CHAPTER 1

INTRODUCTION

More and more manufacturing establishments engaged in batch production of industrial metal components are resorting to the use of CNC machine tools because of the technical and economic advantages offered by these over conventional machine tools. This trend has led to the large scale replacement of existing machine tools with CNC ones. Naturally, a growing demand for these machines is being witnessed and hence there is a need for producing better quality CNC machine tools to cater to this continuously growing demand.

1.1 NEW DESIGN CONCEPTS IN MACHINE TOOLS FOR CNC OPERATION

The quality of a CNC machine tool is largely determined by the accuracy and repeatability of positioning of slides obtained in the machine. This means that the machine tool should be capable of producing components with consistent dimensions, shape and surface quality repeatedly.

Design requirements of CNC machine tools are therefore quite different from conventional machine tools due to a number of reasons listed below:

i) Need for reduction of friction in axes feed drive to improve dynamic response

ii) Necessity for trouble-free operation at high speeds and feeds

iii) Necessity to ensure high dynamic stiffness to reduce vibration levels and high reliability for unmanned operations

iv) Reduction in wear

v) Elimination of stick-slip
The above factors make the design and manufacture of CNC machine tools quite different from that of conventional machine tools in many aspects.

The areas where new design concepts have been incorporated are:

- Slideways
- Lead screw
- Structure
- Drive system
- Control system
- Accessories like tool turret, ATC, APC, Gantry loading devices, tool programme, tool eye etc.

1.2 NEED FOR QUANTITATIVE PERFORMANCE ASSESSMENT

Adequate published data are not available for use by designers to incorporate many of the design features currently incorporated in CNC machine tools, particularly where patented products are used.

A need is thus perceived to quantify the benefits of incorporating these changes in the design of CNC machine tools so as to develop data required to enable the designers to produce better quality CNC machine.

1.3 AREAS CHOSEN

Of the areas mentioned in Section 1.1 where new design concepts have been introduced, slideways and structures may be considered to be relatively more significant in contributing to the dynamic performance of the machine tool and hence they are chosen for the present investigation.

1.4 DEFINITION OF THE PROBLEM

Several unconventional design techniques have been adopted by
designers to overcome many of the problems related to the dynamic performance of machine tools. These include the use of:

i) Plastic inserts in slideways

ii) Epoxy concrete for the structure of machine tools

As mentioned earlier, the non-availability of adequate analytical and experimental data has forced the designers to adopt heuristic approach to design or make them to depend on the recommendations of the manufacturers of the patented products which are used. The present study is, therefore, motivated by the need to quantify the performance of machine tools which incorporate these new design features so that guidelines for future designers can be evolved.

1.4.1 Scope of Work

The undesirable stick-slip motion can be reduced by the introduction of plastic materials in plain slideways. Both thermo-plastics and thermosetting plastics may be used. Many such plastic material have been developed and are available commercially with different trade names. For example,

i) Teflon* and Turcite-B** as inserts for slideways

ii) Thermo-setting resins (for slideway inserts) like: Diamant Moglice*** and SKC-3****.

* Teflon is a registered trade mark for the DUPONT fluorcarbon resins polytetrafluoroethylene.

** Turcite B is a registered trade mark of W.S. Shamban & Company for PTFE compounded with other additives.

*** Diamant Moglice is a registered trade mark for 2-component plastic material based on epoxy resin incorporating high grade fillers.

**** SKC-3 is a registered trade mark for another 2-component plastic material based on epoxy resin incorporating high grade fillers.
1.4.2 Significance of Vibration

Considerable work on friction and wear characteristics of these materials have already been reported elsewhere [1,2,3,4,5,6] and are discussed in Chapter 3. However, very little work has been done on the vibration response of machine tool slideways fitted with these plastic materials. A major part of the present work is therefore devoted to the experimental investigations to determine the response and damping of slideways of plastic inserts as well as epoxy resins.

Another area of application of epoxy material is in the manufacture of epoxy concrete which is used as a material for the structures of high precision machine tools. It is a mixture of about 93% crushed granite and the rest epoxy binder. Several machine tool manufacturers like FRITZ STUDER AG, EMAG, Hembrug etc. have introduced epoxy concrete beds for machine tools because of their exceptional vibration damping characteristics with high rigidity to weight ratios, thermal stability and environmental resistance.

Some investigations regarding the dynamic behaviour, and thermal deformation of epoxy concrete beds have already been reported [7,8] and discussed in Chapter 3. However, it is felt that, the quantitative information needed for the design of such structures are not adequate. Hence, a part of this thesis work deals with the comparison of dynamic response of cast iron and epoxy concrete beds, to evaluate different design approaches.

1.4.3 Outline of Investigations

Thus the present investigation is aimed at:
a) a study of response characteristics of anti-friction guideways and guideways with plastic inserts under non-sliding condition.

b) a study of response of plain slideways with cast iron to cast iron, cast iron to steel, cast iron to Turcite-B, cast iron to Teflon, cast iron to SKC-3 and cast iron to Moglice slide pairs under non-sliding condition.

c) a study of response of thermo-plastic and thermo-setting resin inserts for slideways of machine tools under sliding conditions.

d) a study of the effect of thickness of plastic inserts on the steady state normal vibration amplitudes.

e) a comparative study of vibration behaviour of epoxy concrete and cast iron beds for machine tools.

The results of this investigation show that:

1) the guideway with the plastic insert Turcite-B is better than the guideway with the rolling friction elements with regard to resistance to vibration.

2) the plastic inserts SKC-3, Diamant Moglice, Turcite-B and Teflon have excellent damping characteristics than steel and cast iron.

3) the vibration response is independent of the sliding velocities.

4) plastic inserts of 1.5 mm thickness is optimum for better dynamic performance.

5) epoxy concrete bed designed on equal weight approach will result in a structure with superior damping than cast iron bed.

The results of this experimental investigation will be useful towards establishing data for the selection, design and application of plastics and epoxy concrete for CNC machine tools.