**American Journal of Engineering Research (AJER)**
E-ISSN: 2320-0847 p-ISSN: 2320-0936
Volume-7, Issue-12, pp-221-225
www.ajer.org
Research Paper Open Access

# Synthesis and characterization of Mahua and Simaroubha Oil as a carrier fluid of Magneto-Rheological Fluids (MRFs)

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***ABSTRACT:*** *Magneto rheological fluids are a class of smart fluids that have found their application in many industrial fields like shock absorbers, brakes actuators, prosthetic knee etc.MR fluids are certain materials whose rheological properties can be varied swiftly and controlled easily by application of magnetic field from an external source. Carrier fluids form the base of MR fluids and is one of the important parameters which influences the behavior of MRF. Hence in this research efforts were made to synthesize a carrier fluid from natural sources like Mahua and Simaroubha kernels and their properties have been discussed in this article. The potential use of Mahua and Simaroubha oil as a carrier fluid for magneto rheological fluid is explored in the present work. This study helps us to identify a most stable localized MR fluid.*

***KEYWORDS:*** *Rheology, Carrier fluid, Magneto Rheological fluid etc.*

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Date of Submission: 01-12-2018 Date of Acceptance: 31-12-2018

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## I. INTRODUCTION

With the development in standard materials, science and technology advancements have been brought up in the design of electronics and machinery. Some materials in the presence of external force exhibit certain change in behavior like change in physical state etc. These materials are known as smart materials. Magneto-rheological fluids (MRFs) are a kind of smart fluids, which in the presence or influence of an external magnetic field varies its rheological properties.MR fluids is a colloidal suspension of polarizable micron-sized magnetic particles in a magnetically neutral base fluid in a right combination.The viscosity of the MRF can be varied from a linear viscous fluid with a free flow to semi-solid state (viscoelastic solid) with the influence of an external magnetic field. The carrier fluids act as a dispersed medium and ensure the homogeneity of particles in the fluid. Carrier liquids is a major constituent of MRFs (50-80 percent of volume). The frequently adopted carrier fluids are mineral oil, silicone oil and synthetic oil. Synthetic oils are neither ecological nor biodegradable. In addition to the high-cost synthetic oil doesn't thicken at high temperatures and low friction makes it unsuitable for MR brake application at very high temperatures. Such restraints of the commonly used liquids persuade the examination of an alternative natural obtainable oil such as Mahua and Simarouba oil as a carrier fluid for the said applications. After the comparison between the various available alternatives such as groundnut oil, mustard oil as a carrier liquid for MR applications. Mahua and Simarouba oil are abundantly available in many parts of India and can be cultivated with ease and hence was chosen for the research in the present work.

Many MR Fluids application operate under different modes like value mode, shear mode and squeeze mode. In order to classify and identify materials which is best suitable for a particular application, a number of properties such as density, Kinematic viscosity, flash, fire point, water content was taken into consideration.

Kinematic viscosity is the measure of the resistance offered to the gravity flow of a fluid. This method measures kinematic viscosity by measuring the time for a volume of liquid to flow under gravity through a calibrated glass capillary viscometer. The dynamic viscosity is the measure of the product of measured kinematic viscosity and the density of the fluid. This method is only applicable for Newtonian flow. (That is the ratio of shear stress to shear rate is constant for different viscometers). In viscometer, the time of flow of a fixed volume of fluid is directly proportional to its kinematic viscosity. Higher the kinematic viscosity greater the ability of the fluid to transfer momentum. A fluid with fast momentum transport will account for more laminar flow conditions due to the fact that it balances the inertia forces of the in- and outflowing mass effectively. Interpreting the kinematic viscosity ν as momentum diffusion constant, we find the time required for momentum to diffuse in a fluid.

The water content indicates the danger of corrosion and determines the quality and shelf life.Hence more the moisture content more it is prone to degradation. The amount of water present in the sample is calculated based on the concentration and the amount of iodine in the Karl Fisher titrating reagent consumed in the titration. Sulphur is a naturally occurring element and it has many undesirable properties. It is acidic in nature which can cause the corrosion of the constituent metal parts and also is known as a poison to catalytic converters when used as a fuel and thereby reducing the effectiveness of exhaust systems. Hence reducing its comparability. In the present research work, an experimental study on the synthesis and characterization of the naturally available Carrier fluid for Magneto-rheological applications on certain properties have been reported.

## II. SYNTHESIS OF NATURAL OIL

Application of heat or any change in temperature brings about a drastic change in some high-quality attributes and even the color of the oil. Hence adequate measures were taken to maintain the oil temperature within a certain range. Hence forth cold pressed method was used for the extraction of the oil from Mahua and Simarouba kernels. This method ensures the extracted oil is pure and retains all the chemical properties as it is not subjected to any chemical change. This method relies solely on the applied pressure. In this method, the seeds that are washed, dried and free from impurities are fed into a milling machine where the seeds are ground to a paste. The semi-solid paste was slowly stirred using a rotating screw and oil was extracted. During this process, care was taken to maintain the temperature of the oil within the temperature range. The extracted oil was filtered by passing through layers of cloth which separated all the impurities from the oil.

## III. CHARECTERIZATION

The natural oils that were synthesized using cold pressed method along with the synthetic oil were characterized using a hydrometer, viscometer, bomb calorimeter to measure density, kinematic viscosity and Sulphur content respectively. Karl Fischer method was used for the measurement of the moisture content present in the samples.

The measured results are discussed in the context for carrier fluid of magneto-rheological fluids. Emphasis has been given for the kinematic viscosity as it plays a major role in the transport of momentum and stability of the MRFs when ferromagnetic particles and additives are added. The higher the kinematic viscosity of a fluid, the more efficient it can transport momentum. This property is often also referred to as the potential for momentum diffusion through the fluid. Hence the discussion mainly concentrates on different natural oils in comparison with the synthetic oil for the use as a carrier fluid for Magneto-rheological fluids.

## IV. DENSITY TEST

A hydrometer or aerometer is an instrument used for measuring the relative density of liquids based on the concept of buoyancy. They are typically calibrated and graduated with one or more scales such as specific gravity. The temperature of the sample was maintained at 15˚C. The Hydrometer jar was washed and cleaned with a distilled water and then with acetone. Later it was dried in the oven and for 5-10 minutes and cooled and later filled with sample liquid. The Hydrometer was placed in the jar and was given a twirl to dislodge any air bubble. The reading was recorded once the hydrometer was settled.

**Figure 1.Experimental setup for density test**

## V. FLASH AND FIRE POINT TEST

Bituminous materials leave out volatilities at high temperatures which may catch fire causing a flash. The temperature varies for different materials depending on the grade of the oil sample. The sample to be tested is filled in the cup up to the level indicated. All the accessories including the thermometer are fixed. The test flame is lit and adjusted in such a way that the size of the bead is of 4mm diameter. The sample is heated such that the rate of temperature rise is not more than 5˚C or 6˚c per minute. The lowest temperature at which the flash first appears on the surface of the sample is recorded at the flashpoint of the oil. The heating is continued until the oil is ignited and till it burns for at least 5 seconds. This temperature is recorded as the fire point.

**Figure 2. Experimental setup for flash and fire point test.**

## VI. KINEMATIC VISCOSITY TEST

Kinematic viscosity is the measure of the resistance offered to the gravity flow of a fluid. This method measures kinematic viscosity by measuring the time for a volume of liquid to flow under gravity through a calibrated glass capillary viscometer. The bath is maintained at the required test temperature (40˚C and 100˚C). A calibrated viscometer which is cleaned and dried having a specific range is selected (wide capillary for a very viscous liquid and a narrow capillary for a more fluid liquid). It is selected such that the flow time is not less than 200 seconds. The viscometer is charged in the manner dictated by the design of the instrument. The charged viscometer is allowed to remain in the bath long enough to reach the test temperature. The volume of the test sample is adjusted once it reaches the required equilibrium temperature. Pressure is used to adjust the head level of the test sample to a position in the capillary arm of the instrument about 5mm ahead of the first timing mark.

**Figure3. Kinematic viscosity test at 100 CFigure 4. Kinematic viscosity test at 40□C**

## VII.WATER CONTENT TEST

The Karl Fischer method is used for determining the moisture and is suitable for samples with a high moisture content (titrimetric) and also for those with water content in the ppm range (coulometry). Moisture determination is based on the amount of the reagent used to convert the water present in the sample. Iodine is added to the sample during titration and the amount of iodine consumed is recorded. A Burette is used to add iodine in the form of a solution of known concentration to the sample. The amount of iodine added to the sample is calculated from the volume of iodine solution used. When reacting with water, the brown iodine is reduced to colourless iodine. At the endpoint of the titration when all the water was consumed, the colour of the solution turned increasingly from yellow to brown.

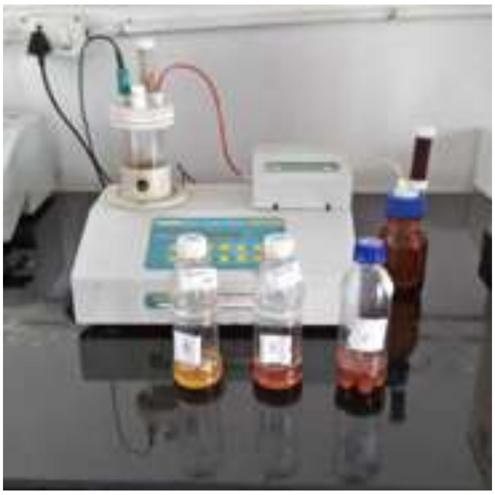

**Figure5. Experimental setup for water content test**

## VIII. SULPHUR CONTENT TEST

The advance bomb calorimeter is one of the accurate and inexpensive methods for the determination of the heat of combustion of fuels and calorific value of the samples.

This method is applicable for any oil sample having sufficiently low volatility so that it can be weighted accurately in an open sample boat containing at least 0.1% sulphur. The sample is burned in the presence of oxygen under high pressure inside a bomb calorimeter containing a fixed quantity of water. The amount of enthalpy released by the reaction is equal to the change in the temperature of the water. Using the specific heat of water (c), mass of water(m) and the change in the temperature($\Delta T$) the enthalpy released is calculated.

$$q = mc\Delta T$$

As the reaction takes place in a rigid sealed container, the pressure-volume work done by the reaction is zero and all the energy released is in the form of heat and no work. Hence the heat represents the change in internal energy ($\Delta U$) but not the change in enthalpy ($\Delta H$).

**Figure 6.Experimental setup for sulphur content test**

## IX. RESULTS AND DISCUSSION

The experiments were conducted, and their following results were recorded and compared with that of the mineral oil. Table 1.1 gives a clear explanation about the characteristic values of some of the properties of these mineral oils

| Tests | Mahua oil | Simaroubha oil | Synthetic oil | Units |
|---|---|---|---|---|
| Kinematic viscosity@40 □C | 42.94 | 41.53 | 69.95 | cSt |
| Kinematic viscosity@100 □C | 9.08 | 9.15 | 15.09 | cSt |
| Density@15 □C | 939.84 | 942.04 | 853.09 | Kg/m$^3$ |
| Flash point | 142.0 | 145.0 | 132.5 | ˚C |
| Fire point | 144.0 | 150.0 | 135.0 | ˚C |
| Water content | 0.22 | 0.35 | 0.33 | % |
| Sulphur content | 0.21 | 0.06 | 0.31 | % |

**TABLE1.1**

## X.CONCLUSION

The MR fluid in the absence of the magnetic field behaves similar to a carrier fluid and exhibits Newtonian fluid properties and flows freely in a capillary. But in the presence of a magnetic field, it exhibits visco-plastic behaviour and doesn't flow by itself. Thus, the fluid needs pressure to flow through the capillary. Hence the fluid should have a low viscosity in absence of an external magnetic field and should possess high viscosity when the magnetic field is applied both the natural oils Mahua and Simarouba possess low viscosity compared to the synthetic oil hence favourable for many MR applications.

Continues application of pressure leads to an increase in working temperature hence the operating range of these fluids must be very high so that they are not inflammable and also act as a coolant during the operation. Mahua and Simarouba oils both have high flash and fire points which indicates high operating range in comparison to the synthetic oil.

Since most of the suspended particles like the additives are ferromagnetic substances, they are usually prone to corrosion due to the presence of water and sulphur which leads to a formation of acid. Presence of water also leads to the formation of rust and hence eroding off the suspended particles. Mahua and Simarouba. Presence of sulphur leads to the formation of acid which erodes the suspended particles and hence decreases the lifespan of the MR fluid.

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Ram Rohit Vannarth. "Synthesis and characterization of Mahua and Simaroubha Oil as a carrier fluid of Magneto-Rheological Fluids (MRFs)." American Journal of Engineering Research (AJER), vol.7, no.12, 2018,pp.221-225