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# Response Analysis of Isotropic and Anisotropic Magnetorheological Elastomer

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***Abstract :***
*The purpose of this paper is to research the response of isotropic and anisotropic Magnetorheological Elastomer (MRE) with 15 and 30 percent of iron particles comprising in matrix of MRE with respect to transmissibility and percentage of vibration absorption. Fabrication and experimental investigation were carried out to study the response of MREs with respect to transmissibility and percentage of vibration absorption by using fast fourier transform (FFT). To ensure the validation of experimental result different readings were taken to compare characteristics in different loading conditions. Result obtained from the experimental analysis of samples of isotropic and anisotropic MREs with with 15 and 30 percent of iron particles were compared. Result show that best performance of vibration control and transmissibility were obtained with fabrication of anisotropic and isotropic MRE with 30 gm iron particle behind that anisotropic and isotropic MRE with 15 gm iron particle have good results of vibration control.*
***Keywords :*** *Smart material, Magnetorheological elastomer, Transmissibility, Vibration absorption.*

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## I. Introduction

Magneto Rheological Elastomers (MRE) have been the topic of extreme study throughout the previous hardly any decades. They show novel properties or are possible materials for the new-age devices. These elastomers are new engineering materials remembered for the class of dynamic objects. Its mechanical property can be limited by an exterior magnetic field[3]. They can be used in transduction and the other way around. These two significant properties of magneto rheological (MR) elastomers provide ascent to numerous possible purposes as actuators, transducers, automobile deferment systems, clutches, breaks, vibration isolators, and constraints. This is comparable to the conduct of an MR liquid system or an electro rheological (ER) system[1,2].

Another smart material, Magneto-rheological (MR) elastomer, guarantees an answer for conquering these difficulties by building up a versatile base isolator. magneto- rheological elastomer comprises of common or synthetic rubber matrix mix together by micron measured (ordinarily 10 to 15 microns) ferromagnetic particles[4,6]. Comparative as MRFs, MREs have a magnetic field-responsive shear module or moisture that can be limited by an attractive external field. below the attractive field, the material changes as of the rubber-like possessions into strong material. Following eliminating the magnetic field, it recovers its unique circumstances as a polymer. Outstandingly, this procedure is the moment, reversible or repeatable. Because of these highlights, Magneto Rheological Elastomers has gotten a lot of consideration regarding be utilized that include advancement of vibration isolators and vibration safeguards[8].

The formation of MRE explains that while a magnetic ground is functional the ferromagnetic atoms organize into chains corresponding to the magnetic field rows, sequences would be linked or part of framing chains.[7].

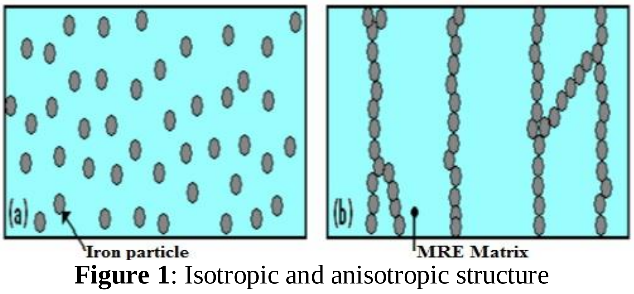


**Figure 1**: Isotropic and anisotropic structure

In given research work fabrication of isotropic and anisotropic MRE were carried out with 15 and 30 percent of iron particles and studied all fabricated samples with respect to transmissibility and percentage of vibration absorption by using fast fourier transform (FFT) analysis.

## II. Fabrication of Isotropic and Anisotropic MRE's

The anisotropic MRE is a kind of pre-structured magnetic elastomer. During the curing process, an external magnetic field is applied to the mixture of elastomer matrix and magnetic particles[9]. The isotropic MR elastomer is a kind of unstructured magnetic elastomers[10,12]. During the curing, No external magnetic field was applied on the mixture. MRE is a matrix of elastomer comprising ferromagnetic particles in it and cured in presence of magnetic field or absence of magnetic field depends on its type[13].
Elastomer used for MRE is Slygard 184 available in type A (liquid reagent) and type B (curing reagent).
Magnetic field were applied with the helped of permanent magnets at the time of curing process of anisotropic MREs. Curing time for all samples were set 48 hours.

**Table 1**: Fabrication of magneto-rheological elastomers

| Sample | SampleType | Samples | Content (by weight in gm.) | | | | | Total weight of sample | Total weight after curing |
|---|---|---|---|---|---|---|---|---|---|
| | | | Liquid Si Rubber | Curing agent | Si oil | Iron particle | Curing time in Hrs. | | |
| 1 | Isotropic MRE |  | 100 | 10 | 10 | 15 | 48 | 135 | 240 |
| 2 | Anisotropic MRE |  | | | | | | | |
| 3 | Isotropic MRE |  | 100 | 10 | 25 | 30 | 48 | 165 | 260 |
| 4 | Anisotropic MRE |  | | | | | | | |

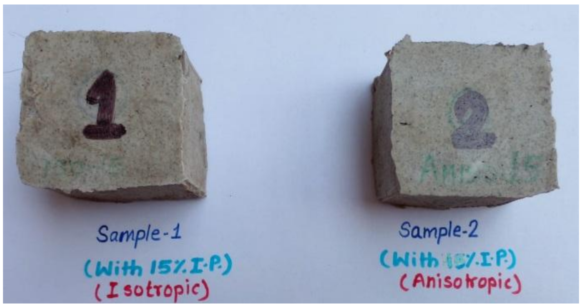


**Figure 2**: Sample 1 and 2

**Figure 3**: Sample 3 and 4

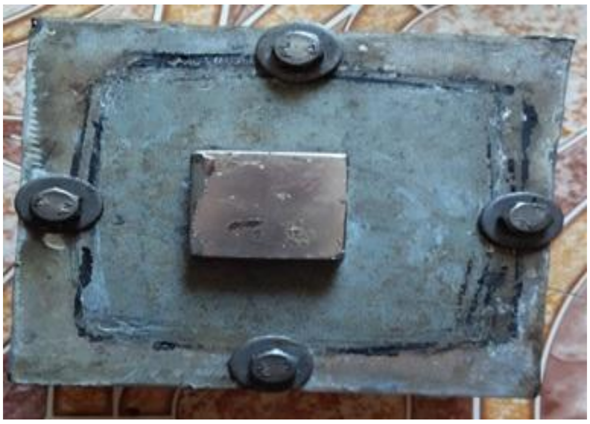


**Figure 4**: Curing of MRE under magnetic field.

## III. Experimental Set Up

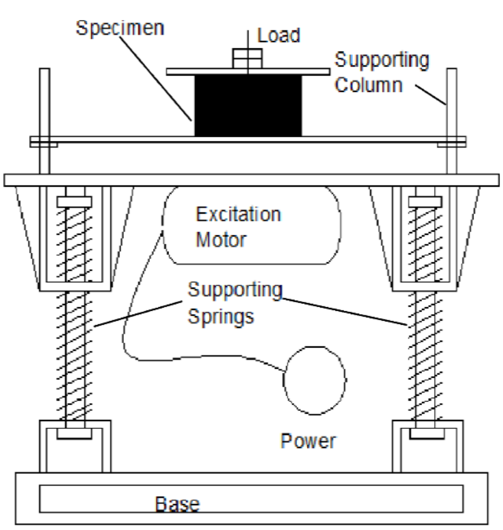



**Figure 5**: Experimental Set up


**Figure 6**: Actual Experimental Set up

### Construction and Testing

The experimental set up consist of portable dead channel FFT, vibration table, laptop and two accelerometers (one placed near or on the vibration exciter and other on top on mass pan). The MR elastomer was used in this study has 50×50×40 (lbh) mm in dimension. Also it requires fixture for testing containing two steel plates for resting the sample in between them by nut and bolt. For this, the test set-up used were shown in below figure 5 and 6.

Prior to the start of the experiment the whole set up were mounted on vibration table with connection of FFT and was ran for 10 min meant to get condition of resonance. The MR elastomer with connecting assembly was clamped to the vibration table shown in figure 5 and 6. The vibration table was actuated by FFT that converted the rotary motion of the motor shaft into linear to and fro motion.

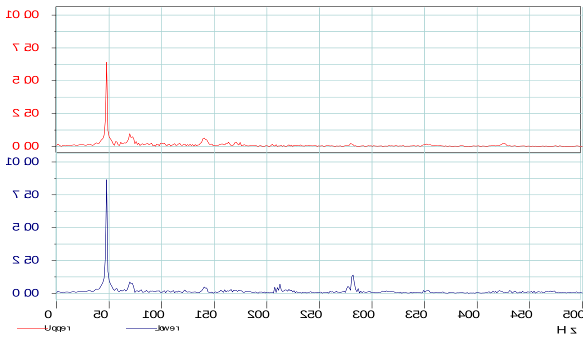
The elastomer was tested with zero load, 10N, 20N and 30N load. The force experienced in the MR elastomer and connecting assembly, were sensed by upper accelerometer fixed at the top of the set-up and lower accelerometer placed near or on the vibration exciter as shown in figure. The test was performed with all the samples of isotropic and anisotropic MRE with zero loads, 10N, 20N and 30N load respectively.

## IV. Result Table And Graphs

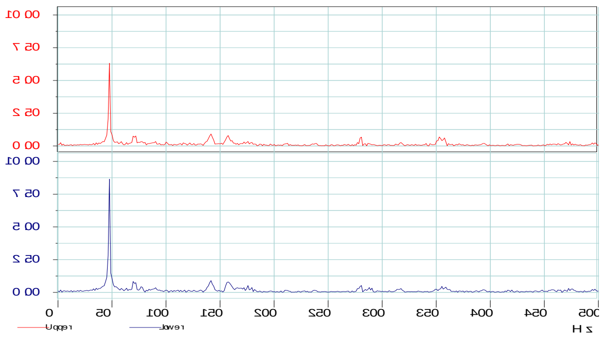
1) Sample No.1 (Natural Frequency – 48.3Hz)

**Table 2**: Result of sample no.1

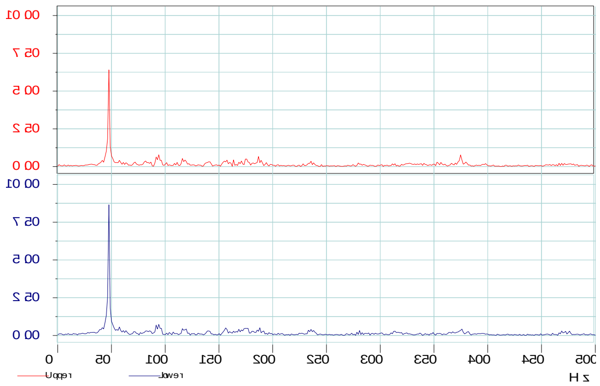
| Isotropic with 15gm Iron Particle | | | | |
|---|---|---|---|---|
| | Readings | | Transmissibility | Percentage |
| | Position | Amplitude | Ratio | % |
| **A** | No Load | | | |
| 1 | upper | 7.13 | 0.744 | 25.574 |
| 2 | lower | 9.58 | | |
| **B** | Load 10N | | | |
| 1 | upper | 6.89 | 0.731 | 26.935 |
| 2 | lower | 9.43 | | |
| **C** | Load 20N | | | |
| 1 | upper | 6.78 | 0.73 | 27.018 |
| 2 | lower | 9.29 | | |
| **D** | Load 30N | | | |
| 1 | upper | 6.28 | 0.724 | 27.566 |
| 2 | lower | 8.67 | | |



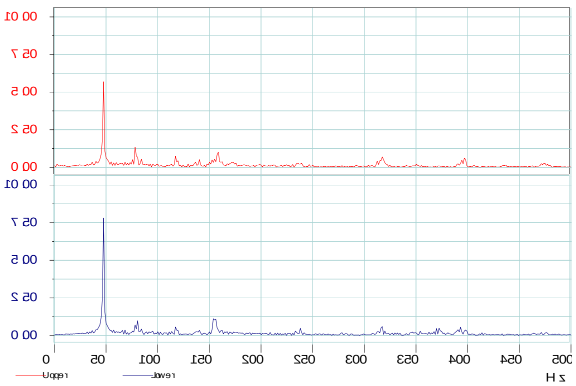
**Graph 1**:Sample no.1 with no load cond.(A)



**Graph 2**:Sample no.1 with 10 N load cond.(B)



**Graph 3**:Sample no.1 with 20 N load cond.(C)

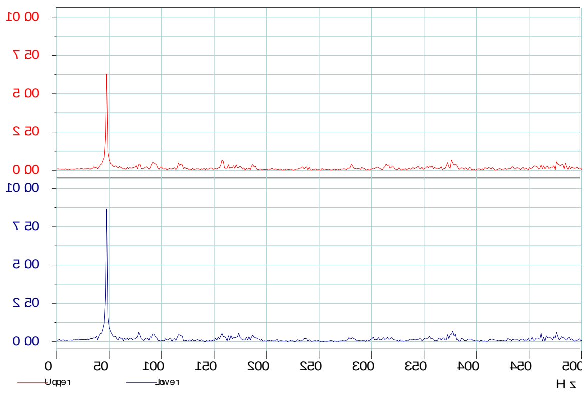


**Graph 4**:Sample no.1 with 30 N load cond.(D)

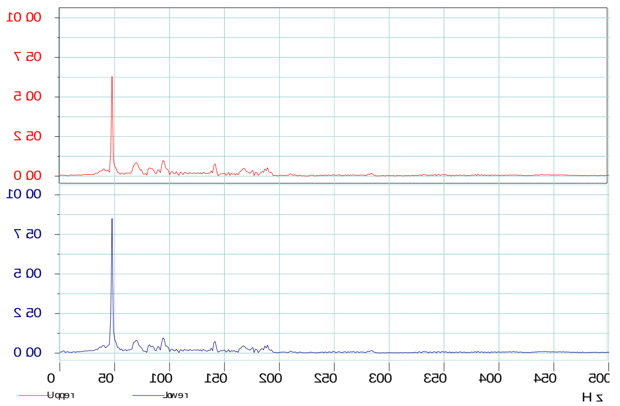
2) Sample No. 2 (Natural Frequency – 48.3Hz)

**Table 3**: Result of sample no. 2

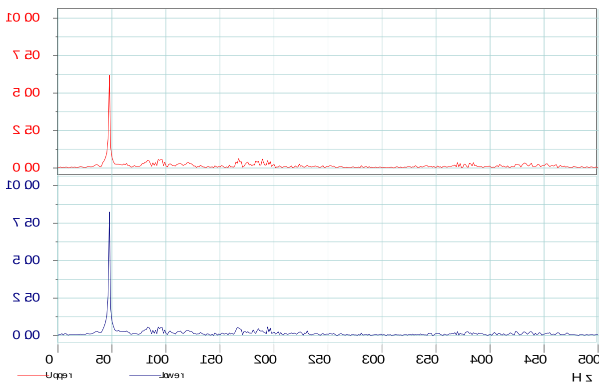
| Anisotropic with 15gm Iron Particle | | | | |
|---|---|---|---|---|
| | Readings | | Transmissibility | Percentage |
| | Position | Amplitude | Ratio | % |
| **A** | No Load | | | |
| 1 | upper | 6.91 | 0.723 | 27.110 |
| 2 | lower | 9.48 | | |
| **B** | Load 10N | | | |
| 1 | upper | 6.89 | 0.731 | 26.858 |
| 2 | lower | 9.42 | | |
| **C** | Load 20N | | | |
| 1 | upper | 6.66 | 0.739 | 26.082 |
| 2 | lower | 9.01 | | |
| **D** | Load 30N | | | |
| 1 | upper | 6.01 | 0.74 | 25.985 |
| 2 | lower | 8.12 | | |



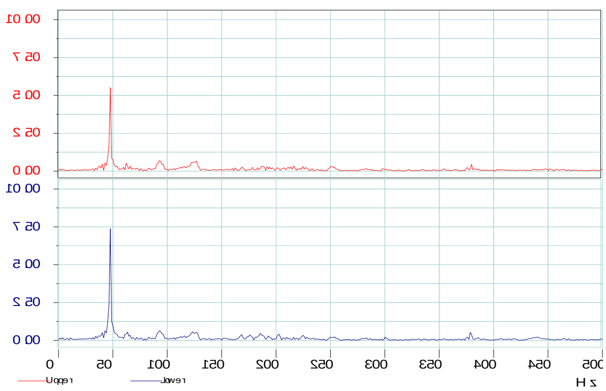
**Graph 5:**Sample no.2 with no load cond.(A)



**Graph 6**:Sample no.2 with 10 N load cond.(B)



**Graph 7:**Sample no.2 with 20 N load cond.(C)

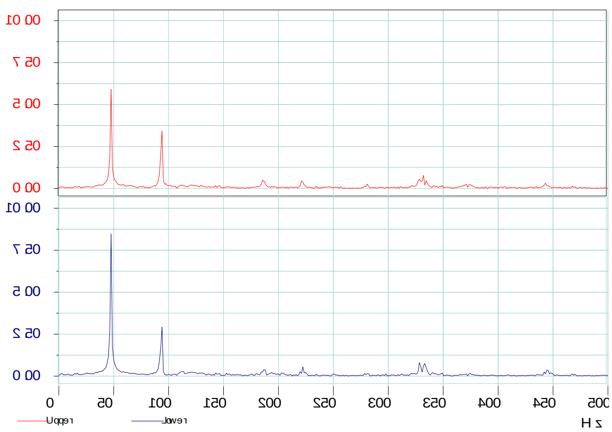


**Graph 8**:Sample no.2 with 30 N load cond.(D)

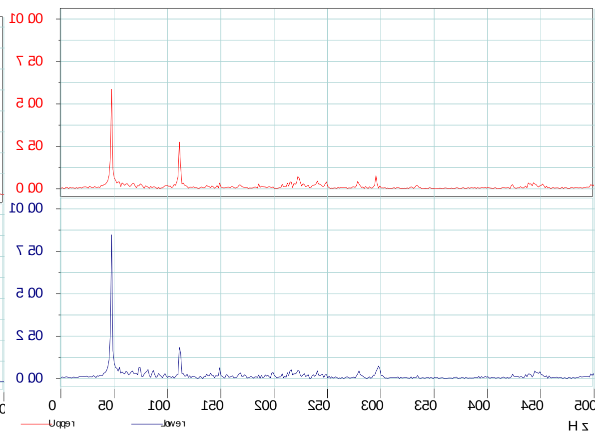
3) Sample No.3 (Natural Frequency – 48.3Hz)

**Table 4:** Result of sample no. 3

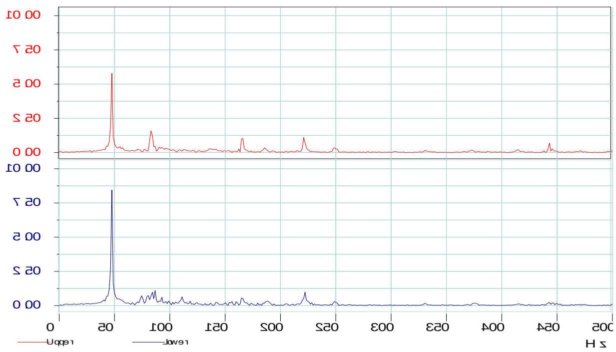
| **Isotropic with 30gm Iron Particle** | | | | |
|---|---|---|---|---|
| | Readings | | Transmissibility | Percentage |
| | Position | Amplitude | Ratio | % |
| **A** | No Load | | | |
| 1 | upper | 6.48 | 0.653 | 29.489 |
| 2 | lower | 9.19 | | |
| **B** | Load 10N | | | |
| 1 | upper | 6.41 | 0.69 | 30.927 |
| 2 | lower | 9.28 | | |
| **C** | Load 20N | | | |
| 1 | upper | 6.39 | 0.686 | 31.364 |
| 2 | lower | 9.31 | | |
| **D** | Load 30N | | | |
| 1 | upper | 6.32 | 0.674 | 32.623 |
| 2 | lower | 9.38 | | |



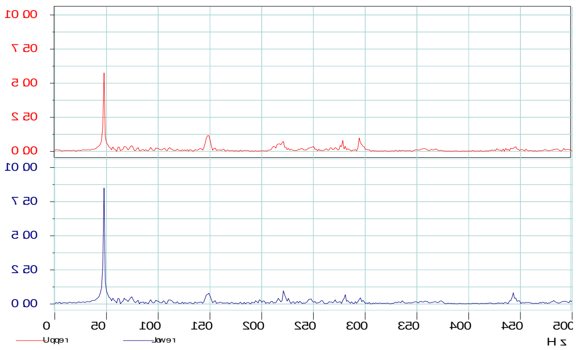
**Graph 9**:Sample no.3 with no load cond.(A)



**Graph 10**:Sample no.3 with 10 N load cond.(B)



**Graph 11**:Sample no.3 with 20 N load cond.(C)

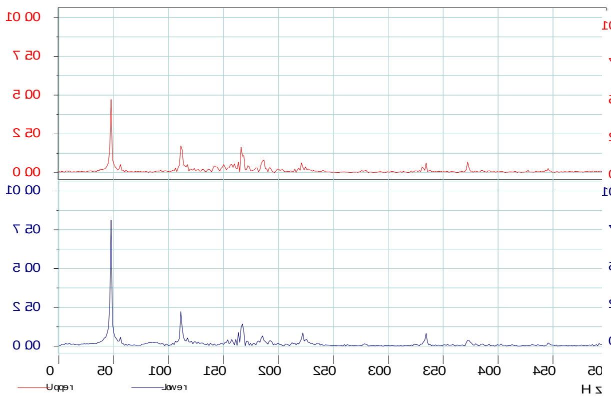


**Graph 12:**Sample no.3 with 30 N load cond.(D)

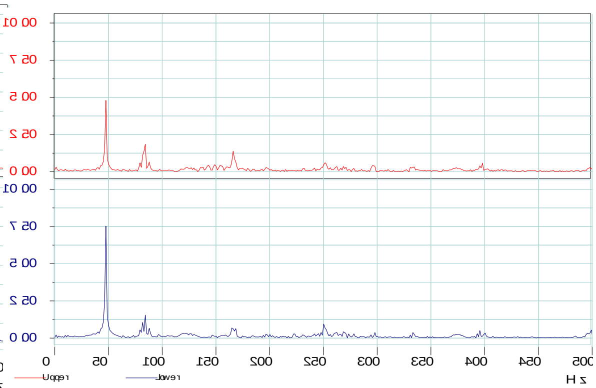
4) Sample No.4 (Natural Frequency – 48.3Hz)

**Table 5:** Result of sample no. 4

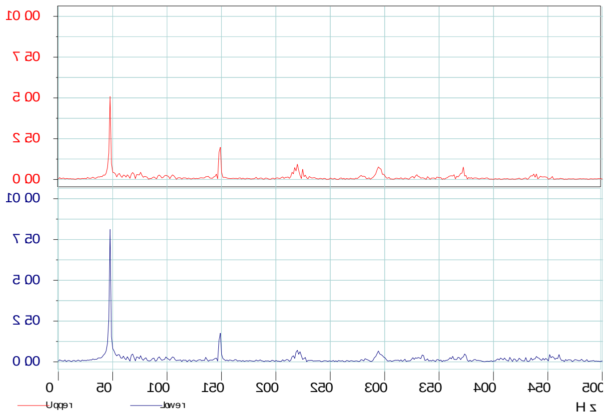
| Anisotropic with 30gm Iron Particle | | | | |
|---|---|---|---|---|
| | Readings | | Transmissibility | Percentage |
| | Position | Amplitude | Ratio(Lower/Upper) | % |
| **A** | No Load | | | |
| 1 | upper | 5.26 | 0.581 | 41.943 |
| 2 | lower | 9.06 | | |
| **B** | Load 10N | | | |
| 1 | upper | 5.12 | 0.614 | 38.609 |
| 2 | lower | 8.34 | | |
| **C** | Load 20N | | | |
| 1 | upper | 5.55 | 0.622 | 37.780 |
| 2 | lower | 8.92 | | |
| **D** | Load 30N | | | |
| 1 | upper | 5.57 | 0.634 | 36.633 |
| 2 | lower | 8.79 | | |



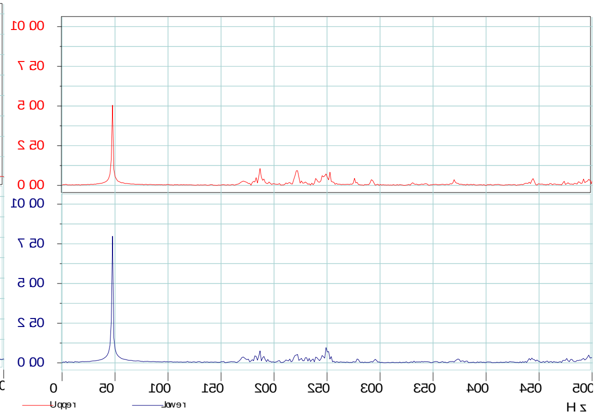
**Graph 13**:Sample no.4 with no load cond.(A)



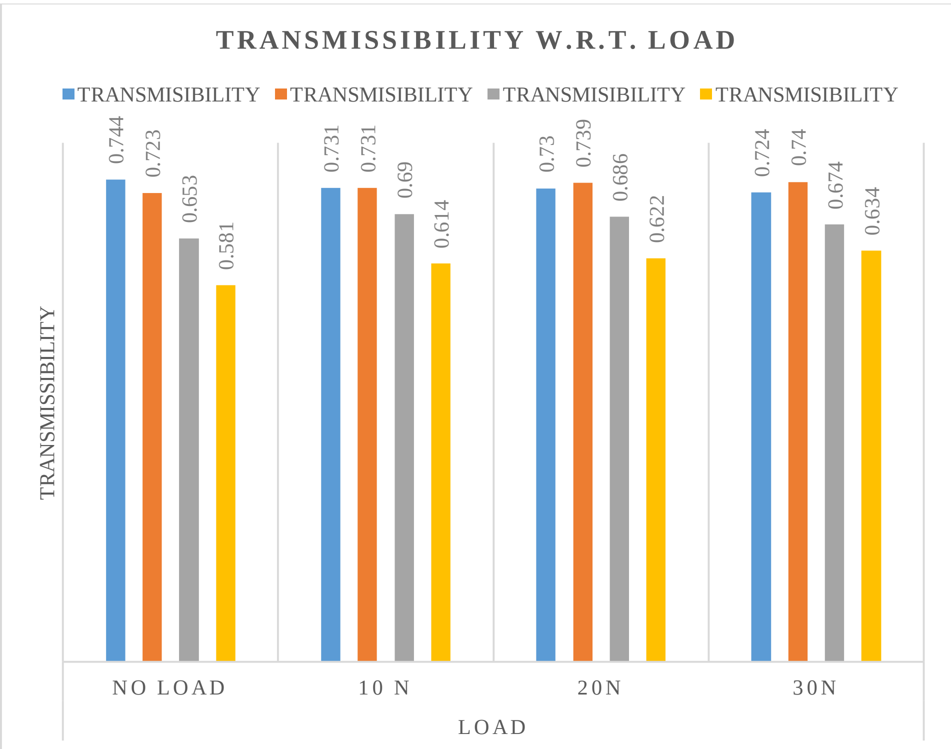
**Graph 14**:Sample no.4 with 10 N load cond.(B)



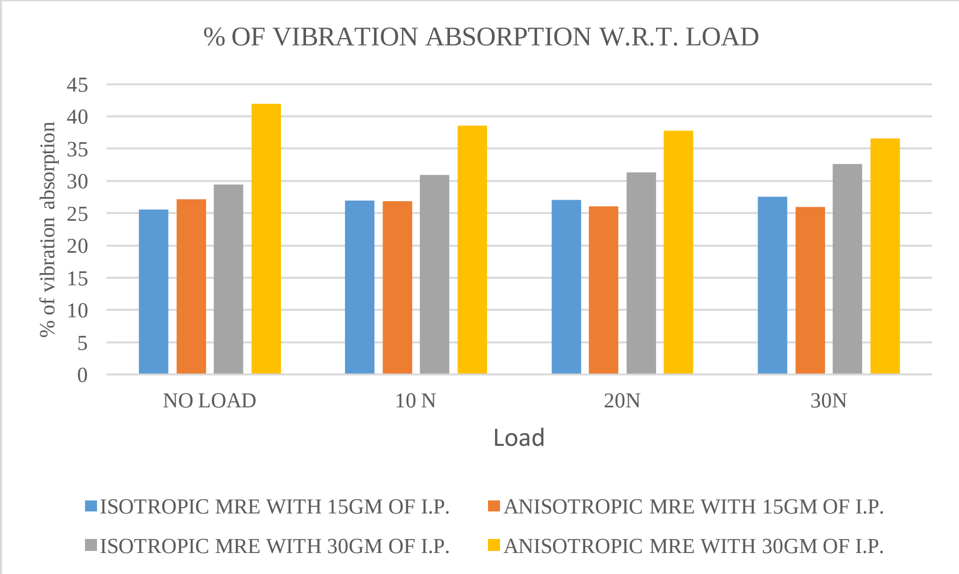
**Graph 15**:Sample no.4 with 20 N load cond.(C)



**Graph 16**:Sample no.4 with 30 N load cond.(D)




**Graph 17**: Transmissibility against Load with constant frequancy




**Graph 18:** Percentage of Vibration Absorption against Load with constant frequancy

As seen from different graphs anisotropic MRE with 30gm of iron particle shown good percentage of vibration absorption as well as good transmissibility characteristics. At no load condition it shown 41.943 percentage of vibration absorption with 0.581 transmissibility which would shown the better performance of that sample among rest of samples.

## V. Conclusion

As when the MR elastomer were tested without magnetic field under zero load, 10N load, 20N load and 30N load respectively reduced the amplitude of vibration at same frequency also transmissibility and percentage of vibration absorption increases with increases the load. And as when the MR damper were tested with magnetic field under zero load, 10N load, 20N load and 30N load respectively transmissibility and percentage of vibration absorption decreases with increases the load.

The best results of percentage of vibration control were obtained with fabrication of anisotropic and isotropic MRE with 30 gm iron particle behind that anisotropic and isotropic MRE with 15 gm iron particle had good results of vibration control. It observed that when we increases the percentages of iron particle in same MRE sample from normal limit transmissibility and percentage of vibration absorption decreases.

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