ABSTRACT

Ever since the discovery of magnetorheological (MR) effect, the interest towards its use in many applications kept on increasing at a faster rate. The applications of MR fluids have grown rapidly in civil engineering, safety engineering, transportation and life science with the development of magnetorheological fluid–based devices. MR fluid comprises of a carrier oil, magnetic suspension and an additive. The viscosity of this composition varies from free flow to quasi-solid state when subjected to an external magnetic field. Magneto-rheological (MR) devices can exhibit rapid response characteristics and can be controlled effectively by a magnetic field and with minimum power requirement. This research work is aimed to utilize the behavioural nature of MR fluid.

The present work characterized biodegradable oils, namely honge oil, mustard oil, jatropha oil and castor oil as a carrier fluid with Carbonyl Iron Particles (CIP) as suspension particles and grease as additive. Static and dynamic tests were conducted on it to select a suitable oil for further application. Research so far have shown excitation displacement, velocity and current to be the primary factors affecting the behaviour of MR damper. However, MR dampers can experience large variation in temperature due to self-heating of the damper, heat addition to the MR damper as a result of increase in temperature of the working environment and heat addition by the magnetic coil. The change in the temperature may result in decay in fluid viscosity and thus a decrease in the post-yield damping of the damper. The carrier fluid selected should undergo the prescribed tests at elevated temperatures. Tests revealed that with increase in temperature, the off-state viscosity and sedimentation rate become poorer. This means loss in

yield strength of MR fluid. Dynamic test was conducted using a vibration shaker on the fabricated test setup. Impact load test was done using a drop impact test machine. Dynamic tests revealed that honge oil performed well compared to other oils in terms of amplitude transmissibility at room as well as at elevated temperatures.

A bio-degradable MR (BMR) fluid filled in the tool post for conventional lathe was designed and fabricated to absorb the vibration during machining to minimize chatter. Design of MR fluid filled tool post to control vibration should reduce the magnitude of dominant mode of frequency response function (FRF) for the conventional lathe. The fabrication of proposed tool-post (PTP) and electromagnet were analyzed and validated using and were using a 2-D axi-symmetric finite element model. Graph of current-shear stress, viscosity-shear stress and force-velocity were obtained for the applied current for each sample fluid and the magnetic flux density (B) values obtained from the finite element numeric electromagnetic analysis. Work revealed that PTP was more robust to uncertainties in damping and input dynamic parameters in comparison with conventional tool post (CTP). The damping characteristic of machine tool was improved by increasing the dynamic stiffness, through the plots of stability lobe diagram (SLD) for dominant mode of machine tool. It showed that PTP increased the chatter free depth of cut.

By using Taguchi L9 orthogonal array, to minimize the number of experiments and conduct the experiments with three times repeatability for improving the accuracy of results and compare the results of surface finish of work-pieces by using surface measurement instrument. The proposed design of BMR fluid filled tool-post is experimentally illustrated to increase chatter free depth of cuts when compared with the conventional lathes with existing tool post. Proposed tool-post when compared with existing conventional tool-

post, the damping ratio of machine tool is increased by 23% and chatter free depth of cut was also increased from 0.85 to 1.35 mm. Experiments were conducted to study the influence of cutting parameters by using analysis of variance (ANOVA). Results showed that minimum surface roughness can be achieved by selecting relatively higher values of speed (>800 rpm), higher values of depth of cut (0.9 mm), and relatively lower values of feed rate (<0.25 mm/rev). Full factorial design analysis showed improved predictability of surface roughness than Taguchi L9 design. Using the PTP, increased MRR with enhanced surface finish was achieved. An ECS interface with PTP, this BMR fluid device possibly delivers a smart system at lower cost.

MR damper and test setup were fabricated to conduct experiments to study impact and dynamic response of the damper and also to simulate whole body vibration (WBV) in a vehicular seat. Whole body vibration in operational vehicles can cause serious musculoskeletal disorders for the occupants. A semi-active control device using a bio-degradable MR fluid was developed. The controller synthesis was realized in two stages: (1) attenuation of continuous vibration; and (2) suppression of end-stop impacts, as these are the two main types of loads acting on a vehicle.

An electronic control system (ECS) was designed for the precise working of the MR damper when fitted on an automobile. The system consisted of two sensors, an ultrasonic range finder and an optical encoder to capture the speed and road undulations, an Arduino Uno micro controller to process the acquired signals and a relay circuit to deliver the current to the damper. It was found that the ECS functioned correctly and can be interfaced with BMR device with lesser difficulty.

Based on the studies carried out, it can be concluded that use of biodegradable oil (honge) as carrier fluid for industrial applications which experiences higher vibrations and requires quicker control is feasible, safe, costs less and environment friendly.