ABSTRACT

An end milling process is a multipoint, interrupted cutting, in which the contact between cutting edge and the work piece is not continuous and the uncut chip thickness varies with spindle rotation. Machining is the removal of the unwanted material from the workpiece, so as to obtain a finished product of the desired size, shape, and surface quality. Today’s manufacturing industry demands higher productivity with tightening tolerances. The demand for high productivity leads to increased material removal per unit time, higher spindle speeds, increased feed rate, and greater depth of cut. Progress and advancement in technologies such as machine tool design, CAD/CAM and tooling technology has led to CNC milling as a viable technology.

The proper selection of process parameters has a strong impact on machining performance. Improperly selected process parameter wears rapidly or unpredictably deteriorates surface finish, increases vibration and cutting force affecting stability of the process and variation in temperature rise at the cutting zone affecting thermal deformation of the cutting tool and workpiece materials. The present study focuses on the influence of the radial rake angle, nose radius, cutting speed, cutting feed rate and axial depth of cut during end milling process on surface finish, cutting force, vibration amplitude, the temperature rise, tool wear and surface topography. Finally a two and three dimensional finite element simulation of cutting processes has been developed to predict the stress, strain, temperature distribution, velocity and cutting force.
Al7075 is a high strength material commonly used for highly stressed structural components. It is strong, lightweight, compared to many steels, has good fatigue strength and a number of different interesting mechanical and thermal properties. It has been widely used in the aerospace industry as a structural material and in the fabrication of aircraft fittings, gears, shafts, fuse parts and regulating valve parts. End Milling processes have been employed to machine aluminium alloys at higher speeds and very high metal removal rates. This is due to the very high metal removal rates that can be attained by utilizing multi-tooth cutters at high speeds. Hence it is necessary to investigate the above responses for this Al7075-T6 aluminium alloy in CNC end milling process.

Surface roughness is a vital parameter in milling which resolves how the work piece components interaction with its assembled parts. A milled surface roughness has a great influence on the functional properties of the product. It is well known that a high quality milled surface significantly improves fatigue strength and corrosion. In addition, surface roughness also affects surface friction, light reflection, ability of holding a lubricant, electrical and thermal contact resistance, appearance, cost, etc. If the quality of the surface after milling is high, then further machining of the surface frequently is not necessary. Hence accurate prediction of surface roughness is also very essential.

The prediction of cutting forces in milling processes is extremely important to effectively design the machining process. A correct estimation of such force could avoid quality problem related to the tool deflection, chatter or fixture improving the productivity. Measured cutting forces are used to compare the machinability of materials and for real time control in monitoring a cutting process, tool wear and failure. Hence accurate prediction of cutting force is also crucial. Vibration amplitude modeling forms the basis
for realizing the cutting process which has to be maintained at the least in order to reduce tool deflection, vibration, tool wear, improve surface finish quality, augment tool life time, enhance of the metal removal, provide a long life of a machine tool and to maintain the process parameters at an optimum level so that it ensures the delivery of a premium product with the minimum machining time. Hence it is necessary to investigate the above responses for this Al7075-T6 aluminium alloy in CNC end milling process.

The prediction of temperature rise in milling processes is important as a lot of economic and technical problems of machining are induced directly or indirectly by this heating action. In case of higher melting point metals and alloys, the tools are heated to high temperatures as metal removal rate increases and, above certain critical speeds, the tools tend to collapse after a very short cutting time under the influence of stress and temperature. It is, therefore, important to understand the factors which influence the generation of heat, the flow of heat, and the temperature distribution in the tool and the work material near the tool edge.

Prediction of tool wear becomes important to increase the maximum utilization of the tool and to minimize the machining cost. The consequence of the tool wear is poor surface finish, increase in cutting force, increase in vibration of the machine tool, increase in tool-workpiece temperature during machining, decrease in dimensional accuracy, increase in the cost and decrease in the production efficiency and component quality. An effective model is essential to predict the tool wear becomes necessary.

To meet the above said objectives, it is essential to develop mathematical models correlating the CNC end milling process parameters with the responses. The mathematical models were developed by conducting experiments based on design of experiments using central composite rotatable
experimental design. The mathematical models were used to study the direct, interactive effects of process parameters on the responses and understand the behavior of machining for AL7075-T6 aluminium alloy during CNC end milling process. In addition to the mathematical models, artificial neural network models were developed to get a more accurate prediction of the above responses.

Optimization is an important tool to find the optimized values for any objective function. The purpose of optimization in this work is to find optimum values of end milling process parameters to minimize responses. Various intelligent optimization techniques like Genetic Algorithm (GA), Simulated Annealing (SA) and Particle Swarm Optimization (PSO) were employed to find the optimum values of process parameters. The results obtained from these techniques were compared and the algorithm which gave best results was identified.

The surface topography of a milled surface is an inherently important process response in end milling. It is one of the most commonly used criteria to determine the machinability of a particular workpiece material. The two and three dimensional finite element simulation of cutting processes is to understand the chip formation process, stress, strain, velocity, temperature distribution, cutting force and to show its capabilities in areas like tool insert design.

The aspects of investigations are very useful to industries when Aluminium alloy 7075-T6 is used for a specified application and it gains prominence as there is no previous work carried out in this aspect for this grade. The current work turns to be an eye opener and depicts that it is possible to control the machining parameters and thereby achieve the desired surface roughness, cutting force, vibration amplitude, temperature rise and tool wear for AL7075-T6 aluminium alloy.