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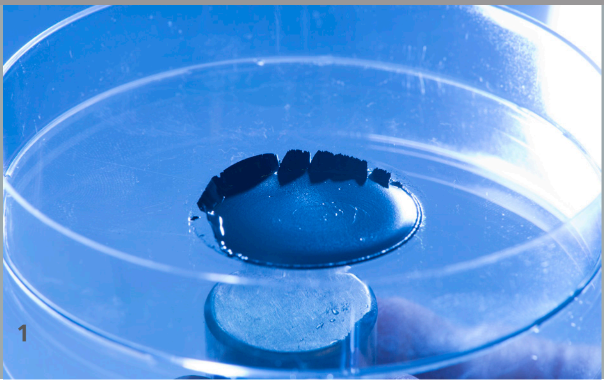

1 | 2 *In a magnetic field, the MRF develops a fibrous structure, with tangled chains of particles along the field lines*

MAGNETORHEOLOGICAL FLUIDS

SWITCHING BETWEEN LIQUID AND SOLID

Magnetorheological fluids (MRF) are free-flowing suspensions whose consistency can be rapidly switched to any intermediate state between liquid and solid. Materials of this type, whose properties can be controlled by applying a magnetic field, have a multitude of potential applications, including adaptive shock absorbers and vibration dampers, clutches and brakes with variable torque transmission, or force-feedback interface devices.

MR fluids consist of a suspension of fine magnetically polarizable particles evenly dispersed throughout a carrier liquid. The most common type of MRF is composed of iron particles suspended in an oil such as mineral or synthetic hydrocarbon oil or silicone oil.

The particles become polarized in the presence of a magnetic field, and align themselves in chains along the field lines, as shown in figure 1 and 2.

The formation of these chains causes the suspension to gradually stiffen, the degree of thickening increasing in proportion to the field strength. This effect can take place within just a few thousandths of a second. When the magnetic field is removed, the solid-like material returns to its original liquid state. In its initial state, a magnetorheological fluid has roughly the consistency of a viscous oil, but can also be designed as a paste. When the magnetic field is activated, the fluid turns into a solid mass that strongly resists mechanical deformation.

The shear stress and hence the resistance force can be increased by up to three orders of magnitude.

This substantial change in consistency, which can be switched rapidly through a continuously variable range by the magnetic field, can be exploited in a multitude of possible applications ranging from adaptive vibration dampers and electrically powered brakes to haptic interfaces and devices.

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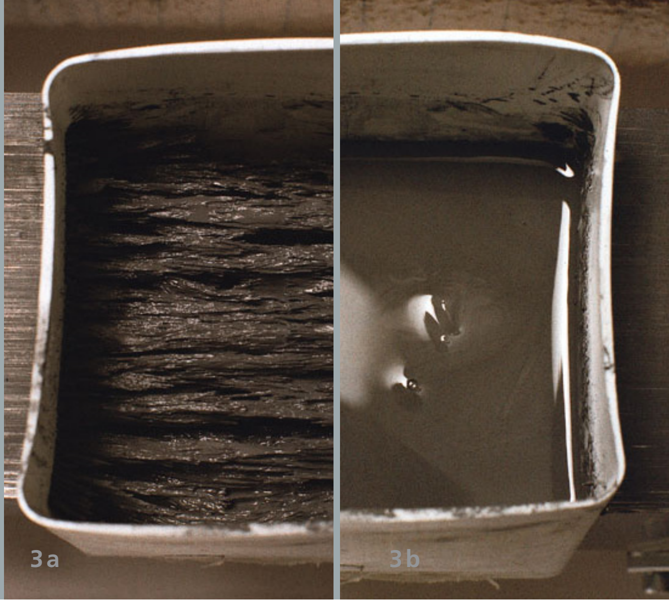


Over time, the iron particles would normally tend to sink to the bottom and form a sediment or to agglomerate, making it impossible to obtain the desired magnetorheological effect. The MRF is therefore stabilized with suitable chemical additives to prevent the particles from agglomerating and hold them in suspension.

Areas of application

Technical applications in which the magnetorheological effect can be exploited include:

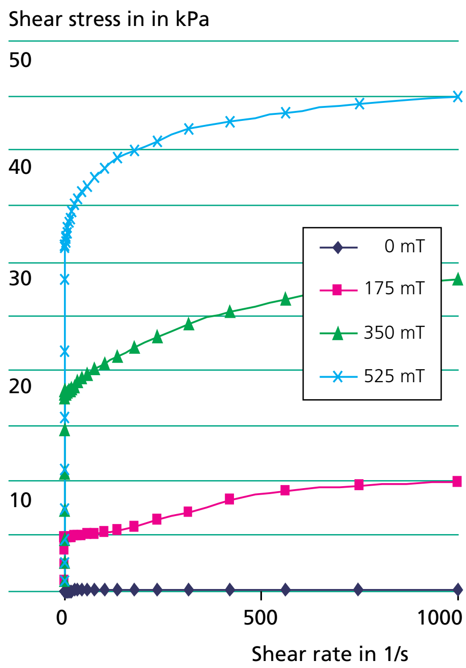
- Shock absorbers in vehicles
- Vibration dampers for machinery and bridges
- Adaptive dampers in prosthetic devices
- Electrically powered brakes
- Clutches with continuously variable torque transmission
- Haptic interfaces and devices (force feedback)
- Fixation devices for elements with complex geometries, figure 4

The ability to control the consistency of the MRF by applying an external magnetic field, as shown in figure 3a and 3b, makes it possible to react to specific situations and respond flexibly to the requirements of the desired application.

Different types of applications require MRFs with different property profiles. This can be achieved by modifying their composition. Common MRF reach shear stress of about 50 KPa in magnetic field. With special formulations up to 100 KPa can be achieved. The usual temperature range in which the MRF is used extends from -30 °C to 100 °C. However, special MRF can be applied even at lower or higher temperatures.

Fraunhofer ISC areas of competence

- Development of MRFs for specific customer applications
- Characterization of material propertie relevant to a particular application
- Support in system development for new products



Flow curves of an MRF with the magnetic field off as well as at various field strengths
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1 *Particle arrangements in MRF with (a) and without (b) magnetic field*
2 *Sheme of particle chain formation of MRF in the magnetic field*
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