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An Investigation of Temperature, Surface Roughness And Material Removal Rate During Hard Turning of EN19 Material - A Review

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Abstract

The main aim of this Project work is to study experimentally the influence of depth of cut, cutting speed, and feed rate on the tool tip temperature, Material Removal Rate, Surface Roughness during turning process. The experiments will be obtained by varying one parameter while, the remaining two parameter were kept constant. So the influence of tool tip on different machining parameters is done in this research work. To increase the tool life, Taguchi Optimization method is used to optimization of machining parameters. The Taguchi method, a powerful tool of design optimization for quality, is used to find the optimal cutting parameters for turning operations. Through this study, not only the optimal cutting parameters for turning operations are obtained, but also the main cutting parameters that affect the cutting performance in turning operations will be evaluated. Experimental results will be provided to confirm the effectiveness of this approach. It will give the best result for turning operation of EN19 Material.
Keywords: EN19, MRR, Surface Roughness, Temperature, Optimization.

I. INTRODUCTION

Now a day, the qualitative and quantitative requirement of customer is frequently change. Maintaining the economic production with optimal use of resources is of prime concern for the engineers. Metal machining is one of them. Metal machining with various process parameters is one of them. Some challenges that the engineers come across are to find out the optimal parameters for the desired product quality and to maximize the performance of manufacturing using the available resources.

Turning is a very important machining process in which a single-point cutting tool removes material from the surface of a rotating cylindrical work-piece. The cutting tool is fed linearly in a direction parallel to the axis of rotation. The turning is carried out on a lathe that provides the power to turn the work-piece at a given rotational speed and to feed the cutting tool at a specified rate and depth of cut.

Therefore, three cutting parameters are listed below

- Cutting speed (v)
- Feed rate (f)
- Depth of cut (d)

It should be properly selected for performance evaluation criteria such as

- Surface finish
- Lower Temperature at Cutting zone,
- Less Tool wear and Long Tool life etc.

Turning is the removal of metal from the outer diameter of a rotating cylindrical work piece to a specified dimension, and to produce a smooth finish on the work-piece. Often the work piece will be turned so that adjacent sections have different diameters.

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.
- 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.

In a turning operation, it is an important task to select the cutting parameters to achieve a high cutting performance. Usually, the desired cutting parameters are determined based on experience or by using a handbook. However, this does not ensure that the selected cutting parameters have optimal or near optimal cutting performance.

Nowadays due to increase demand of people and increase industrial competition the product qualities as well as productivity become important issues in the industries. The challenge of modern machining industries is mainly focused on the achievement of high quality, in terms of work piece dimensional accuracy, high surface finish, high production rate, lower tool wear on the cutting tools, lower cutting forces and economy of machining in terms of cost saving. It is desirable to use modern machining system instead conventional machining system to achieve better product quality and high productivity.

In modern industry Automates and flexible manufacturing systems are employed for that purpose along with Computerized Numerical Control (CNC) machine tools that have become very common in factories and are capable of achieving high accuracy and very low processing time so the computer numerical controlled (CNC) machines play a major role in the modern machining industry. But due to large dimension of the workpiece the (CNC) machine is not capable to perform the machining process. So the machining operation will perform by the lathe machine.

A. TEMPERATURE

Heat phenomena that occur in the narrow and in the broad area of the cutting zone, are directly related to wear rate of tool, to the machinability rate of workpiece material, to the tool stability and related to many other characteristics of the machining process. Almost all work of cutting forces are turned into the thermal energy, as experimental investigations show. Generated heat goes from the cutting zone into the chips, tool, workpiece and into the environment, during which, the decrease of the hardness of tool's cutting elements, cutting wedge deformations, the loss of the tool cutting ability and its bluntness occur. Generated heat distribution in workpiece, in tool and in chips, that is, the temperature level at working elements of the tool, at processed surface and at chips depends on: workpiece material (its mechanical and chemical characteristics), cutting speed, feed rate, depth of cut, tool geometry, lubricants type and many other relevant parameters.

B. SURFACE ROUGHNESS

In today's manufacturing industry, special attention is given to dimensional accuracy and surface finish. The surface quality is an important performance criterion to asses' machinability of any material. Surface roughness is used as the critical quality indicator for the machined surface. Formation of a rough surface is a complicated mechanism involving many parameters. The quality of the work piece (either roughness or dimension) are greatly influenced by the cutting conditions, tool geometry, tool material, machining process, chip formation, work piece material, tool wear and vibration during cutting. Every machining process leaves its impact on the machined surface in the form of finely spaced irregularities. Each cutting tool leaves its own individual pattern on the surface. Roughness may be considered as being superposed on a wavy surface.

The maximum height (H_{max}) or the roughness form produced by a single point cutting tool is given by,

$$H_{max} = \frac{f^2}{8 \times R}$$

Where, f = feedrate,mm/min.
R= Nose Radius, mm

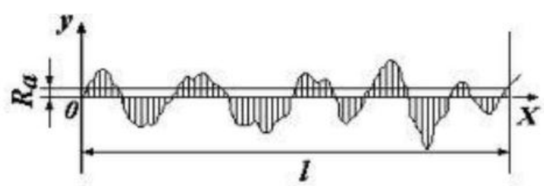

Fig. 1: Average Surfaces Roughness [15]

The CLA or Centre Line Average value of surface roughness (Ra) is the arithmetical average of the departure of the whole of the profile both above and below its centerline throughout the prescribed meter cut-off in a plane substantially normal to the surface.

$$Ra = \left(\frac{1}{L}\right) \int_0^L |z(x)| dx$$

Where z(x) is the ordinate of the profile curve, x is the profile direction and L is the sampling length. The unit of Ra is µm.

C. MATERIAL REMOVAL RATE

The Investigation presents the use of Taguchi method for optimizing the material removal rate in turning medium EN19 which is extensively used as a main engineering material in various industries such as Rollers, Supporting shafts, and Structural column etc. These materials are considered as easy to machining and possess superior machinability. Taguchi's orthogonal arrays are highly fractional designs, used to estimate main effects using only few experimental runs. These designs are not only applicable to two level factorial experiments, but also can investigate main effects when factors have more than two levels.

II. LITERATURE REVIEW ON HARD TURNING

A. Effect of cutting parameters on cutting force and surface roughness during finish hard turning AISI52100 grade steel, Gaurav Bartarya[1], S.K.Choudhury[2], Procedia CIRP 1 (2012) 651 – 656.

In this paper researcher had worked on effect of cutting parameters on cutting force and surface roughness during finish hard turning AISI52100 grade steel. The present work is an attempt to develop a force prediction model during finish machining of EN19 steel (equivalent to AISI 52100 steel) hardened to 60±2 HRC using hone edge uncoated CBN tool and to analyze the combination of the machining parameters for better performance within a selected range of machining parameters. A full factorial design of experiments procedure was used to develop the force and surface roughness regression models, within the range of parameters selected.

The regression models developed show that the dependence of the cutting forces i.e. cutting, radial and axial forces and surface roughness on machining parameters are significant; hence they could be used for making predictions for the forces and surface roughness. The predictions from the developed models were compared with the measured force and surface roughness values. To test the quality of fit of data, the ANOVA analysis was undertaken. The favorable range of the machining parameter values is proposed for energy efficient machining [1].

B. The effect of tool geometry and cutting speed on main cutting force and tool tip temperature, HaciSaglam[1], SuleymanYaldiz[2] ,FarukUnsacar[3] Materials and Design 28 (2007) 101–111.

This Researcher evaluated the effect of tool geometry and cutting speed on main cutting force and tool tip temperature. In this paper, the effects of rake angle and entering angle in tool geometry and cutting speed on cutting force components and the temperature generated on the tool tip in turning were investigated. The data used for the investigation derived from experiments conducted on a CNC lathe according to the full factorial design to observe the effect of each factor level on the process performance. As the experiments were designed using an orthogonal arrays, the estimates of the average effects will not be biased. During the tests, the depth of cut and feed rate were kept constant and each test was conducted with a sharp uncoated tool insert. The average deviation between measured and calculated force results were found as 0.26%. For statistical analyze the orthogonal arrays as L16 was used with a total of 16 tests. Finally, it was found that rake angle was effective on all the cutting force components, while cutting speed was effective on the tool tip temperature. The cutting force signals and temperature values provided extensive data to analyze the orthogonal cutting process [2].

C. Evolution during time of tool wear and cutting forces in the case of hard turning with CBN inserts", Mehdi Remadna[1], Jean FrancoisRigal[2], Journal of Materials Processing Technology 178 (2006) 67–754)

In this paper Researcher had worked on evolution during time of tool wear and cutting forces in the case of hard turning withCBN inserts. The objective of this paper is to determine the evolution of descriptive parameters during time when machining a hard material (alloyed steel 52 HRC-1900MPa) with a cubic boron nitride (CBN) tool. The resulting experimental data enable the analysis of cutting characteristics such as tool life, cutting forces, surface roughness and tool wear to be carried out. A large part of this paper aims at studying the turning of hard materials with CBN inserts, the correlation between wear evolution and the direction of cutting forces during high-speed machining. Due to cost considerations, these trial campaigns were carried out to obtain a maximum of results with a minimum number of attempts. Cutting forces increase gradually with the increase of the cutting distance and the tool flank wear of CBN tools does not directly or appreciably affect the manufactured surface [3].

D. Analysis of surface roughness and cutting force components in hard turning with CBN tool: Prediction model and cutting conditions optimization, HamdiAouici[1], Mohamed AthmaneYallese[2], KamelChaoui[3], TarekMabrouki[4], Jean-François Rigal[5] Measurement 45 (2012) 344–353.

This paper is related to analysis of surface roughness and cutting force components in hard turning with CBN tool: prediction model and cutting conditions optimization. In this study, the effects of cutting speed, feed rate, work piece hardness and depth of cut on surface roughness and cutting force components in the hard turning were experimentally investigated. AISI H11 steel was hardened to (40; 45 and 50) HRC, machined using cubic boron nitride (CBN 7020 from Sandvik Company) which is essentially made of 57% CBN and 35% TiCN. Four-factor (cutting speed, feed rate, hardness and depth of cut) and three-level fractional experiment designs completed with a statistical analysis of variance (ANOVA) were performed. Mathematical models for surface roughness and cutting force components were developed using the response surface methodology (RSM). Results show that the cutting force components are influenced principally by the depth of cut and work piece hardness. [4].

E. The effects of cutting tool geometry and processing parameters on the surface roughness of AISI 1030 steel, HasanGo¨kkaya[1] ,MuammerNalbant[2], Materials and Design 28 (2007) 717–721.

The researcher had worked on the effects of cutting tool geometry and processing parameters on the surface roughness of AISI 1030 steel. In this study, we have investigated the effects of different insert radii of cutting tools, different depths of cut and, different feed rates on the surface quality of the work pieces depending on various processing parameters. Properly, the AISI 1030 steel is processed at a digitally controlled computerized numerical control(CNC) turning lathe without using cooling water with three different insert radii (0.4, 0.8, and 1.2 mm) of cemented carbide cutting tools, coated with three layer coating materials (outermost is TiN) applied by the chemical vapour deposition CVD technique. The effects of five different depths of cut (0.5, 1, 1.5, 2, 2.5 mm) and five different feed rates/advancing steps (0.15, 0.2, 0.25, 0.30, 0.35 mm/rev) on the surface roughness values have been investigated by a turning process while from the cutting parameters the cutting speed is kept constant at (300 m/min). It is seen that the insert radius, feed rate, and depth of cut have different effects on the surface roughness. In the experiments, the minimum average surface roughness has been obtained using the cutting tools of maximum insert radius (1.2 mm). The surface roughness has been improved by 293% when the insert radius (0.4 mm) was increased by 200% (1.2 mm). When the feed rate (0.35 mm/rev) was reduced by 133% (0.15 mm/rev), the surface roughness have been improved by 313%, and by reducing the depth of cut (0.5 mm) by 400% (0.25 mm), an amelioration of 23% has been obtained on the surface roughness[5].

F. *Determination of optimum cutting parameters during machining of AISI 304 austenitic stainless steel, IhsanKorkut[1], Mustafa Kasap[2], Ibrahim Ciftci[3], UlviSeker[4], Materials and Design 25 (2004) 303–305.*

This paper determination of optimum cutting parameters during machining of AISI304 austenitic stainless steel. High strength, low thermal conductivity, high ductility and high work hardening tendency of austenitic stainless steels are the main factors that make their machinability difficult. In this study determination of the optimum cutting speed has been aimed when turning an AISI 304 austenitic stainless steel using cemented carbide cutting tools. The influence of cutting speed on tool wear and surface roughness was investigated. A decrease in tool wear was observed with increasing the cutting speed up to 180 m/min. Surface roughness (Ra) was also decreased with increasing the cutting speed. Correlation was made between the tool wear/surface roughness and the chips obtained at the three cutting speeds of 120, 150 and 180 m/min [6].

G. *Chip formation, cutting forces, and tool wear in turning of Zr-based bulk metallic glass, Mustafa Bakkal[1], Albert J. Shih[2], Ronald O. Scattergood[3], International Journal of Machine Tools & Manufacture 44 (2004) 915–925.*

The Researcher had worked on chip formation, cutting forces, and tool wear in turning of Zr-based bulk metallic glass. The chip light emission and morphology, cutting forces, surface roughness, and tool wear in turning of Zr-based bulk metallic glass (BMG) material are investigated. Machining results are compared with those of aluminum 6061-T6 and AISI 304 stainless steel under the same cutting conditions. This study demonstrates that the high cutting speeds and tools with low thermal conductivity and rake angle activate the light emission and chip oxidation in BMG machining. For the BMG chip without light emission, serrated chip formation with adiabatic shear band and void formation is observed. The cutting force analysis further correlates the chip oxidation and specific cutting energy and shows the significant reduction of cutting forces for machining BMG at high cutting speeds. The machined surface of BMG has better surface roughness than that of the other two work materials. Some tool wear features, including the welding of chip to the tool tip and chipping of the polycrystalline cubic boron nitride (PCBN) tool edge, are reported for turning of BMG. This study concludes that BMG can be machined with good surface roughness using conventional cutting tools [7].

H. *Effect of spindle speed and feed rate on surface roughness of Carbon Steels in CNC turning, N. Satheesh Kumar[1], Ajay Shetty[2], AshayShetty[3], Ananth K, HarshaShetty[4] , Procedia Engineering 38 (2012) 691– 697.*

The Researcher had worked on effect of spindle speed and feed rate on surface roughness of carbon steels in cnc turning. This paper investigates the effect of process parameters in turning of Carbon Alloy Steels in a CNC lathe. The parameters namely the spindle speed and feed rate are varied to study their effect on surface roughness. The experiments are conducted using one factor at a time approach. The five different carbon alloy steels used for turning are SAE8620, EN8, EN19, EN24 and EN47. The study reveals that the surface roughness is directly influenced by the spindle speed and feed rate. It is observed that the surface roughness increases with increased feed rate and is higher at lower speeds and vice versa for all feed rates [8].

III. CONCLUSION

As per review of research papers, we can see that researcher work on material AISI52100 grade steel, EN19, AISI 304 austenitic SS, AISI 1030 steel, MDN250 steel, SAE8620, EN8, EN24 and EN47 and various composite materials which possess high hardness. As per selecting the machining parameter there is increase the surface roughness and decrease the MRR, the aim of the paper is decided on approach of performance measurement of high material removal rate (MRR), low surface roughness (Ra) and low tool tip temperature during hard turning of EN19 material.

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