

# Smart Bullet Proof Vehicle

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**Abstract**— The implementation of Smart Materials (MR-Fluid) which will enhance the safety of passenger against bullets In present scenario a vehicle is made bullet proof using metals and conventional engineering which in turn results into low fuel economy of the vehicle and greater expenses. This paper aims to present a concept of "Smart material" which would enhance the safety of passenger and vehicle also will weigh lighter. The proposed system has a response time of few milliseconds.

**Index Terms**—Automotive Safety, ER Fluid, MR Fluid, Protection Safety, Smart Material

## I. INTRODUCTION

Viscoelastic Fluid is a Non Newtonian-Fluid i.e. material exhibits both viscous and elastic properties while undergoing deformation.

Visco-elastic Fluids offers solutions to many engineering challenges ranging from Automobile to Civil Engineering. One such application that has been considered in the scope of this paper is MR Fluid devices, which aim to dilute the impacts of bullets. Till date the scope of MR fluid has been limited to high velocities and shear subjects.

Types of Viscoelastic Fluids:

- i) Magneto rheological Fluid
- ii) Electro rheological Fluid

### i) Magnetorheological Fluid

A Magnetorheological fluid (MR) is a type Smart fluid that exhibits Visco-elastic nature and when subjected to a magnetic field, the fluid greatly increases its apparent viscosity thereby increasing the yield strength of the material.

Moreover the change in viscosity is continuous and reversible i.e. after the removal of external magnetic field, the MR fluid can revert to a free flowing fluid. Thus it has the ability to provide simple, quiet, rapid response interface between mechanical and electrical control.

Magneto rheological Fluid is smart and controllable materials. It is a non colloidal mixture of Ferromagnetic particles randomly dispersed in oil or water along with some surfactants are poured in it which prevents the setting of suspended iron particles.

The table given shows the properties of MR fluid :

Properties	Values	Units
Initial Viscosity	0.2-0.3	pars
Density	3-4	$\text{g/cm}^3$
Magnetic Field Intensity	150-250	kA/m
Yield Stress	50-100	kPa
Reaction Time	Few Milliseconds	
Work Temp.	-50 to 150	$^{\circ}\text{C}$

### Operation of MR Fluid:

MR Fluid operates in three modes:

- Flow mode:  
Fluid flow as a result of pressure gradient( $\Delta P$ ) between the stationary plates. Fig (a)
- Shear mode:  
Fluid between two plates moving relative to one another. Fig (b)
- Squeeze mode:  
Fluid between two plates moves in a direction perpendicular to the plane.

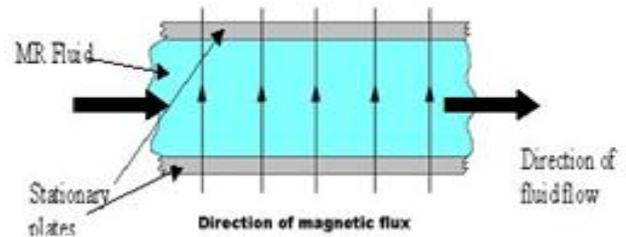


Fig (a)

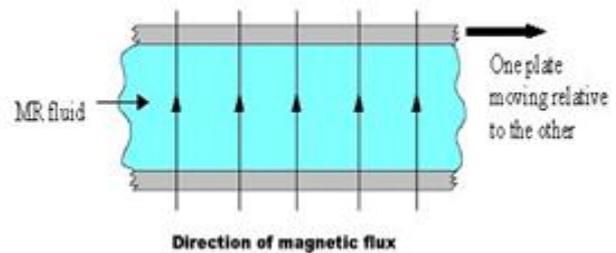


Fig (b)

### Limitation of MR Fluid:

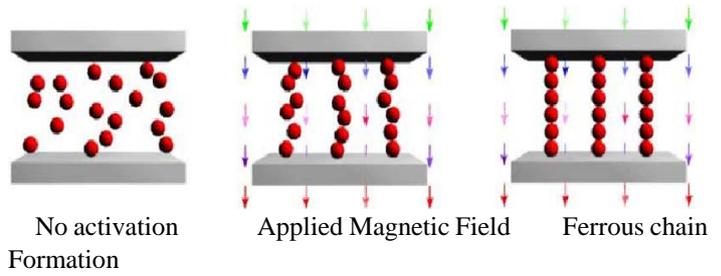
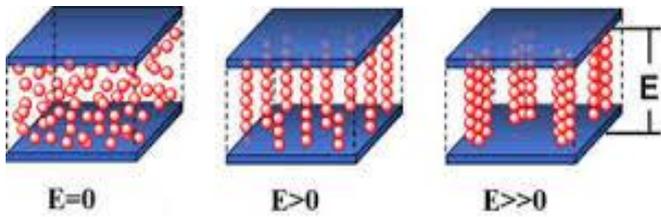
- High density and presence of iron fillings makes it heavier.
- It is expensive.

### ii) Electrorheological Fluid

Just like the MR fluid, Electrorheological Fluid(ER Fluid) are a type of smart colloid capable of varying viscosity or even solidification in response to an applied electric field and the rheological behavior is reversible once the field is removed .The change in apparent viscosity is dependent on the applied electric field i.e. the potential divided by the distance between the two plates.

As the electric field is activated this causes the fluid to have a Visco elastic behavior with a yield point which is determined by the strength of the applied electric field.

The nature of ER fluid under applied electric field is shown below:



Alternate Solution to MR Fluid:

Instead of MR Fluid we use a carrier Fluid (oil with high viscosity) is poured between two aluminium sheets along with iron fillings which are distributed uniformly. The carrier fluid is also mixed with surfactants which tend to reduce the surface tension. The layer between the aluminum sheets tends to act as a barrier to the bullets when fired as the iron fillings aligns themselves on actuation to form as a rigid shield.

The table below shows the properties of ER Fluid:

Properties	Values	Units
Yield Strength	2-5	kPa
Reaction time	milliseconds	
Energy Density	0.001	J/cm <sup>3</sup>
Stability	Poor for most impurities	
Operational Temp.	-25 to 125	°C

**Limitation of ER Fluid:**

- Apparent viscosity variation is limited.
- Presence of impurities makes it unstable.

**Advantages of MR Fluid over ER Fluid:**

- MR Fluid provides higher yield strength compared to ER Fluid upon activation.
- In ER Fluid application, presence of impurities affects its performance whereas it remains unaffected in MR fluid application.

**II. METHODOLOGY:**

This technical paper mainly lay emphasis on creating a smart bullet proof Vehicle with the application of MR fluid Here we provide the way to create the above given..

Since MR fluid is highly expensive in market and so we provide an alternate solution of MR Fluid which will act similarly to the MR Fluid upon activation.

Application of MR Fluid:

Thin layer of MR Fluid is sandwiched between two sheets of Aluminium of negligible thickness and it is installed in the car body panels. Again we have to provide micro-controller which will be coupled with sensors that will sense the in-coming of a bullet fired toward the vehicle. The micro controller is also coupled with the aluminium sheets which

tends to form an electro-magnet once electric current is passed through it and this will cause the MR Fluid to solidify.

The behavior is shown below:

**Abbreviations and Acronyms**

- Ps-Poise
- g/cm<sup>3</sup>-gram per cubic centimeter.
- kA/m-kiloAmpere per meter
- kPa-kilopascal
- °C-degree centigrade
- J/cm<sup>3</sup>-Joule per cubic centimeter

**III. CONCLUSION**

Magnetorheological Fluid has a wide scope in the coming era and its application is useful where controlled fluid with varying viscosity is required. Main properties of MR Fluid such as fast, reliable an quick response makes it suitable for our application. This technology sis simple and it provides better flexibility with improving performance compared to modern bullet proof proof vehicle and provides comparatively longer life.