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An Inexpensive Noncontaminating Gas Recirculation Pump

We have recently developed a noncontaminating gas recirculation pump for use in gradientless reactors. The pump has several distinct advantages over recirculation pumps which have been previously described in the literature, and it has provided over 2000 hr of reliable, maintenance-free operation in hydrogenation and oxidation studies.

Since Temkin and his co-workers (*1, 2*) suggested that the use of recirculation reactors was a superior way to obtain kinetic data undisguised by heat and mass transfer limitations, several recirculation pumps have been developed. The earlier designs are summarized in a note by Chambers, Dougharty and Boudart (*3*), where further improvements are reported.

More recently, Bernard and Teichner (*4*) have described another pump which employs a flexible Teflon bellows activated by compressed air. We have used this pump successfully in initial rate studies where reaction time did not exceed 1 hr (*5*). The only modification was the substitution of high purity nitrogen for compressed air to operate the pump. This was necessary because the Teflon bellows is permeable to light gases, and oxygen was getting into the reactant feed and poisoning the platinum catalysts being used. We attempted to use the same pump in stationary-state kinetic studies of the H_2–O_2 reaction where the reaction time can exceed 5 hr and found it unsuitable because prohibitively large amounts of He, H_2 and O_2 were lost from the reaction loop. We determined the permeation rates of H_2, O_2 and He into 1 atm of N_2 in the volume surrounding the bellows and found them to be about 3×10^{-4}, 1.5×10^{-4} and 3×10^{-4} Torr s^{-1}, respectively. In addition, the ultimate vacuum of the Teflon bellows was 10^{-3}–10^{-4} Torr in a vacuum system capable of attaining less than 10^{-6} Torr without the Teflon bellows, and the large amount of high purity N_2 needed to activate the pump made it expensive to operate.

We found that it was possible to modify a commercially available pump-compressor, equipped with a stainless steel (AM 350) welded bellows, to produce one which suited our needs admirably. The unmodified pump is Model MB-41, manufactured by Metal Bellows Corp., Sharon, MA and Chatsworth, Los Angeles, CA. As supplied, the pump weighs about 6 lb and is equipped with a single speed induction motor operating at 3000 rpm; we measured a maximum pumping rate of 220 cm^3s^{-1} of air with essentially zero pressure drop at 1 atm. The bellows drive shaft and the motor shaft, mounted perpendicular to each other, are connected by an eccentric. Further details of pump construction and specifications can be found in Metal Bellows' bulletin MB 511-71.

In order to provide operating flexibility the induction motor was replaced by an adjustable speed drive system. A shunt wound 1725 rpm, 1/50 HP dc motor, Bodine Model 276, was coupled to the bellows and was driven by a dc motor controller, Bodine Model 902. The cost of this pump, the new motor and the controller is about $200 at the present time.

Alignment of the motor shaft and the eccentric on the bellows shaft was the critical operation in the conversion; a misalignment of the shaft on the bellows may cause the bellows to crack at the welded seams. The tolerances are 0.015 cm in the vertical and horizontal dimensions perpendicular to the bellows shaft and also 0.015 cm in the dimension along the axis of the shaft. The first tolerance is to prevent excessive canting of the shaft; the second avoids excessive expansion and compression of the bellows.

Although the proper mounting of the new motor should pose no problem for a competent machinist, the following description gives the major steps we employed. An aluminum mounting was made to take both the pump and the new motor; allowance was made for movement of both. The old motor housing was removed, the coupling set screw on the eccentric was loosened to free the motor shaft, and the old motor was removed. The entire bellows assembly was removed from its housing and the old motor was bolted into its original place. The position of the center and end of the motor shaft was accurately determined, the old motor was removed and the new one was mounted so that its shaft was in exactly the same place as the old one. Finally, the eccentric was slipped onto the shaft, the pump was remounted in its housing and the coupling set screw was tightened. Before use the bellows was flushed with 250 cm^3 of CCl_4 by manually rolling the motor shaft, and the CCl_4 was completely removed by evacuation to prevent bursting the bellows.

After mounting on our reactor as part of the reaction loop the pumping rate was determined with a Fischer and Porter flowmeter and a stroboscope. With 1 atm of dry air at room temperature and a pressure drop of about 20 Torr in the reaction loop it was possible to get flow rates as high as 100 cm^3s^{-1} at a motor shaft speed of 2600 rpm and as low as 33 cm^3s^{-1} at 500 rpm; the pumping rate changed nearly linearly with motor shaft speed. For helium the pumping rate was variable, again almost linearly, from 70 cm^3s^{-1} at 500 rpm to 170 cm^3s^{-1} at 2500 rpm. The pump requires no cooling air or water, is almost vibrationless and in our studies has proved to be noncatalytic and noncontaminating. In contrast to some of the earlier pumps we have used, there is no detectable pressure spike. A dynamic vacuum of about 2×10^{-6} Torr can be obtained.

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