SYNOPSIS
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Title of the Thesis:
AN INVESTIGATION INTO SIGNIFICANCE OF PARAMETERS IN DRY TURNING OF HARDENED STEEL

INTRODUCTION:

The challenge of modern machining industries is mainly focused on the achievement of high quality in terms of dimensional accuracy, surface finish, high production rate, less wear on the cutting tools, economy of machining and increase in the performance of the product with reduced environmental impact. Surface roughness plays an important role in many areas and is a factor of great importance in the evaluation of machining accuracy. Till date many researchers have developed mathematical models to optimize the cutting parameters to get lowest surface roughness by turning process. The variation in alloying elements present in the work piece material and their mechanical properties, workpiece and tool material combination, vibration between work piece--machine tool--cutting tool combination, lubricants used and process parameters such as speed, feed, depth of cut, tool geometry affect the surface roughness and tool wear. Turning has emerged as a viable alternative to grinding for finished machining of hardened steel due to its reduced capital cost, multi operations in single chucking, reduced setup times, faster cycle time, high precision, easy automation, less electricity etc. A major factor leading to the use of hard turning in place of grinding has been the development of carbide cutting tools, which enable machining of high-strength materials with a geometrically defined cutting edge.

Since dry hard turning reduces machining time, it not only saves the cost but also reduces environmental pollution, as there is no coolant to be disposed off. Finished hard turning is increasingly used in industrial applications and hence there is a need for further exploration in order to improve the productivity and to provide a wide database useful to industries.
Hardened steel has been extensively used in industrial and automotive applications such as manufacturing of gears, bearings, tools, and dies. Requirements of high surface finish and dimensional accuracy of hardened steel can be achieved by grinding, however, grinding operation is comparatively costly as it is time consuming, requires expensive machines and equipments and coolant. Hence in dry hard machining turning is emerged as an alternative to grinding process.

The need to have precise tolerances and minimum surface roughness has driven the metal cutting industry to continuously improve the cutting processes. Surface roughness which is often used to determine and evaluate the quality of a product, is one of the major quality attributes of a turned product. The proper combination of cutting parameters is crucial to produce parts with least surface roughness. The rationale for the present research would be

- The hard turning process is being applied gradually in industry to replace the costly and time consuming grinding process for finishing of components.
- The prediction of hard turning output such as surface roughness and tool wear is essential to optimize the cutting parameters such as cutting speed, feed rate, and depth of cut in order to improve upon quality, productivity and tool life.

This leads the necessity to,
- Develop a methodology to estimate the optimum values of speed, feed and depth of cut in dry, minimum quantity lubrication (MQL) and flooded medium.
- Develop an experimental set up for minimum quantity lubrication (MQL).
- Study the effect of process parameters (speed, feed and depth of cut) on surface roughness (Ra) and tool wear (Tw).

The proposed research is to develop empirical relationship between cutting parameters on surface response such as surface roughness and tool wear and optimizing it by genetic algorithm approach. Thus, the specific objectives of research are:

- To evaluate the effects of different process parameters on hard turning performance.
To develop mathematical model and prediction of surface roughness and tool wear using design of experiments.

To develop experimental set up and to carry out experiments for minimum quantity lubrication (MQL).

To carry out the experiments in flooded medium with the optimum set of parameters.

To compare output responses i.e. Surface roughness and Tool wear in dry, minimum quantity lubrication (MQL) and flooded medium.

RESULTS AND CONTRIBUTIONS:

In addition to the fundamental understanding of hard turning process, the present study contributes to determine the optimum values of speed, feed and depth of cut that are suitable to the hard turning by providing an innovative experimental set up for minimum quantity lubrication (MQL). Genetic algorithm is used to optimize the output parameters i.e. surface roughness (Ra) and tool wear (Tw). The results obtained were validated by suitable optimization technique like Teaching Learning Based Optimization (TLBO) algorithm approach. The obtained results in three different mediums i.e. (dry, MQL and flooded) have been compared and the optimum combination is suggested.

ORGANIZATION OF THESIS:

In Chapter 1, the hard turning is introduced. In view of quality, cost and time components, hard turning is advantageous over grinding and thus can replace it. The rationale and motivation of the present work, research objectives, and experimental approach are explained.

Chapter 2 covers the detailed review of literature on hard turning, dry turning, turning in MQL and flooded turning. The optimization methods of the process adapted by various researchers have been studied and included in the literature review. The aim of
study have been testified to find out the research gap and to finalize the workpiece material, inserts to be used in the experiments, machine on which experiments are to be performed, and coolant to be used in minimum quantity lubrication (MQL).

Chapter 3 contains the machining in dry environment with cutting parameters as speed, feed and depth of cut; observing the responses of surface roughness and tool wear which can be used as the basis for further research. Experimental work was carried out on CNC turning machine (HAAS). The workpiece material used was AISI H13 steel (with a surface hardness of 50 HRC). The cutting was performed by using turning inserts (CNMG120404-26-TN-4000) by WIDIA CVD coated with Ti(C, N)/TiN/Al$_2$O$_3$ which could provide higher heat resistance. The objective of the experiments was to secure the advantageous outcomes such as lower surface roughness, less heat generation, minimum tool wear, better geometrical accuracy and compressive stresses favorable for carbide edges. Detailed measurements of work piece material composition, tool wear and surface roughness were conducted in order to characterize the process and determine the optimal operating conditions. The experiments were carried out using central composite design approach and the results were optimized by genetic algorithm.

Chapter 4 comprises of experimentation using MQL to analyze the effect of process parameters on hard turning. This takes us further to use coolant minimally. To meet the requirements, a specially designed indigenous setup for MQL was fabricated and used in the experiments. The MQL parameters i.e. coolant pressure (CP), angle of impingement (A) and spot distance (SD) were optimized with the help of experiments.

The eco friendly machining with the parameters selected, i.e. spot distance (SD), angle of impingement (A) and coolant pressure (CP) has been performed with minimal use of coolant which gave positive encouraging results. Servo cut S is recommended by various researchers for variety of cutting operations on ferrous and non-ferrous metals and hence used in the experiments. Servocut S is a soluble type high quality cutting oil which yields rich milky emulsion with water. Special emulsifier is incorporated to ensure its complete dispersion in
Chapter 5 consists of experimentation carried out for hard turning using flooded lubrication with optimum process parameters obtained in dry turning and MQL turning. It has been observed that flooded lubrication reduces surface roughness and tool wear resulting in higher productivity and better quality. The results thus obtained are compared with dry machining and MQL turning. The stringent restrictions on the use of coolants from the point of view of environmental circumstances cause occupational hazards to the operator and so also the detrimental to the environment. The results obtained for dry, MQL and flooded were compared and analyzed systematically.

Chapter 6 contains summary of conclusions based on this research work and the future scope for the work in manufacturing system.

In the end, the references have been added which show the current status of related research work at various places, gathered from different professional journals and downloaded from the internet.