

A Review on Optimization of Cutting Parameters of Different Engineering Materials for Surface Roughness in Turning Process

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ABSTRACT: The influence of cutting parameters in the turning process mainly affects the surface roughness and machining time of product. Surface roughness is an important factor at the point of view quality of the product. The important cutting parameters in turning process mainly cutting speed, feed rate, depth of cut, spindle speed affect the surface finish of the finished material. This paper reviews the optimization of cutting parameters in turning process using Taguchi method. Taguchi method is a powerful tool of optimization. A specially designed orthogonal array of taguchi is used to investigate the effect of cutting parameters through the small number of experiments. ANOVA (Analysis of variance) is used to find out which input parameters significantly affect the performance characteristics. Signal to Noise (S/N) ratio is used to measure the variations of experimental data. The analyzed data is used to find out optimum cutting parameters level and also used to find out most contributing factor.

KEYWORDS: Turning, Surface Roughness, Taguchi Method, ANOVA, S/N Ratio

I. INTRODUCTION

The development of manufacturing technologies to improve machining and obtain high productivity has become a very important goal in modern industry. The challenge of modern machining industries is mainly focused on the achievement of high quality, in terms of work piece dimensional accuracy, surface finish, high production rate, less wear on the cutting tools, economy of machining in terms of cost saving and increase the performance of the product with reduced environmental impact.[9] In actual practice, there are many factors affect the surface roughness like cutting conditions (speed, feed and depth of cut), tool variables (tool material, nose radius, rake angle, cutting edge geometry, tool vibration, tool overhang, tool point angle etc.) and work piece variables (material, hardness and other mechanical properties etc.). So, to achieve good surface finish, it is necessary to select the most appropriate machining setting in order to improve cutting efficiency.[10] Metal cutting is one of the vital processes and widely used manufacturing processes in engineering industries. Highly competitive market requires high quality products at minimum cost.[8] Turning operation using a single point cutting tool has been one of the oldest and popular methods of metal cutting.[3] Turning can be done on lathe machine or by using CNC (computer numerical control) machine. A CNC is commonly used with many other types of machine.[12] The cutting tool is fed linearly in a direction parallel to the axis of rotation. Turning produces three cutting force mainly cutting thrust force, feed force and the radial force.[8]

1.1 Surface Roughness

Surface roughness and material removal rate plays a vital role in deciding about the productivity in global manufacturing. Surface roughness and material removal rate is one of the important quality control parameter for evaluating of production process. Efficient turned component improves many functional attribute like excellent tolerance, less tool wear, fatigue strength or creep life, load bearing capacity, corrosion strength and frictional resistance etc.[1,2] Surface roughness determines how a real object interacts with its environment. Rough surfaces

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 6, Issue 6, June 2017

usually wear more quickly and have high friction coefficient than smooth surfaces.[5] As far as turned components are concerned, better surface finish (low surface roughness) is important as it can reduce or even completely eliminate the need of further machining.[2]

1.2 Taguchi Method

Optimization in turning processes is considered a vital role for continual improvement of output quality in product and processes include modelling of input output and in process parameters relationship and determination of optimal cutting conditions. The effects of process parameters on tool life, surface roughness and maximum material removal rate on turning process and the subsequent optimal settings of parameters are accomplished using Taguchi's method.[1,11] Design of Experiments (DOE) is an experimental strategy in which effects of multiple factors are studied simultaneously by running tests at various levels of the factors. Minitab software was used for generating the Taguchi's orthogonal array.[15] The Taguchi method uses *S/N* ratio to measure the variations of experimental design. The word signal says the desirable value and the word noise says the undesirable value.[7]

II. LITERATURE REVIEW

Surendra Kumar Saini et al. (2014) [1] investigated Optimization of Multi-Objective Response during CNC Turning using Taguchi-Fuzzy Application. In this research work CNC turning operation is carried out using L27 Taguchi orthogonal arrays on Aluminum alloy 8011 with carbide insert and influence of CNC turning process parameters like Cutting Speed, Feed and Depth of Cut are analyzed for material removal rate and surface roughness.

Dr. C. J. Rao et al. (2013) [2] studied Influence of cutting parameters on cutting force and surface finish in turning operation. This research showed that significance of influence of speed, feed and depth of cut on cutting force and surface roughness while working with tool made of ceramic with an Al₂O₃+TiC matrix (KY1615) and the work material of AISI 1050 steel. Taguchi method was used for the experiments. Analysis of variance with adjusted approach has been adopted.

M. Durairaj et al. (2013) [3] investigated Parametric Optimization for Improved Tool Life and Surface Finish in Micro Turning using Genetic Algorithm. This paper deals with CNC Micro turning of Inconel 600 alloy with titanium carbide coated tool. Machining is done in DT-110 integrated multiprocessor micro machine tool. Micro turning is carried out with full factorial experiments with various combinations of cutting parameters such as speed, feed and depth of cut and output parameters such as the tool wear and the surface roughness are measured.

Suha K. Shihab et al. (2014) [4] analyzed RSM Based Study of Cutting Temperature during Hard Turning with Multilayer Coated Carbide Insert. In this study the effect of cutting parameters (cutting speed, feed rate and depth of cut) on the cutting temperature in hard turning of AISI 52100 alloy steel using multilayer coated carbide insert were investigated. Significance of the cutting parameters was determined using statistical analysis of variance (ANOVA). Response surface methodology (RSM) was employed to determine optimal values of cutting parameters.

L B Abhang et al. (2014) [5] focused on Parametric investigation of turning process on en-31 steel, investigated turning process parameters on steel. Experiments have been conducted using factorial design, to study the effect of machining parameters such as cutting speed, feed rate, depth of cut, tool nose radius and lubricant on surface roughness while turning En-31 steel. The Results have been analyzed by the variance technique and the F-test.

Arshad Noor Siddiquee et al. (2014) [6] studied Optimization of Deep Drilling Process Parameters of AISI 321 Steel using Taguchi Method for minimizing surface roughness. The experiments were conducted on CNC lathe machine using solid carbide cutting tool on material AISI 321 austenitic stainless steel. Four cutting parameters such as cutting fluid, speed, feed and hole-depth, each at three levels except the cutting fluid at two levels were considered. Taguchi L18 orthogonal array was used as design of experiment. The signal-to-noise (S/N) ratio and the analysis of variance (ANOVA) was carried out to determine which machining parameter significantly affects the surface roughness and also the percentage contribution of individual parameters.

M. Balaji et al. (2016) [7] Studied Optimization of Cutting Parameters in Drilling Of AISI 304 Stainless Steel Using Taguchi and ANOVA. The study deals with the effect of cutting parameters namely cutting speed, feed rate and helix angle on the tool life. The experiments were performed on drilling of AISI304 steel with carbide drill bits. Design of experiments was prepared according to Taguchi orthogonal array of L8 and experiments were performed with two levels of the cutting parameters. The effects of cutting parameters were analyzed by evaluating the amplitude of

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drillbit vibration and surface roughness. Taguchi and Analysis of Variance methods were used to identify significant cutting parameters affecting the drill bit vibrations and surface roughness.

Harsh Y Valera et al. (2014) [8] Investigated Surface Roughness and Power Consumption in Turning Operation of EN 31 Alloy Steel coated tungsten carbide tool under different cutting parameters. The study showed the influences of three cutting parameters like spindle speed, depth of cut and feed rate affecting surface roughness as well as power consumption while turning operation of EN-31 alloy steel.

Sujit Kumar Jha (2016) [9] investigated Parametric Optimization of Turning Process Using Taguchi Method and Anova Analysis. This paper identify the impacts of process parameters such as cutting speed, feed and depth of cut on material removal rate (MRR) during machining on CNC machine of aluminum material. An orthogonal array of size L9 has been constructed to find out the optimal levels of the turning parameters and further signal-to-noise (S/N) ratio has been computed to construct ANOVA table.

Ch. Maheswara Rao et al. (2016) [10] On his paper Optimization of Surface Roughness in CNC Turning Using Taguchi Method and ANOVA, studied the effect of cutting parameters (speed, feed and depth of cut) in CNC turning of AA7075 to achieve low Surface Roughness using tungsten carbide insert. The experiments were designed as per the Taguchi's L9 Orthogonal array technique. Analysis of variance (ANOVA) was performed to find the significance of the cutting parameters on the Surface roughness.

Shivam Goyal et al. (2016) [11] Investigated Experimental Study of Turning Operation and Optimization of MRR and Surface Roughness Using Taguchi Method. In this research work turning operation is performed on AISI 1020 mild steel. The experiments were performed by taking Cutting Speed, Feed Rate & Depth of cut as process parameters and got the optimized value of MRR & SR. An L9 orthogonal array, the S/N ratio are employed to the study the performance characteristics in the turning using carbide insert with a nose radius of 0.8mm.

Table 1: Literature Summary

Sr. No.	Author	Year	W/P Material	Experimental Run	Parameters		Most Significant
					Input	Output	
1.	Surenda Kumar Saini et al	2014	Aluminium Alloy 8011	27	Cutting Speed Feed Depth of Cut	MRR & Surface Roughness	Feed
2.	Dr. C. J. Rao et al.	2013	AISI 1050 Steel	27	Speed Feed Depth of Cut	Cutting Force & Surface Roughness	Feed Rate
3.	M. Durairaj et al.	2013	Inconel 600 Alloy	27	Speed Feed Depth of Cut	Tool Wear & Surface Roughness	At all minimum level of Input Parameter
4.	Suha K. Shihab et al.	2014	AISI 52100 Alloy steel	20	Cutting Speed Feed rate Depth of Cut	Cutting Temperature	All Input Parameters

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5.	L B Abhang et al.	2014	En-31 Steel Alloy	24	Cutting Speed Feed rate Depth of Cut Tool nose radius	Surface Roughness	Feed Rate
6.	Arshad Noor Siddiquee t al.	2014	AISI 321 Austenitic SS	18	Cutting Fluid Speed Feed Hole Depth	Surface Roughness	Speed
7.	M. Balaji et al.	2016	AISI 304 Steel	8	Cutting Speed Feed rate Helix Angle	Surface Roughness & Drill bit Vibration	Helix Angle
8.	Harsh Y Valera et al.	2014	En-31 Steel Alloy	15	Spindle Speed Depth of Cut Feed rate	Surface Roughness & Power Consumption	Speed
9.	Sujit Kumar Jha	2016	Aluminium Material	9	Cutting Speed Feed Depth of Cut	Material Removal Rate	Depth of Cut
10	Ch. Maheswara Rao et al.	2016	Aluminium Alloy 7075	9	Cutting Speed Feed Depth of Cut	Surface Roughness	Feed & Cutting Speed
11.	Shivam Goyal et al.	2016	AISI 1020 Mild steel	9	Feed Depth of Cut Cutting Speed	MRR & Surface Roughness	Depth of Cut & Cutting Speed

III. CONCLUSION

In this work, attempt has been made to present a literature review on optimization of cutting parameters of different engineering materials for surface roughness in turning process. From literature it is observed that Surface roughness is the most significant response parameter at the point of view quality of the product so most of the researchers have taken it into investigation. Input parameters (Controllable factors) such as cutting speed, depth of cut, feed rate, and spindle speed are mainly taken for investigation. From investigation it is found that feed rate is the most significant parameter for surface roughness and also optimal combination of Input parameters is important for good surface finish.

Future research work can be done on further optimization of cutting parameters. In turning process material of cutting tool or insert is an important factor at the point of surface finish. Here more practical options are available to use different types of cutting inserts with varying tool nose radius for future work. Also future work can be done on different engineering material with different response parameters like Material removal rate (MRR), Tool wear, Cutting Force, Power consumption, Machining time (Cycle time) etc.

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 6, Issue 6, June 2017

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