ABSTRACT

Conventionally, cast iron is the material used in machine tool structures, due to its excellent mechanical and thermal characteristics in the class of metallic materials. However, it is observed that, these structures are subjected to self excited vibrations known as chattering, during machining operations. This causes positional error between the tool and the work piece, affecting the accuracy of machine tool. Hence, a study of alternate materials that can improve the damping characteristics of the structure is significant.

The main objective of the present research work is to study the use of epoxy granite as an alternate material for cast iron structures. Test specimens using epoxy resin and granite aggregate were fabricated. Mechanical and thermal characteristics of these test specimens were studied by varying the resin content in the mixture.

From the studies on test specimens a mixture with better characteristics was arrived at. With this combination of epoxy resin and granite, a lathe bed having equal stiffness as that of cast iron micro lathe bed was fabricated. The dynamic characteristics, dimensional stability, surface roughness and wear characteristics of the fabricated epoxy granite lathe bed were studied.
The commercially defined granite used as aggregate in this study is a mixture of three different sizes classified into, a) Coarse particles: granite particle size ranging between 1.4-2.38 mm, b) Medium particles: particle size between 0.5-1.4 mm and c) Fine particles: powdered granite particles with size less than 0.5 mm. The three different sizes of aggregate material were taken in the ratio 50:25:25, respectively. A resin mixture with 12% by weight of epoxy resin (LY 556) and 1% by weight of resin mixture as hardener (HY 951) was used as the binder material.

The tensile and the compressive test specimens were prepared using mineral casting techniques. To arrive at a better composition of the mixture, the test specimens were prepared by varying the resin content between 10% and 18%. Five specimens with the percentage epoxy resin varying in steps of 2% were selected for analysis. Three specimens were prepared from each category and the average value of the test results was taken for analysis. The Young’s modulus for the test specimens with varying epoxy content was obtained from the stress-strain curves plotted during the tensile test.

Analysing the mechanical characteristics, obtained experimentally and from Scanning Electron Microscope (SEM) analysis, it was observed that the composition with 88% aggregate mixture and 12% resin mixture gives better tensile strength (15.9 MPa), Young’s Modulus (33 GPa) and compressive strength (114.35 MPa).
Effective thermal conductivity for the material was determined using Transient Plane Source (TPS) techniques. It was observed that the effective thermal conductivity decreases with an increase in epoxy resin content in the mixture. The effective thermal conductivity for the mineral cast epoxy granite material was found to vary in the range of 2-3 W/mK.

An epoxy granite lathe bed having bending stiffness equal to that of the cast iron micro-lathe bed was fabricated using a resin mixture containing 12% by weight of epoxy resin and 1% by weight of resin used as hardener and 88% of aggregate mixture consisting of coarse, medium and fine particles taken in the ratio 50:25:25. The guide way was fabricated with fine particles of size less than 0.5 mm, to obtain a good surface finish, so as to permit the dynamic components such as tail stock, tool carriage etc., to slide over it.

FEM analysis was carried out to study the deflection characteristics of the lathe bed, to evaluate the constant stiffness characteristics. Modal analysis was conducted to determine the natural frequencies and the mode shapes corresponding to the first four natural frequencies. The natural frequencies obtained through FEM analysis were tested by conducting experimental modal analysis on fabricated epoxy granite lathe bed.

It was observed that the damping ratio for epoxy granite bed was 2.28 times higher compared to cast iron bed. The weight of the epoxy
granite bed was found to be 27.1% lesser than cast iron bed. The material cost for epoxy granite was found to be 29% higher than that of cast iron.

From the dimensional stability tests conducted, a gain in weight of 0.1% and 0.18% were observed from oil and water immersion tests respectively and no dimensional changes were observed.

Wear test was conducted under dry and wet conditions using pin on disc arrangement. Tests were carried out using cast iron and steel discs and epoxy granite pin. It was observed that the coefficient of friction for the epoxy granite material is comparable with that of the cast iron structures in wet conditions. Also, the coefficient of friction between epoxy granite and cast iron was found to be lesser compared to that of epoxy granite and steel. The low coefficient of friction between epoxy granite and cast iron is an added advantage for machine tool structures with epoxy granite bases and movable cast iron components such as tool carriage, tail stock etc.

Within the scope of the study, it was observed that epoxy granite is a suitable alternate material for machine tool structures.