CHAPTER 8

CONCLUSION AND FUTURE PROSPECTS

Research is perennial in nature and no work is cent percent perfect, though nature is an embodiment of perfection. She does not bestow that attribute to her worshippers. This piece of investigation is not above that rule. So there exists room for improvement and perfection. This is what gives rise to removal of obsolescence in technological jargons and in scientific terms it is called the ‘constant endeavor’ to change, improvise and innovate. As the old saying goes it is this ‘constant’ which is called ‘change’ which drives research, innovation and lead to incremental science.

The field of magnetorheological elastomers is nascent and is constantly updated by researchers on a day to day basis. They are the solid state analogues of the much familiar rheological fluid which are in vogue for many engineering applications including automobile, aerospace and biomedical.

However, the main drawback of rheological fluids is that they are to be contained safely in a container and this limits its applications. Though, as a substitute, electrorheological materials came up, they lost their sheen because of the necessity to apply a large electric field as an external stimuli. These lacunae caught the imagination of scientists and engineers and people started thinking of a soft material which can be manipulated by a noncontact external stimulus. This eventually evolved in to magnetorheological elastomers. This piece of work is also to be seen as another attempt in fabricating magnetorheological elastomers under the influence of an external magnetic field during curing/moulding.

The primary task in the first phase of this thesis was to design and fabricate instrumentation and other accessories. This particular task was accomplished with near perfection. Setups for moulding MRE sheets and rods were fabricated in house.
Two separate setups were made for providing a field parallel to the plane of the sheet/rod and perpendicular to the plane of the sheet.

A fully automated system for the measurement of magnetostriction was made based on the principle of Laser Doppler Vibrometry. Power amplifiers and solenoid assemblies were specially designed and made for this. A cell for evaluating the magnetocapacitance of MREs with provision for applying an external magnetic field was also designed and fabricated which was integrated to an LCR meter for automatic data acquisition system.

In the second phase, MREs (both rods and sheets) were made by incorporating Iron and Carbonyl Iron fillers in different weight percentages in a matrix of Natural Rubber. The quality of rods and sheets are almost factory made grade. This process of moulding can be scaled up for mass production.

The evaluation of microactuation of these MREs revealed that MREs based on Natural Rubber and Iron exhibited enhanced actuation and the results were explained based on stiffness and morphology. Comparable results were obtained for MREs based on Carbonyl Iron and Natural Rubber.

The evaluation of mechanical properties of MRE sheets and rods were also conducted and the findings are encouraging. Loading always enhanced the mechanical properties. Stiffness, which is a very important parameter in the performance of an MRE determines the vibration absorbing property of a device, is found to be decreasing on field cured rod/sheet samples. The application of a magnetic field modifies parameters like storage modulus, loss modulus, loss factor (tanδ), Young’s modulus, stiffness, and resonant frequency.

The magneto dielectric properties of MREs were evaluated and the results are quite promising. The dielectric constant of MRE cured under the application of a field
perpendicular to the plane of the sheet was found to be the maximum. Loading always improved the magnetic as well as the magneto dielectric properties of these MREs.

Huge scope exists for improvement. The explanation provided for the modified mechanical properties of MREs is quite tentative and requires further studies to fit the results based on a mathematical model. The interaction process taking place between the polymer and an aligned filler is quite complex and demands a separate investigation. It is a good idea to link morphology with the properties of field cured MREs.

As far as tensile and hardness of MREs are concerned, scope exists to make MREs with reinforcing fillers like carbon black or carbon nano tubes. It is known that carbon black and carbon nano tubes reinforce the mechanical properties of elastomers substantially. The advantage of using carbon nano tubes is that the loading percentage need not be very high to achieve superlative strengths. This is a futuristic proposition.

An altogether different matrix like silicone rubber can be a replacement for Natural Rubber. In the event of employing Silicone Rubber a transparent MRE can be realized by incorporating small amounts of hard magnetic materials like TERFENOL-D or Samarium Cobalt.

The prospects of a transparent MRE which can be externally manipulated by light as well as a magnetic field are quite bright as far as applications are concerned. From an application point of view an active vibration control can be designed with an MRE having the required mechanical and magnetic properties. A force sensor can also be designed and demonstrated.

The magneto dielectric measurements carried out on MRE sheets are quite promising in the sense that they exhibit low loss as well as reasonable dielectric constant. However, as of now, no idea about the dielectric breakdown is available. An
earthquake resistant device could be made with these MREs which can be active and self-controllable. The design of such a system needs modeling based on finite element analysis and is earmarked for the future. Altogether the results are encouraging and have opened up further avenues for future research.