ABSTRACT

The high-volatility in the present market scenario is impacting upon all manufacturing industries including engineering. This is due to globalization and urge for responding to manufacturing agility. Further, responding quickly by manufacturers in time is not only the requirement but also cost effectiveness is the need of the hour. One such impact is also on metal cutting machine tool market that has put the machine tool manufacturers across globe to manufacture more flexible machines at competitive price. The flexibility required is in terms of performance over a wide range of cutting parameters with close tolerance of components being produced. High-speed machine tool is one of the basic needs in high-speed machining that caters to above said manufacturing flexibility.

As the urge for high-speed machines is increasing, on the contrary manufacturers are posed with several challenges associated with machine tool accuracy. This is due to the fact that, the inaccuracy of machine tools themselves is a major contributor to work piece errors. Machine tool errors can be categorized into two main streams namely quasi-static or time independent errors and dynamic or time dependent errors. Out of these two, quasi-static errors are difficult to predict as well to control. In quasi-static type, thermal deformation due to thermal errors is the prime factor that influences accuracy level of component and is directly proportional to the spindle speed as well as machine table feed rate. Thermal deformation comprises more than 50% of distortions for kinematically well-aligned machines.

Most of the research outcomes as on date for thermal error compensation are not been adopted and accepted by the machine tool manufacturers. It was observed through the survey among Indian machine tool manufacturers that, there was a potential for exploring in thermal errors area for understanding as well as implanting of the same.

In order to fulfil the requirements of machine tool manufacturers with respect to the designing and manufacturing of Vertical Machining Center (VMC), the following contributions were made by carrying out the doctoral work presented in this thesis.

i. Predicting the thermal behavior of machine tool structure by conducting the experiments for non-cutting duty cycles on VMC and mapping the temperatures obtained at different heat sources with thermal deformations.

ii. Estimating the heat generation and heat dissipations using classical approach. Using Finite Element Method to analyse the feed-drive system of VMC for thermal behavior.

iii. Suggesting a design modification for minimization of the temperature effect in feed-drive system so as to bring down the thermal error at tool cutting point.

Above mentioned contributions were made by developing a testing set-up for thermal error mapping. Further mathematical models developed for predicting thermal errors were compared which can be very much suited for implementation on VMC. A simple method for predicting thermal errors was suggested by carrying out Finite Element Simulation which will avoid disturbance of shop floor activities. Finally, a through-hole ball-screw was proposed and its performance was compared with and without passing coolants and it was found to be very good option in reducing the thermal deformation of ball-screw which in turn has direct impact on tool cutting point of spindle unit.