Chapter 3

PROBLEM IDENTIFICATION AND DEFINITION

3.1 Background of the proposed work and problem formulation:

Inspection of machined parts confirms their quality achieved during manufacturing. Traditional methods of inspection are off-line type where one needs to interrupt the operation being carried out. The work-pieces need to be removed from the work holding devices and placed at the inspection table. This unnecessary increase the idle time of operation and result in great economic loss. For mass production system, such wastage of time is not affordable. Hence efforts are always being made by technicians to shorten this un-productive time from the overall cycle time of the product.

Boring, as discussed in initial few chapters, is an important and commonly existing process in almost all types of industries. Surface roughness (finish) is an important quality attribute of bored surface which enhances the functionality of the part. Numbers of direct and indirect techniques have been developed for surface roughness measurements which are enumerated in previous chapters. The most simple but assured way of evaluating the surface roughness is the stylus method. But this method cannot be employed during the machining and also consumes a considerable time to execute. Hence efforts are being made to find out a suitable technique which will measure the surface roughness when the metal cutting process is in progress.

Numbers of methods, as discussed in chapter 2, were investigated but they stand to be unsuccessful due to various problems arising during their practical implementation. Hence there is still a need to develop a more rigid, simple and accurate technique for measurement of surface roughness during the machining. This need has worked as a drive to find a simple but accurate technique for the said purpose. After the detail analysis of literature, it was found that on-line measurement of surface roughness is not possible but it is possible to measure the vibrations of tool during machining, which is directly responsible for generating the surface texture during machining. Hence attempts were
made to study the vibrational phenomenon of cutting tool used for boring process and its correlation with the surface roughness produced.

Machining time required to carry out an operation is the direct function of material removal rate. The material removal rate however depends on the value of machining parameters used during the machining. To reduce the machining time, it is possible to maximize the values of machining parameters, which will surely reduce the machining time but may result in poor quality of surface. Thus when one thinks of reduction of the machining time, two aspects should be taken into consideration:

a) Maximization of machining parameters to enhance the material removal rate
b) Maintain the value of surface roughness within permissible limit.

The recommended range of average surface roughness (Ra) for the boring process is 2-6 µm. Thus while deciding the values of the machining parameters a care must be taken such that the surface roughness value must not exceed than 6 µm.

![Fig. 9 Calculation for optimum values of cutting parameters](image)

Literature show that Material Removal Rate (MRR) depends on the machining parameters viz. speed, feed and depth of cut. Surface roughness is also the function of
machining parameters. The value of machining parameters for the maximum permitted value of surface roughness can be calculated as shown in the plot in Fig. 9.

Machine tools available today not take into account the happenings that take place when the material is being cut off. The traditional way to carry out machining is to set an approximate value of machining parameters on machine. There is however no such facility available (equipped) with machine which will inform the machine controller regarding what actually happpening at tool-work piece interface. Hence there is a need to develop some sort of feasible monitoring system which consists of set of sensors which continuously measures variation into the parameters and keep on informing to the machine controller regarding these variations. Machine controller will then take an appropriate action depend on the feedback provided by the set of sensors. Keeping this concept in mind, in the work presented here, efforts are made to develop the on-line monitoring and control system for the boring process. As discussed in the previous section of this chapter, the vibrations of the boring bar are measured by using the vibration sensors (accelerometers), which are mounted on the tool. The output of accelerometer is then given to machine controller which in turn keeps on modifying the machining parameters as per the algorithm developed. The work proposed here is the first step towards development of an intelligent machine tool which will automatically adjust the values of machining parameters suitably, to maintain the surface roughness within permissible limit.

An algorithm can be developed for automatic adjustment of the machining parameters based on the feedback signal received from vibration sensor. Computer simulation now a day is very common practice used for analysis and synthesis of the various machining processes. The technique proposed here can be validated by developing a model with help of some suitable software and further simulated to verify the feasibility of the study.

In the work proposed here, major objective was to develop a correlation between boring vibrations and surface roughness through experimental work since the literature available show that no such effort have been made till time to develop these kind of empirical correlation.
3.2 Problem Definition:

The overall objectives of the proposed work can be summarized as follows.

1. **Literature survey** :
   To carry out in-depth review of literature to study the vibration phenomena of the boring bar. Conduct the review of literature to summarize the various techniques used to monitor the surface roughness on-line and its assessment method. Review the literature to list the various controllable and uncontrollable parameters affecting on boring bar vibrations. Analyze their individual role in inducing the vibrations in boring bar.

2. **Design the pilot experiments** :
   Select the range of machining parameters and machining set-up to conduct the pilot experiments in order to investigate the effect of machining parameters on boring bar vibrations. To find the empirical correlation between the boring bar acceleration and machining parameters.

3. **Boring bar vibrations and surface roughness** :
   Find the correlation between acceleration of the boring bar and surface roughness. Formulate a function for controlling the surface roughness using boring bar accelerations as a feedback.

4. **Optimum values of machining parameters** :
   Suggest the optimum combination of machining parameters so as to maximize the material removal rate in order to minimize the machining time by protecting the quality of surface produced.
5. **Algorithm for automatic control:**

Develop an algorithm for automatic adjustment of machining parameters using the vibrational signal as a feedback.

6. **Simulation of the process:**

Simulate this innovative technique with the help of some suitable software.

7. **Development of control system:**

Develop a working model of a machine to validate the application aspect of the technique proposed.

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3.3 **Assumptions made during the Work**

Following assumptions were made during the study.

3.3.1 **Tool Material and Tool Geometry:**

During machining operations, vibratory motion between the tool and work-piece can lead to reduced performance. In particular, self-excited vibration, or chatter, causes poor surface finish, tool damage, and other unwanted effects. When chatter does occur, the machining parameters must be changed and productivity may be adversely affected. The cutting tool used for performing boring operation is known as boring bar. A sample boring bar is shown in Fig. 10. The stiffness of cutting tool greatly affects the amplitude of vibrations produced during the metal cutting process.

Length to diameter ratio (L/D) of a boring bar is an important parameter to suppress the vibrations which occurs during the machining. Keeping L/D ratio between 3 to 4 can produce a hole without any chatter marks, which is practically difficult due long length requirement of bored surfaces. The properties like natural frequency, damping ratio and dynamic stiffness of a boring bar is the function of L/D ratio.
The technique proposed in the work is developed for mass production. In mass production system, the production set-up is designed to carry out a specific set of operations in a particular sequence. Hence the tool material and geometry is not changed over the period of time. Here therefore the effect of variation of tool material and tool geometry can be considered as constant.

### 3.3.2 Work piece Material and Dimensions:

The vibration induced in the boring process is the result of dynamic cutting forces experienced by the tool during the process. Variation in dynamic cutting force is the result of varying cutting conditions which occurs due to many reasons. Non-uniformity in the material hardness over the size is one of the important cause. The internal flaws, porosity causes the discontinuity in the material properties which tends the tool to jump or digs at the point of defect. This make a considerable variation in cutting forces and hence the vibrations in the tool. And vibrations as discussed earlier causes poor surface finish. Considering the economical aspect in machining, machining centers are mostly used for mass production system. Property variation is considered to be small during the present study. It is assumed that the properties like hardness, stiffness which depend on the microstructure of the material are also assumed to be constant.
3.3.3 Machining Conditions:

As discussed in the previous chapter, the boring vibrations and hence surface roughness are the direct function of variable cutting conditions viz. speed, feed, depth of cut and many more. Research has proved that heat produced due to friction at interface of tool and work piece causes the thermal deformation of the tool, work-piece and also enhances the tool wear rate. This also results in work hardening phenomenon. Surface roughness is greatly influenced by the use of coolant as it helps in heat dissipation process in machining. Literature has shown that variation in coolant flow causes variations in dynamic cutting forces. The rate of coolant flow however is considered to be constant.