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CONSOLIDATED MCF 700

OIL DIFFUSION PUMP

C. E. Normand

Incidental to some work in progress on diffusion pump heaters, fairly complete operating characteristics of CEC's 6", MCF-700, pump have been determined. Since a number of these pumps are in use in the division, a summary of observed characteristics appears worthwhile.

The test set-up is shown schematically in Figure 1. Tests were run with Octoil (recommended by CEC) and with Convoil-20 as pumping fluids.

1. Power - This pump comes equipped with a 120 v, 800 watt ring-type heater. The operating power range for Octoil is given by the manufacturer as 600 watts minimum; 800 watts normal.

Observed average pumping speed for air, base pressure and limiting fore pressure, over a power range from 430 to 960 watts, and for the two pump fluids tested, are shown graphically in Figure 2.

On the basis of pumping speed and base pressure, pumping is satisfactory down to power of 550 watts with Octoil and to 700 watts with Convoil-20. With both fluids, however, the limiting fore pressure is very low at these powers, and another defect, not shown in the graphs, is that the base pressure varies widely at the lower limit of power.

The choice of 800 watts as normal operating power with Octoil appears to be an arbitrary compromise, since both the limiting fore pressure and the base pressure increase substantially at powers above 600 watts.

With Convoil-20 the situation is somewhat different. In this case the base pressure rises only slightly with increasing power; and operation may well be at, or even above, 920 watts.

In general, it appears that the performance of this pump with Convoil-20 is comparable to that with Octoil if about 125-150 watts additional power is supplied in the case of Convoil.

2. Pumping Speed - Pumping speeds for air were measured over the 10^{-4} to 10^{-6} mm pressure range, both for Octoil and Convoil-20, and at a number of operating powers. In all cases, the speed decreased slightly at lower pressures and as indicated above, the average speed increased slightly with increasing power. All speeds were measured with the C.E.C. 6" water-cooled baffle.

The resulting speed curves are given in Fig. 3. The average speeds, 330 L/Sec. with Octoil and 360 L/Sec. with Convoil-20, are quite consistent with the rated unbaffled speed of 650 L/Sec. at 10^{-4} mm.

3. Base Pressure - With both pump fluids, base pressures of 4.0 to 4.5×10^{-7} mm were obtained, but at different operating powers. With Octoil the lowest base pressure occurs at 550 watts power; with Convoil-20 at 735 watts.
4. Limiting Fore Pressure:- The fore pressure characteristics of this pump are poor at the highest power available, and even poorer at lower operating powers. Most diffusion pumps, when operating at normal power against a rising fore pressure, permit little or no rise in head pressure until "breakdown" of pumping occurs at some critical value of the fore pressure. With the onset of breakdown, the pump loses its ability to maintain high vacuum, and the pressure rises suddenly (by orders of magnitude) in a series of pressure surges. The fore pressure at which breakdown occurs is then the limiting fore pressure if high vacuum is to be maintained.

The behavior of the MCF-700 pump is quite different from this. With rising fore pressure, the head pressure also rises - not by a few percent, but many-fold -- prior to the onset of breakdown. Obviously, the fore pressure at which breakdown occurs is of no practical interest in this case. The pump has lost its ability to maintain high vacuum at a fore pressure much lower than this, and limiting fore pressure must be redefined. The fore pressure limits given in Section 1, Fig. 1 were arbitrarily taken as the fore pressure at which the head pressure had risen, not by a few percent but to two times its initial value.

Since even a small increase in fore pressure has a marked adverse effect on base pressure, the MCF-700 pump should, for most applications, be followed by a booster pump.

5. Pressure Variations - As with other pumps tested, the base pressure maintained by this pump undergoes variations characteristic of different operating power levels. At very low powers the pressure varies continuously, but through narrow limits ($2.4 \pm .2 \times 10^{-6}$ mm at 383 w with Octoil, $5.3 \pm .15 \times 10^{-6}$ mm at 640 w with Convoil-20). At intermediate powers the pressure is essentially constant except for occasional momentary pressure bursts of $.3$ to $.5 \times 10^{-6}$ mm. At high power the pressure wanders widely - e.g., from 0.5 to 1.2×10^{-6} mm with Octoil at 800 watts.
6. Hydrogen Pumping - The MCF-700 pump is very ineffective, at pumping hydrogen, even with Octoil fluid at the highest operating power available in our tests, i.e. 960 watts. With higher boiling point Convoil-20 or at lower power input, pumping is even less effective. Since no stable pressure is maintained while hydrogen is being pumped, it is not possible to derive a definite pumping speed from any measurement. The best one can do is calculate upper and lower limits of speed. Fig. 4 shows the results of applying this treatment in the most favorable case, (962 watts operating power, Octoil fluid). Fig. 5 shows the result of decreasing the power to 804 watts.
7. Summary -
 - a. The power supplied to the MCF-700 pump is insufficient for full range operation, particularly for pumping hydrogen and for operating with fluids other than Octoil.
 - b. The pumping speed and the base pressure obtained for air are probably about as rated.
 - c. Fore pressure characteristics at presently available power are so poor as to make use of a booster pump almost imperative. This situation might be improved by increasing the power, but there is no assurance that this would be the case.
 - d. Pressure variations at high power are disturbing, but not unusual. Since these variations are associated with erratic boiling, some improvement in the transfer of heat to the oil is suggested as a possible means of correcting this defect.
 - e. As it now stands, the MCF-700 pump is a very poor choice for any application requiring the pumping of hydrogen, or the handling of large quantities of gas.

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Fig. 1. Schematic of Test Set-up.

Fig. 2. Base Pressure, Limiting Forepressure, and Pumping Speed as Functions of Power Input.

Fig. 3. Pumping Speed for Air, MCF-700 Pump with Baffle.