A note on vortex-tube flows

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Vortex-tube flows have been examined which lack the relatively quiescent, nearly isothermal, core common to those studied by other authors.

In a recent paper Sibulkin (1962) has collected most of the measurements made inside Ranque–Hilsch vortex tubes. A feature common to the several flows examined was a relatively quiescent, isothermal core; Sibulkin's theoretical model appears to depend on this concept. But, as the accompanying measurements show (figures 1–3), a sluggish motion of isothermal gas near the axis is not a universal feature of vortex-tube flows. Similar measurements were made with seven other combinations of blockages at the ends of the tube. Steep temperature gradients were found in the core region for several of them. Commonly, the maximum swirl velocity occurred, as here, much nearer to the axis than in the measurements available to Sibulkin.

The measurements presented here were made in a tube of length 48 in. and diameter 3 in., with a driving pressure ratio of about 2·35. Air entered the tube through eight tangential slots near one end; they were about $\frac{1}{4}$ in. by 1 in. in cross-section. At the end of the tube near the inlet the air escaped through an orifice of diameter 1·25 in., and at the other end through one of diameter 1·35 in. In other configurations the air escaped at the end distant from the inlet through perforated end plates, the perforations being in some cases distributed uniformly over the tube cross-section and, in one case, concentrated in a ring near the tube wall. It was for this last configuration that the velocity and temperature distributions were most like those considered by Sibulkin; it is probably relevant that the internal measurements available to him were all made in tubes from which air escaped around the periphery at the end distant from the inlet.

The pressure was measured using a $\frac{1}{16}$ in. diameter steel tube into which a 0·01 in. diameter hole had been drilled. The total pressure was taken as the maximum achieved as the sensing tube was rotated, the static pressure as the mean of the pressures obtained by rotating the sensing tube by $\pm 33°$ from the position of the maximum. A more accurate estimate of the flow angle was made using the latter two readings. The recovery temperature was measured using a probe whose recovery factor was about 0·60. The introduction of such pressure and temperature probes into the vortex produced large changes in the fields within the tube. These changes were not just local ones; large disturbances occurred throughout the tube. (For the conditions represented in the figures and with driving pressure held constant while a probe was inserted, the wall

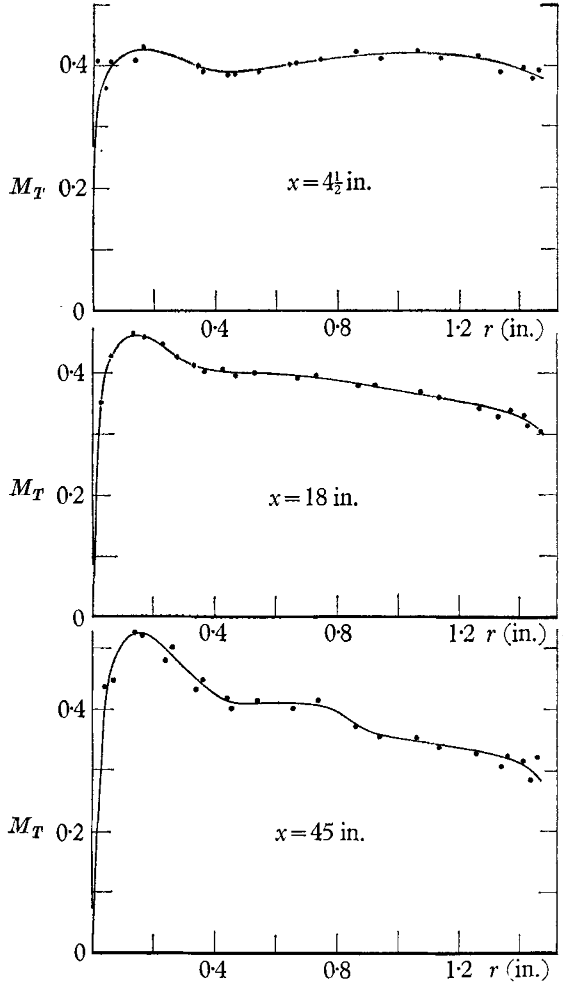

FIGURE 1. Swirl velocity distribution: tangential Mach number M_T distributions *vs* radius r at three sections of the tube identified by their distances from the inlet end.

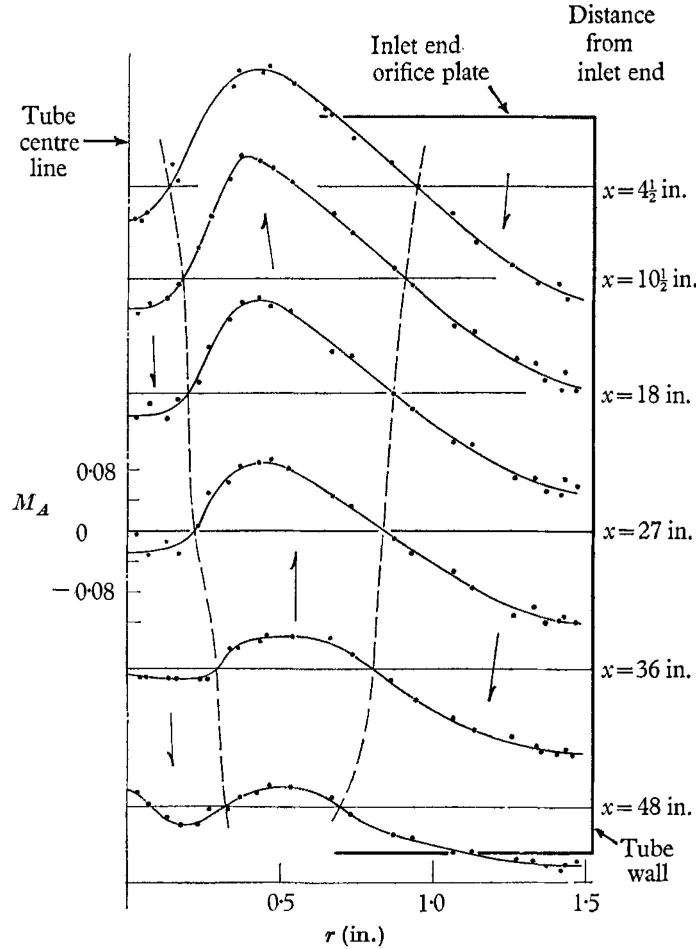

FIGURE 2. Axial velocity distribution: axial Mach number M_A distributions *vs* radius r at six sections of the tube (solid lines). The dashed lines mark the region of reversed flow.

pressure changed by 8 % and the temperature level by 7 C deg.) However, all the measurements made in vortex tubes until now have relied upon instruments of somewhat similar design and of about the size of those used here. All the data must be equally suspect.

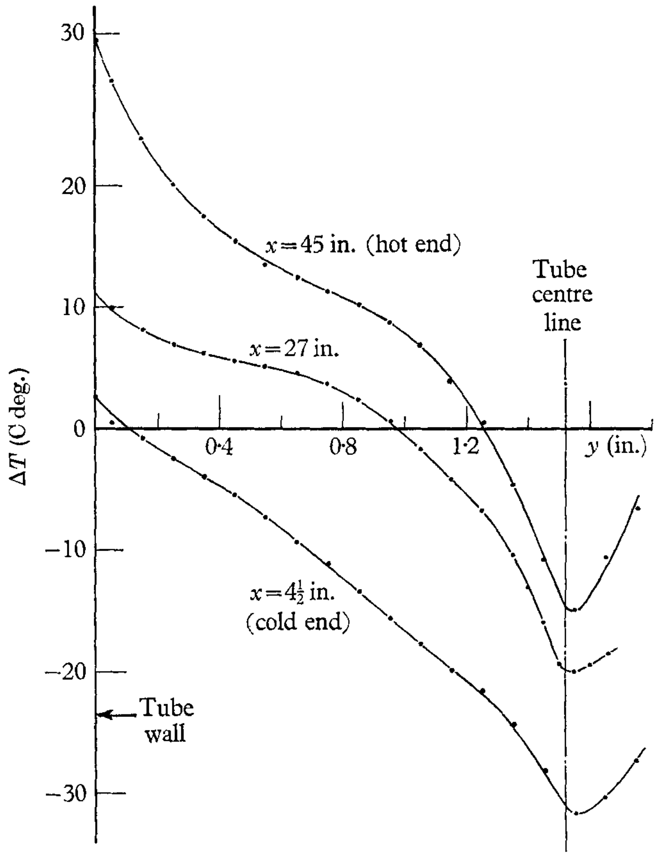

FIGURE 3. Recovery temperature distributions *vs* distance from tube wall at three sections of the tube identified by their distance from the inlet end. Temperatures are measured with respect to the inlet level.

REFERENCES

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