SMART FLUIDS

ELECTRO-RHEOLOGICAL (ER)
&
MAGNETO-RHEOLOGICAL (MR) FLUIDS

Several figures have been taken from different internet sources

ER/MR Fluids

Colloidal suspension of
Of μ-sized particles
(dielectric/ferro-electric)
In electrically
non-conducting fluids

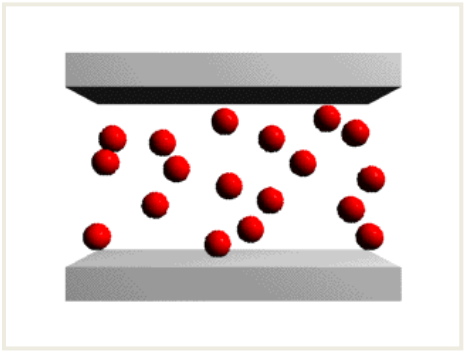
Most mechanical dampers
have fixed viscosity in contrast

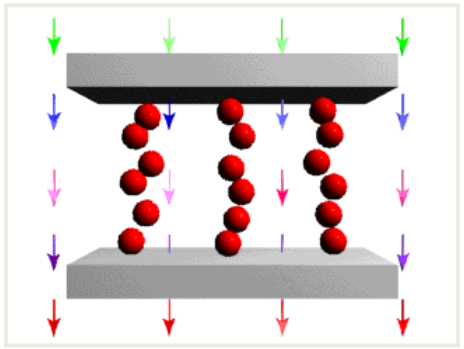
Change in rheological/
viscosity properties due
to application of electric/
magnetic field

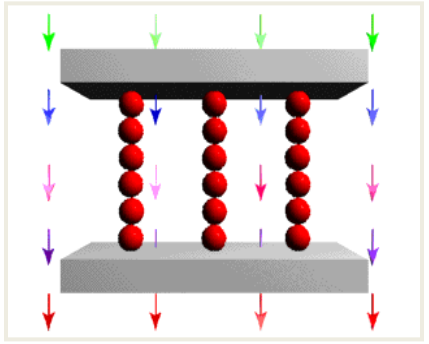
MR fluids are commercially more successful compared to ER fluids

Rudimentary ER Fluids can be made by mixing a cup of cornstarch with a cup of mineral oil

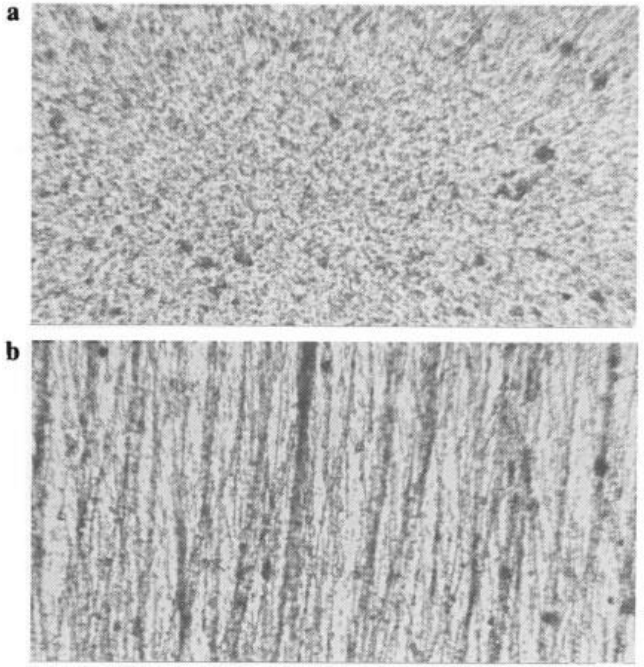
Working Principle of ER/MR Fluids :







The alignment/arrangement of the particles can prevent flow entirely at lower stresses.



Effect of electric field on ER fluid: a, no field; b, field applied. The particles are approximately 10 micron-m in diameter; the field is applied between top and bottom.

ER Effect was first observed by *Willis Winslow* in *1947*

→ Observed that application of a Large electric field across an organic Suspension caused the liquid to solidify

MR effect was first observed by *Jacob Rabinow* in *1948*

→ Abrasiveness, chemical instability, rapid degradation of properties until 1980 after which was used for commercial purpose

Common compositions of ER/MR Fluids :

- Alumino-silicate in silicone oil
- Silica spheres in mineral oil
- Polymer particle in chlorinated hydrocarbon oil

Particle sizes are in orders of 1 to 10 µm

Fraction of particles varies between 30 % to 50 % by weight

Suspended in inert, electrically non-conducting fluids of low permeability, e.g. mineral oils, silicone oils, paraffin oil

Additives to prevent agglomeration of particles, improve suspension, etc

Comparison of ER & MR Fluids :

ER Fluids

- Devices based on ER Fluids are of simpler geometry and easy to construct
- Stable over temperature

-25^{o}C to 125^{o}C

MR Fluids

- Complicacies involved in the development of the magnetic circuit
- Yield stress of MR Fluid order magnitude higher than ER Fluid
- Stable over temperature

-40^{o}C to 150^{o}C

- More tolerant to impurities
- Higher density/heavier fluid

Comparison of ER & MR Fluids :

ER Fluids

- Voltage: 2-10 kV
- Current: 1-10mA
- Maximum yield strength: 2-5 kPa (@ 3-5 kV/mm)
- Maximum field: 4 kV/mm
- Specific gravity: 1-2.5

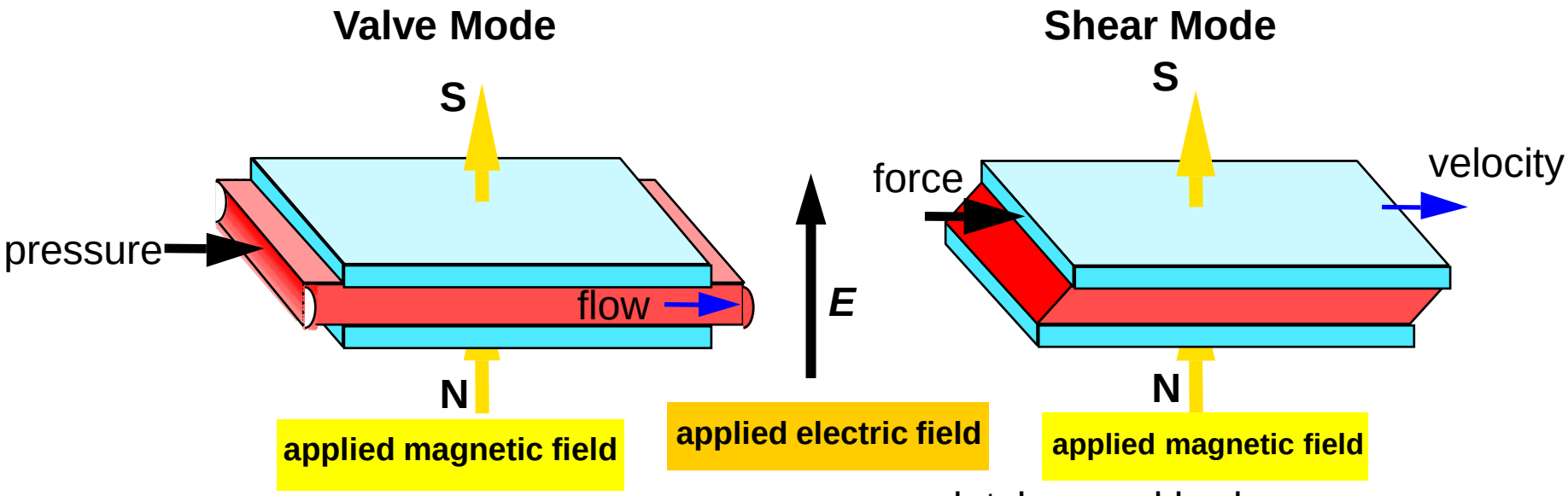
MR Fluids

- 2-25 V
- 1-2 A
- 50-100 kPa (@ 150-250 kA/m)
- 250 kA/m
- 3-4

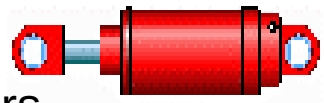
Limitations:

- Durability and life can be considered overwhelming barrier to commercial success
- Force-velocity/force-displacement behavior is highly nonlinear and functions of various factors including size of the device

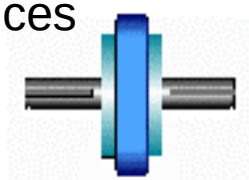
Basic ER/MR Device Configurations



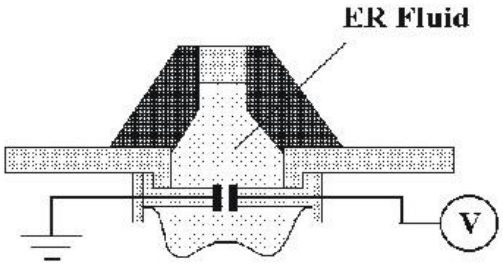
hydraulic controls
servo valves
dampers
shock absorbers
actuators



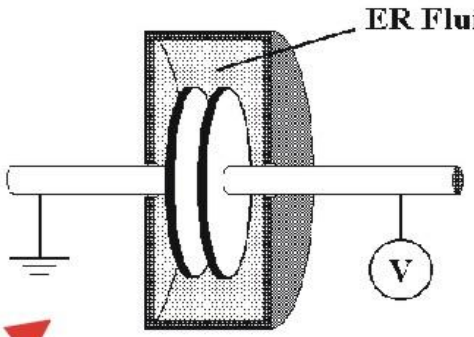
clutches and brakes
chucking/locking devices
dampers
breakaway devices
structural composites



Applications

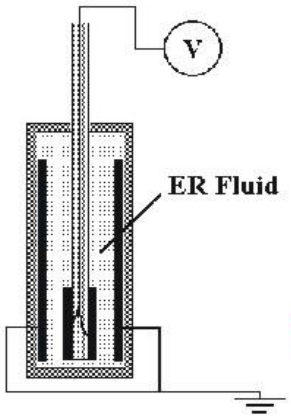


Engine Mount



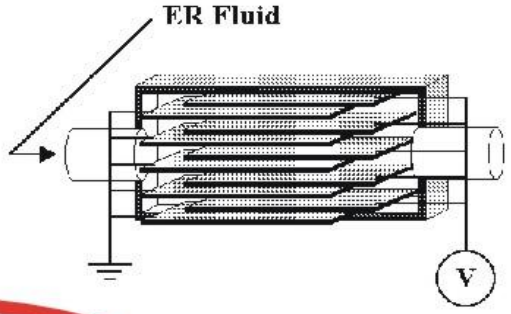
Clutch/Brake

SUVs (GM) 200?



Shock Absorber

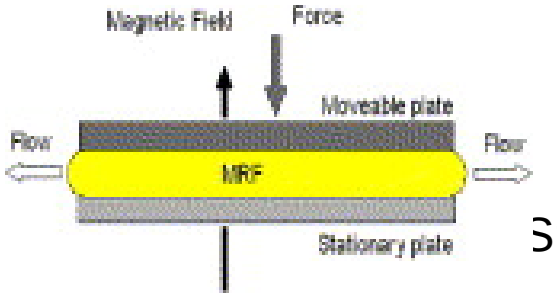
Cadillac Seville 2002



Valve

Squeeze Mode

Acceptable motion transmitted



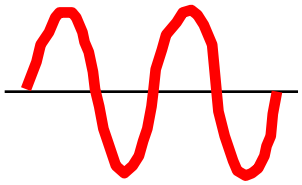
Sensor

Seat

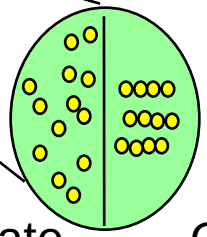
Controller

Spring

Controllable shock absorber



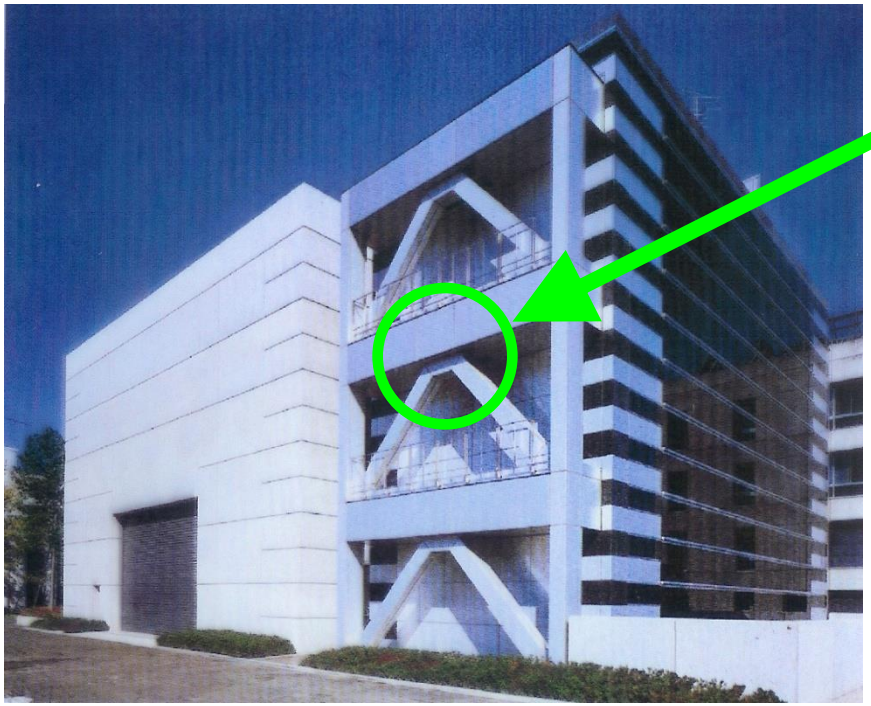
Road input

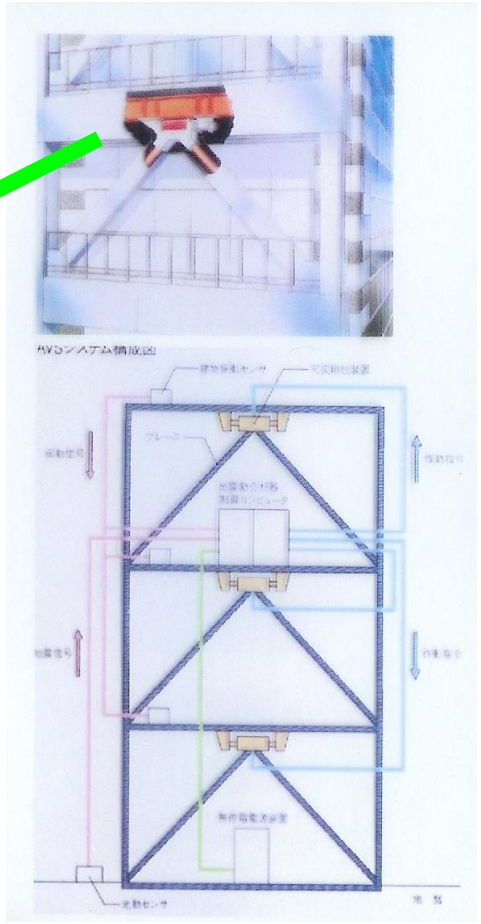


Off-state
Random
pattern

On-State
Ordered
pattern

Vibration/Earthquake Resistant Bldg.





• Seismic excitation

Nihon-Kagaku-Miraikan

National Museum of Emerging Science and Innovation

Opened July, 2001

Tokyo, Japan

2 30-ton MR dampers installed between 3rd and 5th floors

• Wind excitation

Dong Ting Lake Bridge
Hunan Province, PRC