critical for investigations aimed at obtaining parameters for bubble column design and scale-up.

B.6. Comparison with Literature

Qualitative comparisons between average gas hold-up values obtained in the present study and those that have appeared in the literature have been made in the previous sections. Here some quantitative comparisons will be made. Only the results from runs conducted using paraffin waxes are compared here. Hold-up values obtained from runs conducted with Mobil's reactor waxes are compared with Mobil's data with similar waxes in APPENDIX E.

The major highlights of the comparisons are:

- Literature data on hold-up values obtained using the SMP distributor is limited to the "foamy" regime and shows that hold-ups increase with a decrease in pore size. Results obtained from the present studies using the 40 μm SMP distributor are in fairly good agreement with the data reported for SMP distributors having pore sizes in the range 20-60 μm.
- Results obtained using the orifice plate and the perforated plate distributors also show a dependency on the distributor hole size in the "foamy" regime. Higher hold-ups are produced with distributors having smaller holes or perforations. This is in good agreement with data reported in literature. In the absence of foam, hold-up values are not affected significantly by the distributor hole size.

B.6.a Sintered Metal Plate Distributors

Figure V-37 shows a comparison of hold-up values obtained in the present study, using the 40 μm SMP distributor in the 0.051 m ID column,

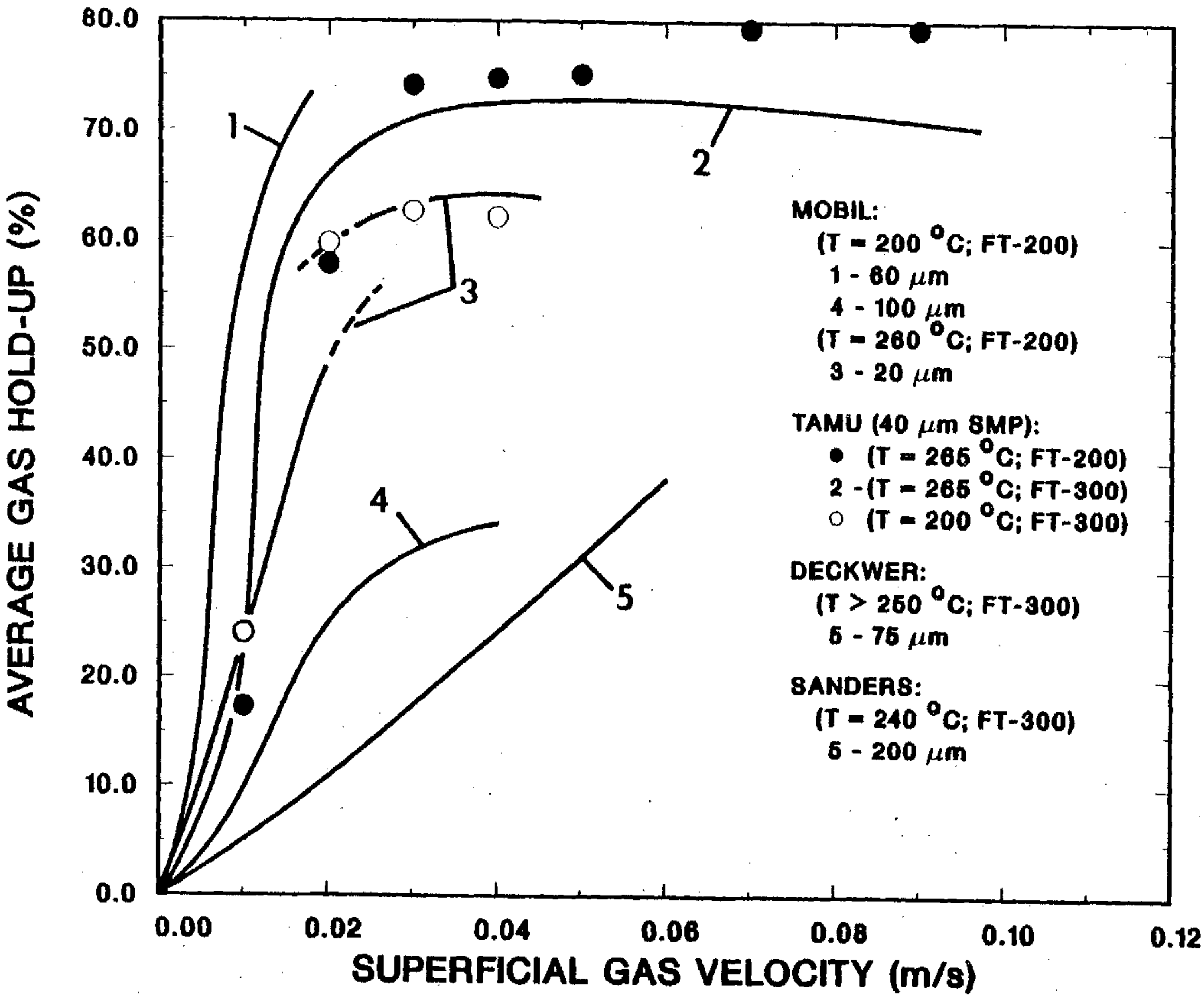

Figure V-37. Comparison of gas hold-ups obtained in studies with sintered metal plate distributors with data from literature. The curve at 265°C (curve 2) represents an arithmetic average of results from 7 runs conducted using FT-300 wax, while only one run was conducted at 200°C with this wax and experimental data are shown (open circles). In the run at 200°C, foam broke when gas velocity was increased from 0.04 m/s to 0.05 m/s and a transition from the "foamy" to the "slug flow" regime took place. Results presented in Figure V-37 are only those obtained in the "foamy" regime; hold-up values obtained in the "slug flow" regime for this run were presented in Figure V-19. Also shown are hold-up values obtained for a run conducted with FT-200 wax at 265°C (solid circles). All of these runs showed hold-up values that are quite similar considering their variability in the "foamy" flow regime (see Section V-B.2). Mobil's data (Kuo et al., 1985) for FT-200 wax obtained using the 60 and 100 μm SMP distributor at 200°C, and with the 20 μm at 260°C (curves 1, 4, and 3, respectively) are also shown in Figure V-37. Results from the present studies are in fairly good agreement with these data. Mobil's data with the 20 μm distributor were obtained in a 0.051 m ID by 9.1 m tall bubble column. A discontinuity in these data is due to the fact that measurements were taken at different static liquid heights (4.83-6.40 m for the low values of u_g and 3.05 m for $u_g > 0.02$ m/s). Mobil's data with the 60 and 100 μm SMP distributors were obtained from experiments conducted in a short hot flow column (0.055 m ID, 1.9 m tall) at 200°C. Deckwer et al. (1980) data for a 75 μm SMP distributor (curve 3) were obtained in two bubble columns having diameters of 0.041 m and 0.10 m, using a hard paraffin wax as the liquid medium at temperatures between 250°C and 285°C. Sanders et al. (1986) data with a 200 μm SMP distributor (curve 5) were obtained in a 0. 05 m ID by 2 m tall bubble column, using FT-300 wax at 240°C.

The gas hold-ups reported by Deckwer et al. (curve 5) are significantly lower than the values obtained in the present study (curve 2 and the open and solid circles), or in Mobil's study (curve 1, 3 and 4), even though the operating conditions, the reactor geometry, and the liquid medium are similar in all cases. The discrepancies are probably caused by the differences in the experimental techniques and duration of runs employed in the different studies.

In Mobil's studies with the 100 μm SMP distributor (curve 4) and Sanders et al. study with the 200 μm SMP distributor (curve 5), lower hold-ups were obtained than in the present study, which may be attributed to the use of larger pore size (100 and 200 μm vs. 40 μm).

Mobil's gas hold-ups obtained with the 60 μm SMP at 200°C (curve 1) appear to be too high in comparison to their own data as well as data from the present study. This is partly due to the poor reproducibility of results in the "foamy" regime. The discrepancy might also be caused by the use of a small static height (0.6 m) in experiments with low superficial gas velocities.

In general, there is fairly good agreement between data from the present study and that from literature for SMP distributors. The data from different sources show that the hold-up values tend to decrease with an increase in pore size for the sintered metal plate distributors, which is as expected, since smaller pore sizes would produce smaller bubbles and therefore higher hold-ups.

B.8b. <u>Orifice and Perforated Plate Distributors</u>

Gas hold-ups, obtained with orifice and perforated plate type distributors, are presented in Figure V-38. Results from our experiments with paraffin waxes (FT-200 and FT-300) conducted in the 0.051 m ID column with the 1, 1.85 and 4 mm orifice plate distributors, and in the 0.229 m ID column with the 19 x 1.85 and 19 x 1 mm perforated plate distributors and the 30 x 1.5 mm perforated pipe distributor are presented. Data from all runs with a given distributor were divided into two groups based on the presence or absence of foam and averaged. Figure V-38 also includes data from literature for experiments conducted under similar conditions.

Gas hold-ups for the run conducted with FT-200 wax using the 1 mm orifice plate distributor in the 0.051 m ID column at 265°C, are in very good agreement with Mobil's results (Kuo et al., 1985) under similar conditions. Foam was present at all velocities with this distributor, resulting in relatively high gas hold-ups. Hold-up values with FT-300 wax in the "foamy" regime decrease as orifice size increases, which is as expected. The 1.0 mm orifice produced the highest hold-ups in this regime, and the 1.85 mm and 4 mm orifice plate distributors produced lower hold-ups. Hold-up values in the larger column (0.229 m ID) were lower than those in the 0.051 m ID in the "foamy" regime, and the effect of orifice hole diameter was rather small. Majority of the distributors employed in the present study produced foam in the velocity range 0.02-0.05 m/s. For velocities greater than 0.05 m/s a transition from the "foamy" regime to the "slug flow" regime (in the 0.051 m ID column) or the "churn-turbulent" regime (in the 0.229 m ID column) occurred.

In the absence of foam, hold-ups do not show any significant effect of distributor type for experiments conducted in the present study. Literature data for flow in this regime (i.e. "slug flow" or "churn-

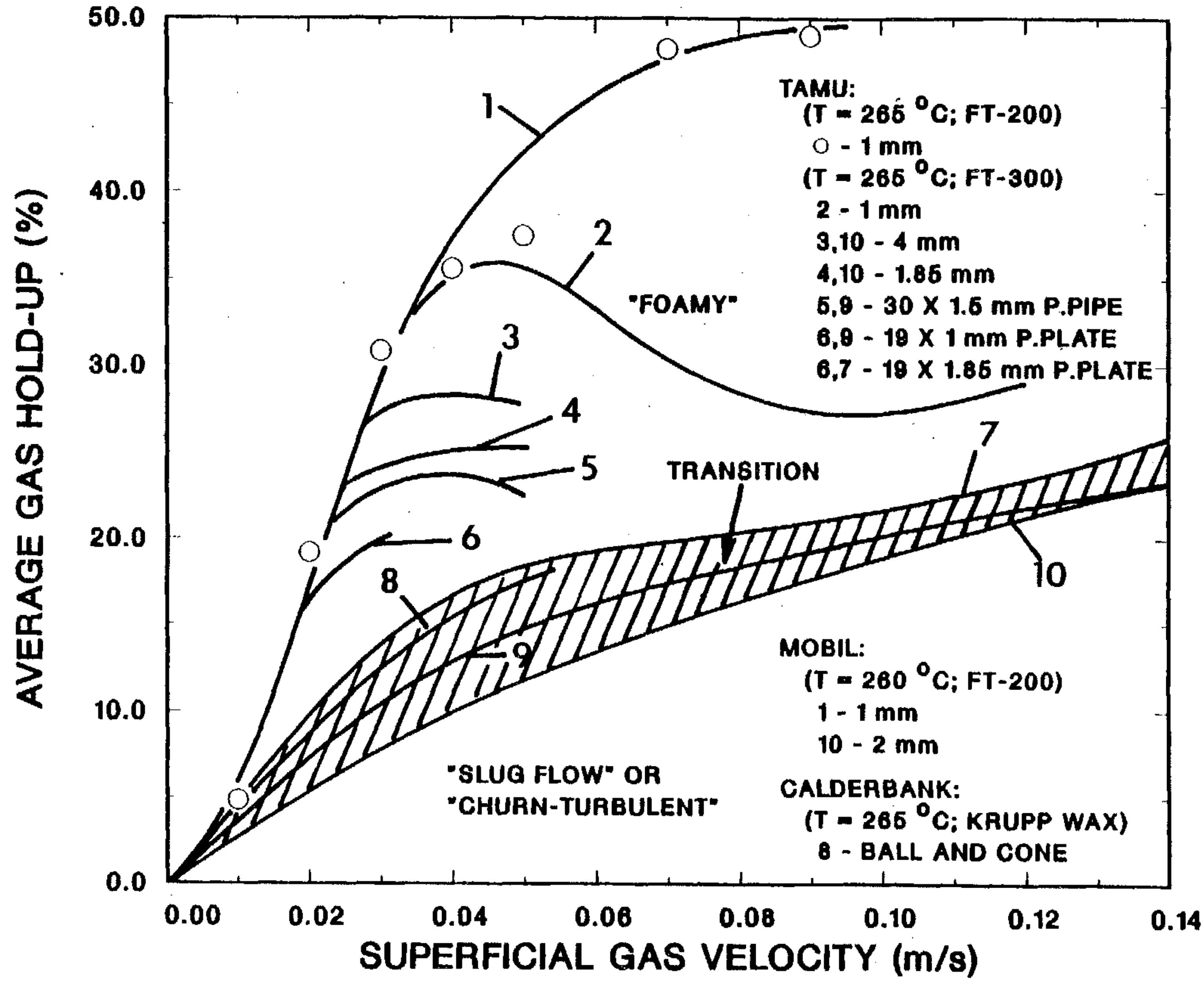

Figure V-38. Comparison of gas hold-ups obtained in studies with perforated plate distributors turbulent") is very limited. Kuo et al. (1985) presented results from studies conducted with a 2 mm orifice plate distributor. There was no foam produced during this run for the entire range of velocities investigated (0.01-0.12 m/s). This is probably due to the use of a very tall column which provides long residence time and thus facilitates bubble coalescence. The hold-ups obtained in the Calderbank et al. (1963) study with a ball and cone distributor lie between the "foamy" data and the data obtained in the absence of foam. The slight discrepancies could be attributed to the differences in static heights and reactor geometries employed in the different studies. Hold-up values, in the absence of foam, fall in a narrow region (shaded region in Figure V-38), irrespective of the distributor type. This region represents a transition region, and lies between the "foamy" regime and "slug flow" (in small diameter columns) or "churn-turbulent" (in large diameter columns) regime. When hold-up values are in this region, a distinct layer of foam is not present, however, very fine bubbles are still present in the system. The transition region becomes narrower at higher velocities compared to velocities in the range 0.01-0.03 m/s.

Results presented in Figure V-38 show that distributors with smaller holes have a greater tendency to foam. This is consistent with observations reported in literature that in systems with foaming capacity, the "foamy" regime is obtained with SMF distributors and perforated plate distributors having smaller holes, while the "slug flow" or the "churn-turbulent" regime occurs with perforated plate distributors having larger hole diameters (e.g. Zahradnik and Kastanek, 1979; Pilhofer, 1980).