THE INFLUENCE OF SEAL CLEARANCE ON THE PERFORMANCE OF STIRLING COOLER

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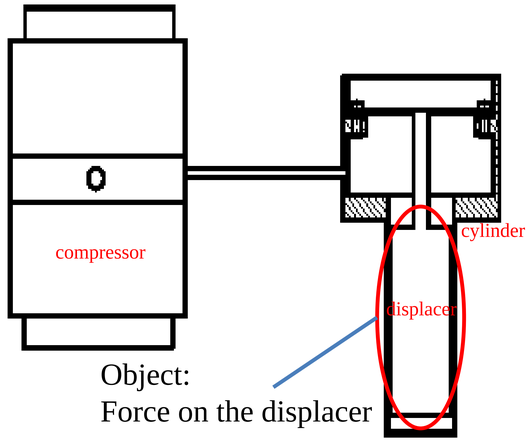
Background

- the resonance between the compressive piston and displacer is an especially important factor;
- The resistance on the displacer will affect its resonance characteristics with the piston in the compressor.

Research object

- This paper focus on the force on the displacer in a flexure bearing Stirling cyocooler.
- The diameter of the displacer in the expander is 22mm, and the length of it is 70mm. The mass of total moving parts is 80g, and the natural frequency is 50Hz. The refrigerant is helium.



methodology

Some assumptions for the force calculation on the displacer:

(1) Flow in the gap is laminar;

(2) The refrigerant can be seen as Newtonian fluid;

(3) Roundness of displacer and cylinder is 0.

For concentric condition:

$$F = \iint_A \mu \frac{\partial u}{\partial y} \mathrm{d}s$$

For the eccentric condition:

$$F_e = \int_0^{2\pi} \mu r l \frac{u}{h_0(1+\varepsilon\cos\theta)} d\theta$$

Where: $h_0 = (d_1 - d_2)/2$

$$h = h_0(1+\varepsilon\cos\theta)$$

$$\varepsilon = e / h_0$$

Calculation

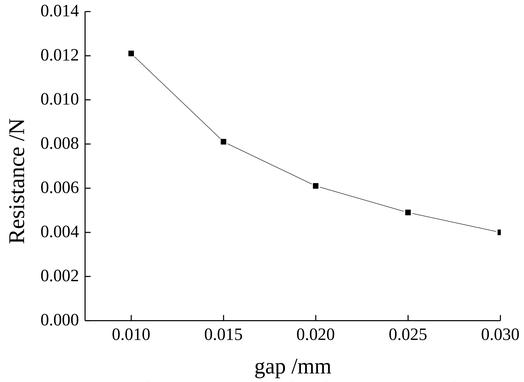


Fig. 2 The resistance of refrigerant on the displacer in concentric condition

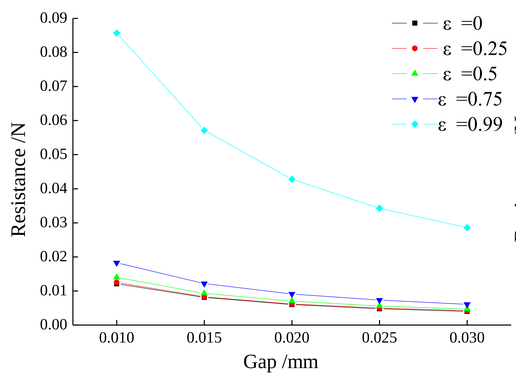


Fig. 3 The resistance of refrigerant on the displacer in eccentric condition

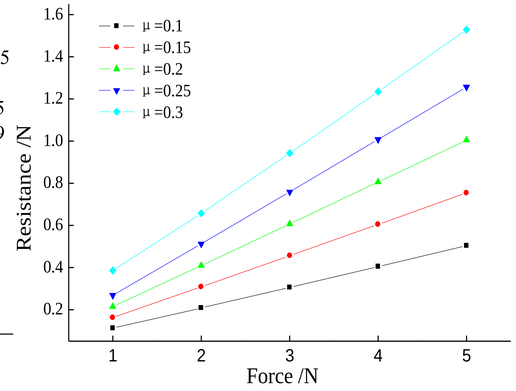


Fig. 5 The friction force on displacer versus friction coefficient and pressure

Experiment

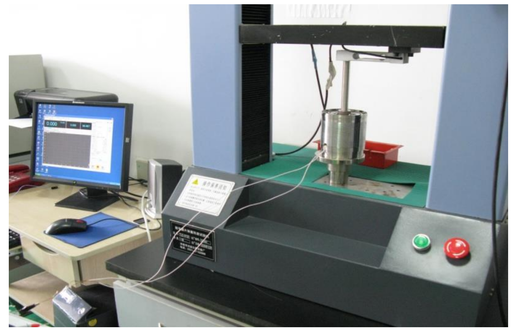


Fig.6 Test instrument for friction force

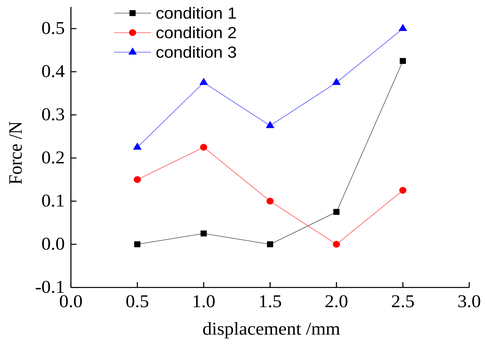


Fig.7 Test results for different friction conditions

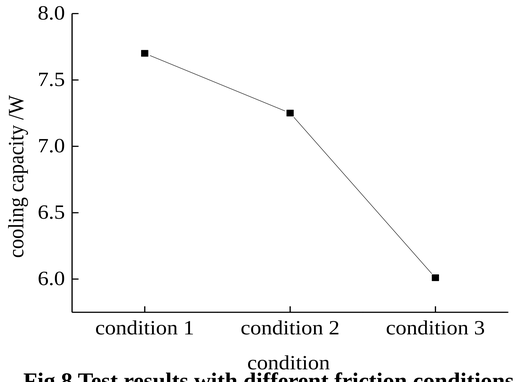


Fig.8 Test results with different friction conditions

Conclusion:

- ✓ In concentric condition, the resistance of the displacer nonlinear decreases with the increase of the gap between the displacer and cylinder. when the gap is quite small, the viscous effect of the refrigerant is quite important. When the gap increases, the resistance of the displacer decreases sharply.
- ✓ In the eccentric condition, unless there is a quite small gap, it has no obvious effect on the resistance of the displacer. Due to uneven force and the poor flatness of the supporting plane, the displacer will have contact with the cylinder and the friction between them will be increased. To provide the better cooling capacity of the cooler, material with low friction coefficient should be selected to reduce the running resistance of displacer.
- ✓ Experimental results show that resonance between the compressor piston and displacer can be destroyed with the increasing of frictional force, the cooling capacity of the refrigerator drops sharply. But, it can be concluded that the slight friction will not significantly affect the performance of the refrigerator. The allowable value of friction can be calculated.