diameter columns (0.041 m and 0.10 m). For temperatures below 250°C hold-up in the smaller diameter column was consistently higher than the hold-up in the 0.10 m column for the range of velocities investigated (0.005-0.03 m/s). It should be noted that foam was present under these conditions. However, for temperatures greater than 250°C, hold-up values from the two columns were similar. Shah et al. (1982) summarized the findings of various researchers, from hold-up measurements made with systems which did not produce foam (mostly air-water), which show that the effect of column diameter on the average gas hold-up is minimal. In general slightly lower hold-ups were obtained in large diameter columns compared to smaller columns.

In summary, our results show that the effect of column diameter is not very pronounced in the absence of foam. However, when foam was present, hold-up values in the smaller column (0.051 m ID) were higher than those in the larger column (0.229 m ID). This difference was more pronounced when distributors with smaller holes were used.

B.5. Effect of Distributor Type

The performance of the different distributors was investigated in the 0.051 and 0.229 m ID columns using FT-300 wax. Three orifice plate distributors (1, 1.85 and 4 mm holes) and a 40 μm sintered metal plate (SMP) distributor were evaluated in the smaller diameter column. The orifice plate distributors provided jet velocities in the range 1.6 m/s to 310 m/s for the superficial gas velocities in the range from 0.01 m/s to 0.12 m/s. Two perforated plate distributors, 19 x 1 m and 19 x 1.85 mm, used in the 0.229 m ID column gave jet velocities similar to those obtained with the 1 mm and 1.85 mm orifice plates in the 0.051 m column. A 5 x 1 mm perforated plate was used in the large column in order to obtain jet velocities (up to 720 m/s) similar to those in the Quicker and Deckwer (1981) study. In addition to these three distributors, a 30 x 1.5 mm perforated pipe distributor (commonly encountered in fluidized beds) was also used in the larger column. Results from a few runs conducted with FT-300 wax are also presented here.

The major highlights of these investigations are:

- In the smaller diameter column, hold-up in the "foamy" regime increases with a decrease in orifice diameter, with the SMP distributor giving the highest hold-up values.
- In the large column, the distributor type does not have a significant effect on hold-up values in the "foamy" regime.
- The type of distributor does not have a significant effect on hold-up in the absence of foam in either column.

Figure V-26 shows results obtained in the 0.051 m ID column with FT-300 wax at 265°C using the four distributors. Substantial differences in hold-ups were obtained in the "foamy" regime. All measurements were conducted using increasing order of velocities, therefore, foam was produced at lower velocities, followed by a transition to the "slug flow" regime at higher velocities. These results show that in the "foamy" regime, hold-up increases with decreasing orifice size with the highest amount of foam being produced by the 40 μm SMP distributor and the lowest amount of foam being produced by the 4 mm orifice plate distributor. The velocity range, over which foaming occurs, also increases with decreasing orifice size. In general, the differences in hold-up values in the "foamy" regime with the different orifice distributors could be attributed to differences

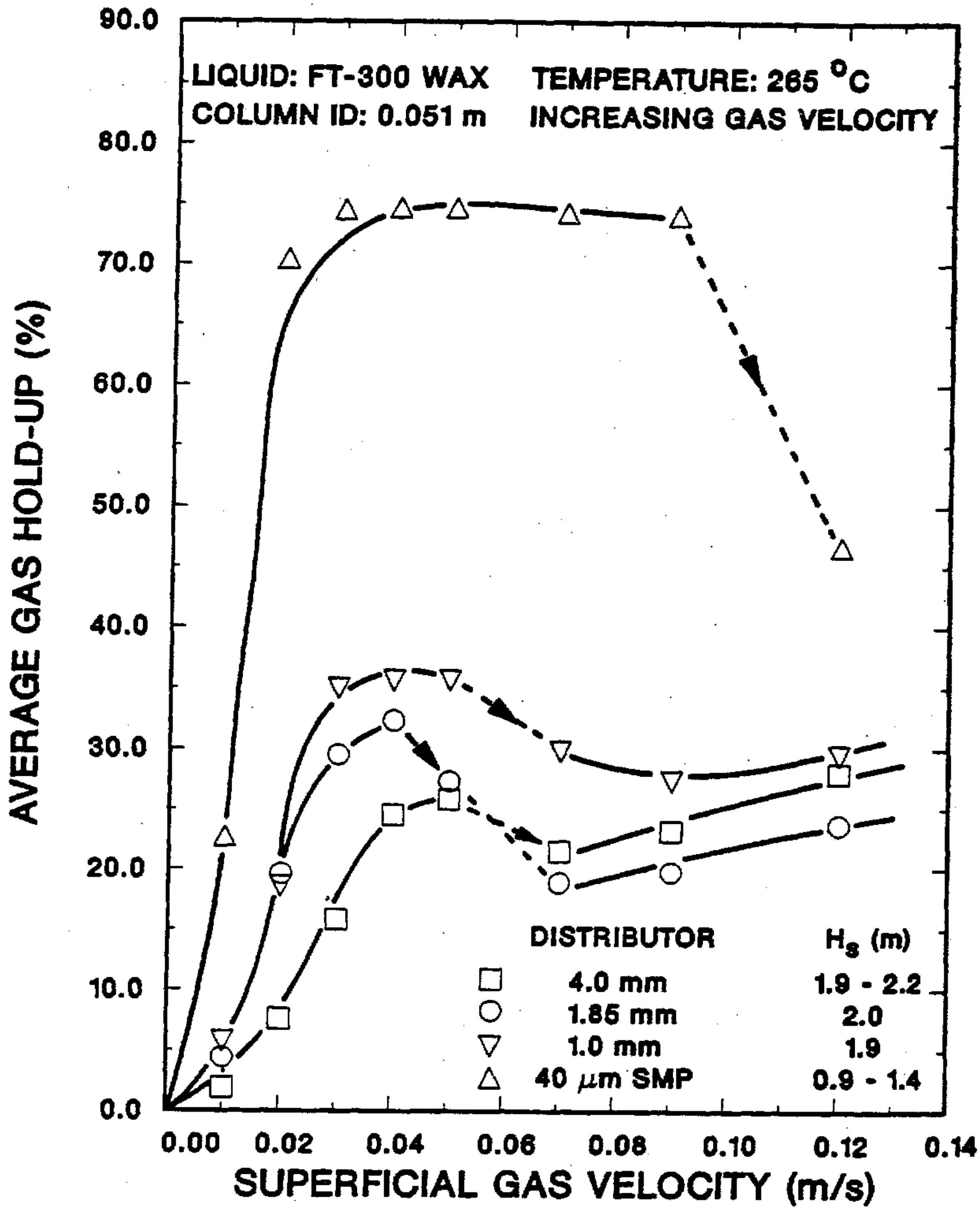

Figure V-26. Effect of distributor type on gas hold-up (□ - Run 6-2; ○ - Run 13-1; ▽ - Run 15-1; △ - Run 5-1) in jet velocities. It is known that for the same superficial gas velocity, jet velocity increases with an increase in column diameter or a decrease in orifice size. A higher jet velocity would translate into a higher kinetic energy and therefore a greater number of small bubbles would be formed, resulting in higher hold-up values.

Results presented in Figure V-26 show that, once the transition from the "foamy" regime to the "slug flow" regime takes place, hold-up values for the different distributors are similar. In the run conducted using the SMP distributor, the transition from the "foamy" regime to the "slug flow" regime was not complete, and thus higher hold-up was obtained at 0.12 m/s. There is a lack of data in literature relating the effect of distributor type to hold-up in the "slug flow" or "churn-turbulent" flow " regime, with molten wax as the liquid medium. However, based on data for non-foaming systems (mostly air-water), Shah et al. (1982) found that in the "slug flow" regime, the effect of sparger type is insignificant. Heijnen and van't Riet (1984) postulate that when coalescence persists (e.g. in FT-300 wax in the absence of foam), larger bubbles are formed within a short distance of the distributor and the identity of the bubbles formed at the distributor is lost. thus hold-up values for different distributors would be similar.

Figure V-27 shows results obtained in the 0.229 m ID column with the four distributors, using FT-300 wax at 265°C. The experiments, conducted in increasing order of gas velocities, show the presence of foam at lower velocities followed by a transition from the "foamy" regime to the "churn-turbulent" regime. The trends are similar with the 19 X 1 mm and the 19 X 1.85 mm perforated plate distributors, with foam breaking in the velocity

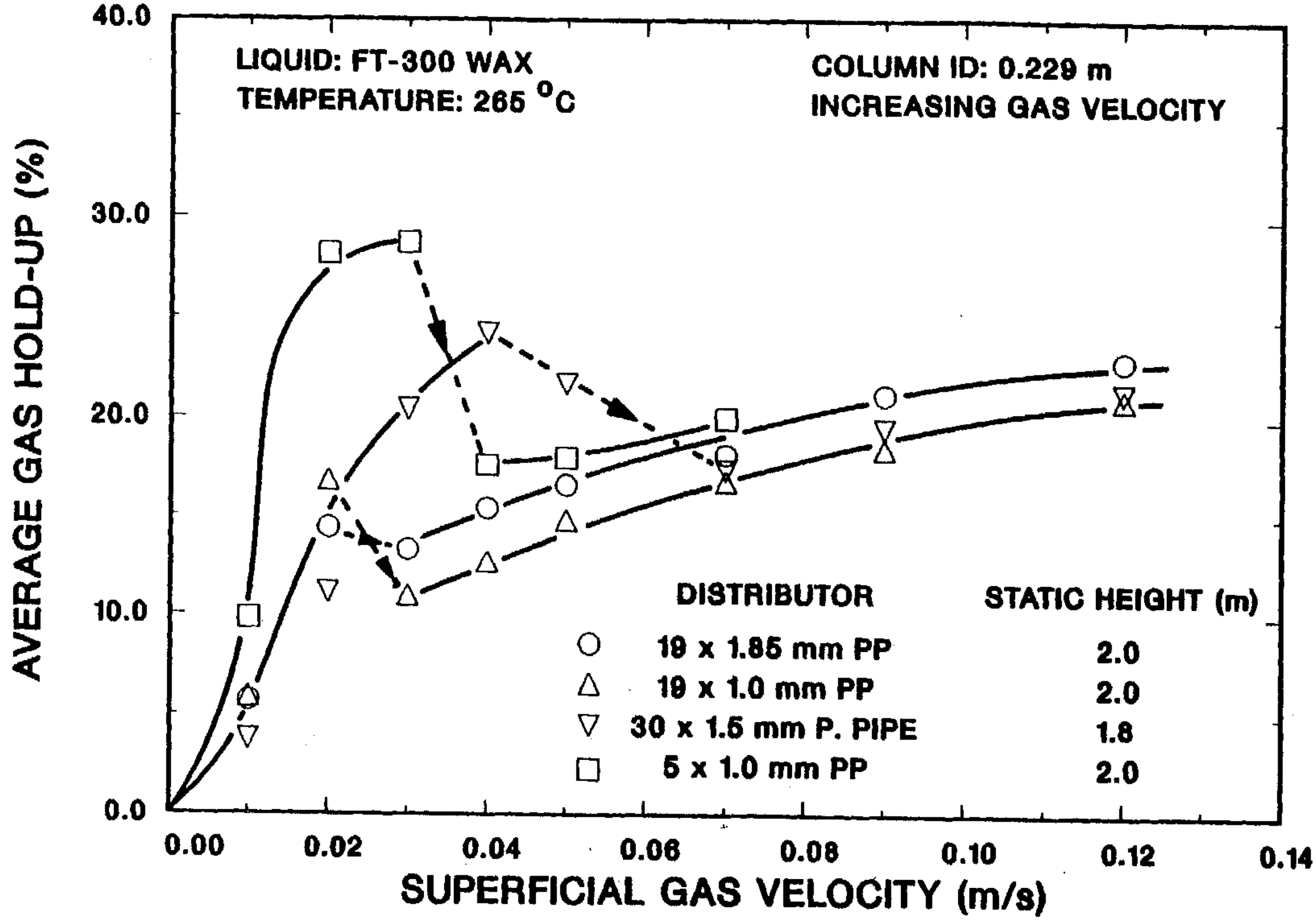

Figure V-27. Effect of distributor type on gas hold-up (○ - Run 2-3; △ - Run 2-2; ▽ - Run 1-5; □ - Run 4-1) range 0.02-0.03 m/s for both runs. The wider range of gas velocities over which foaming occurred, with the perforated pipe distributor (1.5 mm holes) is not as expected. However, only one run was conducted with this distributor and the results may not be typical of the actual behavior for this type of distributor. The 5 X 1 mm distributor gave the highest hold-up in the presence of foam. This is as expected since jet velocities associated with this distributor were significantly higher than those for the other three distributors investigated. With this distributor, foam broke in the velocity range 0.03-0.04 m/s, which is higher than the foam breakup range with the perforated plate distributors. In the "churn-turbulent" regime, hold-up values for the different distributors are very similar. The slightly higher values with the 19 X 1.85 mm distributor (around 2.5% absolute) are not as expected, however, the difference is not significant.

Figure V-28 shows hold-up values obtained with FT-200 wax in the 0.051 m ID column using the 40 μm SMP, 1 mm orifice and the 1.85 mm orifice plate distributors at 265°C. These results are qualitatively similar to those for FT-300 wax under similar conditions with higher hold-ups produced when small hole size distributors were used. Hold-ups were highest with the 40 μm SMP distributor, whereas hold-ups with the 1.85 mm orifice plate distributors were significantly lower. Most of the data presented in Figure V-28 were obtained in the presence of foam and a transition from the "foamy" regime to the "slug flow" regime was not as pronounced with FT-200 wax compared to FT-300 wax. The results for the SMP distributor do show a decrease in gas held up when velocity was increased from 0.09 m/s to 0.12 m/s. This could be attributed to the initiation of the foam breakage process. The trends are similar to the findings by researchers at Mobil (Kuo

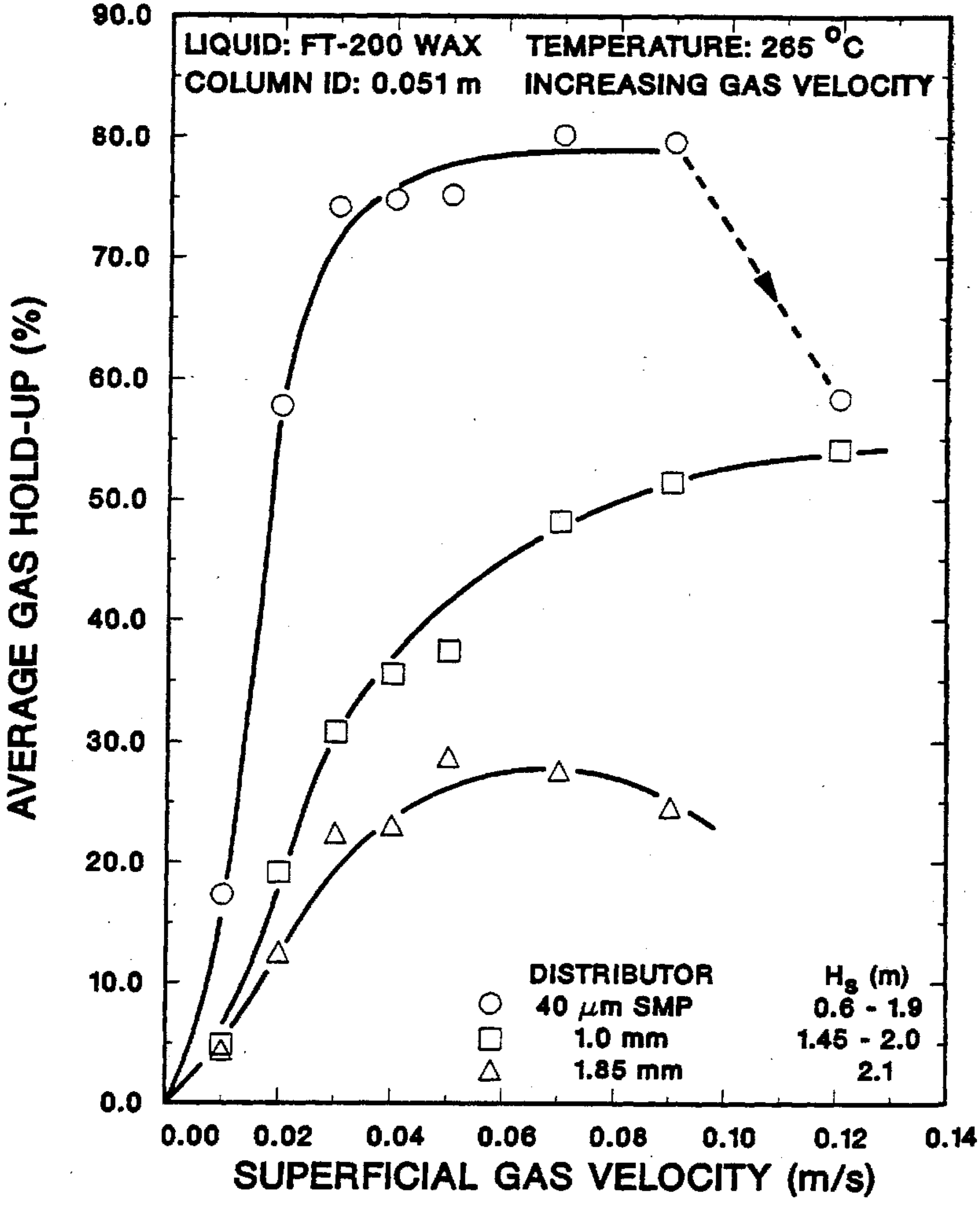

Figure V-28. Effect of distributor type on gas hold-up (○ - Run 20-1; □ - Run 17-1; △ - Run 11-5) et al., 1985). Their experiments with FT-200 wax at 200°C, using three different SMP distributors (15, 60 and 100 μm) and three different orifice plate distributors (0.25, 0.39 and 0.57 mm) in a 0.032 m ID column, showed that hold-up values were highest with the 15 μm SMP distributor and lowest with the 0.57 mm orifice plate distributor. However, these investigations were carried out for superficial gas velocities less than 0.04 m/s, therefore, the transition from the "foamy" to the "slug flow" flow regime was not observed. The maximum hold-up obtained in the Mobil studies was around 70%, when foam filled the entire column (with the 15 and 60 μm SMP distributors). This value compares well with that obtained with the SMP distributor in the present study.

Experiments conducted with reactor waxes showed no significant effect of distributor type. However, hold-ups obtained using the SMP distributor were marginally higher than those obtained using the 1.85 mm orifice plate distributor in the 0.051 m ID column (see Section V-B.7.).

Experiments with FT-300 and FT-200 waxes conducted to study the effect of distributor type indicate that the effect is most significant in the presence of foam. Smaller orifice diameters and SMP distributors produce higher hold-ups compared to larger orifice distributors. However, in the absence of foam, even though there is a similar trend, its magnitude is rather small. The effect of distributor type is less pronounced in the larger (0.229 m ID) column than in the 0.051 m ID column.

B.6. <u>Effect of Oxygenates</u>

The hydrodynamic behavior of reactor waxes is significantly different from that of paraffin waxes (e.g. FT-200 and FT-300). The reactor waxes, in addition to long chain paraffins, also contain high molecular weight ole-