Magneto-Rheological Fluid Technology

John A. Marshall, PHD
University of Southern Maine

Key Words: Rheology, fluid and mechanical power transmission, hydraulics.

Perquisite Knowledge: Elementary concepts of magnetism and flow.

Objective:

To observe the unusual characteristics of magneto-rheological fluids. To understand how these fluids change from a liquid to a solid. To understand the potential power transmission advantages of these fluids.

Equipment and Supplies:

Two connected syringes containing magneto-rheological fluid and a strong magnet.

Introduction:

Magneto-rheological fluids change their flow characteristics when subjected to an electrical field. Response, which takes only milliseconds, is in the form of a progressive gelling that is proportional to field strength. With no field present, the fluid flows as freely as hydraulic oil (Korane, 1991).

Magneto-rheological fluids represent a technology that has the potential to widen the performance range of automated electromechanical and electrohydraulic equipment. Research and ongoing developments are refining this technology and experts predict an important future for these fluids.

Importance of Magneto-rheological Fluids:

Current automation capabilities are not advanced enough to build a robot that could play tennis. Even though cameras and computers could direct the robot towards a ball, robot's move in an awkward, lumbering fashion because conventional hydraulic valves cannot keep pace with the commands of the computerized controllers.

With magneto-rheological fluid technology, this type of response time is possible. This technology will allow devices that can operate instantly and without mechanical valves. Increased productivity and better product quality through more dependable and responsive automated equipment is just a small part of what this maturing technology can deliver.

How Magneto-rheological Fluid Functions:

Magneto-rheological fluids are composed of two primary components. They are the carrier fluid and the suspended particles. The carrier fluid needs to be a good insulator, compatible with the materials they contact. Typical particle materials include polymers, minerals, and ceramics (Scott, 1984).

When an magnetic field is applied to the fluid, positive and negative charges on the particles respond by separating, so each particle then has a positive end and a negative end. Particles of the magneto-rheological fluid then link together in the same manner that the north pole of one magnet is attracted to the south pole of another magnet (Duclos, 1988).

Potential Applications:

Magneto-rheological fluids can change from solids to liquids so fast, they will work well with fast-acting computers. These characteristics suggest a number of unusual engineering applications such as fluid clutches and vibration isolators (Duclos, 1988).

According to Hans Conrad, professor of materials science and engineering at North Carolina State University, magneto-rheological fluids will lead to a whole new generation of brakes, automatic transmissions, actuator devices, hydraulic valves, pump parts, and motors (Conrad, 1992).

Procedure:

Safety Considerations:

1. Protective eye wear is mandatory for all those in the lab area.

2. Do not force the syringes as they may break. Breakage may result in plastic fragments as well as exposure to the magneto-rheological fluid.

3. Obtain a "Material Data Safety Sheet" on the fluid from the supplier. Read the sheet completely and ask questions to any information you do not understand.

Observing Magneto-rheological Fluid as a Liquid:

1. With the magnet removed, slowly push on one syringe allowing the fluid to force the opposite syringe outward.

2. Record on the data sheet the nature of fluid flow and if power is being transmitted through the magneto-rheological.

Observing Magneto-rheological Fluid as a Gelled Solid:

1. With the magnet attached, slowly push on one syringe allowing the fluid to force the opposite syringe outward.

2. Record on the data sheet the nature of fluid flow and if power is being transmitted through the magneto-rheological.

Sample Data Sheet:

Record below the characteristics of the fluid when the magnet was <u>not</u> present:

Record below the characteristics of the fluid when the magnet <u>was</u> present:

Instructor Notes:

1. When the magnet was not attached, the students should have observed the fluid flowing easily between the syringes, transmitting the input power to the output syringe.

2. When the magnet was attached, the students should have observed a resistance to fluid flow between the syringes.

References:

Korane, K.: Putting ER Fluids To Work. Machine Design, May 9,1991, pp. 52-57.

Scott, D.: Amazing Hardening Fluids Open a New World of Hydraulic Drives. Popular Science, April 1984, pp. 42-46.

Duclos, T.G.: Electrorheological Fluids and Devices. Automotive Engineering, December 1988, pp.45-48.

Conrad, H.: The Impact of ER Fluids. Compressed Air Magazine, March 1992, pp. 14-17.

Source of Supplies:

Internet resource to supplies and additional information:

http://www.rmit.edu.au/departments/ch/rmpc/

Biographical Information:

Dr. JOHN ALLEN MARSHALL taught senior high school prior to receiving his Ph.D. from Texas A&M University. He has seventeen years of university teaching experience, and is currently the Coordinator of the Power and Energy curriculum and laboratories as well as the Internship Coordinator for the University of Southern Maine's Department of Technology.