Enhancement Of Surface Finish For CNC Turning Cutting Parameters By Using Taguchi Method

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ABSTRACT: The turning operation involves a lathe machine (conventional or CNC turning centre), a tool, lubricant, operator and a raw material (stock) for effecting the production. The parameters for machining like the speed, feed, and depth of cut should be set to achieve the desired rate of production, longer tool life and a desired surface finish over the component. To take care of these conflicting requirements, the parameters for machining need to be optimized for suggesting a best mix for realizing, say, the given surface finish. Achieving a higher rate of production for the intended surface finish would be the objective of this paper. For experimentation over this proposed work, a CNC turning centre would be engaged for machining the different workpiece material with different types of cutting tool inserts with a set of values for the given parameters. The process would be repeated for different values of the parameters while keeping the other constant. Data would be recorded for further treatment with statistical tools like Minitab. Taguchi method is used for finding the optimized solution.

Keywords: **Taguchi Method, Cutting Tool, Surface finish.**

1.1 INTRODUCTION

In modern industry the goal is to manufacture low cost, high quality products in short time. Automated and flexible manufacturing systems are employed for that purpose along with computerized numerical control (CNC) machines that are capable of achieving high accuracy and very low processing time. Turning is the most common method for cutting and especially for the finishing machined parts. Furthermore, in order to produce any product with desired quality by machining, cutting parameters should be selected properly. In turning process parameters such as cutting tool geometry and materials, the depth of cut, feed rates, cutting speeds as well as the use of cutting fluids will impact the material removal rates and the machining qualities like the surface roughness, the roundness of circular and dimensional deviations of the product (Kalpakjian and Schmid, 2001)

Turning is the removal of metal from the outer diameter of a rotating cylindrical work piece. Turning is used to reduce the diameter of the work piece, usually to a specified dimension, and to produce a smooth finish on the metal. Often the work piece will be turned so that adjacent sections have different diameters. Turning is the machining operation that produces cylindrical parts. Figure 1.1 shows the turning process. In its basic form, it can be defined as the machining of an external surface:-

- With the work piece rotating,
- With a single-point cutting tool, and
- With the cutting tool feeding parallel to the axis of the work piece and at a distance that will remove the outer surface of the work.

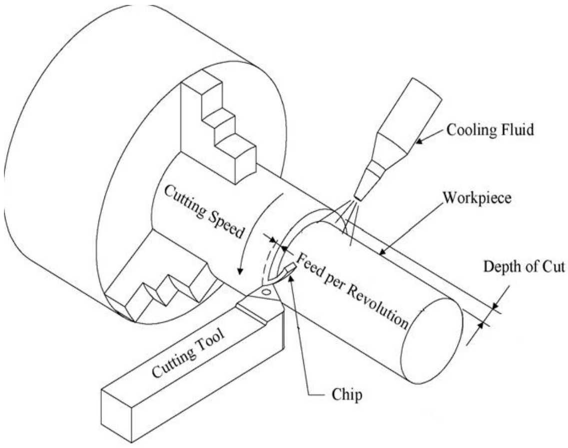

Figure.1.1

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Turning was a widely used machining process in which a single-point cutting tool removes material from the surface of a rotating cylindrical workpiece. Three cutting parameters, i.e., cutting speed, feed rate, and depth of cut, must be determined in a turning operation. Common methods of evaluating machining performance in a turning operation are based on the following performance characteristics: tool life, cutting force, and surface roughness. Basically, tool life, cutting force, and surface roughness are strongly correlated with cutting parameters such as cutting speed, feed rate, and depth of cut (Nian et. al., 1998).6

Turning constitutes the majority of lathe work. Thus, it was the process of machining straight, conical surfaces, external cylindrical, curved and grooved workpieces. The cutting tool was attached to the tool post, which is driven by the lead screw, and removes material by travelling along the bed (Kalpakjian, 2006).

1.2OBJECTIVES

- To study the effect of different machining parameters for turning operation over the surface roughness of the selected variants of Steel workpieces
- Demonstrate a systematic procedure of using Taguchi parameter design in process control of turning machines.
- To optimize these parameters for surface roughness.

The objective of this research is to study the effect of cutting speed, feed, depth of cut, machining time on surface roughness. Taylor showed that an optimum or economic cutting speed exists which could maximize material removal rate. Considerable efforts are still in progress on the use of hand book based conservative cutting conditions and cutting tool selection at the process planning level. The need for selecting and implementing optimal machining conditions and most suitable cutting tool has been felt over the last few decades. Despite Taylor’s early work on establishing optimum cutting speeds in machining, progress has been slow since all the process parameters need to be optimized. Furthermore, for realistic solutions, the many constraints met in practice, such as low machine tool power, torque, force limits and component surface roughness must be overcome.

As a future engineer, know how to establish a machining optimization turning parameter with high quality material that will be produced in order to increase the profit is vital. By understanding the concepts, develop and implement the suitable optimization technique for a wide variety of problem in the area of design and manufacturing can be done. This project also will increase the knowledge about the way to optimize the machining parameter in order to obtain the minimum surface roughness. These optimization technique parameters is also prevent engineer or production controller from doing something that waste in production such as time and produce a better product.

The importance of this study was to investigate the surface roughness and hardness produce by different controllable parameter such as cutting speed, feed rate and depth of cut by turning `Steel'. By using Taguchi Method, the values for the parameters in design the experiment can be determined. Besides, the technique of the optimization was implemented to obtain better surface finish (better Ra values).

2.0 PROBLEMS WITH TURNING OPERATIONS:

In machining operations, the quality of the surface finish was playing an important role for many turned workpieces. However, human operators or programmer normally inspecting the surface according to their experiences or refer from machining handbooks.

With regard to the quality characteristics of turning parts, some of the problems included surface roughness, burr, and tool wear, etc. The machining parameters such as cutting speed, feed rate, depth of cut, features of tools, work piece material and coolant conditions were highly affect the performance characteristics. It was necessary to select the most appropriate machining settings in order to improve cutting efficiency, lower the process cost, and produce high-quality components.

a) What is the relationship between the controllable factors (in the study: spindle speed, feed rate, and depth of cut) and the response factor (surface roughness)?

b) What are the significant controllable factors that produce a better surface finish?

In machining, boring is the process of enlarging a hole that has already been drilled (or cast), by means of a single-point cutting tool (or of a boring head containing several such tools), for example as in boring a cannon barrel. Boring is used to achieve greater accuracy of the diameter of a hole, and can be used to cut a tapered hole. Boring can be viewed as the internal-diameter counterpart to turning, which cuts external diameters

3.0 VIBRATION AND SURFACE FINISH RELATION:

In the turning operation, vibration is a frequent problem, which affects the result of the machining, and, in particular, the surface finish. Tool life is also influenced by vibration. Severe acoustic noise in the working environment frequently occurs as a result of dynamic motion between the cutting tool and the work piece. In all cutting operations like turning, boring and milling, vibrations are induced due to the deformation of the work-piece. This implies several disadvantages, economical as well as environmental.

Today the standard procedure toavoid vibration during machining is bycareful planning of the cutting parameters. The methods are usually based on experience and trial and error to obtain suitable cutting data for eachcutting operation involved in machining a product. Machining vibration exists throughout the cutting process. While influenced by many sources, such as machine structure, tool type, workmaterial, etc., the composition of the machining vibration is complicated. However, at least two types of vibrations, forced vibration and self excited vibration, were identified as machining vibrations. Forced vibrations a result of certain periodical forces that exist within the machine. The source of these forces can be bad gear drives, unbalanced machine-tool components, misalignment, or motors and pumps, etc. Self-excited vibration, which is also known as chatter, iscaused by the interaction of the chipremoval process and the structure of themachine tool, which results indisturbances in the cutting zone. Chatter always indicates defects on themachined surface; vibration especially self-excited vibration is associated with the machined surface roughness

A large number of theoretical and experimental studies on surface roughness of machined products have been reviewed where cutting conditions (such as cutting speed, feed rate, depth of cut, tool geometry, and the material properties of both the tool and work piece) significantly influence surface finish of the machined parts. The surface roughness can be affected by built up edge formation. The analysis of tool vibration on surface roughness is also investigated by some authors.

4.0 TAGUCHI METHOD AND EXPERIMENTAL SETUP

4.1 Taguchi Method

Taguchi defines as the quality of a product, in terms of the loss imparted by the product to the society from the time the product is shipped to the customer. Some of these losses are due to deviation of the products functional characteristic from its desired target value, and these are called losses due to functional variation. The uncontrollable factors, which cause the functional characteristics of a product to deviate from their target values, are called noise factors, which can be classified as external factors (e.g. unit to unit variation in product parameters) and product deterioration. The overall aim of quality engineering is to make products that are robust with respect to all noise factors.

Taguchi has empirically found that the two stage optimization procedure involving S/N ratios, indeed gives the parameter level combination, where the standard deviation is minimum while keeping the mean on target. This implies that engineering systems behave in such a way that the manipulated production factors that can be divided into three categories:

1. Control factors, which affect process variability as measured by the S/N ratio.
2. Signal factors, which do not influence the S/N ratio or process mean.
3. Factors, which do not affect the S/N ratio or process mean.

In practice, the target mean value may change during the process development applications in which the concept of S/N ratio is useful are the improvement of quality through variability reduction and the improvement of measurement. The S/N ratio characteristics can be divided into three categories when the characteristic is continuous: nominal is the best, smaller the better and larger is better characteristics.

4.2. Cutting Tool Inserts and Work piece

The three different types of cutting inserts are used in this experimentation and they are carbide, ceramic and CBN. Also three different types of materials are used Stainless Steel (Type 304), Carbon Steel (EN9) and Alloy steel (SAE 8645) is shown in figure 4.1

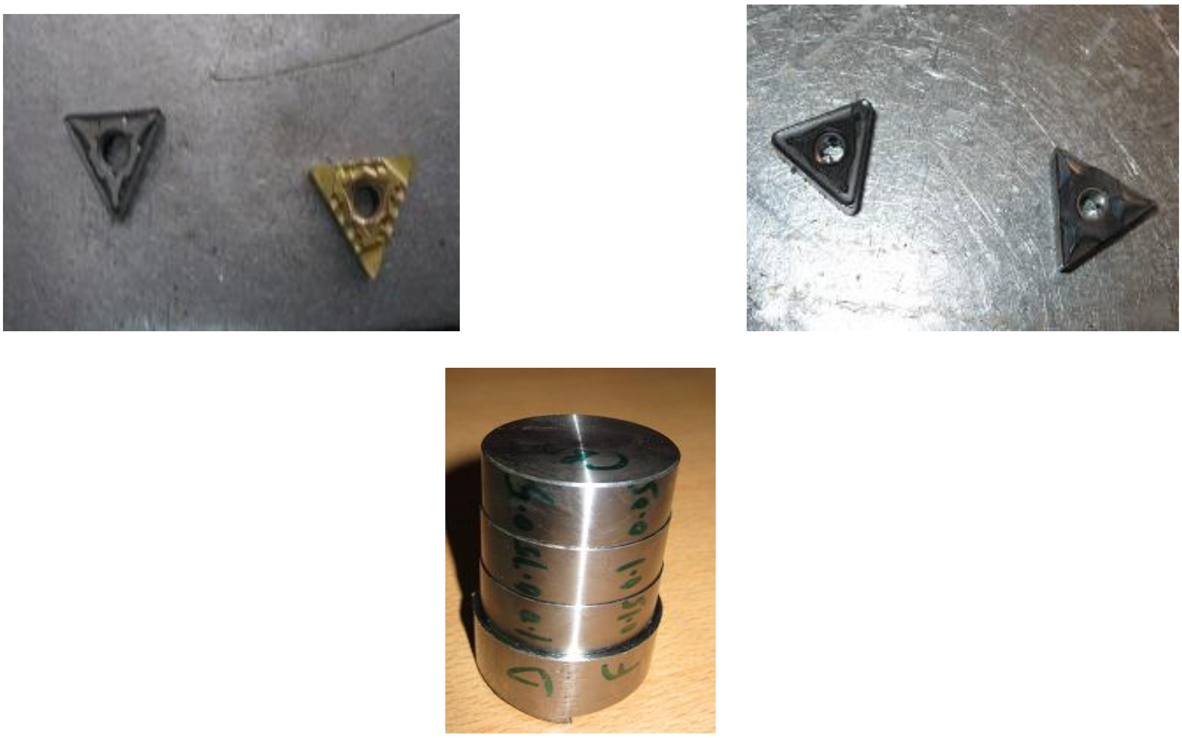

Figure 4.1 Cutting Inserts and Workpiece Material

4.3. Experimental Procedure

The work piece was mounted using a pneumatic chuck in CNC turning centre and the clamping pressure was set as10 bar. The machining parameters like feed, depth of cut, cutting speed, etc. were selected based on the manufacturer's recommendations. Only the cutting speeds, feed, depth of cut, cutting tool inserts, and workpiece material was changed.

Figure 4.2: CNC turning centre

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5.0 RESULTS

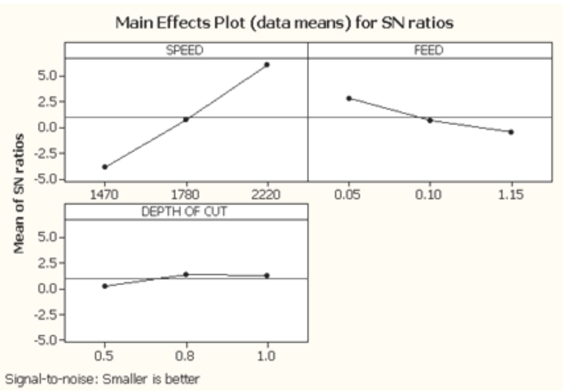
Input /Output Values

Material→	M1 (SS304)								
Parameter↓	T1 (Carbide)			T2 (Ceramic)			T3 (CBN)		
Speed	2220	1780	1470	2442	1958	1617	2686	2154	1779
Feed	0.05	0.10	1.15	0.06	0.12	1.32	0.06	0.13	1.45
Depth of cut	0.5	0.8	1.0	0.6	0.9	1.2	0.7	1.0	1.4
Surface finish	0.37	0.99	1.72	0.34	0.84	1.61	0.28	0.76	1.53

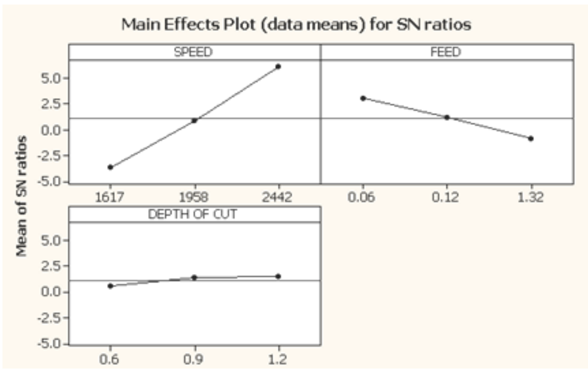
Material→	M2 (SAE 8645)								
Parameter↓	T1 (Carbide)			T2 (Ceramic)			T3 (CBN)		
Speed	2553	2047	1691	2808	2252	1860	3089	2477	2046
Feed	0.06	0.11	1.27	0.06	0.13	1.45	0.07	0.14	1.60
Depth of cut	0.6	0.9	1.2	0.7	1.1	1.4	0.8	1.2	1.7
Surface finish	0.58	1.9	2.54	0.54	1.54	2.36	0.51	1.52	2.3

Material→	M3 (EN9)								
Parameter↓	T1 (Carbide)			T2 (Ceramic)			T3 (CBN)		
Speed	2808	2252	1860	3089	2477	2046	3398	2725	2250
Feed	0.06	0.12	1.39	0.07	0.14	1.60	0.08	0.15	1.76
Depth of cut	0.6	0.9	1.3	0.8	1.1	1.5	0.9	1.3	1.7
Surface finish	1.36	1.88	3.14	1.29	1.85	3.01	1.17	1.78	2.9

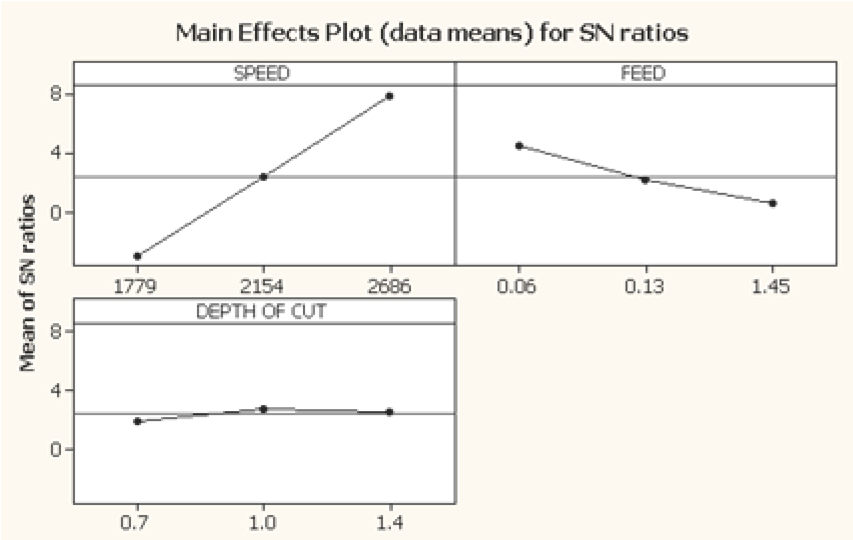
Plots for material Stainless Steel (SS304) using Taguchi Methods



(a) Carbide Tools



(b) Ceramic Tools



(c) CBN Tools

6.0 CONCLUSION

This paper has discussed an application of the Taguchi method for optimizing the cutting parameters in turning operations. This study discusses machining parameters, including different cutting tools for different materials, depth of cut, cutting speed and feed rate. The conclusions of this study may be summarized as follows:

1. Taguchi's robust design method is suitable to optimize the surface roughness in Turning.
2. It is found that the parameter of the taguchi method provides a simple, systematic, & efficient methodology for the optimization of the machining parameters.
3. The significant factors for the surface roughness in Turning were the spindle speed and the tool grade, with contribution of 10.2979 and 8.36734 respectively.
4. CBN Tools gives better surface finish compare to ceramic and carbide tools at all speeds, feeds and depth of cut

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