CHAPTER 3

PROBLEM DEFINITION

3.1 INTRODUCTION

In this chapter, the details of the problem considered for the research are presented. A modern manufacturing system needs on-line tool failure sensing system to predict the tool failure. The failure diagnosis helps the end user to predict the tool life and surface roughness.

3.2 PROBLEM STATEMENT

In a turning operations surface roughness is an important quality characteristic and the adverse effects from tool wear must be carefully considered during the planning of turning operation. At the same time, the remaining tool life has to be considered to minimize the change of tool or tool failure. If a tool is cutting a different batch of parts, the decision must be made whether or not the tool is safe to use and whether or not it will produce the desired results. The main decisions are

- To replace the current tool before starting a new batch, and
- To keep using the tool for the change in the machining parameters to adapt to the tool condition and the characteristic of the new operation.
Either approach has limitations because (1) the safest way is to use new tool for a new batch and discard the old tool, yet a premature tool replacement incurs extra tool cost and increased machine downtime, (2) continual use of a worn tool beyond its life limit can induce in-process tool failure and/or defective parts, and (3) the exact prediction of tool failure is difficult because of the randomness in the mechanism of tool failure, in order to achieve maximum production rate within the surface roughness requirements. In such an environment, the optimal point is to be predicted to change the tool. To determine whether or not a tool can be safely and continually used for the next operations, both tool wear and tool life limit must be accurately measured to predict tool change.

In a metal cutting operation, the rake face of the cutting tool comes into contact with the chip, and the flank face with the machined workpiece, both at high velocities. So friction exists between these surfaces of the tool, chip and workpiece as results in gradual wear of the tool. Among all the types of tool wear, flank wear and the resulting the recession of the cutting edge affect the workpiece dimension, as well as quality.

Tool wear is an extremely complex phenomena influenced by many variables. Several researchers have placed more emphasis in recent years on sensing tool wear on-line with combinational measurements. Many of these techniques are capable of detecting and diagnosing tool wear and failure relating to particular classes of faults.

The developments in computer technology have made faster computation possible and economically viable for common users. This research is focused to develop models on tool flank wear prediction and surface finish measurement considering the vibration of the tool.
3.3 RESEARCH OBJECTIVES

The primary objective of this research has been focused to develop an accurate and reliable machining process model towards optimal performance by using non-traditional optimization procedure. These procedures have been interfaced with the modeling and simulation of machining process to investigate the optimal performance of tool life and surface finish for higher productivity considering the vibration of the tool with the following objectives

- To develop quick detecting and forecasting techniques that will respond to the computer–integrated machining environment.
- To develop more reliable and practical criteria that reflect tool wear on-line and to improve surface finish of the workpiece.
- To develop faster data processing strategies to control the compensation of the cutting tool during precise machining.
- To develop new methods for reducing vibration of the tool and to achieve better surface finish of the workpiece.

To develop new methods and techniques by keeping the above research objectives, the following secondary objectives were set:

i) To predict the flank wear and surface roughness by response surface methodology and back propagation neural network models.

ii) To study the effect of various input parameters (i.e., sensitivity analysis) on tool flank wear and surface roughness of the components and to determine the input parameters exerting the most influence upon model output.
iii) To analyze the stability of machining process using ANSYS software.

iv) To investigate the reduction of machining vibration by use of rubber layered laminates between tool holder and tool for the following cases:

- HSS tool for turning mild steel component with and without laminates.
- Carbide insert tool turning mild steel component with and without laminates.
- HSS tool for turning stepped and slender component with and without laminates.

3.4 RESEARCH METHODOLOGY

The methodology followed to accomplish this research is shown in Figure 3.1.

Figure 3.1 Research methodology
Mathematical models for flank wear and surface roughness have been developed. Then, the sensitivity analysis has been conducted by using these models followed by the study of dynamic behavior of cutting tools. The behavior of damped tools has been experimentally investigated.

### 3.4.1 Models development

During this investigation, tool flank wear and surface roughness have been taken as the response (output) variables during the turning process. The impact of the four factors: cutting speed, feed rate, depth of cut and force ratio on tool flank wear was evaluated by using Response Surface Methodology (RSM) and Back Propagation Neural Network (BPNN) models.

The main and interaction effects of the input factors on flank wear and surface roughness have been plotted. This helped in selecting quickly the process parameters to achieve the desired quality of machining surface by controlling the wear of the cutting tool. The predicted values of the flank wear and surface roughness by both techniques were compared with the experimental values and closeness with the experimental values was determined.

### 3.4.2 Sensitivity analysis

A sensitivity analysis was performed and compared with the relative impact of input parameters on tool flank wear and surface roughness. This type of analysis enables to measure the accuracy of the important parameters and to determine the input parameters exerting the most influence upon model outputs.
3.4.3  **Dynamic behavior of cutting tool**

In this study finite element analysis has been used to analyze the stability of machining process. The tools model is shaped in ANSYS software based on the real dimensions. The model analysis, harmonic and transient dynamic analysis have been performed. The vibration characteristics of tools with and without laminates have been performed and compared.

3.4.4  **An investigation of damped tools**

The experimental analysis has been carried out using laminates (Steel nitrile laminates, Brass nitrile laminates and Copper nitrile laminates) between tool holder and tool. The vibration of the HSS tool, Carbide insert tool and cantilever workpiece have been predicted and its effect on surface roughness have been analyzed.

3.5  **CONCLUSION**

Models of flank wear and surface roughness have been predicted by using response surface methodology and back propagation neural network models. The results are compared with the experimental results and closeness is measured through validation. The predictions are presented in chapter 4.