

Smart Materials- Electrorheological Fluids

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ABSTRACT: A research is never ending process. The instable demand in the international market place for high performance structural and Mechanical systems for the aerospace, defense and advanced manufacturing industries has triggered the evolution of advanced composite materials. With world's technological revolutionary era, we come across various smart materials which can be successfully implemented into new practices for the fulfillment of human as well as technology requirements. Radical improvements of industrial processes cannot be achieved solely by increasing the efficiency of traditional production techniques and tools, but requires new solutions, employing novel ideas. One promising and novel technique exists which is based on the electro rheological effect present in the electro rheological fluids. This paper focuses on microstructure behavior & properties of ER fluids along with preparation & applications in engineering field so as to focus the evolution of new areas in which ER fluids can be used, which will becomes a new horizon for the new generation.

KEYWORDS: ER fluid, composite materials, structural systems.

I. INTRODUCTION TO ELECTRO RHEOLOGICAL FLUIDS

1. 1. What is Rheology:

It is the relationship between shear stress and shear strain for solid materials & relationship between shear stress and shear strain for liquids. For liquids it is called the science of fluidity. The fluidity of material is usually based on properties curves.

1.2 Electro rheological fluids:

Electro rheological Fluid is known as a functional fluid whose yield shear stress can be varied by the applied electric field strength. This unique fluid was known to the world through the patent obtained by W. Winslow in (1948). He reported the following features of suspension of silica gel particles in low viscosity oils.

1) In an electric field of magnitude of the order of 3 kv/mm, the suspension show a tendency to fibrillate on highly elongated condensed structures of particles formed parallel to the field.

2) A force proportional to the square of the electric field is necessary in order to shear the fluid between the electric plates. Thus at low shear stresses, the system behaves like a solid.

3) At stresses greater than this yield stress, the fluid flows like a viscous fluid, But with a large viscosity, again proportional to the square of the electrical field. In the early 1980's, R Stanway, Sproston, developed a class of ER fluids made from ionic polymers with greatly improved properties.

4) ER fluids are colloidal suspensions of particles of size 1-100 microns in non conducting solvents

5) The viscosity of ER suspensions can increase 2-3 orders of magnitude when electric fields ~1kV/mm are applied across them. The response takes ~ 1ms.

6) More recently, un-hydrous fluids (with no absorbed water) have been developed by the C.J.Cow and C.F.Zukoski at the University of Illinois. These "third generation" ER fluids are very promising for future applications.

1.3 Microscopic view: The widths of bright bands increase with increasing electric field. It is well known that when an electric field is applied, the ER fluid undergoes a transition to a gel-like state, the particles first form chains along the field direction, which then coalesces into columns, if the particle concentration is not too dilute.

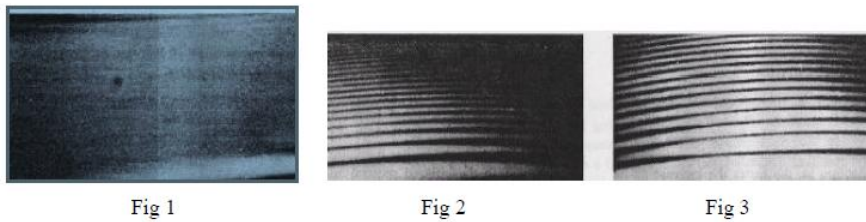


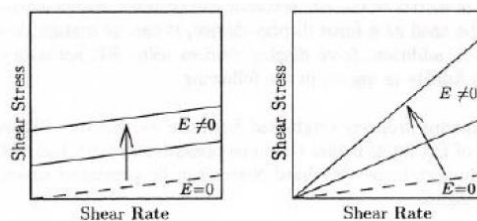
Fig. Scattering pattern of the ER fluid. (1). $E = 0$. (2). $E = 510$ V/mm. (3). $E = 710$ V/mm

1.4 Two-types of ER Fluids:

An ER fluid is a substance which changes its apparent viscosity (rheological characteristic) according to the strength of the electric field immersing it, and its main features include a fast response speed and extremely low power consumption, among others. The ER fluids currently being developed may be classified into two types in terms of their characteristics:.

(a) Particle-type: ER fluids of this type are colloidal fluids which are solvents containing dispersed particles, and show characteristics as shown in Fig.4 (a). The horizontal axis represents shearing speed, while the vertical axis indicates shearing stress, & the characteristics change according to the strength of the electric field E as shown in the diagrams. It is clear from this diagram that the particle-type ER fluids exhibit the characteristics of a Newtonian fluid when no electric field E is present but that they reveal the characteristics of a Bingham fluid when an electric field is applied. In other words, when a voltage is applied, these ER fluids behaves very much like Coulomb friction.

(b) Homogeneous-type: Fluids of this type have been developed by using low molecule liquid crystal or macromolecular liquid crystal, and exhibit characteristics as shown in Fig.4 (b). Shearing stress nearly proportional to shearing speed is generated and its slope namely viscosity can be controlled by the electric field. As a result, it is possible to acquire a mechanical control force proportional to the speed under a constant electric field and to mechanically realize what is equivalent to the so called differential control.



1.5 The ideal ERF should contain the following qualities in the view of its application in engineering:

- 1) Be able to produce an obvious ER effect when an electric field is applied i.e., the viscosity and yield stress can be developed on a large scale (even to the solid state). The highest yield stress of shear resistance in the ER fluid can reach 7-10 kPa. Surely, the higher the value the better. It has been reported that, for the most ideal ERF produced so far, yield stress values can reach 20 kPa.
- 2) Be able to turn the ERF into a solid at a low voltage (the lower the voltage the better). Normally, it is hoped that the electric field strength is no more than 3kV/mm. The fluid can be punctured with high voltage, i.e. discharge may occur.
- 3) The insulation value of the base liquid should be low (i.e. the electric resistance should be high). Thus, the strength of the electric fields can be raised and can make the ER effect more obvious and, at the same time, the power necessary to cause the ER effect can be lowered.
- 4) The chemical stability of the ERF should be high and should not degrade in storage and service.
- 5) The specific gravity of the base liquid should be close to that of the particles in it, and this ERF can prevent the sedimentation of its particles.

- 6) The ERF should be non toxic for the safety of its users.
- 7) The production of ERF should be as easy and as economical as possible.
- 8) The ERF should be waterless. Water increases the current density so that more power is consumed. In addition, ERF will freeze at 0°C and boil at 100°C with water in it. Today, many scientists devote their research to finding waterless ERF and have succeeded on a large scale. ERF has been developed to withstand temperatures of 200°C, but the ideal operating range is 40-150°C.
- 9) The viscosity of the ERF should be as low as possible when no electrical field exists therefore, we can regulate its viscosity within a wide range, and this is one of the most important factors limiting its application in engineering.
- 10) The ERF should be non corrosive and cause no wear and tear on metal particles.

II.CONCLUSION

The most advanced characteristics of ER fluid as a smart material can be summarized as follows according to current reports:

- 1) As obvious ER effect can be seen when an electric field is applied, causing a change in the fluid e.g., from solid to liquid and vice versa. In appearance, the fluid becomes thicker and thicker and this viscosity increases in accompanied by the development of shear resistance.
- 2) The change of the ER fluid from liquid to solid should be reversible when an electric field is applied, i.e. the fluid goes from solid to liquid when the electric field disappears. The change in viscosity should be stepless.
- 3) The change between liquid and solid should be very rapid under control of the electric field. It has been reported that the period of change is only about 10-5 seconds.
- 4) The change between liquid and solid can be controlled only by an electric signal (voltage). With this characteristic, the technique can be easily linked to modern. Advanced micro computer control techniques. ER technique is a new kind of future challenge because, as its fascinating Properties become more widely used; it may bring about a revolution to some areas of industry. The ER fluid is the key to ER technique and should be put into engineering applications and ER fluid dampers are the good solution for vibration control.

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