CHAPTER 1

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Manufacturers around the world continuously try hard for better solutions in order to be in competition for machined components. The trend is toward higher quality, lower cost and smaller batch sizes. It is necessary to explore appropriate new technological solutions that can help to enhance business field. Technology has played an enormous role in advancing the metal working industry and creating opportunities to reduce costs and improve quality. Achievement of high quality, in terms of dimensional accuracy and surface quality along with increased production rate and saving in cost is an increasing challenge in modern machining enterprises. Such goals are achieved by emerging innovated machining technologies.

Though it is smaller but significant, technology evolution is occurring in the area of hard turning. Producers of machined components and manufactured goods are continually challenged to reduce cost, improve quality and minimize setup times in order to remain competitive. Frequently the answer is found with new technology solutions. At one time, machining was very much an operator dependent, skill critical process. Such is the case with grinding where the traditional operations involve expensive machinery and generally have long manufacturing cycles, costly support equipments, and lengthy setup times. The newer solution is a hard turning process which is best performed with appropriately configured turning centers or lathes. Today, CNC machine tools, which operate with mature technology and provide both, consistency and reliability, have now become the biggest contributor to part quality and cost. There is an increasing use of this technology in several industrial applications, especially in automotive and bearing industries because of its advantages of higher flexibility, higher production rate, lower cost per part, and significantly less costly machine tools. However, success of this technology in the precision machining is to be able to achieve the demands of the part quality and reasonable tool life which depends on fully understanding the specific machining process and correct selection process conditions such as cutting parameters,
lubrication conditions, tool geometry etc. The current technology has played a major role in transforming routine machining operations.

1.2 BRIEF BACKGROUND:

Hard turning is a process, in which materials in the hardened state (50–60 HRC) are machined. Since a large number of operations are required to produce the finished product, if some of the operations can be combined, or eliminated, or can be substituted by the new process, product cycle time can be reduced and productivity can be improved. The traditional method of machining the ferrous materials includes rough turning, heat treatment, and then finished by grinding process. Hard turning eliminates the series of operations required to produce the component and thereby reducing the cycle time and hence resulting in productivity improvement. Since adequate surface roughness can be achieved by hard turning, it is often considered as a replacement for grinding operations or as a pre-grinding process. Thus hard turning can be developed as an alternative process to grinding with reference to reduce the setup changes, product cost and lead time without compromising on surface quality to maintain the competitiveness in the world market.

The process of hard turning shares many fundamentals with its “soft turning” sibling. As with any new application, there is a learning curve for hard turning, but the fundamental principles follow those of the same turning operations that are commonly performed in shops today. This gives it an inherent advantage over grinding, which requires specific knowledge and experience that not all machinists possess. While any new process can be learned, most machinists and programmers today will have an easier time absorbing the hard turning process compared with grinding.

While hard turning can achieve impressive results, however, since parts can typically be finished in a single chucking, hard turned parts often show superior concentricity and perpendicularity characteristics to their ground counterparts. The cost advantages of hard turning compared with grinding are numerous. The immediately
apparent cost advantage is the reduced cost in capital equipment as several types of grinding machines may be needed to perform the operations able to be performed on a single turning center.

As mentioned above, a turning center can complete ID turning, OD turning, taper turning, and grooving in a single chucking. In addition to improving the accuracy of squareness, concentricity and straightness, this drastically reduces cycle and setup times as well. High precision threading operations can also be performed, guaranteeing concentricity with other part features compared with offline threading operations. Hard turning also allows for the finishing of radius and free-curved surfaces. Grinding processes require a custom-dressed wheel, which is time consuming to produce, or highly customized grinding machines that can be expensive.

In addition to the inherent cost advantages of combining multiple operations into one, hard turning cycle times are drastically shorter than comparable turning operations. A number of features of the hard turning process reduce environmental impact as well as cost. Turning centers consume less electricity than grinding machines, reducing both electrical consumption and the monthly electrical bill. Hard turning is often performed dry, eliminating both coolant costs and the need for coolant disposal. Hard turning produces easily recycled chips, whereas grinding produces sludge that must go through a costly separation process or be disposed off as an industrial waste.

As accuracy and surface finish are fundamental requirements for hard turned parts, not all lathes and turning centers are ideally suited for hard turning applications. In addition to being able to meet the speed requirements of the cutting tools, machines used for hard turning must maintain thermal stability, rigidity and precision over time.

Although hard turning is not an alternative for all grinding operations, the potential cost savings from reduced setup times, faster cycle times and lower equipment costs are too big to ignore. Since it shares many fundamentals with standard turning processes, hard turning has the additional benefit of being able to be easily assimilated
into most shops. With a little help choosing the right application, right machine and right tooling, hard turning can quickly enhance the profitability of a variety of tight tolerance applications.

The performance of hard turning is measured in terms of surface roughness, tool wear, cutting forces, and power consumed. Surface roughness influences functional properties of machined components. Surface roughness, in hard turning, has been found to be influenced by a number of factors such as feed rate, cutting speed, work material characteristics, work hardness, cutting time, tool nose radius and tool geometry, stability of the machine tool and the work piece set-up, the use of cutting fluids, etc.

In the area of machine tool development it is becoming more common to see equipment that supports multiple processes and is designed or targeted for greater versatility and utilization. Such is the case with hard turning and it is seen as a growing trend in plant operational strategies and lean manufacturing. The need to find ways for a greater utility from a machine investment will remain a driving force in the advancements of hard turning which is a viable process that has real and measurable economic and quality benefits. This is particularly true with a machine tool that has a high level of dynamic stiffness and the necessary accuracy performance. The more demanding the application in terms of finish, roundness and size control, the more emphasis must be laid upon the characteristics of the machine tool. The hard turning process is similar enough to conventional “soft” turning that the introduction of this process into the normal factory environment can happen with relatively small operational changes. Even though many users choose to maintain the confidentially of their hard turning operations, the general knowledge of the implementation strategies is becoming more widespread and readily available.
1.3 RATIONALE AND MOTIVATION OF THE RESEARCH:

The following observations explain the rationale for the present research:

- The hard turning process is being applied gradually in industry to replace the slow and costly grinding process in finishing mechanical components.
- The hard turning operation can be performed in different mediums i.e. dry, minimum quantity lubrication (MQL) and flooded.
- The prediction of hard turning variables (Surface roughness, tool wear, cutting forces, workpiece and tool temperature, tool stresses, residual stresses, etc) is essential to the optimization of cutting tool design (tool material and geometry, coatings) and cutting conditions (cutting speed, feed rate, depth of cut) such that product quality, productivity and tool life are optimized.
- Operators usually select the machining parameters according to handbook or their experience and the selected machining parameters are usually conservative to avoid machining failure. The proposed genetic algorithm based procedure for solving the optimization problem is both effective and efficient and can be integrated into an intelligent manufacturing system for solving complex machining optimization problems.

The above observations indicate that it is necessary:

- To optimize the cutting parameters such as cutting speed, feed and depth of cut by predicting the hard turning output responses such as surface roughness and tool wear.
- To develop an innovative experimental set up to carry out the experiments in minimum quantity lubrication (MQL) medium.
- To develop the mathematical models and prediction of output responses by using design of experiments.
- To study the effect of cutting speed, feed and depth of cut upon surface roughness and tool wear.
1.4 RESEARCH OBJECTIVES AND APPROACH:

The machining processes have a large share in manufacturing sector that demand precise and accurate outputs. There is ample scope in order to see the possibility of reducing the pressure of obtaining the required outputs with high quality and quantity. Surface roughness and tool wear are the important and influential parameters while measuring the quality of the product in hard turning. The workpiece material i.e. (AISI H13) selected for the study is widely used in the industrial area for the manufacturing of moulds and dies, however a systematic approach in obtaining adequate data useful to industries need to be generated. A very few researchers were attracted towards such situations. Increased use of AISI H13, due to improved properties as compared with conventional work materials has provided with a wider area of investigation. Hard turning of this material in three different mediums i.e. dry, minimum quantity lubrication and flooded can be studied with a view to optimize the cutting parameters such as speed, feed and depth of cut over the output responses such as surface roughness and tool wear.

In case of hard turning, surface roughness and tool wear are important and evident factors. These two factors affect the cost and quality of the product and hence demands detailed and precise investigation having specific reference to the surface quality and tool condition. To fulfill the research objectives, the research is conducted through the following approach:

- To determine Effect of speed, feed and depth of cut upon surface roughness and tool wear.
- To develop an experimental set up for hard turning in minimum quantity lubrication.
- To suggest the optimum combination of speed, feed and depth of cut for hard turning in dry, minimum quantity lubrication and flooded medium using genetic algorithm.
- To verify the results by Teaching Learning Based Optimization algorithm. (TLBO).

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