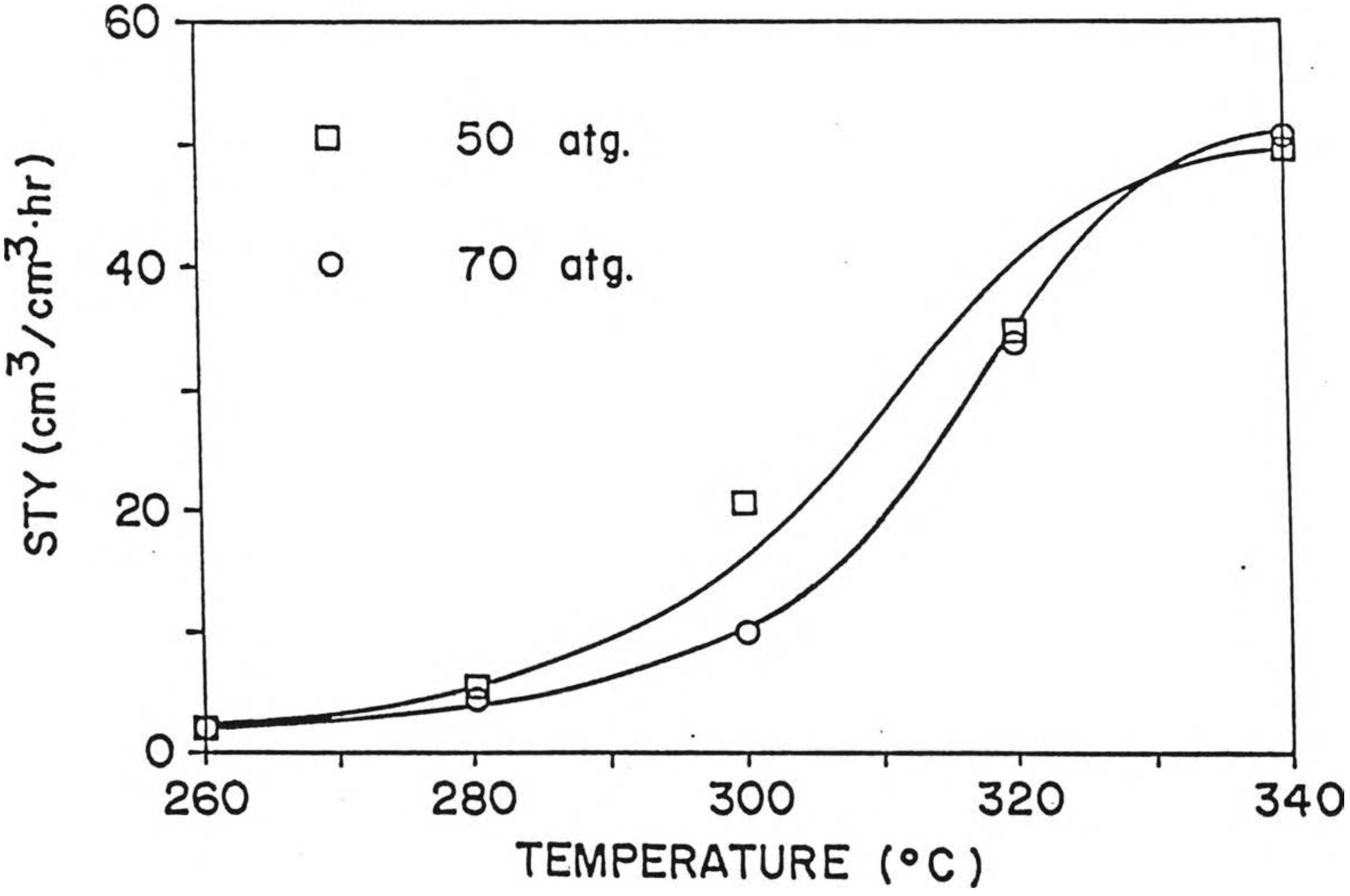

Figure 4-20 STY of Gasoline VS. Temperature of H-Y Catalyst for P = 50, 70 atg ; SV. 4000 hr^{-1}

Similarly, the effect of pressure effect was slight at 260° C, 280° C and 300° C, but more pronounced at 320° C and 340° C. In this case, however, gasoline selectivity was enhanced when the pressure was increased from 50 atg to 70 atg.

iii) Effect of Pressure on STY

Figure 4-19 showed that the effect of pressure on the STY of LPG was similar to that on LPG selectivity. This meant that the STY of LPG was higher at 50 atg than at 70 atg, especially above 320° C.

As shown in Figure 4-20 the pressure effect on the STY of gasoline was less remarkable except at 300° C.

c. Effect of Space Velocity

i) Effect of Space velocity on the Total Conversion of n-Hexane

The experimental data of Runs No. 7-1 to 7-5 and 8-1 to 8-5 in Appendix A were tabulated in Table 4-17 and plotted in Figure 4-21, in order to see the effect of space velocity (4000 hr^{-1} and 2000 hr^{-1}) on n-hexane conversion. Figure 4-21 revealed that at SV 2000 hr^{-1} more n-hexane was cracked than at SV 4000 hr^{-1} because of the longer contact time.

ii) Effect of Space Velocity on Product Selectivities.

Table 4-17 Effect of Temperature on Conversion for the H-Y Catalyst (PRESSURE = 50 atg)

TEMPERATURE	CONVERSION (%)	
(°C)	S.V. = 4000 hr^{-1}	S.V. = 2000 hr^{-1}
260	1.24	19.16
280	3.54	43.52
300	14.89	44.86
320	31.17	52.13
340	57.01	57.07

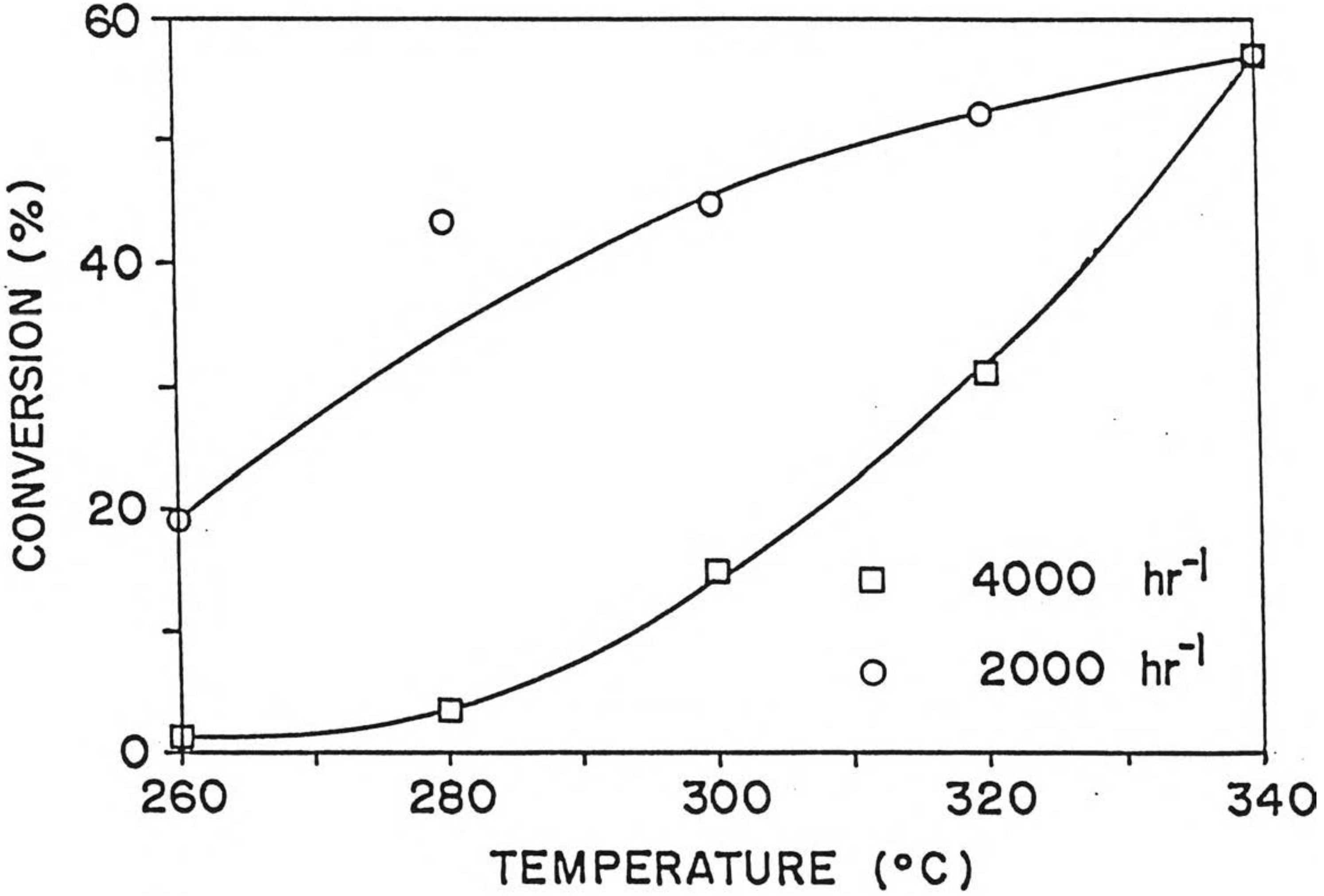

Figure 4-21 n-Hexane Conversion VS. Temperature of H-Y Catalyst for $P = 50$ atg ; SV. 2000, 4000 hr^{-1}

Figure 4-22, which was plotted using the data in Table 4-18, showed that at the three lower temperatures, LPG selectivity was higher at SV 2000 hr^{-1} than at 4000 hr^{-1}. The trend, however, was reversed at 320° C and 340° C.

Figure 4-23, which was based on Table 4-19, showed that gasoline selectivity was higher at SV 4000 hr^{-1} than at 2000 hr^{-1} at the three lower temperatures (260° C, 280° C and 300° C). The reverse was however true at 320° C and 340° C.

By the way, Figure 4-24 showed the product distribution at SV 2000 hr^{-1} and pressure 50 atg. The figure stated that LPG was more produced as temperature rose, especially propane, but gasoline was less produced with temperature.

d. Deactivation of the H-Y Catalyst

As in the case of the H-mordenite catalyst the performance of the fresh and used H-Y catalyst was compared by repeating the experiments under the same conditions after fourty hours. The results thus obtained were shown in Table 4-20 as well as Figure 4-25. The conversion difference between fresh and used H-Y catalyst was graphically shown in Figure 4-25, which illuminated that the H-Y used catalyst gave two times less than the fresh one. And so were the comparison of LPG selectivity and STY

Table 4-18 Effect of Space Velocity on LPG Selectivity for the H-Y Catalyst (PRESSURE = 50 atg)

TEMPERATURE (°C)	LPG SELECTIVITY (%)	
	S.V. = 4000 hr^{-1}	S.V. = 2000 hr^{-1}
260	4.58	18.84
280	7.77	15.97
300	10.00	17.20
320	27.57	25.22
340	42.41	35.35

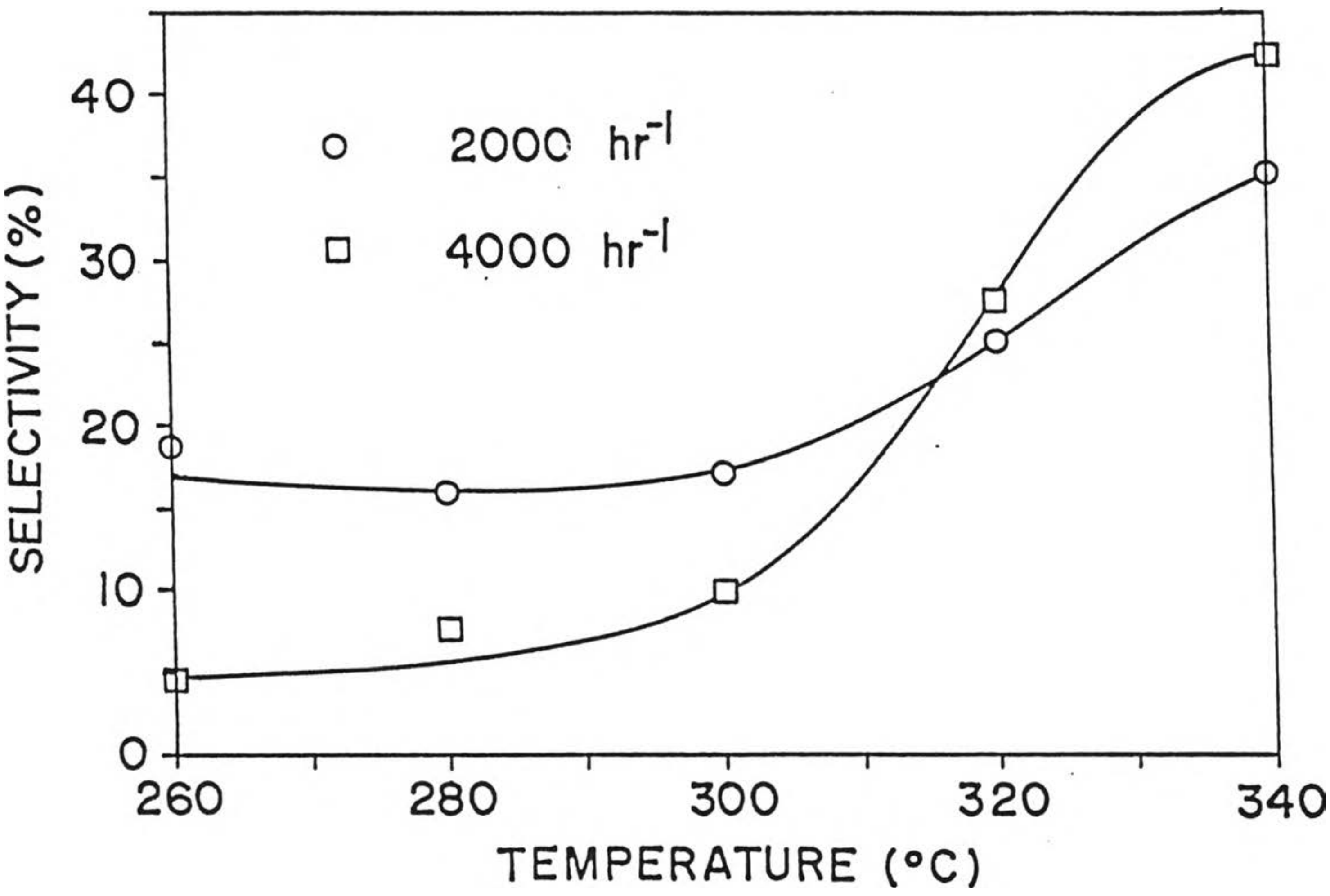

Figure 4-22 LPG Selectivity VS. Temperature of H-Y Catalyst for P = 50 atg ; SV. 2000, 4000 hr^{-1}

Table 4-19 Effect of Space Velocity on Gasoline Selectivity for the H-Y Catalyst (PRESSURE = 50 atg)

TEMPERATURE (°C)	GASOLINE SELECTIVITY (%) S.V. = 4000 hr^{-1}	S.V. = 2000 hr^{-1}
260	95.42	81.09
280	91.71	83.89
300	89.60	82.58
320	71.83	74.39
340	56.83	64.04

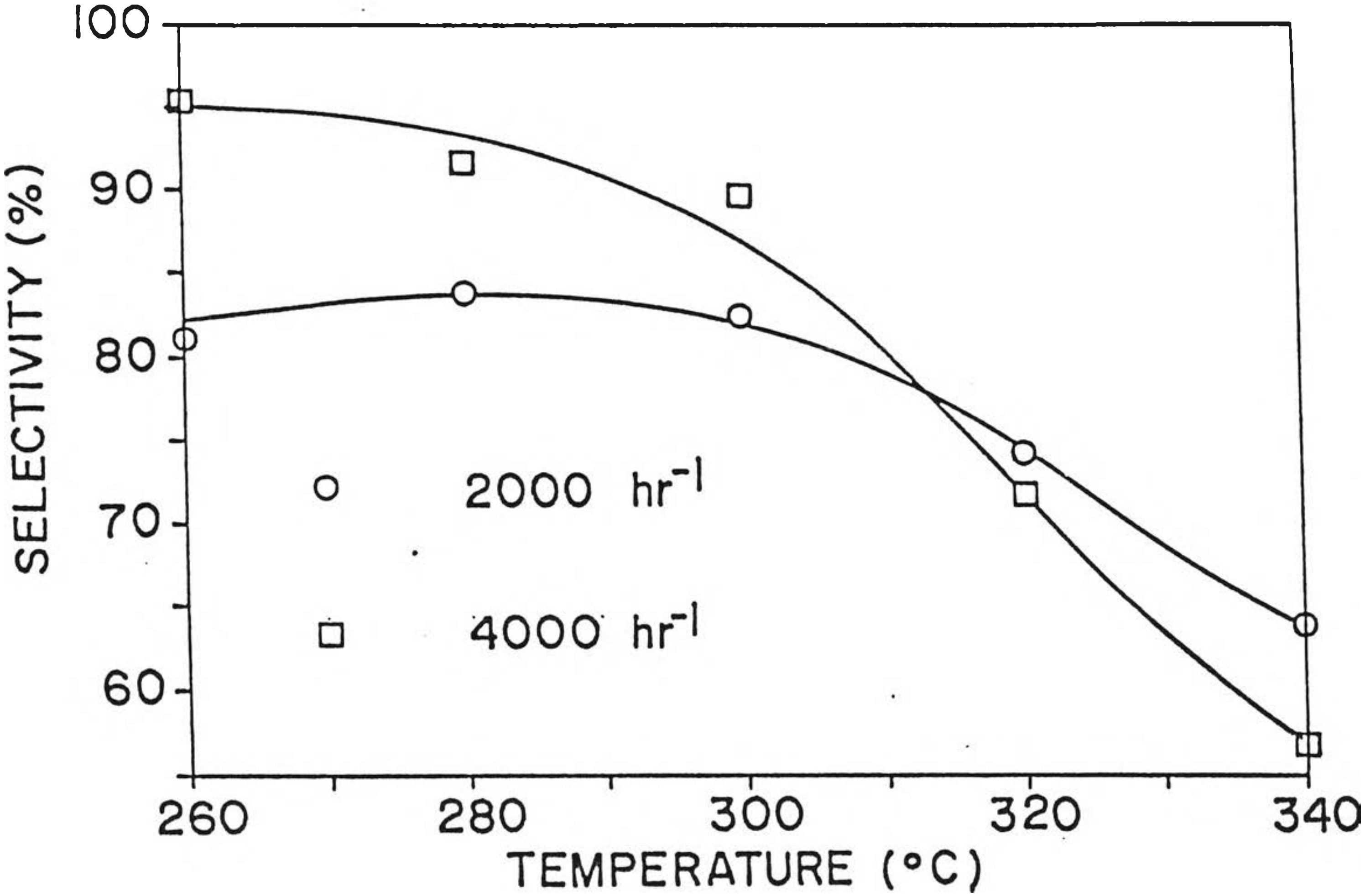

Figure 4-23 Gasoline Selectivity VS. Temperature of H-Y Catalyst for P = 50 atg ; SV. = 2000, 4000 hr-1

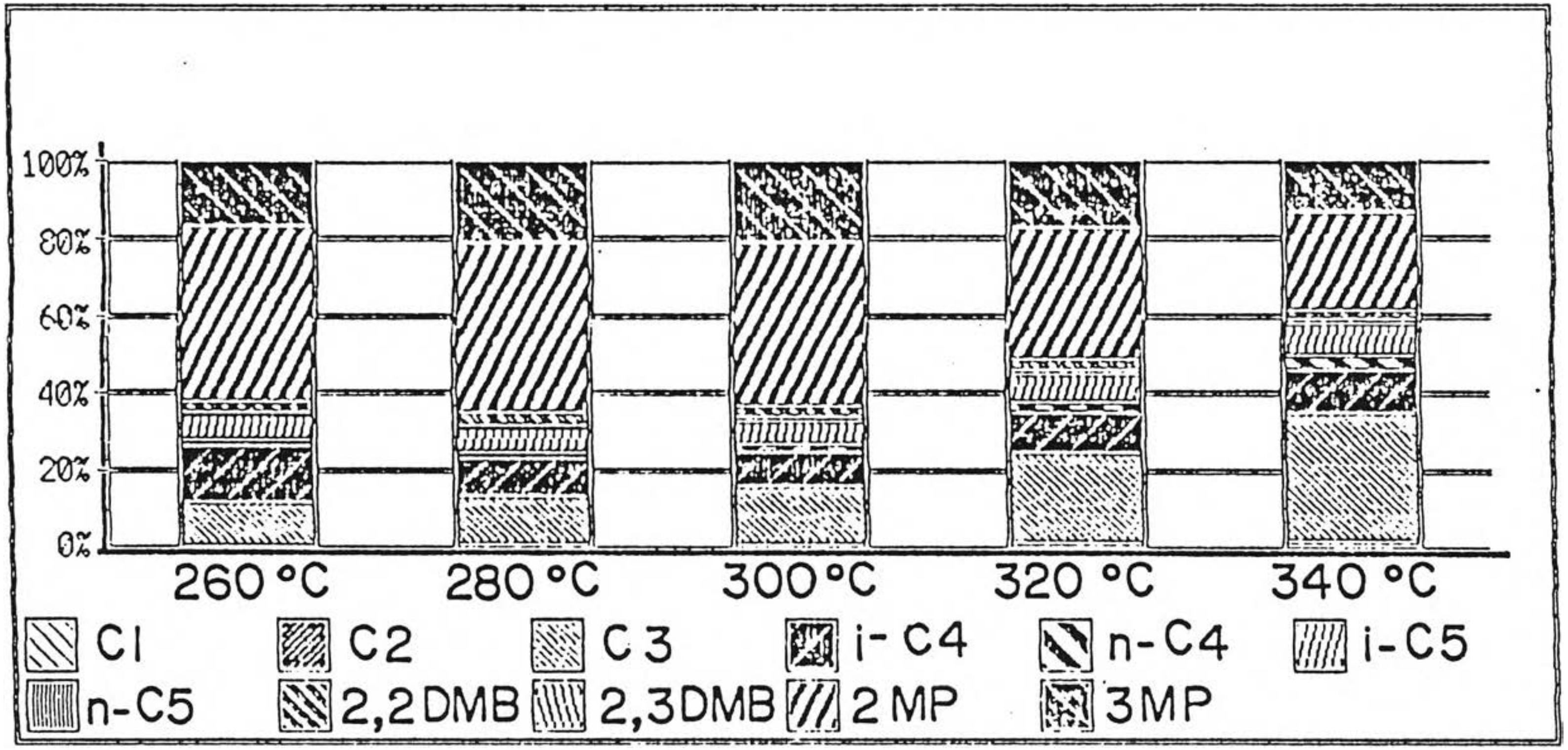

Figure 4-24 Product Distribution VS. Temperature of H-Y Catalyst for P = 50 atg ; SV. = 2000 hr^{-1}

Table 4-20 Comparison between Fresh and Used H-Y Catalyst

Experimental Conditions :

Pressure = 50 atg

SV ≐ 4000 hr^{-1}

TEMPERATURE	CONVERSION (%)		SELECTIVITY (%)				STY (cm^3/cm^3hr)			
(°C)	FRESH CATALYST	USED CATALYST	LPG		GASOLINE		LPG		GASOLINE	
			FRESH	USED	FRESH	USED	FRESH	USED	FRESH	USED
260	1.24	-	4.58	-	95.42	-	0.09	-	1.81	-
280	3.54	-	7.77	-	91.71	-	0.42	-	4.99	-
300	14.89	5.50	10.00	7.02	89.60	92.48	2.29	0.81	20.51	10.67
320	31.17	-	27.57	-	71.83	-	13.21	-	34.41	-
340	57.01	30.12	42.41	19.26	56.83	80.08	37.17	12.71	49.80	50.61

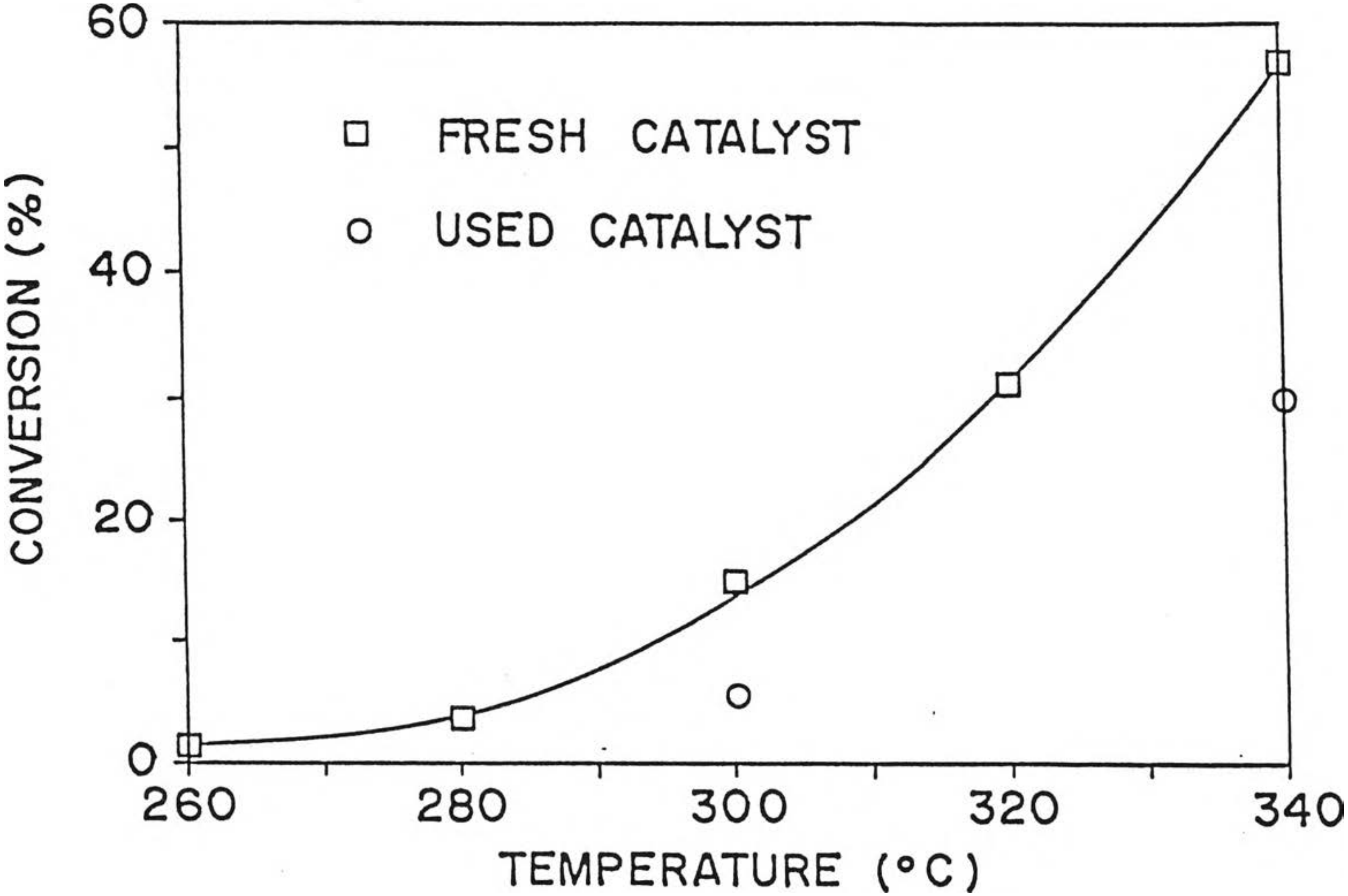

Figure 4-25 n-Hexane Conversion VS. Temperature of H-Y Catalyst for P = 50 atg ; SV. = 4000 hr^{-1} (Comparison between Fresh and Used) of LPG between fresh and used H-Y catalyst. But the gasoline selectivity and STY of gasoline for fresh catalyst were less than the used one. The product distribution was plotted to see which products were produced and the change of products when temperature was raised. Figure 4-26, the product distribution of used catalyst at 300° C and 340° C, showed that propane was more produced at 340° C which is the same direction as the fresh catalyst.

4.3 COMPARISON BETWEEN H-MORDENITE AND H-Y CATALYSTS

The present investigation showed that qualitatively both the H-mordenite and H-Y catalysts exerted similar effects of temperature, pressure and space velocity, respectively, on the total conversion of n-hexane, product selectivities and STY of LPG and gasoline. A more detailed comparison now followed.

a. Comparison of Temperature Effect

The experimental results from Runs No.2-1 to 2-5, Runs No.7-1 to 7-5, Runs No.3-1 to 3-5 and Runs No.8-1 to 8-5 in Appendix A were reorganized and tabulated in Table 4-21 to Table 4-23 and then shown graphically in Figure 4-27 and Figure 4-28 to compare their temperature effects on the total conversion of n-hexane.

Table 4-21 showed that at the same temperature, the H-mordenite catalyst gave a significantly

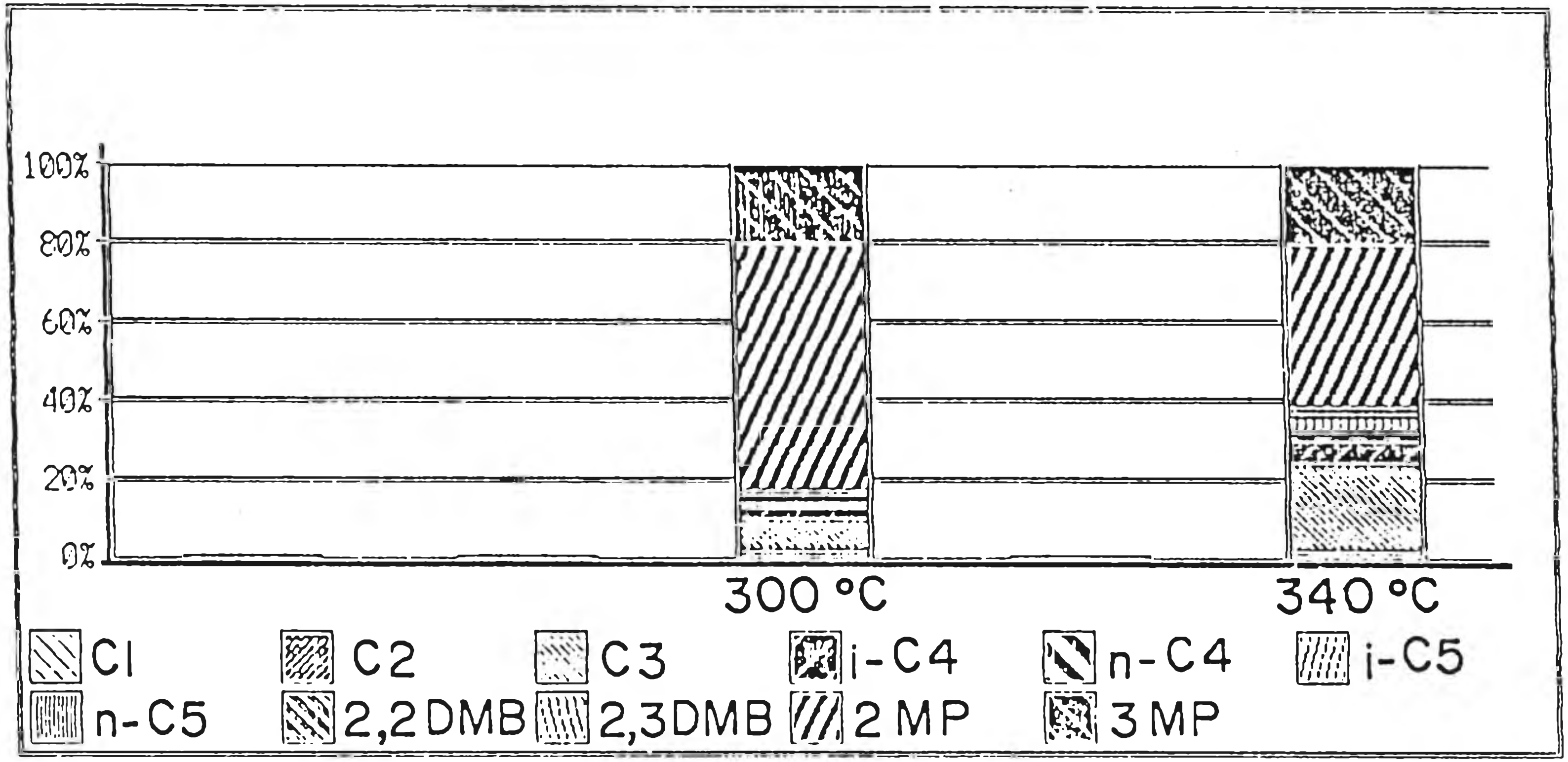

Figure 4-26 Product Distribution VS. Temperature of Used H-Y Catalyst for P = 50 atg ; SV. = 4000 hr^{-1}

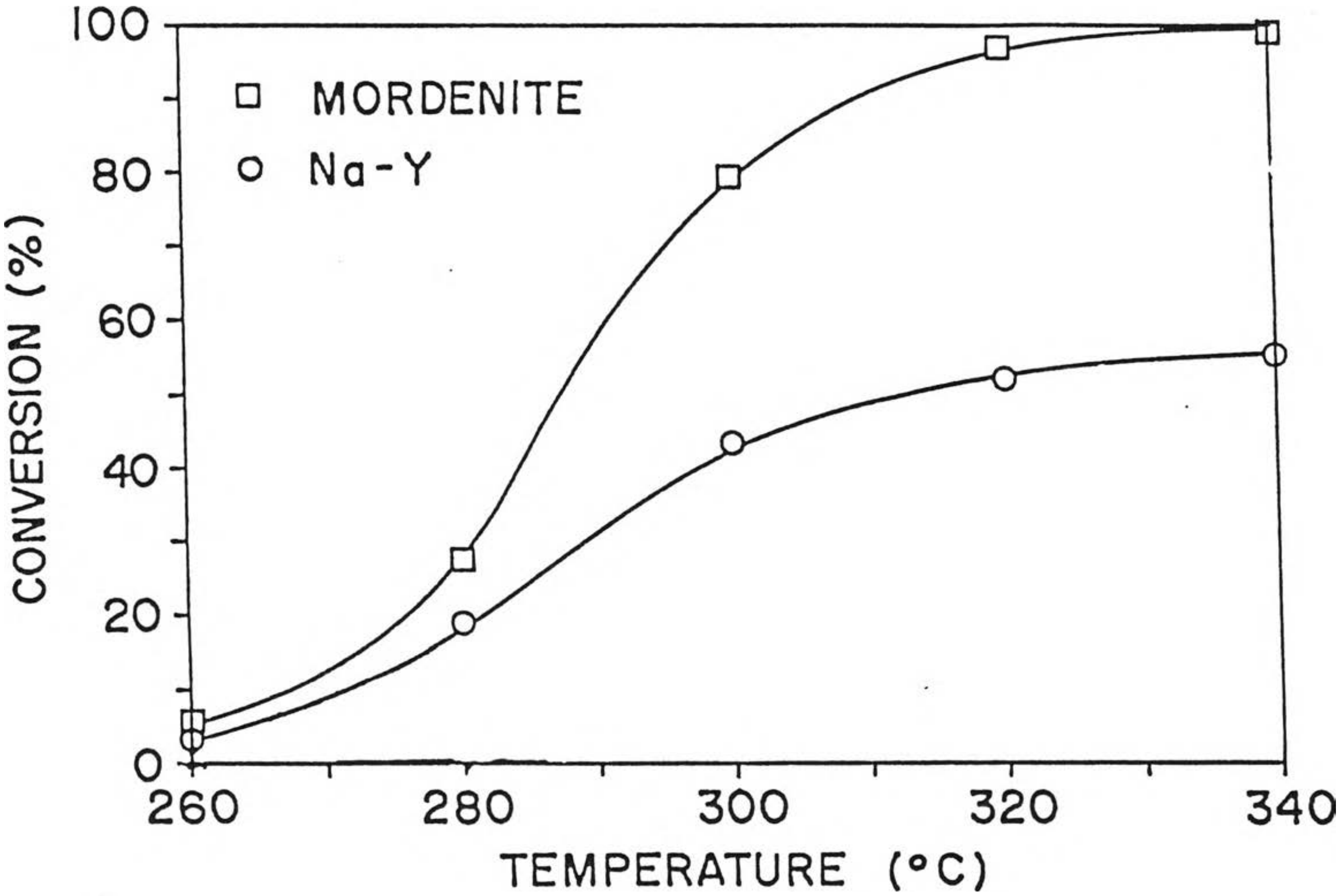

Figure 4-27 n-Hexane Conversion VS. Temperature for P = 50 atg ; SV. = 4000 hr^{-1} (Comparison between Two Catalysts)

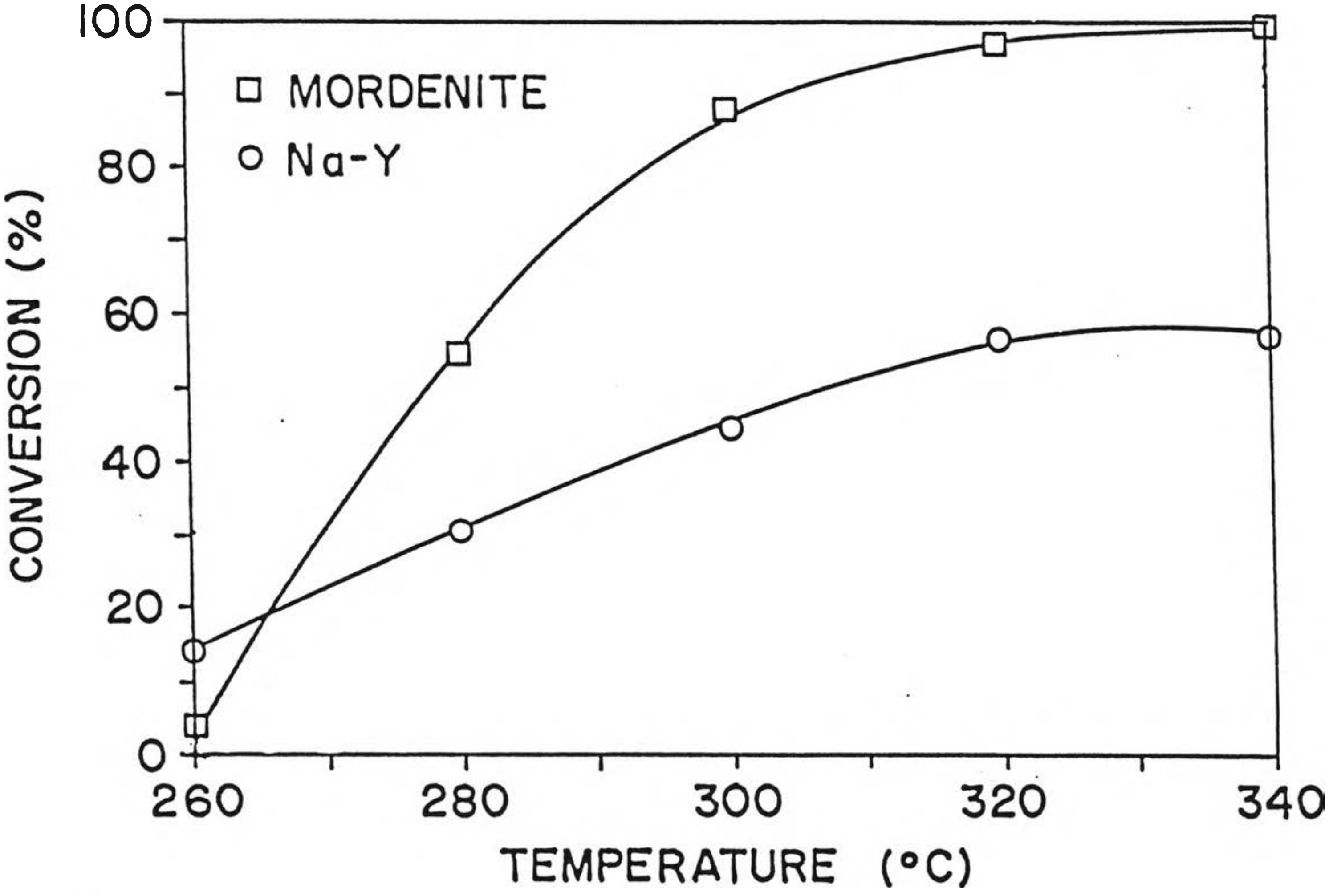

Figure 4-28 n-Hexane Conversion VS. Temperature for P = 50 atg ; SV. = 2000 hr^{-1} (Comparison between Two Catalysts)

Table 4-21 Comparison of Temperature Effect between H-Mordenite and H-y Catalyst (PRESSURE = 50 atg)

TEMPERATURE (°C)	CONVERSION (%)			
	SV = 4000 hr^{-1}		SV. = 2000 hr^{-1}	
	H-MORDENITE	H-Y	H-MORDENITE	H-Y
260	5.61	1.24	3.79	19.16
280	27.56	3.54	54.82	43.52
300	79.68	14.89	88.04	44.86
320	97.03	31.17	97.04	52.13
340	98.90	57.01	99.28	57.07

higher conversion of n-hexane than the H-Y catalyst, even though the effect of temperature on n-hexane conversion showed the same increasing trend. Here the pressure was 50 atg and SV 4000 hr^{-1}.

As seen from Table 4-22, the H-mordenite catalyst had a higher LPG selectivity than the H-Y catalyst, especially at 320 and 340° C. The same conditions were obtained at space velocity 4000 hr^{-1} and 2000 hr^{-1}, and 50 atg.

On the other hand Table 4-23 showed that the H-Y catalyst was more suitable for gasoline production in terms of high octane of gasoline.

Table 4-22 Comparison on Selectivity for LPG Between H-Mordenite and H-Y Catalyst

OPERATING PRESSURE = 50 atg

TEMPERATURE (°C)	LPG SELECTIVITY (%)			
	S.V. = 4000 hr^{-1}		S.V. = 2000 hr^{-1}	
	H-MORDENITE	H-Y	H-MORDENITE	H-Y
260	6.22	4.58	62.62	18.84
280	11.60	7.77	54.85	15.97
300	67.35	10.00	55.20	17.20
320	81.48	27.57	88.32	25.22
340	89.79	42.41	93.46	35.35

Table 4-23 Comparison of Gasoline Product between H-Mordenite and H-Y Type

OPERATING PRESSURE = 50 atg

TEMPERATURE (°C)	GASOLINE SELECTIVITY (%)			
	S.V. = 4000 hr^{-1}		S.V. = 2000 hr^{-1}	
	H-MORDENITE	H-Y	H-MORDENITE	H-Y
260	92.86	95.42	35.28	81.09
280	87.06	91.71	44.08	83.89
300	41.26	89.60	33.84	82.58
320	15.63	71.83	8.13	74.39
340	6.15	56.83	1.31	64.04