World Scientific Research Journal (WSRJ) ISSN: 2472-3703
www.wsr-j.org

Magnetorheological Transmission Structure

Zixin Zhang [a], Niandong Si [b]

College of Mechanical and Electronic Engineering, Shandong University of Science and Technology, Qingdao, China

[a]84169669@qq.com, [b]1191166847@qq.com

Abstract: Magnetorheological fluid is a new type of smart material that undergoes drastic changes in rheological properties under the influence of an external magnetic field. Magnetorheological transmission introduces magnetorheological fluid as a working medium for transmitting torque, and uses the yield shear stress of magnetorheological fluid to transmit power. The magneto-induced yield stress of magnetorheological fluid plays a leading role in torque transmission. Magnetorheological transmission device can transmit large torque and has good constant torque characteristics. The magneto-rheological transmission mode affects the output torque of the magneto-rheological transmission device. Therefore, when designing the transmission device, it is necessary to consider factors such as the structure form, coil arrangement mode, and application occasions.

Keywords: Magnetorheological fluid, shear stress, structure type, coil.

1. INTRODUCTION

The magnetorheological fluid transmission is based on the magneto-rheological fluid as the transmission medium and transmits the transmission mode of torque and rotation speed. By changing the applied magnetic field strength, changing the shear yield stress of the magnetorheological fluid and achieving different output torque and rotational speed, it is a new application of the magnetic rheological fluid, a smart material in the field of mechanical transmission.

2. STRUCTURE ANALYSIS

Due to the unique magneto-rheological and rheological properties of magnetorheological fluids, the commonly used magneto-rheological devices work in three modes: flow mode, shear mode, and extrusion mode [1], as shown in Fig.1:

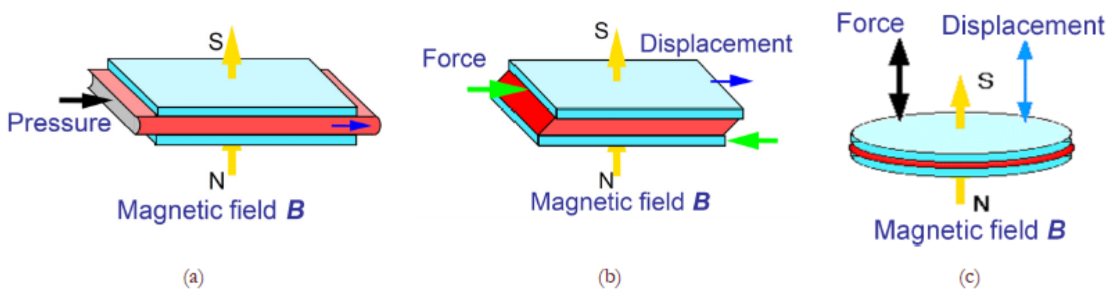


Fig.1 Working mode of MRF

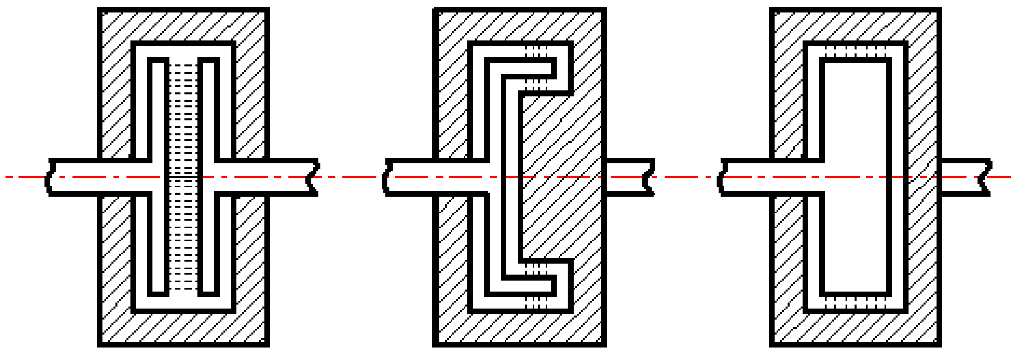
(a)Flow Mode: The magnetic rheological fluid is chained under the action of a magnetic field, and is flooded in the working space. When a pressure is applied to the magnetorheological fluid in the working zone, the magnetorheological fluid flows in a direction perpendicular to the magnetic field and generates a large amount in the working zone. The damping force hinders this flow, and this mode of operation is called a flow mode and is mainly applied to devices such as dampers, shock absorbers, and drivers.

(b)Cut mode: The magnetic rheological fluid is chained under the action of a magnetic field, and is flooded in the working space. When the upper plate is subjected to a horizontal force, the yield stress of the magnetic flux linkage of the magneto-rheological fluid impedes the relative movement of the magnetorheological fluid and can carry a certain load. As the applied magnetic field increases, this mode of operation is referred to as the shear mode, which has a wide range of applications in the fields of transmission system, tension control, soft start of heavy-load equipment, and the like.

(c)Extrusion mode: The magnetic rheological fluid is chained under the action of a magnetic field, and is flooded in the working space. When the upper plate is subjected to a vertical force, the magnetorheological fluid is squeezed in the direction of the magnetic flux, and a large compression elastic force is generated to hinder the extrusion. Pressure, this work mode is called squeeze mode and is mainly used for vibration damping devices.

3. STRUCTURAL ANALYSIS OF MRTD

According to the working gap design of the magnetorheological fluid device and the shape characteristics of the transmission components, the magneto-rheological fluid transmission device can be generally divided into three basic forms of disc type, cylinder type and cylindrical type[2], as shown in Fig.2:



(a) Disc type (b) Cylinder type (c) Cylindrical type

Fig.2 Structures of MRTD

(a)Disc type: The disk-type transmission method is widely used and has the advantages of simple and compact structure, fast response speed, and small rotational inertia of the output part, as shown in Fig. 2(a). The number of discs can be reasonably increased according to the work requirements to improve the transfer capability of the entire device, and have a certain adjustment ability, but the structure has a weak transfer torque (limited transmission area), and MRF particles are greatly affected by the centrifugal force.

(b)Cylinder type: The cylindrical working gap has more contact area, which means that the same size of cylinder MR fluid drive can transmit more torque, as shown in Fig. 2(b). The driven part of the structure has a small moment of inertia and rapid response. However, the cylindrical structure is more complex and requires higher processing and installation. There are double working gaps in the radial direction, and the uniformity and dispersibility of the MRF are easily affected by the centrifugal force.

(c)Cylindrical type: The cylindrical working gap is in the horizontal direction as shown in Fig.2(c). The distribution of magneto-rheological fluid in the working space of the cylindrical structure is even and the transmission medium is affected by the centrifugal force in the transmission process. However, the cylindrical type requires large axial dimensions, the existing structure is not easy to be improved, the moment of inertia is large, and the system response time Due to the lack of length, the structure is suitable for applications with large torque transmission.

Since the MRF shear stress is small, the magnitude of the transmission torque is limited. Therefore, in order to increase the transmission torque, a cylindrical structure is adopted. During normal operation of MRTD, there is a rotational speed difference between the active and driven transmission walls. The friction between the particle chain and the transmission wall surface and the gravitational force between the particles chains are used for power transmission. Therefore, the MRTD is based on the MRF cutting operation mode.

The magnetic columns at both ends of the transmission are immersed in the MRF, so the MRF needs to be sealed. There are two types of static seals and dynamic seals. There are two kinds of dynamic seals: rotary seal and reciprocating seal [3]. Obviously, the MRTD seal is a rotary seal. Sealing methods that can be applied to rotary seals include mechanical seals, magnetic fluid seals, and the like. In the MRTD, the pressure of the MRF is moderate and the rotational speed is not high. Therefore, the oil seal is selected and the MRF is sealed using a lip seal with a skeleton as shown in Fig. 3.

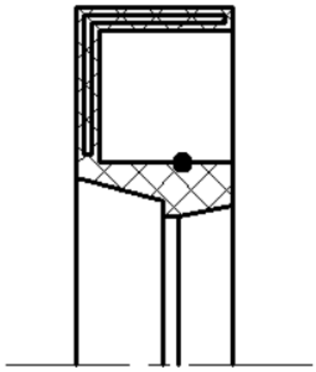
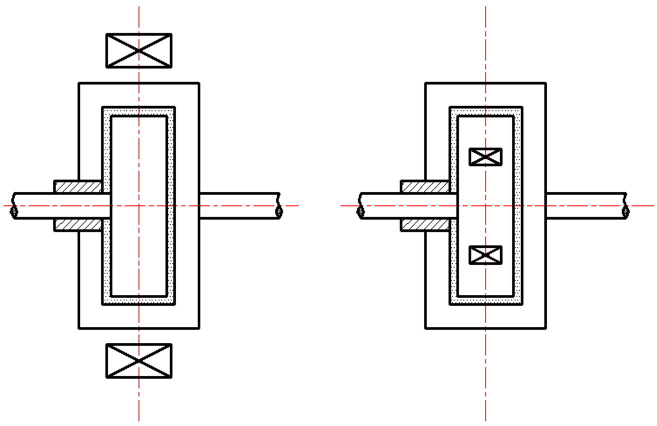


Fig.3 Structure of lip seal

To produce magnetic field strength that satisfies the design requirements, the layout of the coil is very important. The coil can be divided into two types of coil external and built-in, depending on the placement, as shown in Fig. 4.



Coil external Coil built-in

Fig.4 Coil arrangement type

(a)Coil external: Outside the coil, when the MRTD is in working condition, the coil is at rest and the program-controlled current source is directly connected with the excitation coil. This structure coil has a large space for heat dissipation and can dissipate the coil in the form of a fan, but it is generated in the working space. The magnetic field intensity is small and the magnetic field utilization is low.

(b)Coil built-in: The coil has a built-in structure and the coil rotates with the drive shaft. Therefore, a through-hole slip ring installed on the shaft is needed to supply the excitation coil, which reduces the reliability of the transmission to some extent. Compared with the external structure, the heat dissipation performance of the coil is insufficient, and the rotational inertia value of the drive shaft is increased. However, for the cylindrical MRTD, the coil can be built with a large magnetic field strength, high magnetic field utilization, compact and simple structure.

4. CONCLUSION

The magneto-rheological transmission device introduces the magneto-rheological fluid as the medium for power transmission. The structure is simple and the response is rapid. It is a new type of transmission device with wide application prospects. Through theoretical analysis, it is known that most cylinders should be selected as a magneto-rheological transmission device, which effectively increases the transmission torque.

REFERENCES

[1] Mingjie Li, Design and Experimental Study of Cylindrical Magnetorheological Coupling [D], Wuhan, Hubei: Wuhan University of Science and Technology, 2010.
[2] Fei Chen, Preparation of magnetorheological fluid and its power transmission technology [D], Beijing: China University of Mining and Technology, 2013.
[3] Ping Fu, Degong Chang. Seal Design Manual [M]. Beijing. Chemical Industry Press, 2009: 147-155.