Analysis On the Development of Electro-Magneto Rheological Fluid For The Mechanical Systems

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ABSTRACT

ERMR fluid is the electro-magneto rheological fluid. My project is experimentally work on this fluid. This fluid will change it's density as well as viscosity with applied electric current and magnetic field. By using this logical concept , we can solving many of the mechanical system which are concern with hydraulic system and suspension system. I will doing various chemical processes for got the properties of electro-magneto rheological fluid.

In this experimental work , In chemical process taking particular viscous fluid and try to achieve changeable viscosity by various ways. After this achieved fluid will used in any mechanical system for better prospect.

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1. Introduction

Now a days various mechanical systems are available in the market which are concern with the fluid for getting force or sustain force. Like wise suspension systems , hydraulic systems , friction mechanical systems , etc. as we know , the fluid concern with this type of purpose having good properties for sustain the impact , making pressure force , reduce the friction, reduce wear , etc . but , most important property of that fluid was VICOSITY . because of the better viscosity , this fluid making easier operating of mechanical system .

In my experimental work , I am focus on the fluid which is use in that type of mechanical systems. I am selecting particular suspensions from those mechanical systems which are concern with the fluid. Now, we will see first " what is suspension ? ". Parallel we discuss about the fluid.

Suspension is mostly listenable word in the automobile areas. but, it's main work is to absorb the shock from impact of load and reduce the vibration. So, it's also useful in other mechanical system. theoretical definition of suspension is " **Suspension** is the system of springs, shock absorbers and linkages that connects a load to its working part and allows relative motion between the two".

Here, I am just share basics of the suspensions. because, I have not design the suspension. There are mostly basic three types of suspension which are explain below.

(1) Leaf spring suspension

(2) Coil spring suspension

(3) Torsion beam suspension

1.2 Basic working of suspension

Here , we understand basic working of suspension. In this working construction of coil spring is as per shown in figure. In short, one hollow cylinder contain one rod with it's origin. This both and rod are covered by one helical spring. In the action load is acting from one side is shown in figure(1). Where load is axial acting in suspension is compressive load. In the reaction of that suspension will compact shown in figure (2). At that time impact of load is sustain by spring. Suspension structure is absorb the energy. This stored energy will be release by suspension shown in figure(3). So, in this suspension is comes in it's real position by releasing the energy .
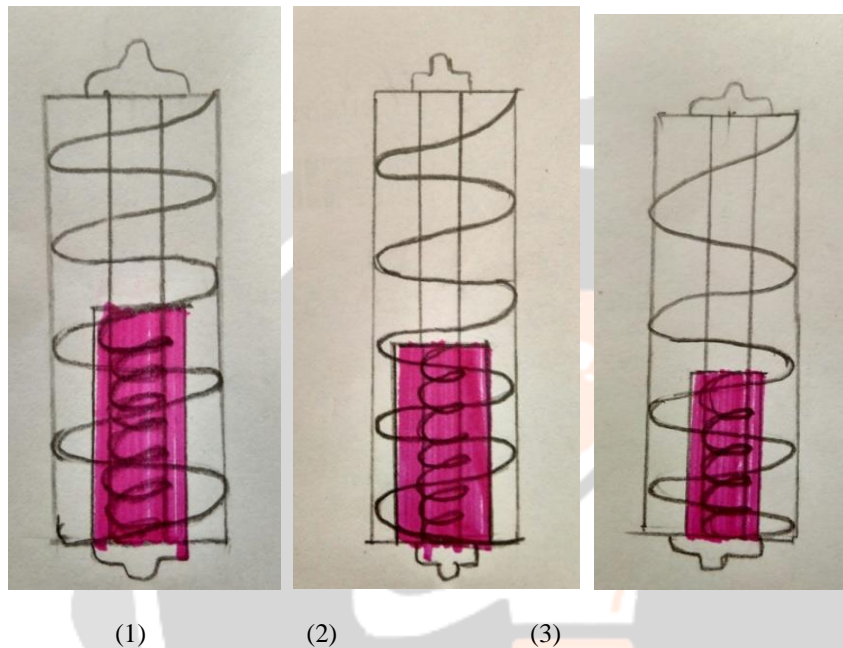

(1)   (2)   (3)

Fig : 1.4 : working of suspension

1.3 : Role of fluid used in suspension

The fluid is mention is the figure by yellow color. It is fill in the hollow cylinder and covered by rod. In the cylinder gap fluid attached with rod and between the turn of inner spring. Now, we will see at the working condition fluid how react? In working condition when load acting from one side of suspension as per figure(1). At that time fluid support the inner spring to compact or absorb the energy. And the important role of the fluid is in last phase. Fluid will release the store energy from spring very smoothly. So, the shock of spring release energy will be reduced. Now, we logical understand fluid having some property which is making operation smoothly is the nothing but it's only one property is the viscosity. Due to the higher viscosity fluid will release spring energy smoothly.

1.4: Problem formulation

Now , we see the total phenomena of the suspension in further description. From the of the data we conclude particular issue which are being helpful to me for the purpose of formulate 16 the problem. Before problem formulate, I am focusing on the fluid used in suspension. Some issue from available fluid used in suspension are describe below.

(1) Now days when we are going to purchase any automobile vehicle, we will always ask or verify the maximum loading capacity in terms of weight. figure shows that type of particular load capacity in the vehicle. Usually Greece is the fluid is used in suspension of automobile vehicle because of better viscosity. But , problem arise at that time when load is increase suddenly more than capacity of suspension at that time suspension will be brake out.

(2)Design of the suspension will be mostly depend on the weight of vehicle and specified passenger or load. So, the spring used in suspension is design for the weight of vehicle. This spring having elasticity for the sustain against load. The range of elasticity of spring is limited. So , in the case of overweight in the vehicle suspension is get fail. It means the load react on spring over it's elesctic limit, spring will not regaing it's shape or original length .

(3)Fluid use in the suspension having chemical property, so we can easily understand it will be affect by seasonal climate condition. So, fluid pour in the suspension will be maintain in particular quantity level. And other issue is the density and viscosity of fluid will be remain not same because temperature and pressure will affect. So , this issue will result as the jamming of suspension. In short , when suspension get jam. It will be react as solid shaft which will not absorb energy or release energy.

1.5 : Problem identification

We can see the issue or limitation of the now available suspension. In my experimental work, I can solve this issue by changing the fluid use in the suspension. In short , I having achive fluid which will be not make issue shown in problem formulation.

We see the important property of fluid is viscosity, now we will focus on the viscosity. So , according to solution side we achieve fluid having more viscosity. But , it is also particular viscosity. So , I can get the fluid which have variable viscosity in proportion of variable loading condition .

Let's , I have introduce the one fluid which having changeable viscosity is ELECTRO-MAGNETO RHEOLOGOCAL FLUID. We getting confuse, what is ERMR fluid. ERMR fluid is the fluid which can change it's viscosity according to the applied current or created magnetic field.

In this experimental work, I will prove this ERMR fluid will give better performance than right now used fluid in suspension. In this phenomena ERMR fluid is change is viscosity according applied current or created magnetic field. And this both electrical and magnetic quantity will be make proportion of the load affect.

1.6 : Application of ERMR fluid

(1)ERMR fluid is the useful in the case of the very heavy duty automobile vehicle suspension system.

(2)ERMR fluid is also featuring for chemical reactive process.

(3)ERMR fluid will be more efficient in the use of where temperature and pressure working condition.

(4)With help of ERMR fluid some mechanical element like suspension, shock absorber , actuator , etc are give better performance.

1.7 Property of ERMR fluid

(1)ER fluid is the reactive with applied electric field according to the requirement of viscosity .

(2)MR fluid is the reactive with applied magnetic field according to the requirement of viscosity

(3)This ERMR fluid is the very negligible react from the effect of the atmospheric condition like temperature and pressure.

2. LITERATURE REVIEW

If we are focusing on the problem than biggest two issue are arising. Those are the issue of making of ERMR fluid and it's use in the suspension. So, from the literature review of some research paper of ERMR international conference. We got some idea which are being helpful to us for achieving particular solution.

(1) H.S.PARK

In this research paper reviewer try to achieve the magneto-rheological fluid properties from ionic fluid. In his research paper mention that the prepare dispersing mixture of two carbonyl iron powder in the ionic liquid have been investigated for MR properties. Carbonyl iron powder CM and HQ are mixing in ammonium ionic liquid for achieve MR fluid. first of all investigate the MR properties by bi-cylindrical viscometer. In that investigation, with help of proper apparatus generate the magnetic field and investigate MR property. He conclude that the MR property are depending on the particle size of carbonyl iron powder and particular 60% of large size particles give the highest MR property. Important is this fluid can stable even at higher temperature of working.

(2) H.SEE.

In this research paper reviewer investigate behavior of the ferrofluid liquid mixing the various size inert particle. This ferrofluid magnetisable fluid which already contain single domain nanoparticle. This ferrofluid with inert particle under the magnetic field performs as MR fluid , because this inert particle are elongated in direction of the magnetic field. In this experiment the prepared fluid having shown as very low shear stress which shows that fluid having better viscosity under magnetic field. So , this MR fluid will be compare for the result of shear stress according to changing of the particle size of inert.

(3) R.TAO.

In our focus we try to achieve more viscosity fluid but, in inverse direction by reduce the viscosity in ERMR fluid reviewer take advantage. By reducing the viscosity of fluid we 20 also take biggest advantage like reduce the blood viscosity we increase circulation, by reducing diesel viscosity achieve more efficient fuel combustion and less pollution. By applying the magnetic field and pulse electric current on the fluid is change in viscosity. So, in the fluid we can change the suspended particle size and suspended particle polydispersity distribution. This reducing viscosity of fluid are important in the various application and it is also known as ERMR fluid.

(4) DANIEL J.

In the research of the working condition of ERMR fluid done by reviewer in this paper and get result. He achieve the body force on the ERMR fluid such as gravity and centrifugal force influence the structure and the rheology of ER as well as MR suspension even magnetic or electric field applied. In this if body force very small compare to the magnetic or electric field applied on the ER and MR suspension than the effect of body force on the structure of the ERMR fluid. So, ERMR fluid structure affected by the body force than it will be losing the rheological properties.

(5) E.V.KOROBKO.

Very important experimental work done by this reviewer making the concept of electrosensitive lubricant. In this concept sliding friction pair of bearing and it's support are getting wear on working surface when lubricant having low viscosity. But, in the case of more viscosity of lubricant speed of that pair may be reduced. Property of electrosensitive lubricant is solve that problem by decrease and increase it's viscosity. In the logical concept according to the relative speed of the sliding pair component the viscosity of the lubricant will be change. Now, we are combine this concept with the ER fluid. As our investigated experiment composition of the electro-rheological property fluid and electrosensitive lubricant are very significantly change it's viscoplastic property by applying the electric field. In this experiment very important parameter of the fluid will be continuously proportionally with thickness of fluid in the accordance of the applied electric current. Finally , we understood compositions of electrosensitive fluid and ER fluid achieve more efficient quality.

3. Design of Experiment

Experimental work for Develop Base Fluid (MR Fluid)

From the review paper , we get that the fluid and particles are responsible for the MR property . But, there are variables for the fluid composition. These variables are effective at best composition of their quality as well as quantity . first of all , we derive the variables for the best composition of fluid.

(1) Selection of carrier fluid

(2) Selection of particles material

(3) Particles Size

(4) Sedimentation reduction fluid

(5) RPM of stirring

(6) Volume Ratio

(7) Duration of stirring

Let's we have understand all the variables in brief for the particular response in base fluid. In that variables some variables are important as the construct the fluid and other important for the composition of fluid. Now, we have understand one by one in brief at below.

Carrier Fluid	This fluid will mix in the some solid particles for the purpose of deriving MR property.
Particles	This is solid particles which are used to mixing in the carrier fluid for the purpose of generating MR fluid.
Particles Size	This is the important variables for mixing carrier fluid and solid particles , because it's directly affect the viscosity of fluid.
Sedimentation Reduction fluid	This fluid for the purpose sedimentation of particles in the carrier fluid . otherwise fluid lost it's MR property.
RPM (stirring - Device)	This the rotational speed of mechanical starer for the mixing of carrier fluid in the solid particles with sedimentation fluid. Well mix the combination is necessary to obtain MR property.
Volume Ratio	This percentile ratio of carrier fluid, solid particles and sedimentation fluid. Which lead us to better composition.
Duration of Stirring	This is the time for the taken for the mix up carrier fluid . solid particles and sedimentation.

List of variables in MR fluid Composition

Now , we focused on the all those variables and try to best combination of those variables by it's quality as well as quantity. So, from the refer review paper getting some information . in the reference paper[13]. the reviewer was made trial for the selection of the carrier fluid from the Mineral oil , Synthetic oil and Silicon oil. But,he was selected the silicon oil because of particular reason as below:

Carrier Fluid	In our trial, we will use the silicon oil as carrier fluid because of it's property.
Particles	In our trial, we will use the carbonly iron powder particles as solid particles for mixing in the carrier fluid.
Particles Size	Carbonyl iron particle having better performance in mixing with fluid when they are use in smaller size . so , we will use carbonyl iron particles of 2.5 ,4.5 , 6 micron size Particles.
Sedimentation reduction fluid	Oelic acid is used sedimentation reduction fluid, because of it's coating ability.
RPM (stirring - Device)	We will stir mixture by mechanical starer which having 2000 RPM capacity. So , we will use 1500 , 1700 , 2000 RPM.
Volume Ratio	In the volume ratio , there are three substance are having mix into the base fluid. So, maintain the volume ratio as 100%. so, we will adjust the volume ratio of three substance.
Duration of Stirring	This the time duration for the mixing of carrier fluid , solid particles ans sedimentation fluid. More time making even time mixture so taking time 10 ,12 , 14, hours.

Importance of Variables for MR fluid Composition

Taguchi Method For Base Fluid

Taguchi Model WIth Minitab **:** Minitab offers four of designed experiments: factorial , response surface , mixture and Taguchi. The step follow in minitabt to create , analyze and graph an experimental design are similar for all design types, after conducting the analysis and entering the results minitab provides several analytical and graphing tools to help understand the results.

Signal -to-Noise Ratio for Resonse Characteristics : Taguchi separate factors into two main groups control factors, as mentioned above control factors are those which are set by the manufacturer and control be directly changed by the customer. An engine manufacture can dictate the material for the pistons , the tension on the piston ring , the piston bore clearance , etc. Which cannot easily modified by the customer. Noise factors are those on which manufacturer has no direct control, but which caries by customer's environment and use. In this experiment work following response characteristics we study:

**Response Name** : Viscosity

Response Type : Medium-to-better

Unit : pa.s

MEAN RATIO OF RESULTS

Volume Ratio	Particles Size	Stirring RPM	Stirring Duration	Viscosity
a	2.0	1500	10	0.005
a	4.0	1700	12	0.010
a	6.0	2000	14	0.012
b	2.0	1500	14	0.007
b	4.0	1700	10	0.111
b	6.0	2000	12	0.116
c	2.0	1500	12	0.009
c	4.0	1700	14	0.121
c	6.0	2000	10	0.124

MEAN RESPONSE VALUE

|				
1	0.008000	0.072667	0.081000	0.080667
2	0.113667	0.081333	0.081667	0.081333
3	0.121667	0.083333	0.080667	0.081333
Delta	0.113667	0.004667	0.001000	0.000667
Rank	1	2	3	4
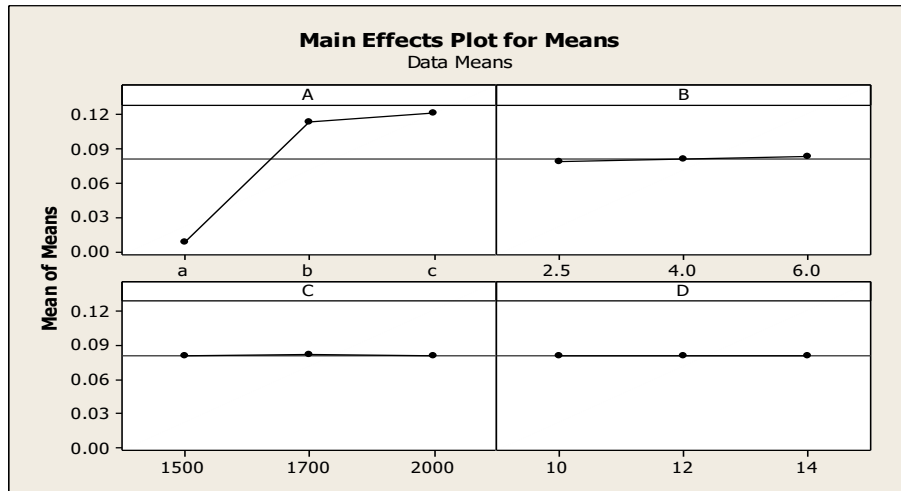
Practical Analysis of Base Fluid

Now , we were done design of experiment by taguchi method for the getting best combination of all variables. All variable settled in particular quality and quantity. This combination leads to better output. We have selected some combination of the variables and go for trial for that.

Let's go for trail of prepared base fluid which having the some percentile volume ratio of silicon oil , oleic acid , carbonyl iron particles. As per describe in the taguchi design of experiment result. This fluid was prepared by stirring on mechanical starer with rotational speed and duration as per describe in the taguchi design of experiment result. All parameter and variable will be taken for trial in practical set-up.

Practical set-up :

It is very easy and simple arrangement for the decide about viscosity. In the practical set-up using two flask and ball valve arrange as shown in figure below:
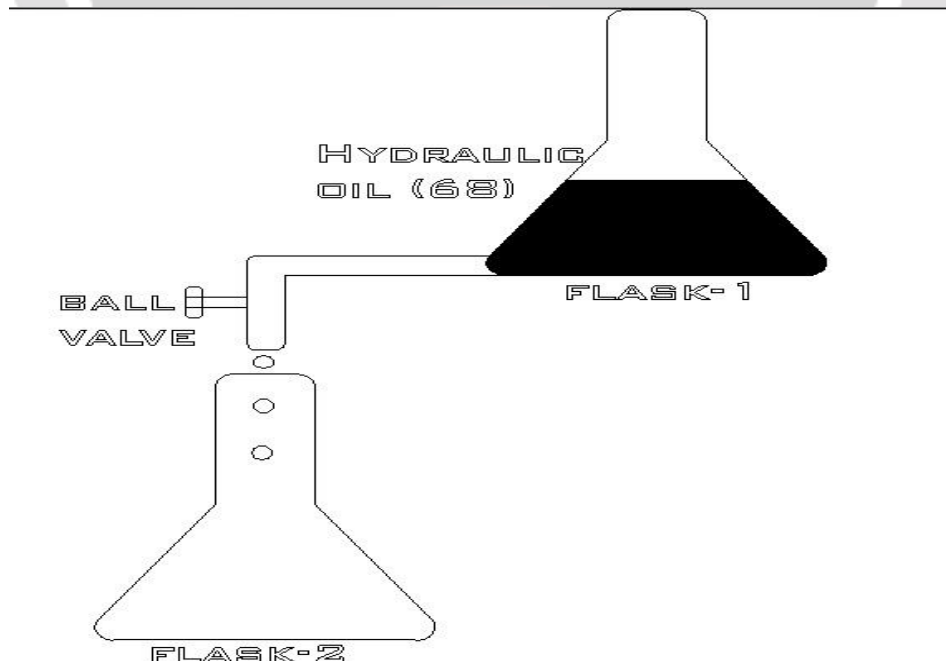
Practical set up for Base Fluid

Procedure :

In this practical set up taken two flask having same volume capacity. From these both flask one of the flask -1 is mounted with ball valve at bottom as shown in figure. Now, the procedure is follow set as per below.

(1) Fill Hydraulic oil (68) in the flask -1 having the ball valve , at this time ball valve is being closed

(2) Then start ball valve at fully open condition which drops the Hydraulic oil (68) in flask-2 at below.

(3) This way totally empty flask -2 is filled by flask-1 , at time we have noted perfect time duration.

(4) This time duration should be accurate for for passing oil from flask -1 to flask-2

(5) This whole procedure would be repeated for the our prepared base fluid.

(6) And family , both time duration for passing oil flsak-1 to flask-2 is noted and compared.

(7) The comparison of duration for passing fluid should be taken for all observation mention in the taguchi method.

(8) This comparison sheet for all observation with the duration of passing will be shown as per below.

For Hydraulic oil(68)

Observation	Time duration
1	3 sec
2	3 sec
3	3 sec
4	4 sec
5	3 sec
6	2 sec
7	4 sec
8	3 sec
9	2 sec

For Developed Base Fluid

Volume ratio	Particle size	Stirring RPM	Stirring Duration	Time Duration
a	2.5	1500	10	6
a	4.0	1700	12	10.3
a	6.0	2000	14	11.1

b	2.5	1500	10	9
b	4.0	1700	12	10.5
b	6.0	2000	14	11.9
c	2.5	1500	10	10
c	4.0	1700	12	11.3
c	6.0	2000	14	12.2

Experimental work For Suspension

As we discussed earlier, the developed MR fluid will be inspected the mechanical system which is pre-define TWO WHEELER SUSPENSION. Now, we will use that MR fluid in our prepared suspension practical demo set-up. Let's we understand first suspension practical demo. This demo is also concern with the damper vibration measurement.

Construction :

As we know the rudely available suspension in market are mono-tube suspension and twin-tube suspension with nitrogen gas. Whole construction of that mono-tube nitrogen suspension was modified for our aim to prove about the MR fluid effect on suspension system. The figure shown mono-tube nitrogen gas suspension. mono-tube nitrogen gas suspension having arrangement of cylinder , piston, piston rod, nitrogen booster and seal of cylinder as per shown in figure.
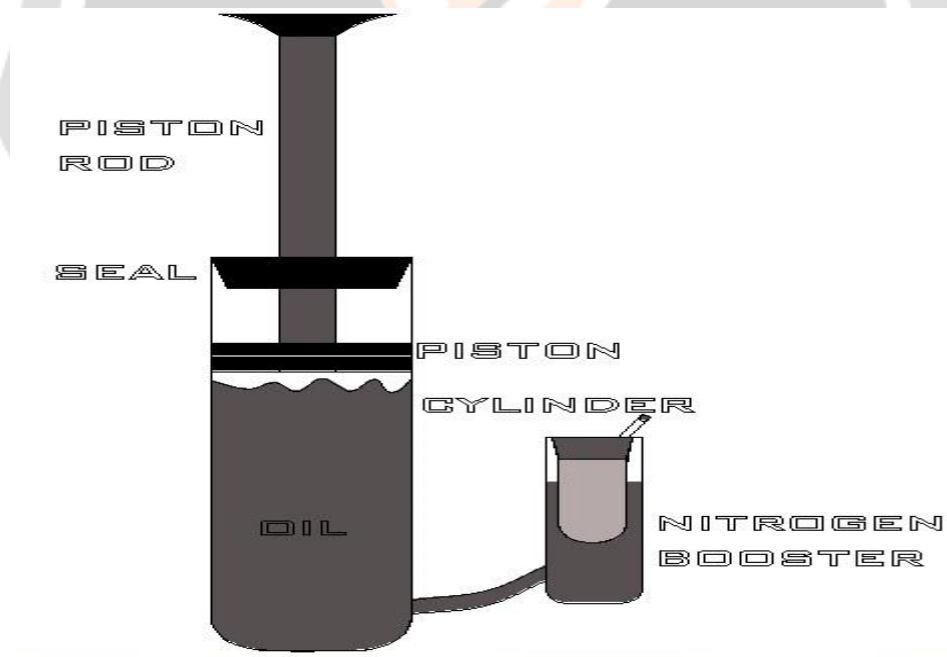
mono-tube nitrogen suspension

Working :

In this suspension dynamic load impact with vibration will affect on the piston rod. Which was push the piston downward in the cylinder, oil in the cylinder will sustain the impact of load as well as vibration. When load suddenally act in the piston oil in the cylinder moves in nitrogen booster. Nitrogen booster having important role which compress when fluid is loaded in booster and get expand after pressure of fluid removed mans load is removed.

4. Result and Discussion

observation

In the observation from all four fluid trial with it's options are derive in the table. There will be we take three options for motor RPM which give us the various torque. This different torque will be generated various load on piston. So , directly there was three observation for all four fluids and these are also do for 5 min and 10 min. So we can generated observation table as per below.

Observation table for Hydraulic Oil(68)

No. Of observation	Motor RPM	Time Duration (min)	Number of oscillation	Maximum Length of stroke (mm)	Minimum Length of stroke (mm)
01	500	3	20	15	4
02	1000	3	23	8	3.5
03	1500	3	28	5	2
04	500	5	31	14	5
05	1000	5	36	10	3.8
06	1500	5	39	6	2.6

Now we are changing the fluid from the suspension and fill out the MR fluid-1. and re-set-up whole practical set-up.

Observation table for MR fluid-1

No. Of observation	Motor RPM	Time Duration (min)	Number of oscillation	Maximum Length of stroke (mm)	Minimum Length of stroke (mm)
01	500	3	9	7	2
02	1000	3	13	6.3	2
03	1500	3	18	5.4	1.9
04	500	5	17	11	3.6
05	1000	5	22	9.2	3.2
06	1500	5	31	7.8	3.7

Now we are changing the fluid from the suspension and fill out the MR fluid-2. and re-set-up whole practical set-up.

Observation table for MR fluid-2

No. Of observation	Motor RPM	Time Duration (min)	Number of oscillation	Maximum Length of stroke (mm)	Minimum Length of stroke (mm)
01	500	3	10	7.5	2.6
02	1000	3	16	6.9	3
03	1500	3	20	6	3.8
04	500	5	18.5	13	5.1
05	1000	5	26	13.9	5.9
06	1500	5	32	10.2	6.4

Now we are changing the fluid from the suspension and fill out the MR fluid-3. and re-set-up whole practical set-up.

Observation table for MR fluid-3

No. Of observation	Motor RPM	Time Duration (min)	Number of oscillation	Maximum Length of stroke (mm)	Minimum Length of stroke (mm)
01	500	3	12	9	3
02	1000	3	16	8.5	3.5
03	1500	3	20	7	4.2
04	500	5	19	16	5
05	1000	5	29	14.6	6.8
06	1500	5	37	12.8	7.6

Results

In the all observation table , we can easily understand the all results are not being to derive because all entity shows the results are very known. Now , we discuss some important result from the observation tables.

Let's focused on the all tables for the compare with each others. In the focusing of all variables in the table are as below.

1) Fluid in the cylinder of suspension

2) Motor RPM

3) Time duration of Oscillation

4) Number of oscillation

5) Maximum length of stroke

6) Minimum length of stroke

These all parameter are responsible for the oscillation rate of the MR suspension. Now we are focused on these all parameter which lead us to some absolute results. We are settled very easy result method. Where just comparing all result of observation table we can take decision about the the effect on the MR suspension. This decision is not easy to explain but we have to ready for the showing comparable result in proper way. So in the table shown at below is compared all data achieve in the observation tables. So , follow the result of all table and generate some conclusion about the result to target goal.

Now , accroding to the observation tables , we have to compare about the oscillation. Where oscillation having small length of stroke and less number of oscillation   these one is better and where oscillation having long length of stroke and more number of oscillation is bad.

Number of oscillation in increasing Rank
Hydraulic oil(68)
MR fluid-3
MR fluid-2
MR fluid-1

Now, all having question what is the result I got and how it will connect with my target goal in the starting of the project. This goal is define in abstract. But this goal is actual achieve or not ??. for that question mark we go for new chapter is named conclusion.

5. Conclusion

This chapter is named as conclusion. What it means?. In my thinking of focus conclusion is the answer of your all promise done before you start your all project work. In other word when you targeted some goal in particular direction for the better prospects are achieved or not? . and achieved then how results achieved? , what was be the reference?.

Now, these all are the other matters. But, let's we focused in our project work. In the whole experimental work and analysis are describe in the earlier chapter. But, this chapter is properly explain the result In focus of the targets claim in the start of project. Let's clear about the perfect conclusion is the matching of analyze results to targeted abstract.

Now let's we compare the abstract defined goal and achieved analyze results. So, we discussed the abstract goal with analyze results in sequence forms.

(1) in the abstract, we targeted for the develop the fluid which having changing viscosity in the propersition of applied current of magnetic field. This thing is achieved in the result where MR suspension fluid is change it's viscosity with change of supply current as well as applied load.

(2) In the abstract , we targeted for the hydraulic mechanical application and braking system should be easy and comfortable. so, in the project work we will select the only two wheeler suspension. But, from the analyze results of oscillation of MR fluid loaded suspension are able to show it's capacity. In this way that's type all application would be solve for easiness as well as comfort.

(3) In the abstract, we try to do develop the ERMR fluid as well as prove it's performance for the particular Mechanical application. So in the result, we have done this both targets develop the MR fluid which can be also react as ER fluid. And develop MR suspension in the aspects of mechanical application.

(4) Not in the abstract but as per projects lead ago we also target for the prepare the demo or prototype of the MR fluid develop suspension. Which will be works in describe property with MR fluid. In the result we can easily got that we prepared MR suspension is working as per our targeted aspects.

(5) In the final conclusion of this done research is the try to achieve some mechanical application property. With help of this research done in this project work is making comfort for the suspension system

Advantage:

➢ By this research, mechanical aspect for the suspension , braking , hydraulic application and other automotive purpose will be being easy.

➢ This research will be lead us to the some chemical side development also in concern of electro-magneto effect.

➢ This research can be very much helpful in area of the vibration condition of all aspect.

Disadvantage :

➢ This development is complicated, costly with unavailable quantity as well as quality of material.

6. REFERENCE

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BOOKS

Electrorheological fluid and magnetorheological suspension

FIGURE

{1} from Wikipedia

{2} from Wikipedia

{3}from wikipedia