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SYNTHESIS AND CHARACTERISTIC TESTING OF MAGNETO-RHEOLOGICAL FLUID FOR GRIPPING ACTION

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Abstract- The aim of this work is to prepare electro magnetically activated magneto rheological fluid for enabling the gripping action. Magneto rheological fluid is prepared using almond oil mixed with cast iron powder. So as to decrease sedimentation rate of magneto rheological liquid oil is included as stabilizers. Magneto rheological liquid with great properties can have the option to transmit holding power to the control of robot gripper. The greatly wanted quality of long term stable sedimentation dependability, high direct consistency and their brisk reaction time to the applied magnetic field has brought into robot gripper. The significant properties viscosity, sedimentation rate and strength of magnetic field of magneto rheological liquid and also gripping test are tried. Examinations were taken on magneto rheological liquid and results have been researched under various conditions.

Keywords: **Magneto rheological fluid, Viscosity, Sedimentation rate, Strength of magnetic field, Gripping test.**

I. INTRODUCTION

Magneto rheological (MR) liquid is a unique sort of liquid with micron measured particles suspended in almond oil bearer liquid. The significant property of the MR liquid is the adjustment in their liquid thickness as for attractive field. When applied with the magnetic field, the alignment of iron particles brought a continuous uniform chain like structure shown in Fig.1 which is increases the stiffness and strength of the fluid. When the absence of magnetic field, the working fluid return to its initial stage. Because of this liquid significant stage change properties, MR liquid is utilized in numerous mechanical applications like grasps, dampers, safeguards and gripper, and so forth. Magneto rheological (MR) liquids could offer a remarkable capacity in its applications.MR liquids are a class of controllable liquid that reacts to an applied attractive field and ready to give straightforward, peaceful, quick reaction, interfaces between mechanical frameworks and electronic controls. Jeron cramer et al [1] utilized MR liquid in automated gripper for creating adaptable gripper.MR fluid was filled with elastic membrane in robotic gripper and their performances have been investigated. Two different MR grippers are fabricated. One is non-magnetisable that is silicon rubber bladder and other one is magnetisable magneto rheological elastomer bladder. Young T. Choi et al [2] designed a cup type elastic bladder filled with a MR fluid, mixed by 35 % volume of carbon iron powder suspended in highly viscous linear Polysiloxane [4]. Chiranjit Sarkar et al [5] considered the property of MR liquid arranged by blending oleic corrosive asantifriction added substances and tetramethyl ammonium hydroxide as surfactant when it was utilized in antifriction. They found that the quality of attractive molecule was a component of relative speed among stator and rotor. Bhau K. Kumbhar et al [6] incorporated MR liquid by blending oil as a stabilizer, oleic corrosive as an antifriction added substance and gaur gum powder as a surface covering and it was utilized in brake application with most noteworthy shear quality of 92.34 kPa. N.P.Sherje et al [7] arranged and examined the portrayal of magneto rheological liquid for damper application [8-10]. They noticed that

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increasing the amount of additives increases its stability. Shashikant K Nimbalkar et al [11] prepared MR fluid MR fluid by using soybean oil and it is tested in parallel plate rheometer. They proved that the shear stress and shear rate property of the prepared fluid varies between 0-2A. After that the property will not be changed.

However, Be that as it may, the readiness and getting wanted qualities of magneto rheological liquids includes a few difficulties. Sedimentation and consistency are the significant test, in any event, when put away for moderate timeframes. The properties of the MR liquid are influenced by different parameters, for example, temperature, dampness, pH, electric or attractive field, strong substance, thickness and the size of the particles. James Sathya Kumar et al [12] saw that more difficulties in strategies for arrangement of MR liquid, challenges experienced away and use. They gave potential answers for beat the difficulties. The dependability of MR liquid is relied upon its added substances. Shreedhar Kolekar [13] examined that the dependabilityof MR liquid improves with expansion of added substances. To improve the solidness of MR liquid various added substances can utilize and discover ideal level of it specific blend to accomplish better dependability. S.K.Mangal et al [14] amalgamation MR liquid which was demonstrated that the yield worry of MR liquids increments with an expansion in molecule stacking of the iron particles. The yield pressure became 1.05 occasions its incentive for the MR liquids having mineral oil as bearer liquid in contrast with silicon oil.

From literature review, robotic gripper is needed MR fluid with good stability which is improved by the additives presence on the magneto rheological effect [15-17]. There still exist a requirement for reliable methods of preparation and synthesis. The aim of this work is to prepare magneto rheological fluids and investigate their rheological properties.

II.PREPARATION METHOD FOR MAGNETO RHEOLOGICAL FLUID

Material for the preparation of MR fluid, micro sized carbon iron powder (5 µm) with and almond oil as carrier fluid which has stable temperature in the interval -40℃ to 150℃ are used. Here all purpose (AP3) grease is used as additives. First, commercially purchased grease is added with almond oil in a beaker as shown in Fig.1. Then the dispersion medium is mixed with a stirring machine at 450 rpm in room temperature. Then wait for two hours so that grease gets completely soluble in almond oil. After that add cast iron particles 5 µm in above mixture and again stir it with the help of mechanical stirrer for 15-20 mints for proper mixing. In the preparation of MRF AP3 grease is added into almond oil in order to reduce settle down of iron particles.The quantity of fluid is 100ml. The constituents of MR fluid are given in Table 1.

Table 1 - Constituents of MR fluid

Constituent	Sample1	Sample2	Sample3
Iron particle 5 µm (gram)	90%	80%	70%
Almond oil (ml)	8.5	16.5	24.5
AP3 grease (gram)	1.5	3.5	5.5

Figure1. MR fluid preparation setup

III.RESULT AND DISCUSSION

There are three properties test have been investigated for this prepared MR fluid A. Viscosity test, B. Sedimentation rate and C. Strength of magnetic field and also D. Gripping test have been investigated.

A. Viscosity test: It is a resistance of fluid to a change in shape, or movement of neighbouring portions relative to one another is called viscosity. The viscosity test done by redwood viscometer. Fill the given sample in such a way that the sample level is exactly up to the mark in the cup. Fix the cup in to the device and spread with top. Addition thermometer in the thermometer holder given in the cup in such a way, that it won't legitimately contact the lower base of the cup and the oar stirrer inside the cup. Fill the water shower with the virus water. Close the sliding screen and light the standard fire. Change the size of fire (4mm breadth) as for the metal globule. Mix the oil utilizing paddle stirrer. Present the fire by opening the shadeand check the presence of the glimmer. Presently heat the mechanical assembly and set the pace of temperature increment at the pace of 1 to 2℃ every moment. Check the glimmer purpose of given example at the interim of 3℃ ascend in the temperature. Cease the blending the example during the presentation of the test fire. On watching a blaze, stop the warming procedure and permit the temperature to diminish. Check the event of a glimmer at each 1℃ drop in temperature at which the blaze is seen as the glimmer purpose of the example. The observations are done and the reading are tabulated in the table 2.

100 ml samples have been taken for viscosity test. All sample have perform under different temperature. All samples gave same kind of result when increasing temperature of water. The following result belongs to sample 3.

Table 2 - Observation of viscosity test

Temp of water (°c)	Temp of Oil (°c)	Temp of 100ml Collection for sample3 MR fluid (Sec)	Kinetic Viscosity (Centi stoke)	Dynamic Viscosity (Centi stoke) (10^3)
80	67	1168	303.51	267.25
85	71	1130	293.64	257.48
90	76	1117	290.26	253.18
95	82	1080	280.64	243.24
100	89	973	252.81	217.48

Model calculation of kinetic and dynamic viscosity:

Kinetic viscosity (v):

Kinetic viscosity, v =AT-B/T = 0.26*1168-171.5/1168

= 308.2051 Stroke, Where, A=0.26 and

B= 171.5 is the standard machine value

Dynamic viscosity (μ):

Dynamic viscosity μ= v *Density of oil-(specific gravity of oil) (temp of oil-room temp)=308.2051-(0.92) (67-35) =274.475*10^3CP Where, Room temperature=35°c.

All data are tabulated and the relations are plotted as shown in Fig.2, Fig.3 and Fig.4.

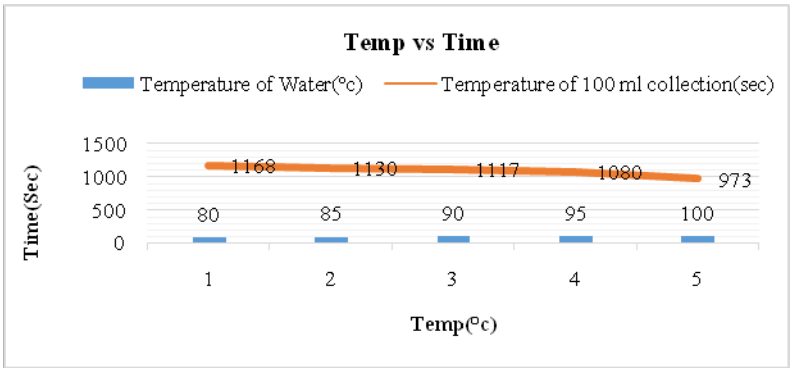

Figure 2 .Temperature vs Time

The reason for taking temperature from 80°c is that could not collect the MR fluid into beaker when it is 70°c due to iron particles and other additives mingle with almond oil. Where the density of oil is high. At 80°c the density of oi

Getting reduced which is found during the experiment.

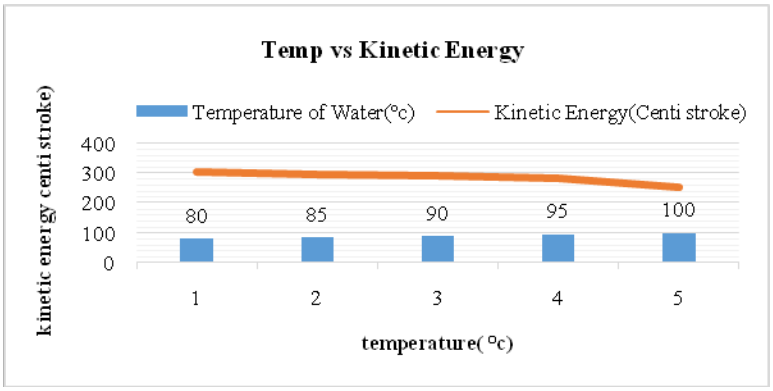

Figure3. Temperature vs Kinetic Energy

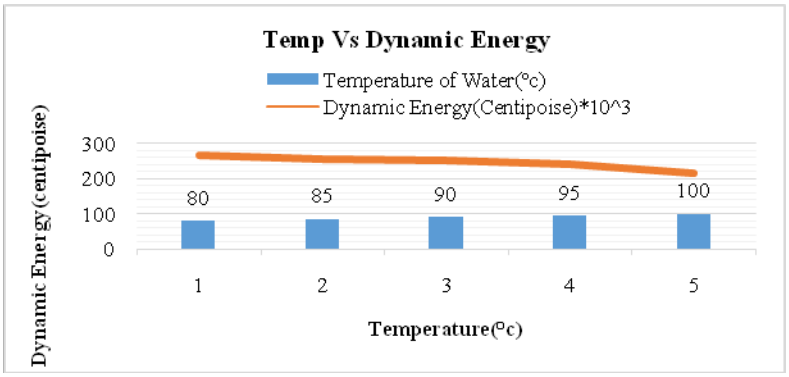

Figure4.Temperature Vs Dynamic Energy

Magnetorheological (MR) liquid shows various performances under various temperature, which causes such a significant number of issues like the decrease of rheological properties of MR liquid under a high temperature condition. The investigation results indicate that temperature highly influences the viscosity of MR liquid. Fig.3 and fig.4 shows that the kinetic and dynamic viscosity of MR liquid slowly decreases when temperature rises.

B.Sedimentation test: It is the process in which particles separate from a liquid because of gravity. It can be test by visual absorption where position changes of limit between clear and turbid part of carrier oil. The test was absorbed by time (days) for three different mixing ratio of MR fluid as shown in Fig.5. The MRF with different ratio Sample1 (S1), Sample2 (S2) and Sample3 (S3) have been taken into 5ml graduated tube marked 1ml. The test was absorbed by five days, ten days and fifteen days are plotted in the Fig.6. Sedimentation ratio (V) = (a/ (a+ b))*100% Where, V [%] sedimentation ratio, 'a' is length of the clear part and 'b' is length of the turbid part.

Figure 5.Different ratio of MR Fluid

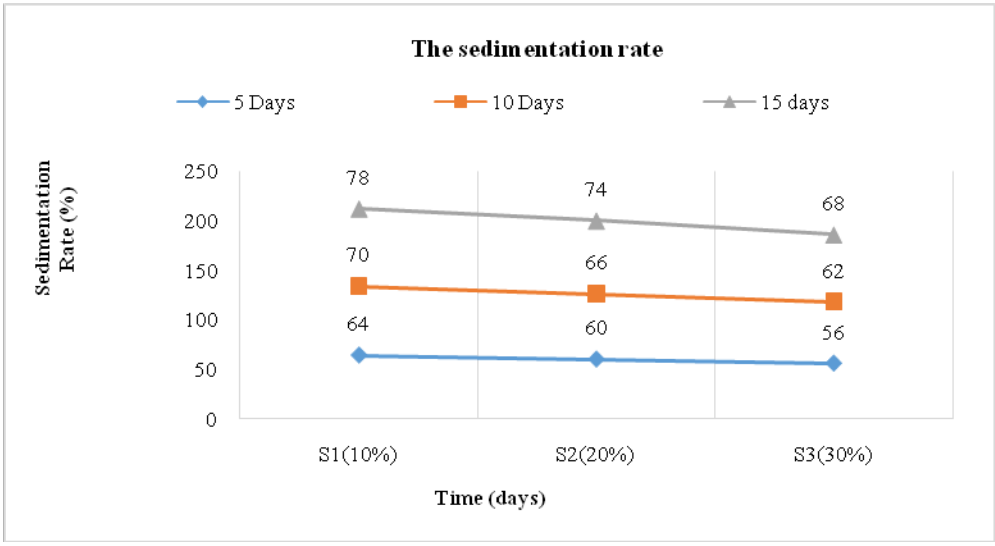

Figure 6. Sedimentation Rate

The impact of added substances on the dependability of the MRF has been seen by outwardly. Suspensions of cast iron (CI) particles in almond oil have arranged as the model of MRF. Dependability of arranged MRF was diverse for each situation and it shifts from every day. The security of MRF relies upon the cast iron powder and kind of oil. Expansion to the MR Fluid adjustment operators should additionally build their steadiness. There are three distinctive proportion of MRF test have been taken that named as S1, S2andS3. For the most part, higher substance of cast iron increment the security. The best outcome was gotten for S3 as appeared in fig.6. The sedimentation rate high for S3 due to it contain somewhat higher CI particles and stabilizer than S1 and S2.

C. Measuring the strength of magnetic field: For the testing of MR liquid quality after instruments are required. Guassmeter Electromagnet, Electrical circuit (Step down transformer, Ammeter and Rheostat). Guassmeter is a magnetometer that used to gauge the quality of attractive field. The guassmeter have a test which is tip in a MR liquid to gauge attractive field power with the assistance of electromagnet and rheostat. Diverse voltage given to the

electromagnet to charge the iron particles in MR liquid and the qualities are arranged in table 3.By using step down transformer to convert 230V AC into 12V DC supply.

Table 3- Magnetic field intensity test

Input current (A)	Magnetic strength output in gauss
0	0
0.2	9
0.4	1.4
0.6	18
0.8	22
1.0	25
1.2	29
1.4	34
1.6	39
1.8	44

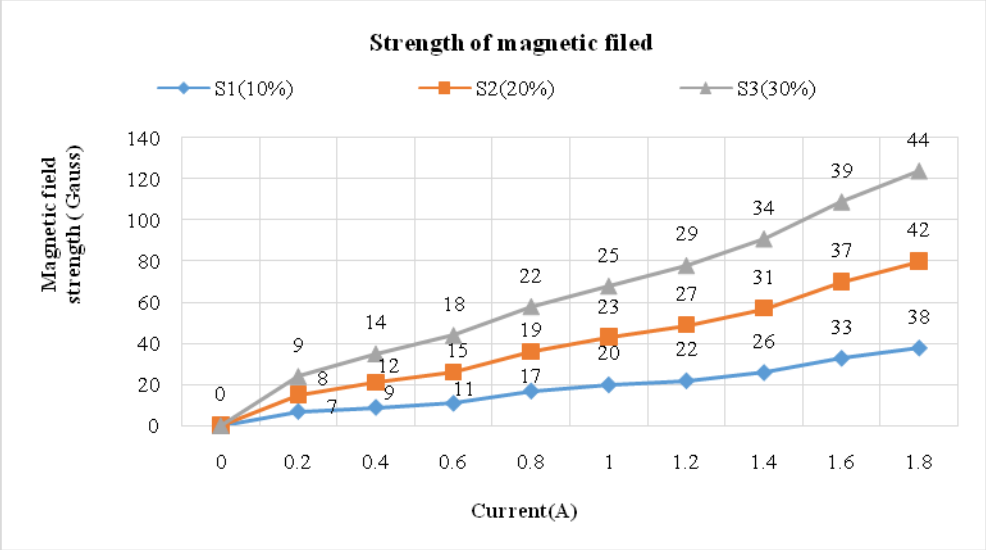

Figure 7. Magnetic field strength

Magnetic field is created due to shifting expenses in a winding. Each electron in a winding creates its personal magnetic field. The Amount of current in a winding is directly proportional to magnetic field intensity. The graph shows that as the current increases magnetic field intensity also increases. There is a non-straight extent among Current and attractive field power as appeared in Fig.7. An examination of MR effect was carried out to check the guidance of magneto rheological fluid composition on its operational characteristic that is type of liquid carrier, magnetic ratio and presence of additional substances. Here additionally three distinctive proportion of MRF test

have been taken named as S1, S2 and S3. Guassmeter demonstrated the estimation of attractive field force by differing the current. Fig.7, indicated that as current increments attractive field quality likewise increments. Here is straight extent among present and attractive field force. From this trial sample 3 must be discovered high quality of attractive field than sample 1 and sample 2.

D. Gripping tendency test: The most extreme burdens lift by the gripper for a specific volume of Magneto Rheological liquid and consistent gripper distance with fluctuating magnetic fields is alluded to the holding inclination test. This test method approves the benefit of progress in thickness under various attractive fields. The setup was specially made and for simplicity, the grippers are fixed on surface of electromagnet as shown in Fig.8. Latex rubber as pouch because of flexible elastic membrane. MRF filled inside latex balloon. The latexballoon mounted on surface of electromagnet. When applied voltage to the electromagnet, that influenced inside the balloon to change liquid to semi solid state. Sample has been taken for evaluate gripping capacity MR fluid (sample3) 50ml and Electromagnet = DC 12v. A force gage is used to measure the force during the pulling test.

Table 4 - Evaluating the gripping performance

Material		Wood	Metal	Plastic
m (g)	6v	29	36	12
	12v	61	55	18

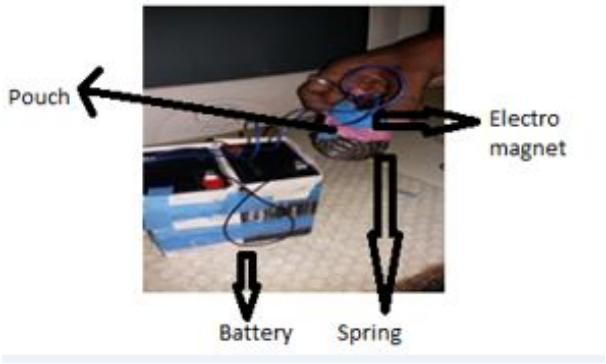

Figure 8. Gripping tendency test

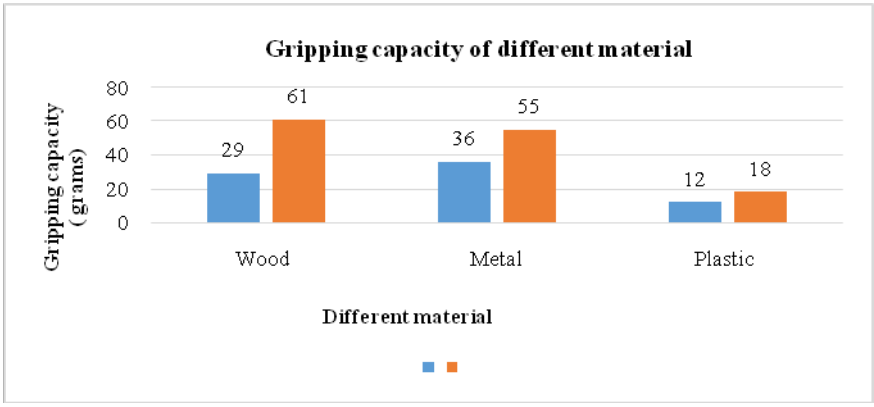

Figure 9. Gripping capacity vs different material

From this simple gripping experiment using object with varying materials, it was found that the developed gripper is able to adopt to various shape. Moreover, in these experiments the object were never damaged. Furthermore, in this experiment, it was confirmed that stable gripping could be achieved without strictly setting the position of various objects. Fig.9, it clearly revealed if increasing voltage, the lifting capacity also improved.

IV. CONCLUSION

The main aim of this project is to prepare MR fluids micro sized Cast iron powder (5 µm) with almond oil as carrier fluid and AP3 grease is used as additives. Experimental tests were taken on viscosity test, sedimentation stability test, magnetic field intensity test and gripping tendency test. The prepared MR fluid sample3 shows great efficiency in presence of external magnetic field. MR fluid sample3(30%) fluid is contain almond oil mixed with cast iron powder which is 70% cast iron powder, 24.5% almond oil and 5.5% AP3 grease. So as to decrease sedimentation pace of magneto rheological liquid oil is included as stabilizers.

The exploratory outcome shows great effectiveness of arranged MR liquid in nearness of outer attractive field. The MR liquid is tried on gauss meter which indicated the great attractive field quality outcome. It changes the physical state that is liquid state to slightly thicker when voltage applied to electromagnet. The gripper is able to grip to various shape of material without causing damage.

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