

# Investigation of a striling cryocooler driven by moving magnet linear motor

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**Abstract:** The attention is focused on the Stirling cryocooler driven by moving magnet linear motor because of its advantages of high efficiency, small vibration, and long life. In order to find the parameters influencing the efficiency of the compact Stirling cryocooler, a linear motor structure was proposed and designed, The relationship between diameter of the coil and the motor constant and the performance of the cryocooler was experimentally explored. The stiffness and assembling structure of the flexure bearings, the filling pressure and operating frequency were optimized by comparing the performance of the cryocooler. In the experiment, the maximum cooling power of the cryocooler is 2.3W@80K with input power less than 50W. The investigation provides reference to the development of the compact and high-efficient Stirling cryocooler.

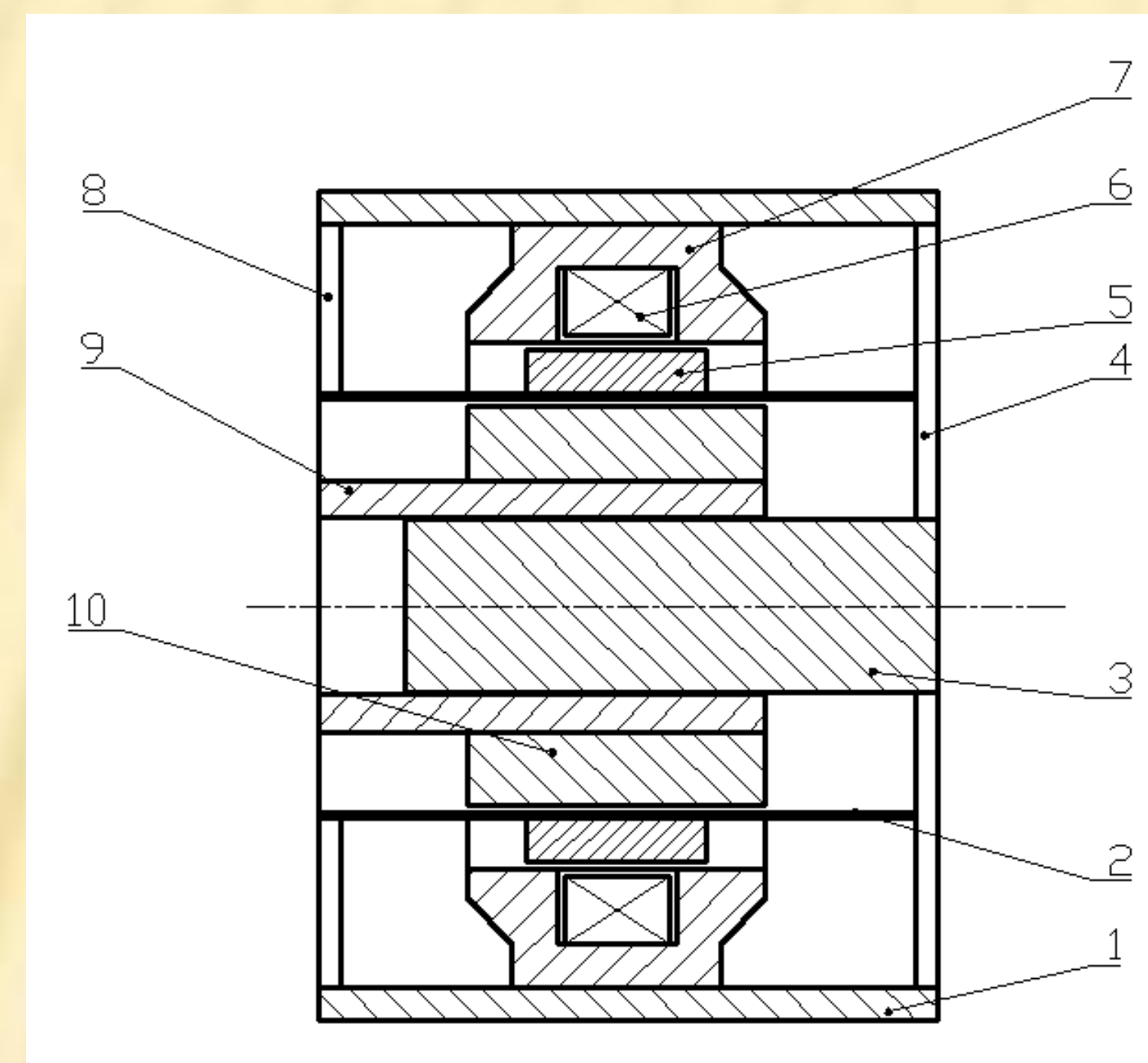
**Key words:** moving magnet , linear motor, Stirling cryocooler, stiffness, operating frequency

## 1. Overview

A linear motor structure with moving magnet is proposed and designed. Its parameters are experimentally optimized. The aim of the compact and high-efficient Stirling cryocooler has achieved.

## 2. The structure of the linear motor

- 1--the motor casing
- 2-- the mover frame
- 3--piston
- 4-- the flexure bearings with small inner diameter
- 5--the magnetic steel
- 6--the coil
- 7--the outer core
- 8--the flexure bearings with large inner diameter
- 9-- the cylinder
- 10--The inner core



## 3. Experimental study on the linear motor

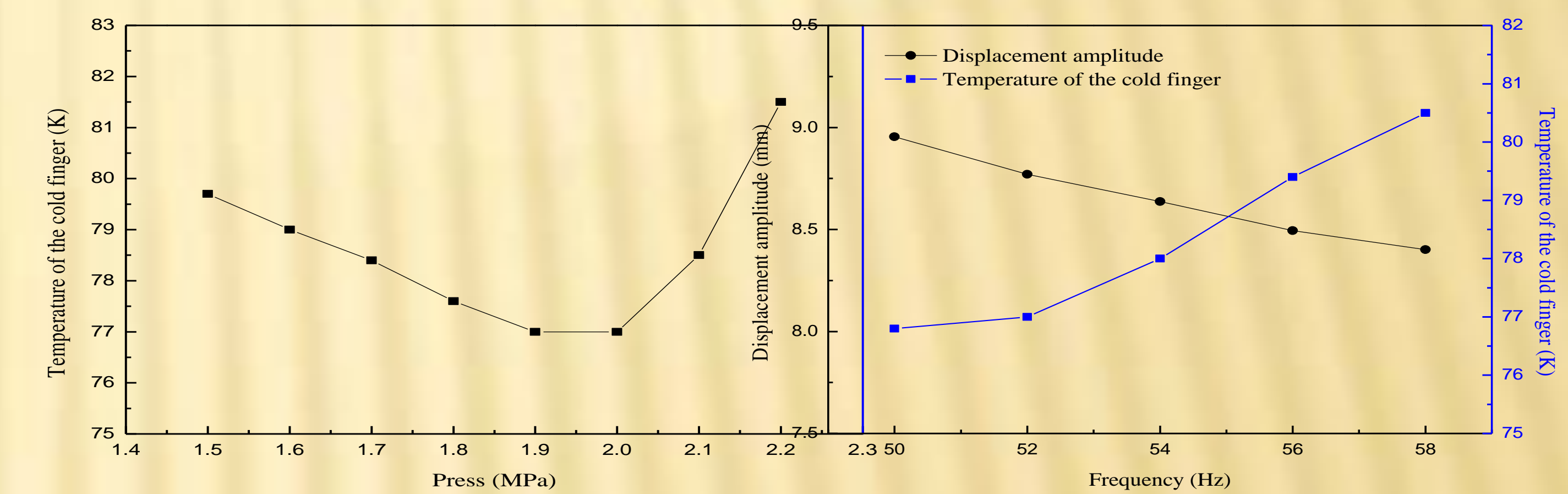
The effect of the coil is experimental study in this paper, as well as the stiffness of the flexure bearings, filling pressure and operating frequency.

the result of different coils testing

diameter (mm)	length (mm)	resistance (Ω)	motor constants (N/A)	the cooling time @80K	the cold finger temperature
0.38	20497	3.07	13	11'05"	73.4K
0.41	11060	1.43	9.95	6'05"	56.4K
0.5	1130	0.87	8.18	8'00"	69.4K

the performance of cryocoolers with different stiffness of the flexure bearings

stiffness of the flexure bearings (N/mm)	cooling time	cooling capacity (W)
5.4	11'05"	0.83
5.8	6'35"	1.91
6.55	7'33"	1.9
7.7	8'10"	1.61



the influence of the filling pressure and the operating frequency

- (1) The diameter of the linear motor coil is finally confirmed of 0.41 mm.
- (2) The stiffness and thickness of flexure bearing is finally confirmed by comparison experiment.
- (3) When the filling pressure is among 1.9-2.0MPa, the cold finger can maintain a lower temperature.
- (4) When operating frequency is among 50-52Hz, the cold finger can maintain a lower temperature.

## 4.summary and prospect

The final performance of the linear motor striling cryocooler is 2.3W@80K, with input power less than 50W. The linear motor will be optimized further in order to achieve better performance.



the appearance of the stirling cryocooler

performance of the stirling cryocooler

Cooling capacity	2.3W@80K(23°C)
Cooling time	6.25min@23°C(850J/80K)
compressor size	Φ60×126mm
Cold finger size	Φ14.3mm
quality	1.686kg