affected by the presence or absence of foam. The correlations presented above are based on a large number of data points, therefore, it is expected that they describe the hold-up behavior of molten waxes fairly well. For the mode of operation in the "foamy" regime, with orifice and perforated plate distributors, Weber number and column diameter have a significant effect on the gas hold-up, therefore a correlation that accounts for these effects is necessary for predicting the average gas hold-up values. Equation (VI-14) provides a good fit of data in this regime. In the "slug flow" and "churn-turbulent" regimes, hold-up is independent of column diameter and distributor type. Equation (VI-16) should be used to predict hold-up values in this flow regime. Hold-ups with the SMP distributor are essentially functions of the gas velocity alone. In the "foamy" regime, the dependence on u_g is very weak at velocities greater than 0.02 m/s and Equation (VI-17) can be used to predict hold-ups under these conditions. In the "slug flow" regime, with the SMP distributor, a limited amount of data were available and they could be correlated with Equation (VI-18).

C. CORRELATIONS FOR SPECIFIC INTERFACIAL AREA

The dynamic gas disengagement technique allowed the estimation of the Sauter mean diameter at different superficial gas velocities during a given run. The Sauters along with the corresponding average gas hold-up values were then used to estimate specific interfacial area from

$$a = \frac{6\epsilon_g}{d_s} \qquad \text{(VI-26)}$$

The specific interfacial area values were divided into the following six groups:

Group 1: Data from experiments conducted with FT-300 wax at 200°C.

Group 2: Data from experiments conducted with FT-300 wax at 265°C.

Group 3: Data from experiments conducted with Sasol's Arge wax at 200°C.

Group 4: Data from experiments conducted with Sasol's Arge wax at 265°C.

Group 5: Data from experiments conducted with Mobil reactor wax at 200°C.

Group 6: Data from experiments conducted with Mobil reactor wax at 265°C.

Two empirical correlations were tested with each of these groups and the goodness of fit determined. In these correlations the superficial gas velocity was used as the only independent variable and the units of area are m^{-1}.

$$a = k_1 u_g^{k_2} \tag{VI-27}$$

$$a = k_1 u_g^{k_2} e^{-k_3 u_g} \tag{VI-28}$$

The first of these correlations has the same functional form as that used by Deckwer et al. (1980) to obtain the specific interfacial area. The second correlation has the same functional form as the Gamma function (a skewed Gaussian distribution). FT-300 wax has a tendency to foam at lower gas velocities ($u_g < 0.06$ m/s), therefore, it is expected that the specific interfacial area would go through a maximum in the "foamy" regime and then decrease as the foam breaks. Equation (VI-28) can therefore be used to correlate this type of behavior.

The major highlights of these studies are:

- The specific interfacial area (m^{-1}) for FT-300 wax at 265°C can be predicted using two separate correlations depending on the superficial gas velocity employed:

$$a = 3.3\text{X}10^8 u_g^{2.72} e^{-71 u_g} \qquad u_g < 0.08 \text{ m/s} \tag{VI-29}$$

$$a = 971 u_g^{-0.216} \qquad 0.08 \le u_g \le 0.15 \text{ m/s} \tag{VI-30}$$

- The specific interfacial area (m^{-1}) for Sasol's Arge reactor wax at 265°C can be predicted using

$$a = 1000 u_g^{0.25} \qquad 0.01 \le u_g \le 0.12 \text{ m/s} \qquad \text{(VI-31)}$$

- The specific interfacial area (m^{-1}) for Mobil's reactor wax at 265°C can be predicted using

$$a = 300 u_g^{0.01} \qquad 0.01 \le u_g \le 0.12 \text{ m/s} \qquad \text{(VI-33)}$$

C.1. <u>Results from Statistical Analysis</u>

The goodness of fit for the correlations was tested using criteria similar to those used for the average gas hold-up correlations. The mean square errors (MSE) were estimated for each case, and the percentage of points within a ±30% band determined. Tables VI-6 and VI-7 summarize results from the goodness of fit tests and the parameters (constants) for the different correlations.

Results for FT-300 wax at 200 and 265°C are shown in Table VI-6. A limited amount of data was available at 200°C (data from only 1 run) and the correlations appear to fit the data fairly well, with 75% of data within ±30% of the values predicted by the second correlation. The fit for data at 265°C is relatively poor and at best only 53.1% of the data were within a ±30% error band. The primary reason for the poor fit is the relatively high scatter in the original data. Results presented in Table VI-6 show that by using a Gamma function type of correlation, the MSE value for FT-300 wax at 265°C was reduced from 1.11×10^{6} (for the first correlation) to 6.85×10^{5}. Therefore, data for FT-300 wax at 265°C were subdivided into two groups, the first contained data for $u_g < 0.08$ m/s and the other contained data for $u_g > 0.08$ m/s. The break point was determined at 0.08 m/s since specific interfacial areas for gas velocities below 0.08

Table VI-6 Goodness of fit and parameters for area correlations - FT-300 wax.

Correlation 1:

$$a = k_1 u_g^{k_2}$$

Correlation 2:

$$a = k_1 u_g^{k_2} e^{-k_3 u_g}$$

Temperature (°C)	200	265
No. of points	8	64

MEAN SQUARE ERROR:

Correlation 1	2.01×10^5	1.11×10^6
Correlation 2	7.50×10^4	6.85×10^5

PERCENTAGE OF POINTS WITHIN ±30%:

Correlation 1	62.5	43.8
Correlation 2	75.0	53.1

PARAMETERS FOR CORRELATION 1:

k_1	997	2411
k_2	0.021	0.071

PARAMETERS FOR CORRELATION 2:

k_1	1.31×10^6	9.51×10^5
k_2	1.61	1.43
k_3	42	31

m/s showed a Gaussian behavior and could be fitted using Equation (VI-28), while values for gas velocities above 0.08 m/s showed a behavior that could be fitted using Equation (VI-27). This procedure reduced the mean square error to $5.21X10^{5}$ for the entire data set with 61.3 percent of data within the ±30% error band. Figure VI-6 compares the predicted values with the experimental specific interfacial area values for FT-300 wax at 265°C. The specific gas-liquid interfacial area correlations for FT-300 wax at 265°C are:

$$a = 3.3X10^{8} u_g^{2.72} e^{-71u_g} \qquad u_g < 0.08 \text{ m/s} \qquad \text{(VI-29)}$$

$$a = 971 u_g^{-0.216} \qquad 0.08 \le u_g \le 0.15 \text{ m/s} \qquad \text{(VI-30)}$$

Results for Sasol's Arge reactor wax are summarized in Table VI-7. The correlations fit the data fairly well for this case, with 80 to 85% of the data within the ±30% band. The marginally better fit with the second correlation could be as a result of the extra parameter involved in that equation. Since there was no foam present for this wax, the Gamma function type of correlation does not lead to a significant improvement in the goodness of fit. The correlations for specific gas-liquid interfacial area at the two temperatures are:

$$a = 1000 u_g^{0.25} \qquad 0.01 \le u_g \le 0.12 \text{ m/s} \qquad \text{(VI-31)}$$

at 265°C and

$$a = 492 u_g^{0.256} \qquad 0.01 \le u_g \le 0.12 \text{ m/s} \qquad \text{(VI-32)}$$

at 200°C. The different temperatures do not appear to have a significant affect on the exponent, only the coefficient appears to change. As expected, lower temperatures give smaller specific interfacial area, a direct consequence of larger bubbles present at 200°C compared to 265°C. The experimental values of the specific interfacial area are compared with

Table VI-7. Goodness of fit and parameters for area correlations - Sasol's Arge wax and Mobil reactor wax.

Correlation 1:

$$a = k_1 u_g^{k_2}$$

Correlation 2:

$$a = k_1 u_g^{k_2} e^{-k_3 u_g}$$

	SASOL WAX		MOBIL WAX	
Temperature (°C)	200	265	200	265
No. of points	8	20	8	13
MEAN SQUARE ERROR:				
Correlation 1	1940	11610	240	1240
Correlation 2	1700	9090	170	740
PERCENTAGE OF POINTS WITHIN ±30%:				
Correlation 1	87.5	80.0	100.0	100.0
Correlation 2	87.5	85.0	100.0	100.0
PARAMETERS FOR CORRELATION 1:				
k_1	492	1000	165	300
k_2	0.26	0.25	0.01	0.01
PARAMETERS FOR CORRELATION 2:				
k_1	1569	8368	378	1110
k_2	0.53	0.75	0.20	0.31
k_3	5.7	10.2	4.4	6.6

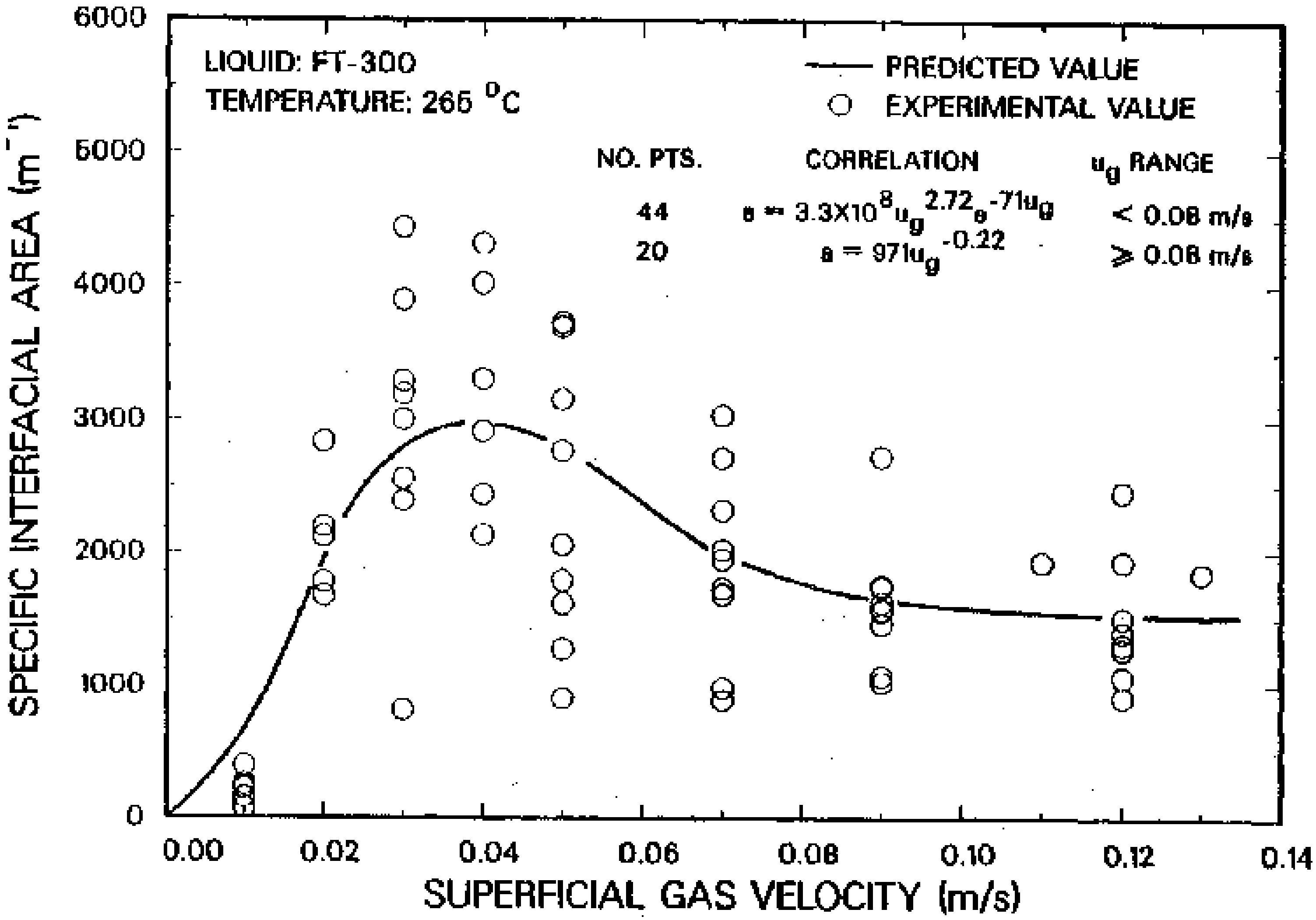

Figure VI-6. Comparison between experimental specific gas-liquid interfacial areas and predictions

the predicted values in Figure VI-7. Despite some scatter, the correlation appears to fit the data fairly well.

Table VI-7 also summarizes results for Mobil reactor wax. Both correlations provide an excellent fit for the data. All data are within ±20% of the predicted values. The correlations for specific gas-liquid interfacial area at the two different temperatures are:

$$a = 300u_g^{0.01} \qquad 0.01 \le u_g \le 0.12 \text{ m/s} \qquad \text{(VI-33)}$$

at 265°C and

$$a = 165u_g^{0.01} \qquad 0.01 \le u_g \le 0.12 \text{ m/s} \qquad \text{(VI-34)}$$

at 200°C. Once again the different temperatures only affect the coefficient for reasons similar to those mentioned above. These correlations also show that for Mobil wax, specific interfacial area has a weak dependence on the superficial gas velocity. This is further illustrated in Figure VI-8 where the experimental values are compared with the values predicted by the correlation. The specific interfacial area remains fairly constant over the range of gas velocities employed.

The results presented above show that wax type has a significant effect on the specific interfacial area. FT-300 wax produces the greatest interfacial area due to the large number of tiny bubbles, whereas, Mobil reactor wax gives the smallest specific interfacial area. The specific interfacial area for FT-300 wax is an order of magnitude larger than that for Mobil reactor wax. Sasol's Arge reactor wax produces interfacial areas that are approximately twice as large as those for Mobil reactor wax. Results from DGD studies showed that, for superficial gas velocities greater than 0.05 m/s, the typical value of the Sauter mean diameter for FT-300 wax at 265°C is around 0.8 mm with orifice and perforated plate

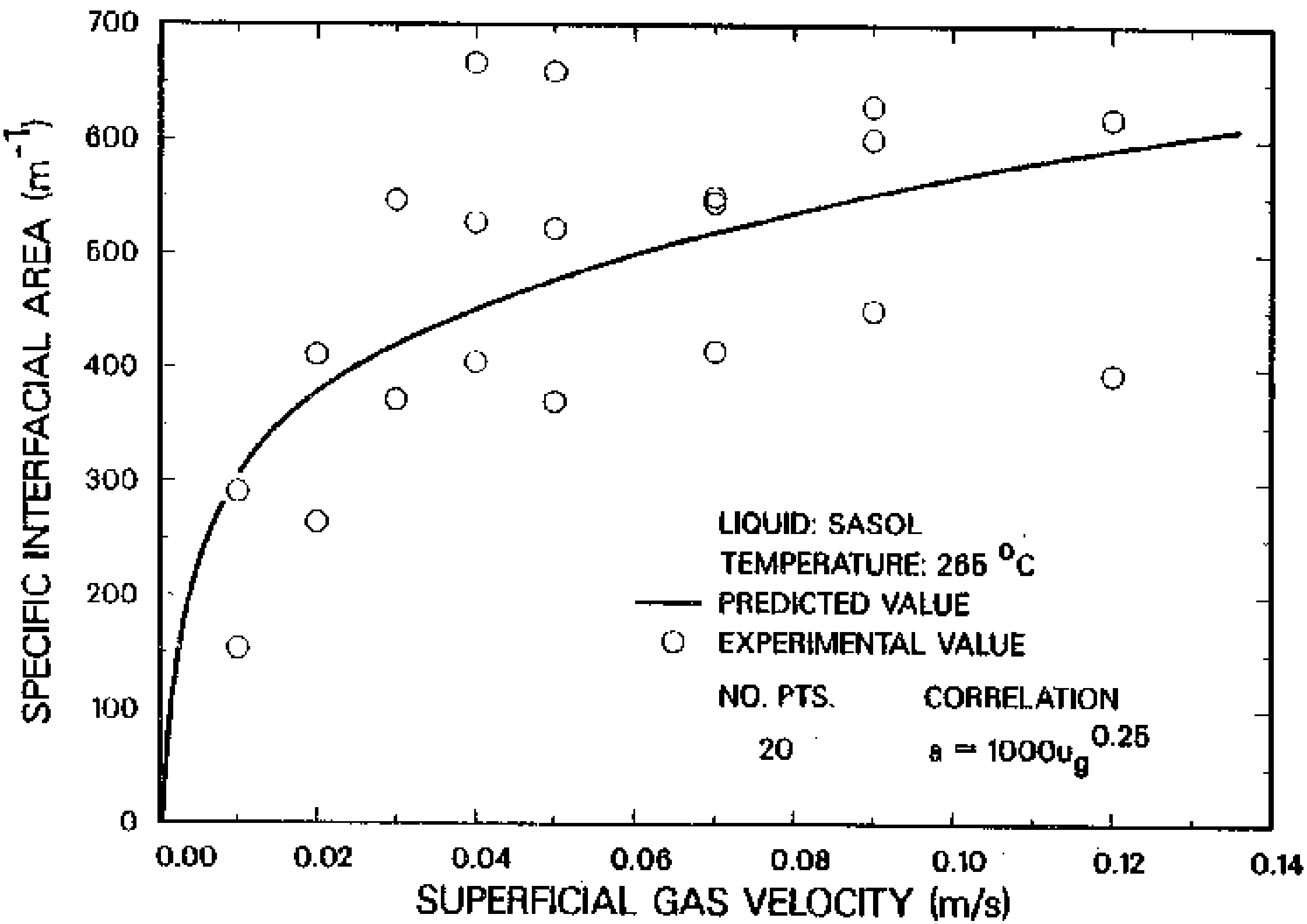

Figure VI-7. Comparison between experimental specific gas-liquid interfacial areas and predictions

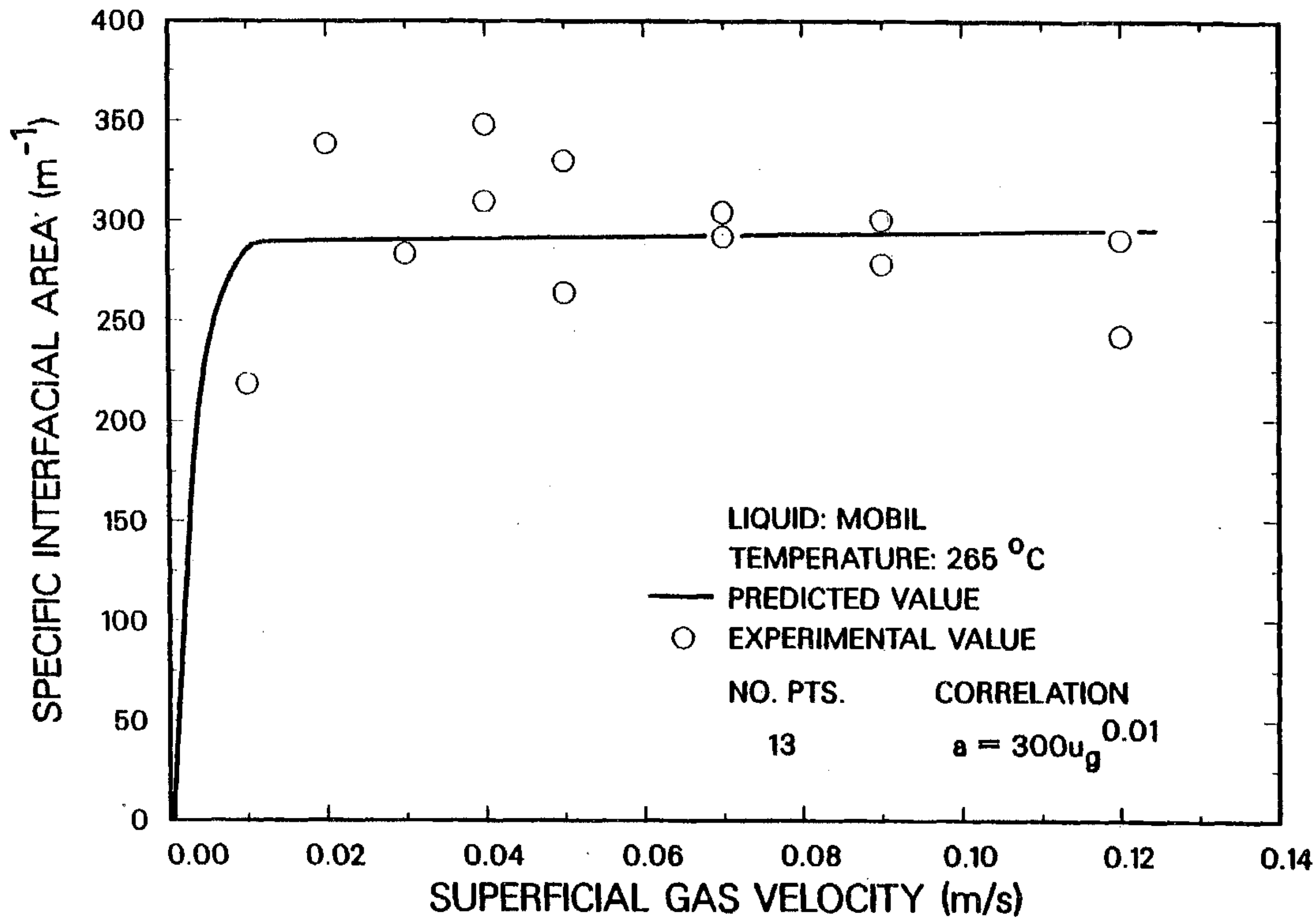

Figure VI-8. Comparison between experimental specific gas-liquid interfacial areas and predictions

distributors and around 0.6 mm with the 40 μm SMP distributor (from photography). These values can be used together with the hold-up correlations (Equations (VI-23) and (VI-24)) to obtain the following correlations for the specific interfacial area (according to Equation (VI-26)):

$$a = 6323u_g^{0.59} \qquad 0.05 \leq u_g \leq 0.15 \text{ m/s} \qquad \text{(VI-35)}$$

for orifice type distributors and

$$a = 9820u_g^{0.61} \qquad 0.01 \leq u_g \leq 0.12 \text{ m/s} \qquad \text{(VI-36)}$$

for the 40μm SMP distributor. Similarly for Sasol wax d_s is around 2 mm at 265°C and the resulting correlation for the specific gas-liquid interfacial area (using Equation (VI-23) for ϵ_g) is

$$a = 2529u_g^{0.59} \qquad 0.07 \leq u_g \leq 0.12 \text{ m/s} \qquad \text{(VI-37)}$$

For Mobil wax d_s is around 4 mm, giving the following correlation for area

$$a = 1265u_g^{0.59} \qquad 0.07 \leq u_g \leq 0.12 \text{ m/s} \qquad \text{(VI-38)}$$

Deckwer et al. (1980) obtained a correlation for the specific interfacial area (Equation (VI-39)) by using their correlation for average gas hold-up and a Sauter mean bubble diameter of 0.7 mm. The correlation is based on experiments conducted with the SMP distributor for $u_g < 0.04$ m/s (the "foamy" regime).

$$a = 71320u_g^{1.1} \qquad \text{(VI-39)}$$

The correlation for ϵ_g, based on data obtained from the present study with the SMP distributor in the "foamy" regime, can be used with a d_s value of 0.6 mm to obtain

$$a = 10600u_g^{0.15} \qquad \text{(VI-40)}$$

At 0.04 m/s this correlation gives a value of 6541 m^{-1} while Deckwer's correlation (Equation (VI-39)) gives 2068 m^{-1}. The correlation with the SMP distributor, based on data obtained in the "slug flow" regime (Equation (VI-36)), gives a specific interfacial area of 1378 m^{-1}. The difference between specific interfacial area from Deckwer's correlation and that from Equation (VI-40) could be due to the differences in the amount of foam present in the two studies.

The correlations presented above show that for FT-300 waxes, the specific interfacial area can be predicted using two different equations, depending on the superficial gas velocity employed. For $u_g < 0.08$ m/s, Equation (VI-29) may be used, while for $u_g > 0.08$ m/s Equation (VI-30) is recommended. Specific gas-liquid interfacial area for Sasol's Arge reactor wax can be predicted using Equation (VI-31) at 265 °C and for Mobil's reactor wax using Equation (VI-33).