



“Study on process parameters for CNC turning using Taguchi Methods for EN24 alloy steel with Coated/Uncoated tool inserts”

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Abstract: The tool inserts, coated/uncoated offers a certain degree of control on the desired rate of material removal or the surface roughness to an extent. This work will helps to compare the results in terms of effectiveness of the performance of coated and uncoated tool inserts by varying process parameters at dry cutting condition. Levels shall be manipulated over the given range of operation while results would be recorded for analysis further. ANOVA & Taguchi methods are being considered to address the statistical treatment to the data. Significant input parameters shall be identified through the analysis of this data and the Design of experiments shall be performed to seek solution towards finding an optimal setting for the operation. The result shall be validated for a single optimal setting recommended towards the concluding phase of this work.

Keywords: Turning, Taguchi methods, ANOVA, coated/uncoated inserts, surface roughness

I. Introduction

Nowadays, Machining industries continuously demanding for higher production rate and improved machinability as quality and productivity play significant role in today's manufacturing market. The extent of quality of the procured item (or product) influences the degree of satisfaction of the consumers during the usage of the procured goods. Higher production rate can be achieved at high cutting speed, feed, depth of cut which is limited by tool wear, capability of tooling, surface finish and accuracy required selection of cutting parameters is generally a compromise between several variables and it can be easily possible to determine by using Response surface methodology. CNC machines are commonly used in industry. The operation of this machine is expensive because it has many parameters to consider. Optimization of cutting parameters is usually a difficult work where the following aspects are required: knowledge of machining; empirical equations relating the forces, power, surface finish, and dimensional accuracy etc. It has been long recognized that conditions during cutting, such as feed rate, cutting speed and depth of cut.

Trends in manufacturing industry have drive trends in metal cutting inserts developments. Changes in cutting parameters catalyze parallel advances in metal cutting tooling technology. Coated tools have found widespread use in today's metal cutting industry, bringing about significant improvements in tool performance and cutting economy through lower tool wear reduced cutting forces and better surface finish of the work piece. Coated and uncoated tools are widely used in the metal-working industry and provide the best alternative for most turning operations.

Figure.1 Uncoated and Coated tool inserts

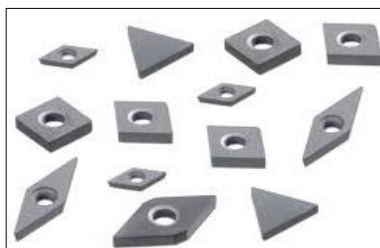


Figure 2 Insert holder tools



II. Literature Survey

J. S. Senthilkumaar et al [1] heat-resistant super alloy material like Inconel 718 machining is challenging task even in modern manufacturing processes. Therefore the genetic algorithm coupled with artificial neural network (ANN) as an intelligent optimization technique for machining parameters optimization of Inconel 718. The combined effects of cutting speed, feed, and depth of cut on the performance measures of surface roughness and flank wear were investigated by the analysis of variance.

Waleed Bin Rashid et al [2] provided the experimental results of hard turning of AISI 4340 steel (69 HRC) using a cubic boron nitride (CBN) cutting tool. An orthogonal array was implemented using a set of judiciously chosen cutting parameters. Taguchi's approach allows the study of the whole parameter space with a limited number of experiments, as long as they are carried out in a planned orthogonal array. This methodology helps reduce the variability of the response variable and is therefore an important tool for improving the productivity of the experiments.

Carmita Camposeco-Negrete et al [3] material removal rate was set to a constant value in all the experimental trials so as to analyze the effect that the cutting parameters have on the energy consumed. Environmental studies indicate that most of the environmental impacts related to machine tools are due to their energy consumption. Traditional estimates of the power required for turning processes are based on the process parameters, which are optimized in order to minimize the power needed for material removal.

Radhakrishnan Ramanujam et al [4] investigation on turning Aluminium Silicon Carbide particulate metal matrix composite (Al-SiC-MMC) using polycrystalline diamond (PCD) 1600 grade insert. Analysis of variance (ANOVA) is used to investigate the machining characteristics of metal matrix composite (A356/10/SiCP). The objective was to establish a correlation between cutting speed, feed and depth of cut to the specific power and surface finish on the work piece. Analysis of Variance is a method of apportioning variability of an output to various inputs. The purpose of the analysis of variance is to investigate which machining parameters significantly affect the performance characteristic.

Chinnasamy Natarajan et al [5] surface roughness is an indicator of surface quality and is one of the most-specified customer requirements in a machining process. For efficient use of machine tools, optimum cutting parameters (speed, feed, and depth of cut) are required. So it is necessary to find a suitable optimization method which can find optimum values of cutting parameters for minimizing surface roughness. In this work, machining process has been carried out on brass C26000 material in dry cutting condition in a CNC turning machine and surface roughness has been measured using surface roughness tester. To predict the surface roughness, an ANN model has been designed through feed-forward back-propagation network using Matlab software for the data obtained. Comparison of the experimental data and ANN results show that there is no significant difference and ANN has been used confidently. The results obtained conclude that ANN is reliable and accurate for predicting the values.

Dong Chen et al [6] during turning process, the cutting force is generated between the cutting tool and workpiece, incurring an elastic deformation upon the machining system comprising of chuck, cutting tool, and workpiece. Furthermore, the chatter may also be caused under certain conditions. Unstable cutting caused by chatter vibration in the machining process has major effect upon the surface quality of the workpiece, as a result, improving the cutting stability becomes one of the key aims regarding the dynamic optimization. Recent works on the analysis of stability is proposed a new spindle speed regulation method to avoid regenerative chatter in turning operations. According to the method, the material removal rate could be greatly improved regardless of the complex cutting dynamics.

Surinder Kumar et al [7] the performance of different tool materials, such as ceramic, cemented carbide, CBN, and diamond, was observed while turning. The experimental results showed that only diamond tools are suitable to finish the turning. The turning of glass fiber-reinforced polyester and epoxy increased surface roughness with the increase in feed rate, while demonstrating independence on the cutting velocity.

S. Rajesh et al [8] presents the findings of an experimental investigation into the effects of cutting speed, feed rate, depth of cut, and nose radius in CNC turning operation performed on red mud-based aluminum metal matrix composites and investigates optimization design of a turning process performed on red mud-based aluminum metal matrix composites. The major performance characteristics selected to evaluate the process are surface

roughness, power consumption, and vibration, and the corresponding turning parameters are cutting speed, feed, depth of cut, and nose radius.

Tian-Syung Lan et al [9] surface roughness, tool wear, and material removal rate are major intentions in the modern computer numerical controlled machining industry. Through the machining results of the CNC lathe, it was shown that both tool wear ratio and MRR from our optimum competitive parameters are greatly advanced with a minor decrease in the surface roughness in comparison to those of benchmark parameters. Surface roughness, tool life, and cutting force are commonly considered as manufacturing goals for turning operations in many of the existing research studies. It is also recognized that lighter cutting force often results in better surface roughness and tool life.

Lakhdar Bouzid et al [10] in modern industry, the goal is to manufacture low-cost, high quality products with maximum productivity in a short time. Turning is the most common method for cutting and especially for the finishing of machined parts. Furthermore, in order to produce with desired quality and maximum productivity of machining, cutting parameters selected properly. In turning process, parameters such as materials, tool's geometry and cutting conditions (depth of cut, feed rate, cutting speed) have impact on the material removal rate and the machining qualities like the surface roughness. Usually, roughness is taken as a good criterion for a mechanical component performance and to appraise production cost, while material removal rate can be defined as the volume of material removed divided by the machining time. Another way to define MRR is to imagine an "instantaneous" material removal rate as the rate at which the cross-section area of material being removed moves through the workpiece.

III. Concluding Remark

Thus from the literature survey it is concluded that, surface roughness, tool wear and material removal rate are the major intentions in the modern CNC machining industry. Turning is the most common method for cutting and especially for the finishing of machined parts. Many researchers investigate the effects of cutting speed, feed rate, depth of cut, and nose radius in CNC turning operation performed on various materials. Thus from the literature survey it is concluded that many researchers have studied the influence of various machining parameters that affect the surface roughness during machining. The various optimization techniques are used for minimization of surface roughness. Review of literature shows that optimization is one of the effective techniques used in manufacturing sectors to arrive at the best manufacturing conditions, which is an essential need for industries towards manufacturing of quality products at lower cost.

The geometry of the insert, its composition and coating on its working surface influences the rate of material removal. The study over the extent of contribution of the surface coating over the insert is relevant in this context of performance enhancement of the cutting operation. The efficiency of the operation given the variables like Speed, Feed and Depth of cut shall be investigated to offer optimum settings for realizing high rate of material removal or to offer a good surface finish or to minimize tool wear. The study would benefit the industry in realizing higher productivity with a better quality product while minimizing the operating cost in terms of number of spares for tool inserts.

IV. Problem Definition

Turning refers to the machining operation effected by chip removal from the stock of the raw material using a CNC machine. The control parameters for the operation need to be optimized to effect the best response in terms of surface roughness or the temperature at the cutting tip. The desired value of surface roughness should be attempted while optimizing the resources assigned to the operation. If the surface speed of the turning operation is increased, a favorable surface roughness could be realized but at the cost of lower tool-life (due to increased cutting temperature) or any other side effects of maintaining a high surface speed. Similarly, the use of coated tool inserts could be beneficial but the increased purchase cost should be negated with the realization of the additional benefit in using coated inserts. The rate of material removal consequently the production rate is influenced by the choice of the levels assigned for these control parameters. Work needs to be undertaken for determining optimum levels for the significant parameters to ensure that the process does not run on sub-optimal setting leading to reduced production and/or increased rejections in terms of response parameters.

V. Workpiece Material and Tool Inserts

EN24 alloy steel -

Tensile Strength – 850/1000 N/mm²

Typical Chemical composition of EN24 alloy steel							
C	SI	MN	S	P	Cr	Mo	Ni
0.36/0.44	0.10/0.35	0.45/0.70	0.040 max	0.035 max	1.00/1.40	0.20/0.35	1.30/1.70

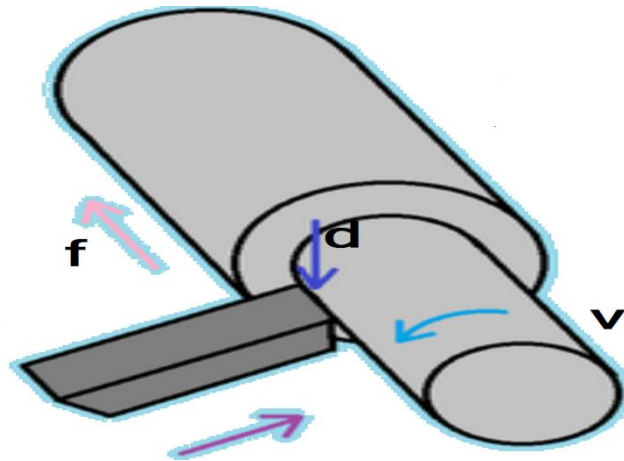
Applications of EN24 alloy steel:

- Propeller or Gear shaft
- Connecting rod

Tool inserts - The uncoated i.e. Cemented Carbide insert and Coated i.e. PVD coated TiAlN insert using for machining of EN24 alloy steel.

VI. Parameters

Figure 3 Principle of metal cutting



A) Input Parameters:

- Cutting Speed v (m/min)
- Feed Rate f (mm/rev.)
- Depth of Cut d (mm)

B) Output Responses:

- Surface Roughness- Surface roughness tests are to be conducted on all the samples, after each of the trials.
- Material Removal Rate (MRR) – The material removal rate of the work piece is measured by ratio of the difference between weight of the workpiece before and after machining to the machining time that is achieved.

VII. Methodology

1. The literature reviewed on effect and optimization of different machining parameters speed, feed, depth of cut flutes for minimum surface roughness and maximum material removal rate in turning operation.
2. The experiments will be planned according to Taguchi design of experiments method to find the effect of machining parameters i.e. speed, feed and depth of cut on response variables under study.
3. The surface roughness and material removal rate for different combinations of speed, feed, and depth of cut will be measure.
4. The experimentation will be done on CNC machine for EN24 alloy steel workpiece. The surface roughness and material removal rate will be record.
5. For the analysis purpose, 'Minitab' Software shall be used. In this research work, we shall use the tools such as Taguchi Method/ANOVA.
6. Optimization of process parameters will be carried out by using suitable techniques.
7. The result and discussion carried out from observed data.

VIII. Expected Outcome

This research work will helps to compare the results in terms of effectiveness of the performance of coated and uncoated tool inserts by varying process parameters at dry cutting condition. The tool inserts, coated or uncoated

offers a certain degree of control on the desired rate of material removal or the surface roughness to an extent. This work pursues the quest for realizing the optimal values for the significant process parameters that bears an influence on the response parameters.

IX. Conclusion

The literature review suggests that the critical parameters for turning operation could be listed as Speed, Feed and Depth of cut. While the maximum allowable cutting speeds could be referred from the catalogue of the tool manufacturers, the feed and depth of cut could be arrived at upon experimenting with the test samples. Coated and uncoated tool inserts from well-known manufacturer shall be used for the experiment. Analysis is considered using Statistical treatment for the data with DOE tools. EN24 being a steel finding wide applications in Engineering industry, has been identified as the material for the Test Piece for pursuing this research work.

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