(Kuo et al., 1985) used FT-200 wax as the liquid medium and found that hold-up values at 138°C were substantially lower than those at 260°C. Despite some inconsistency in results, the overall trend is that hold-up increases with an increase in temperature, in the "foamy" regime (note that all of the literature dealing with this system reports results for runs with velocities less than 0.04 m/s, i.e. in the "foamy" regime). Results from our study are in agreement with these findings.

Due to the lack of literature data, with molten wax as the liquid medium, on the effect of temperature on hold-up in the "slug flow" regime or the "churn-turbulent" regime, only a comparison with results from other systems is possible. Shah et al. (1982) have shown that the increase in viscosity, by increasing the CMC (carboxy methyl cellulose) concentration, did not have an effect on gas hold-up in the "slug flow" regime, a behavior similar to that for FT-300 wax as shown in the present study.

B.4. Effect of Column Diameter

Commercial size bubble columns are expected to operate in the heterogeneous ("churn-turbulent") flow regime, while majority of the studies, with a molten wax as the liquid medium, were carried out in small diameter columns (up to 0.12 m) and thus only the ideal bubbly (homogeneous) and "slug flow" regimes were observed. Results from studies conducted in the 0.051 m ID and 0.229 m ID glass columns are reported here showing the effect of column diameter. The comparison is based on runs conducted at 265°C using the 1 mm and 1.85 mm orifice plate distributors in the 0.051 m ID column, and the 19 X 1 mm and the 19 X 1.85 mm perforated plate distributors in the 0.229 m ID column. Data from a total of 13 runs in the 0.051 m ID column and from 6 runs in the 0.229 m ID column are available for comparison. The gas velocity range employed in these experiments was 0.01-0.12 m/s.

The major highlights of these investigations are:

- With FT-300 wax, foam consistently broke at a higher velocity in the 0.051 m ID column compared to the 0.229 m ID column. However, no significant effect of column diameter was observed in the absence of foam.
- Distributors with smaller holes (1 mm orifice plate in the 0.051 m ID column and 19 X 1.0 mm perforated plate in the 0.229 m ID column) gave higher hold-up values in the smaller column, compared to the larger column, irrespective of the presence or absence of foam.
- Experiments conducted with Sasol's Arge reactor wax did not show a significant effect of column diameter on the gas hold-up in the range of velocities investigated (0.01-0.12 m/s).

Figure V-22 compares results obtained at 265°C in the two columns using the 1.85 mm orifice plate distributor in the 0.051 m ID column and the 19 X 1.85 mm distributor in the 0.229 m ID column. The jet velocities produced by the two distributors, for a given superficial gas velocity, are very similar (the jet velocity in the smaller column was approximately 94% of the jet velocity in the larger column). The experiments, conducted using increasing order of gas velocities, show similar trends in the two columns, however, hold-up values in the "foamy" regime are consistently higher in the smaller diameter column and the transition from the "foamy" to the "slug flow" regime occurs at a higher velocity in the 0.051 m ID column. Once the foam broke, hold-up values in the two columns are similar at all subsequent velocities. Results presented in this figure are typical of the

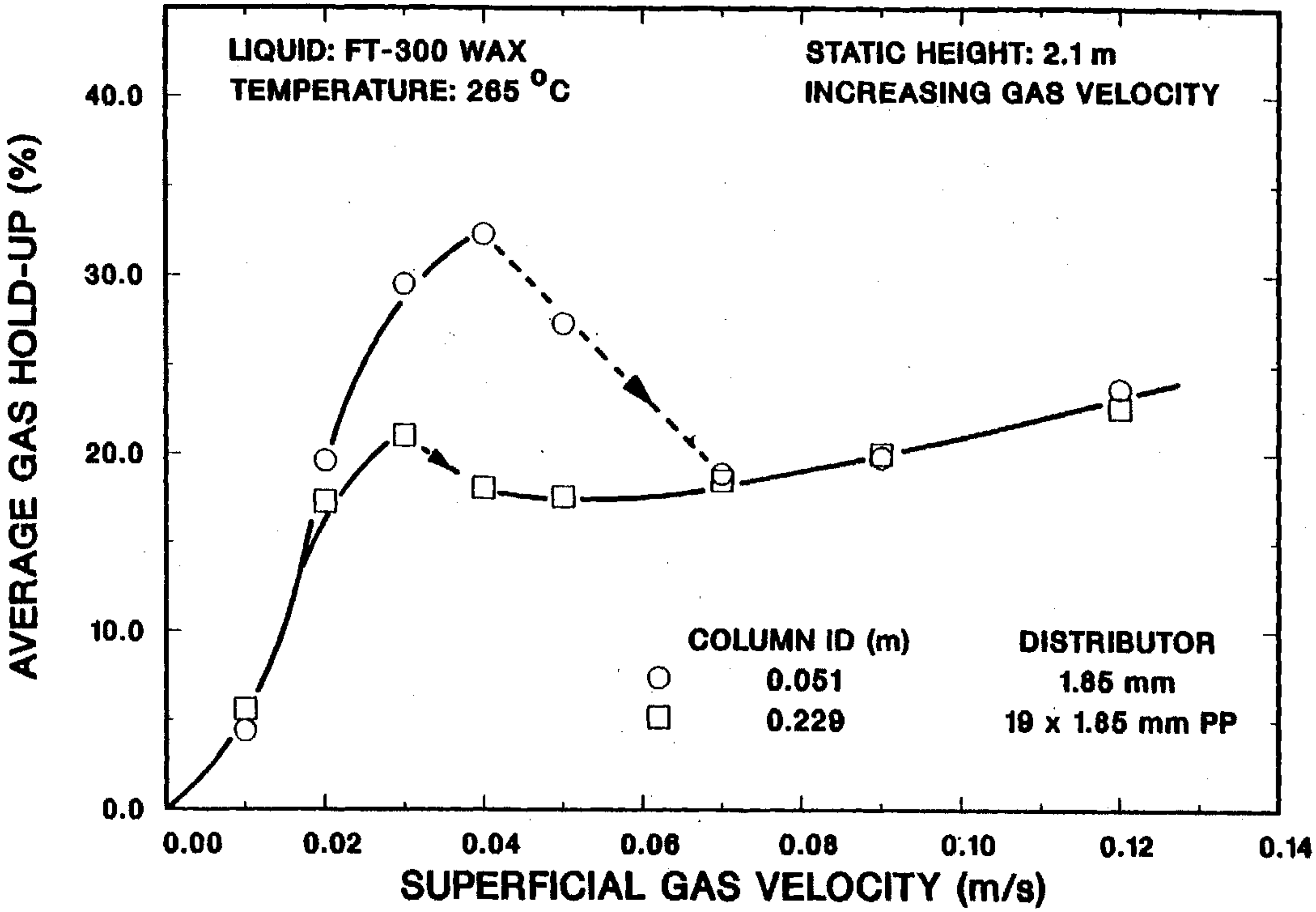

Figure V-22. Effect of column diameter on gas hold-up (Increasing order of velocities; ○ - Run 13-1; □ - Run 2-8) behavior of FT-300 wax in the two columns. Figure V-23 shows a similar comparison for runs made in the two columns using decreasing order of gas velocities. These results show trends which are qualitatively similar to those observed using increasing order of gas velocities (Figure V-22). However, there were runs in which hold-up values in the 0.051 m ID column were lower than those in the 0.229 m ID column, particularly in the gas velocity range 0.03-0.07 m/s. This usually occurs when a transition from the "slug flow" regime to the "foamy" regime does not take place in the 0.051 m ID column (e.g. see Figure V-10). It appears that in such situations the dispersion in the large column, despite the obvious absence of foam, has a large concentration of tiny bubbles. These tiny bubbles increase the hold-up to levels which are similar to those obtained in the presence of foam in this column. In general, results presented in Figures V-22 and V-23 are indicative of the trends observed with hold-up values for majority of the runs conducted in the two columns.

Figure V-24 compares results from the two columns using the 1 mm orifice plate distributor in the 0.051 m ID column, and the 19 X 1 mm perforated plate distributor in the 0.229 m ID column. Once again, the jet velocities for the two distributors are similar at a given gas flow rate. These runs, conducted using increasing order of velocities, show results which are qualitatively similar to those shown earlier in Figure V-22 in the "foamy" regime. However, after an apparent foam breakup, the hold-ups in the 0.051 m ID column are consistently higher than those in the 0.229 m ID column.

Experiments were also conducted with Sasol's Arge reactor wax in the two columns at 265°C using the 1.85 mm distributor in the 0.051 m ID column

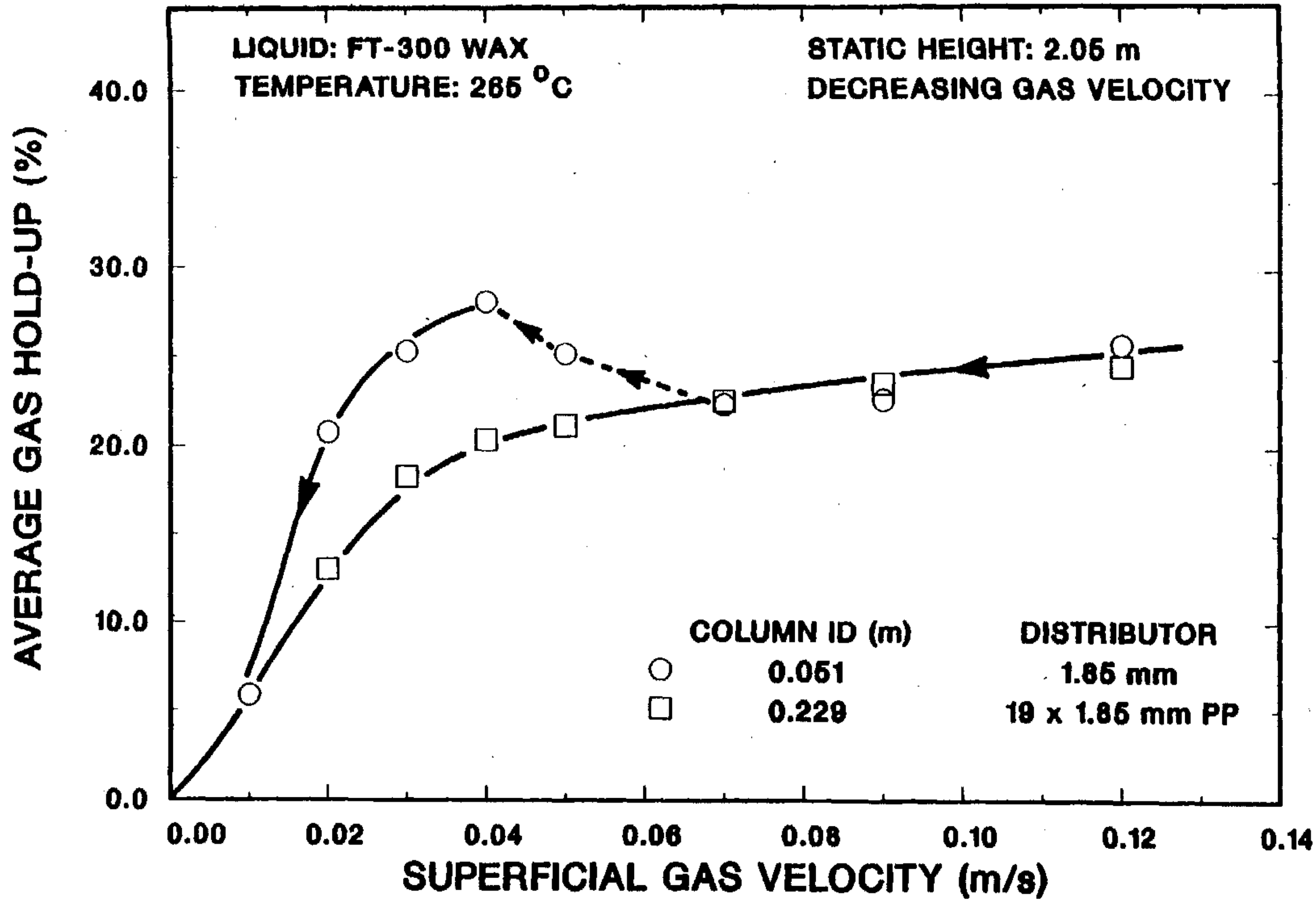

Figure V-23. Effect of column diameter on gas hold-up (Decreasing order of velocities; ○ - Run 13-3; □ - Run 2-9)

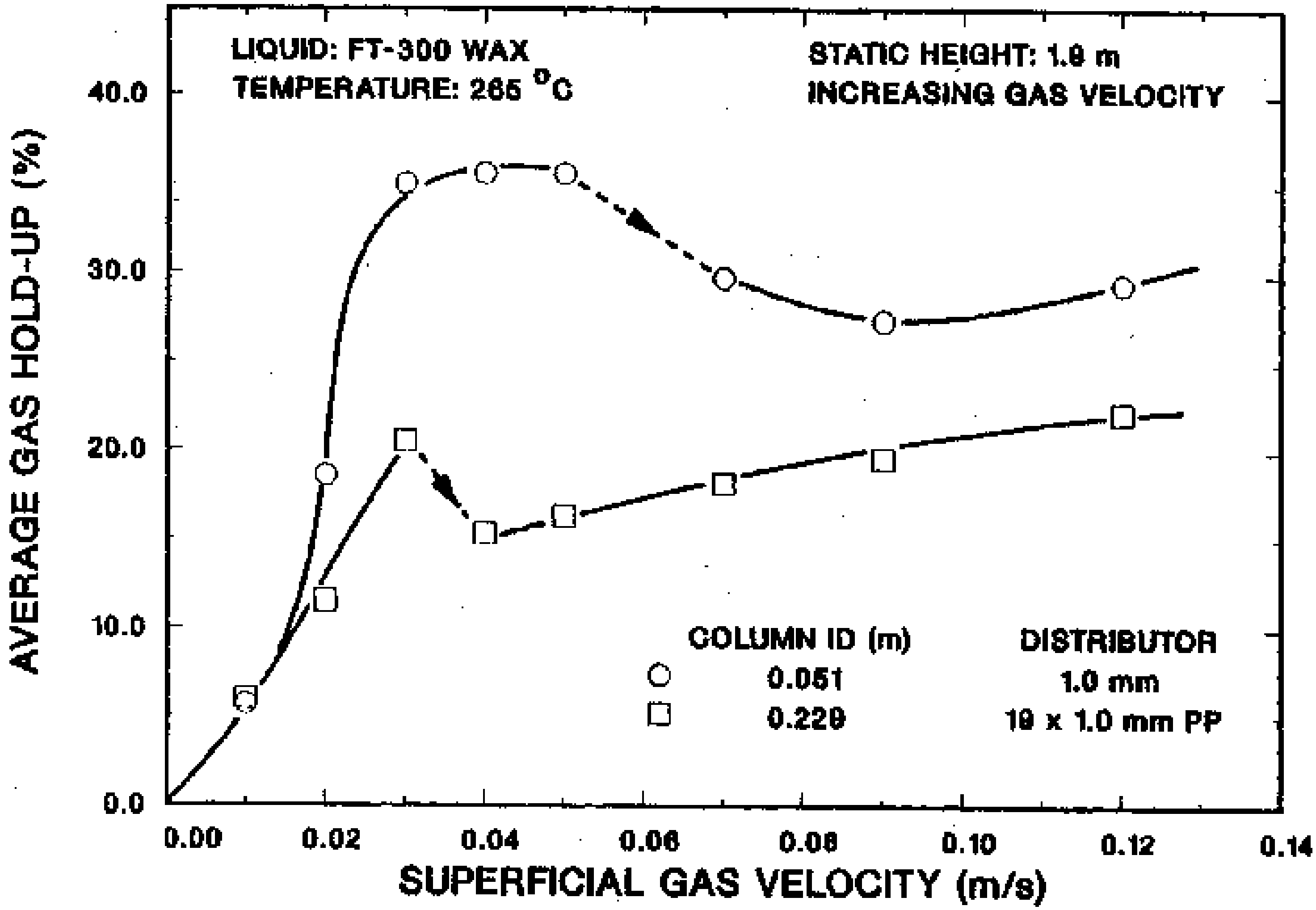

Figure V-24. Effect of column diameter on gas hold-up (○ - Run 15-1; □ - Run 1-6) and the 19 X 1.85 mm distributor in the 0.229 m ID column. No foam was produced during any of these runs and hold-up values were very similar in both columns, as shown in Figure V-25. Researchers at Mobil (Kuo et al., 1985) conducted experiments in 0.051 m ID and 0.102 m ID columns with reactor wax produced in their bench scale unit (Run CT-256-7 and CT-256-8 waxes). The hold-up values in the 0.102 m ID column were 30-40% higher than those in the 0.051 m ID column over the gas velocity range 0.015-0.065 m/s. They attributed this difference to the fewer slugs (or large bubbles) in the large column compared to the smaller column.

In general, the above results do not show a significant effect of column diameter on the gas hold-up. The major differences are in the "foamy" regime, and the earlier discussion on reproducibility showed that large deviations in hold-up are possible in this regime. These findings are consistent with results reported in literature. Researchers at Mobil (Kuo et al., 1985) conducted studies with FT-200 wax in 0.032 m ID and 0.053 m ID columns, each being 2.2 m in height, in order to assess the effect of column diameter on gas hold-up. Their results indicate that for similar jet velocities, column diameter did not have a significant effect on the gas hold-up values. Also hold-ups in the "foamy" regime were higher for runs made in the smaller diameter column, which is in agreement with the findings from the present study. Kuo et al. conducted similar studies in two tall columns (0.051 m ID and 0.102 m ID, 9.14 m tall) with FT-200 wax and reactor waxes produced in their bench scale units. These studies showed no effect of column diameter on gas hold-up for FT-200 wax, however, in experiments with reactor waxes higher hold-ups were obtained in the larger column. Deckwer et al. (1980) conducted experiments in two different

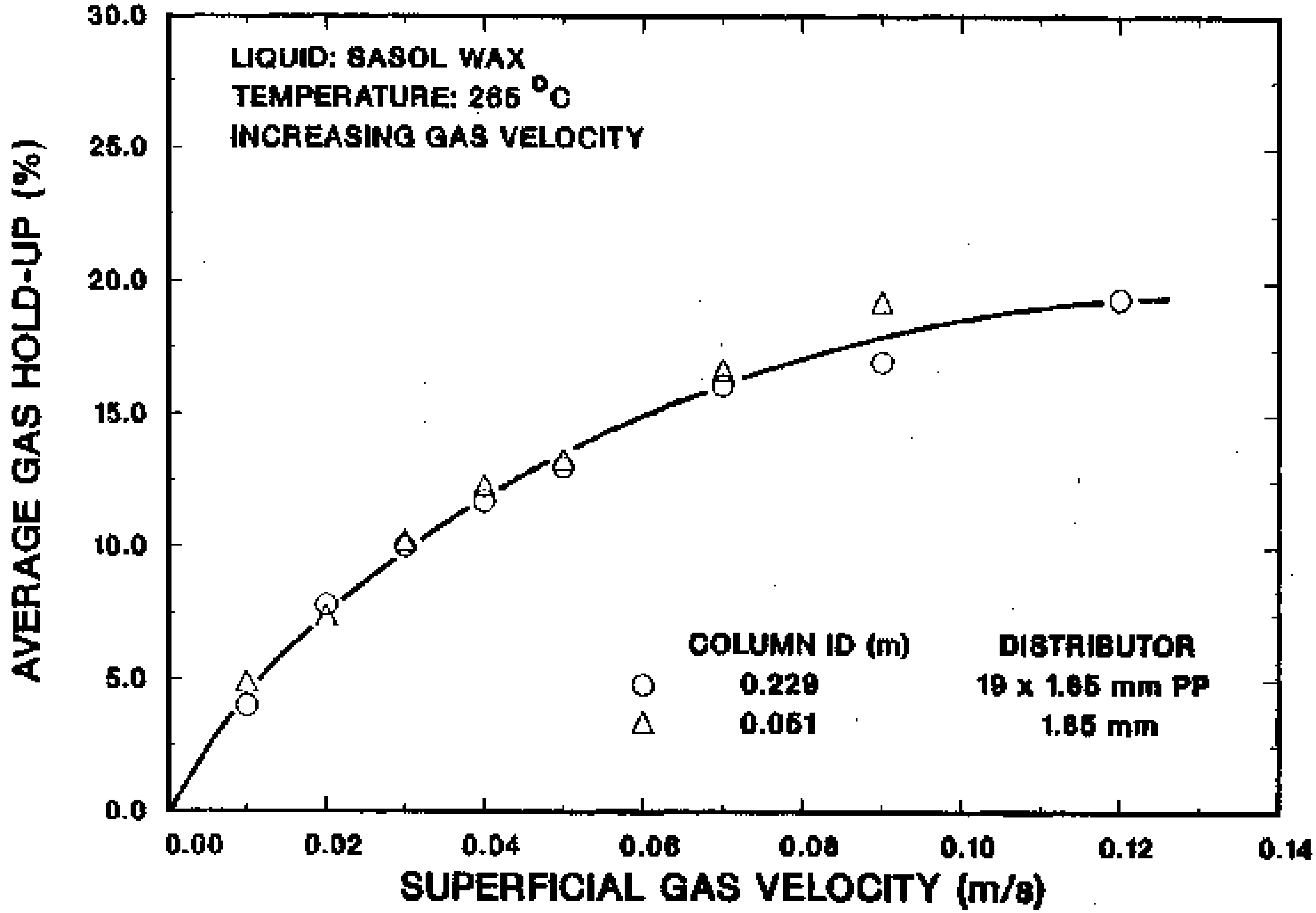

Figure V-25. Effect of column diameter on gas hold-up (○ - Run 3-2; △ - Run 8-4) diameter columns (0.041 m and 0.10 m). For temperatures below 250°C hold-up in the smaller diameter column was consistently higher than the hold-up in the 0.10 m column for the range of velocities investigated (0.005-0.03 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. <u>Effect of Distributor Type</u>

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