A Review Paper on Optimization of Tool Wear And Cutting Force By Effective Use of Cutting Parameters In Center Lathe Machine of Mild Steel By HSS Tool

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ABSTRACT

The manufacturing process includes fundamental activities like metal cutting and metal shaping, but metal cutting is typically employed for item shape. Any machining operation's mechanism for removing material determines the quality of the surface it produces. Considerations like machine quality, the kind of material being machined, tool quality, relative motion imparted to the work piece tool, chip cross section related parameter viz. depth of cut, spindle speed and feed, etc. are taken into account in order to achieve a quality surface. The bulk of machining methods aim to maximise material removal rate in order to obtain the required form.

In order to decrease both of these elements while utilizing a single point cutting tool to convert mild steel, the main objective of this thesis is to assess and optimize the influence of the cutting parameters on tool wear and cutting force. Numerous research employ various spindle speeds, cut depths, and feed rates. In this study, the effects of turning mild steel utilizing high speed steel tools on tool wear and cutting force are evaluated. The Taguchi method is then used to the collected data to optimize tool wear and cutting force. For optimization, the Taguchi L27 array optimization method was used. The best machining settings (Spindle speed, depth of cut, and feed rate) for the least amount of tool wear and cutting force were found using Taguchi's signal-to-noise ratio in order to increase tool life. The Taguchi optimizing approach states that the ideal feed, spindle speed, and depth of cut will increase tool life by decreasing tool wear.

Keywords: Tool wear, cutting force, cutting parameter, Taguchi optimization technique

1.1 INTRODUCTION

Although turning employs the metal cutting process largely for object shape, basic operations like metal cutting and metal forming are a component of the production process. The process of material removal governs the quality of the surface created by every machining operation. In order to achieve a quality surface, consideration must be given to variables such machine quality, the kind of material being machined, tool quality, relative motion imparted to the work piece and tool, chip cross section related parameter viz. depth of cut, spindle speed and feed, etc. Recently, the cutting process has seen significant advancements. A few of the numerous factors that affect the turning process and tool wear rate are the material and grades of the cutting tool, the material of the workpiece, and the cutting circumstances. Tool variables include tool material, cutting edge geometry, clearance angle, cutting edge inclination angle, nose radius, rake angle, and tool vibration. Workpiece variables include material, mechanical qualities, chemicals, and physical properties, among others. Cut depth, feed rate, and cutting speed are examples of cutting circumstances. It might be difficult to choose the appropriate process parameters, but doing so is essential for controlling the machining process and achieving improved product quality, high productivity, and low cost.

A key indicator of how efficiently the turning operation is performing during the production process is tool wear. Studies and assessments of the turning process usually depend on cutting parameters such as depth of cut, feed rate, and cutting speed. The goal of this study is to use Taguchi design of experiments to examine how these characteristics impact the prediction of tool wear during turning operations. Various cutting conditions were tested in machining studies using test specimens. A comparable development would guarantee the geometrical and surface criteria, improving the product's quality Estimating tool wear during machining is crucial for the design of cutting tools and the choice of cutting conditions in tool change methods. The substantial amount of study that has been conducted in this area over the past century or so has allowed us to have a much better understanding of the problem. The relationship between tool wear, cutting force, cutting conditions, tool geometrical parameters, and tool material characteristics has not yet been sufficiently addressed by any machining technology.

One of the key objectives should be to monitor and detect tool wear in order to generate the needed end products. This prevents any dangers to the machine or degradation of the surface finish by utilizing a fresh tool at the exact moment the old one has worn out. Increases in interface temperature, plastic deformation, mechanical breaking, blunting of the cutting edge, and tool brittle fracture are all causes of cutting tools breaking. This study's main objective is to prevent cutting tool cutting edges from deteriorating. Tool wear has an impact on all aspects of machining, including cutting power, quality, tool life, and cost. When tool wear surpasses a certain threshold, increased cutting force, vibration, and cutting temperature lead to diminished surface integrity and dimension accuracy that is outside of tolerance. The cutting instrument has served its purpose. The cutting process must then be interrupted in order to grind or replace the cutting tool. Costs and productivity are increased by the expense and lead time of changing a tool to make a machine tool adjustment. Predicting tool wear is essential for simplifying the cutting process since it impacts machining costs.

The main objective of this work is to empirically measure cutting force and tool wear. The secondary objective is to further investigate the effect of cutting parameter on tool wear and cutting force using graphical analysis and Taguchi analysis. This will make it simpler to understand the relationship between cutting force and cutting parameter.

1.2 PROBLEM STATEMENT

In order to obtain optimum performance, choosing the ideal cutting parameter values is a typical task in machining processes. These traits are often decided by knowledge and the usage of the Machinery's Handbook. Some machine operators employ the 'trial and error' technique while configuring the cutting conditions for turning machines. Using these strategies to reach a goal value in a repeated operation might be time-consuming and unsuccessful. Instead, the experimental approach will be used to adjust the cutting and machining settings to achieve the desired quality. The most effective set of independent variables to predict output values may be found using the experimental strategy and Taguchi techniques. This study aims to investigate the cutting force and tool wear of a single point high speed steel (HSS) cutting tool used in a turning operation. Cylindrical specimens made of mild steel (MS) are machined using the single point cutting tool. At varying spindle speeds, depths of cut, and feed rates, a series of experiments are conducted to gauge cutting force and tool wear. Cutting forces and tool wear are calculated using the results of these trials. The study of the cutting parameter and measured variable will be aided by the information provided.

there is as yet no machining strategy to provide adequate relationship between tool wear cutting force and cutting conditions, tool geometrical parameters and tool material properties.The selection of optimal process parameters is usually a difficult work, however, is a very important issue for the machining process control in order to achieve improved product quality, high productivity and low cost. The main problem companies face in the metal-cutting industry is the need to increase manufacturing quality and at the same time to decrease production costs. There are many variables which affect the quality and production costs of the product, including cutting parameters, tool wear, cutting force, tool materials, tool geometry, cutting technology and lubricants etc. Consequently, companies are forced to operate by using the trial-and-error method. The method is time consuming and less accurate. The optimization of controllable variables can make a considerable contribution towards solving the problem. At this point, the variables leading to a final solution are being optimized by using the Taguchi technique. Therefore, by employing the optimization technique the production costs can be decreased significantly and time loss can be minimized. As a result, now-a-days, this and similar methods have become the focus of interest for both academics and companies, with the goal of increasing production quality and operating with greater efficiency

1.3 OBJECTIVE

• Measure cutting force experimentally at various cutting parameters and investigate the impact on tool wear.

• Cutting parameter optimizations to decrease tool wear

1.4 RESEARCH SCOPE

As industry competition has risen in recent years, manufacturing systems are being pushed harder. There is therefore always space for development. Therefore, we might take into account the following factors to get more precise results:

• A CNC machine may be used for experimentation to set parameters with the appropriate precision and to increase control of process factors.

• It is possible to examine different machine, cutting tool, and work piece material combinations.

• The study may be broadened to use CBN and other hard tool materials.

• Various parameters may be examined.

• The experiment may be carried out repeatedly indefinitely.

1.5 EFFECTS OF TOOL WEAR

Some general impacts of tool wear are listed below:

• Increase in cutting forces; • Increase in surface roughness; • Lower production efficiency and component quality; • Increase in vibrations; • Increase in cutting temperatures; • Increase in noise.

• Reduced finished-part precision • Tool breakage

The effectiveness and profitability of metal cutting operations are significantly impacted by tool wear. Because of this, it is important to identify the practices that reduce tool wear. Only a few of the many variables that effect tool wear include the material of the tool, the material of the workpiece, the cutting parameter, etc. The criteria for selecting a conventional lathe for experimentation, as well as its specifications, workpiece and cutting tool materials, and other equipment for measuring cutting force and tool wear, are all covered in this chapter. This chapter provides a brief summary of the ongoing experimental activities.

2.1 MATERIALS AND ITS SPECIFICATION

The characteristics of the material are taken into account while selecting a cutting tool and work piece in order to produce high-quality products. Cutting tools must be made of a material that is tougher than the material being cut and can resist the heat generated during the metal-cutting process. For varied machining operations, several types of cutting tool materials are required. The ideal material for cutting tools should have each of the attributes listed below.

• High temperature stability • Resistance to wear and thermal shock

• Impact-resistant

Mild steel with up to 0.30% carbon makes up the workpiece. Mild steel is the most widely used form of steel because it is inexpensive and has material properties that are ideal for a wide range of applications. Carbon content in mild steel and low carbon steel is 0.16 to 0.30 percent. Although mild steel has a relatively low tensile strength, it is inexpensive, malleable, and its surface hardness may be increased by carburizing it. It is used in circumstances when flexibility or ductility are essential. In addition to tin plate, wire goods, tubes, and girders, it is used for items like nuts, bolts, and screws.

The cutting tools were constructed using high speed steels (HSS). It is made up of multi-component alloys having a ferrous basis, where X denotes a collection of alloying elements that mostly consists of Cr, W or Mo, V, and Co. These steels are mostly used for cutting tools because they can keep a high level of hardness while quickly cutting metals. More than 7% of the X component and more than 0.60 percent carbon are often found.

• Carbon produces carbides, which increase wear resistance and are what give the matrix its fundamental hardness.

• Tungsten and molybdenum increase red hardness, hardness retention, and high temperature strength of the matrix and produce unique, extremely hard carbides.

Chromium encourages depth hardening and produces carbides that are easily soluble. Vanadium forms specific, extremely hard carbides that strengthen the matrix's high temperature wear resistance.

Cobalt enhances red hardness and matrix hardness retention.

Table 2.1 Mechanical Properties of Mild Steel

Hardness	Elongation	Tensile Strength	Yield Strength	Young's Modulus
130 BHN	10-14%	490 MPa	300 MPa	210 GPa

Table 2.2 Chemical Composition of Mild Steel

C	Si	Mn	S	P	Al
0.16-0.18%	Max 0.40%	0.70 – 0.90%	Max 0.040%	Max 0.040%	0.02%

(Source: Metals Handbook,1990)

High speed steels (HSS) were chosen as the material for the cutting tools. It consists of multi-component alloys with a ferrous base, where X stands for a group of alloying elements that primarily includes Cr, W or Mo, V, and Co. Due to their ability to maintain a high level of hardness while cutting metals at a fast speed, these steels are mostly utilised for cutting tools. Typically, there is more than 7% of the X component and more than 0.60% carbon present.

Table 2.3 Mechanical Properties of High Speed Steel

Hardness	Elongation	Tensile Strength	Yield Strength	Young's Modulus
180 BHN	18%	490 MPa	460MPa	225 GPa

(Source: Metals Handbook,1990)

Table 2.4 Chemical Composition of High Speed Steel

C	Cr	W	V	Mn	Si
0.65-0.80%	3.75- 4%	17.25- 18.75%	0.90- 1.30%	0.10-0.40%	0.20-0.40%

(Source: Metals Handbook,1990)

2.2 CUTTING CONDITIONS

After deciding machine tool and cutting tool, the following main cutting conditions have is to be considered.

2.2.1 Spindle Speed

The spindle speed is the rotational frequency of the spindle of the machine, measured in revolutions per minute (RPM). Cutting speed refers to the relative surface speed between tool and work, expressed in surface feet per minute. Either the workpiece, or the tool, or both, can move during cutting. Because the machine tool is built to operate in revolutions per minute, some means must then be available for converting surface speeds into revolutions per minute (RPM).

2.2.2 Depth of cut

The depth of cut related to the depth the tool cutting edge engages the work. The depth of cut determines one linear dimension of the area of cut. For example to reduce the outside diameter of a workpiece by 0.500 mm, the depth of cut would be

0.250mm.

2.2.3 Feed

The feed for lathe turning is the axial advance of the tool along the work for each revolution of the work expressed as mm per revolution .The feed is also expressed as a distance travelled in a single minute or MPM (mm per minute).

Feed, spindle speed and depth of cut have a direct effect on productivity, tool life, and machine requirements. Therefore, these parameter must be carefully chosen for each operation. Whether the objective is rough cutting or finishing will have a great influence on the cutting parameter selected.

2.3 TURNING PROCESS

In the turning process, the cutting tool is set at a certain depth of cut (mm or in) and travels to the left with a certain velocity as the workpiece rotates. The feed (mm/rev) is the distance the tool travels horizontally per unit revolution of the workpiece. This movement of the tool produces a chip, which moves up the face of the tool.

In order to analyze the process a cutting tool moves to the left along the workpiece at a constant velocity and a depth of cut. A chip is produced ahead of the tool by plastically deforming and shearing the material continuously along the shear plane.

3.1 CONCLUSION

The conclusion of the entire work is reached in this chapter based on the literature review, the results of the graphical analysis, and the Taguchi experimental analysis. This study has looked at how cutting parameters affect tool wear and cutting force throughout the machining process. The effects of cutting speed, feed, and depth of cut on tool wear and cutting forces throughout the turning process using an HSS tool and a 50 mm long MS bar on a center lathe have been examined. Both depict the connection between cutting force and cut depth as well as the connection between tool wear and cut depth.

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