EXPERIMENTAL INVESTIGATION ON THE EFFECT OF CUTTING PARAMETER ON SURFACE FINISH OBTAINED IN CNC TURNING OPERATION BY USING TAGUCHI METHOD: A REVIEW

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Abstract: Nowadays, surface finish has become an important indicator of quality and precision in manufacturing processes and it is considered one of the most significant parameter in industry. In this present study, the influence of different machining parameter surface roughness has been analyzed through experiments. For this experiment the material used is stainless steel420. Stainless steel420 is one of the highly used materials in thermodynamic steam trap and manufacturing industries. Most of the metal parts are manufactured by machining resulting in one of the most vital characteristics of all metal parts which is the surface roughness of the machined surfaces. Moreover, DOE techniques have been used to predict the surface quality and to select the optimal turning conditions. In this study an experimental investigation of cutting parameters (spindle speed, feed and depth of cut) in turning operation of stainless steel420 was done and influence of cutting parameters on surface roughness, tool wear, material removal rate was studied. The machining was performed using tool such as tungsten carbide tool (0.4). Taguchi method is used to find optimum result. Orthogonal array, signal to noise ratio and used to study the performance characteristics in turning operation

Keywords: SR, TWR, MRR, ANOVA, S/N-RATIO,

1. Introduction

Turning is an important and widely used manufacturing process in engineering industries. The study of metal removal focuses on the features of tools, input work materials, and machine parameter settings. The technology of metal removal using turning operations has grown substantially over the past decades and several branches of engineering have contributed to this to achieve the various objectives of the process. Selection of optimal machining conditions is a key factor in achieving these objectives. There are large numbers of variables involved in the turning process. These can be categorized as input variables and output variables. Various input variables involved in the turning process are: cutting speed, feed, depth of cut, number of passes, work material and its properties, tool material and tool geometry, cutting fluid properties and characteristics, etc. Similarly, the output variables associated with the turning process are: production cost, production time, tool life, dimensional accuracy, surface roughness, cutting forces, cutting temperature, and power consumption, etc. For optimization purposes, each output variable is taken as a function of a set of input variables. To achieve several conflicting objectives of the process, optimum setting of the input variables is very essential, and should not be decided randomly on a trial basis or by using the skill of the operator. Use of appropriate optimization techniques is needed to obtain the optimum parameter settings for the process.

2. Literature Review

Bhosale et al. [1], discusses on the parameter optimization of CNC lathe machining for surface roughness using the Taguchi method, where surface roughness generated during machining. In the parameter optimization, the parameters are cutting speed, feed, and depth of cut. After selecting parameters turning on CNC lathe is to be done and selected orthogonal array and parameters used for the optimum set of combined controlled parameters for surface roughness. Into this combination of parameters selected for minimum surface roughness value and for the optimum combination of parameters by Taguchi design. Taguchi orthogonal array L9 for three parameters cutting speed, feed rate, and depth of cut with its combination surface roughness measured.

Material-Mild Steel

Result-cutting speed-1800rpm, feed rate-0.1mm/min, depth of cut-0.4mm, surface roughness-1.27µ.

Davis et al. [2], The present experimental study is concerned with the optimization of cutting parameters (depth of cut, feed rate, spindle speed) in wet turning of EN24 steel (0.4% C) with hardness 40+2 HRC. In the present work, turning operations were carried out on EN24 steel by carbide P-30 cutting tool in wet condition and the combination of the optimal levels of the parameters was obtained. The Analysis of Variance (ANOVA) and Signal-to-Noise ratio were used to study the performance characteristics in turning operation. The results of the analysis show that none of the factors was

found to be significant. Taguchi method showed that feed rate followed by depth of cut and spindle speed was the combination of the optimal levels of factors while turning EN24 steel by carbide cutting tool.

Material-EN24Steel

Result-cutting speed-2340rpm, feed rate-1.81mm/min, depth of cut-1.5mm, surface roughness-20.06µ.

Rudrapati et al. [3], Present work is to analyze the significance of turning parameters on surface roughness in computer numerically controlled (CNC) turning operation while machining of aluminium alloy material. Spindle speed, feed rate and depth of cut have been considered as machining parameters. Experimental runs have been conducted as perBox-Behnken design method. After experimentation, surface roughness is measured by using stylus profile meter. Factor effects have been studied through analysis of variance. Mathematical modelling has been done by response resurface methodology, to made relationships between the input parameter s and output response. Finally, process optimization has been made by teaching learning based optimization (TLBO) algorithm. Predicted turning condition has been validated through confirmatory experiment.

Material-Aluminium alloy

Result-cutting speed-700rpm, feed rate-25mm/min, depth of cut 0.2mm, surface roughness 0.42081µ.

Ganesh et al. [4], CNC turning is one among the metal cutting process in which quality of finished product mainly depends upon the machining parameters such as speed, feed, depth of cut, type of inserts used etc. similarly work piece material plays an important role in metal cutting process .Soft material such as aluminium, aluminium alloys are easy to machine due to their high accuracy. While machining their soft materials, optimized machining parameters results in good surface finish, tool wear, MRR etc. This study involves in identifying the optimized parameters in CNC turning of aluminium. The optimization technique numerical optimization used in this study is response surface methodology. These optimization techniques are very helpful in identifying the optimized control factors with high level of accuracy.

Material-aluminium material

Result-The desirability of the optimization value 0.7692

Saraswat et al. [5], In the present work the cutting parameters (depth of cut, feed rate, spindle speed)have been optimized in turning of mild steel of in turning operations on mild steel and as a result of that the combination of the optimal levels of the factors was obtained to get the lowest surface roughness. The Analysis of Variance (ANOVA) and Signal-to-Noise ratio were used to study the performance characteristics in turning operation. The analysis also shows that the predicted values and calculated values are very close, that clearly indicates that the developed model can be used to predict the surface roughness in the turning operation of mild steel.

Material-EN9

Result-cutting speed m/min-1, feed rate-1mm/rev, depth of cut-1mm, surface roughness 2.220µ

Magdum and Naik. [6], study used for optimization and evaluation of machining parameters for turning on EN8 steel on Lathe machine. This study investigates the use of tool materials and process parameters for machining forces for selected parameter range and estimation of optimum performance characteristics. Develop a methodology for optimization of cutting forces and machining parameters.

Material-EN8 steel

Result-Trust force z has been found minimum at second level of parameter A (Tool shape and material - (-49.17), second level of parameter B (cutting speed-(-48.17), first level of parameter c (depth of cut-(-47.53), first level of parameter D (feed-(-46.7).Similarly feed force Y has been found minimum at second level of parameter A (-41.9), second level of parameter B (cutting speed -(-41.17),first level parameter C (depth of cut-(-41.82), first level of parameter D-(-39.99).

Kumar and Kumar. [7], optimization of process parameters in turning process using Taguchi method (L9) in order to obtain efficient Material Removal Rate (MRR). EN 24 is used as work piece for carrying out experiment to optimize Material Removal Rate which is influenced by three machining parameters namely spindle speed, feed rate and depth of cut. Different experiments are done by varying one parameter and keeping other two fixed so that optimized value of each parameter can be obtained. In this project dry turning operation of EN 24 graded steel is performed using HSS tool. The range of cutting parameters at three levels are spindle speed (200, 350 and 500 rpm), feed rate (0.1, 0.15 and 0.2

mm/rev), depth of cut (1.0, 1.5 and 2.0 mm) respectively. Taguchi method is a good method for optimization of various machining parameters as it reduces number of experiments. Taguchi orthogonal array is designed with three levels of process parameters and ANOVA is applied to know the influence of each parameter on Material Removal Rate. For the given set of conditions, spindle speed influences more on Material Removal Rate followed by feed rate and depth of cut.

Material-EN-24

Result-cutting speed-350rpm, depth of cut-1.5mm, feed 0.1mm, SN.ratio67.10, MRR-4123.341mm3/min.

Raveendra et al. [8], Finding optimal control parameters to get the minimum Surface roughness. It considers the analysis of effect of the process parameters, cutting speed, feed rate and depth of cut on cutting forces during turning operation. Machining is the process of removing the excess material from the work piece or unwanted material from the work piece using cutting tool. Surface finish obtained in machining process depends upon so many factors like work material, tool material, tool geometry, machining conditions, cutting fluids used and feed rate etc. In this experimental work it is planned to study the effect of process parameters on surface finish obtained in the machining process of materials like stainless steel and aluminium.

Material-cobalt steel

Result-cutting speed-1200rpm, depth of cut-0.1mm, feed rate-0.25mm/min, surface roughness-1.38µ.

Pawar and Palhade. [9], machining parameters including cutting speed, feed rate and depth of cut on surface roughness(Ra) and material removal rate(MRR) in a turning of HSS(M2) are investigated using the Taguchi method and ANOVA. A three level, four parameter design of experiment,L9 orthogonal array using Minitab 14 software, the signal-to-noise (S/N) ratio is employed to study the performance characteristics in the turning of HSS(M2) by taking nose radius of Tin coated carbide inserts tool of 0.4,0.8 and 1.2 mm on CNC turning centre. The analysis of variance (ANOVA) is applied to study the percentage contribution of each machining parameters while CNC turning of HSS (M2) material. The all experimental trials are conducted in dry machining environment and at a constant spindle speed 2800 rpm. The results are verified by taking confirmation experiments. The present investigation indicates that feed rate and nose radius are the most significant factors in case of material removal rate and surface roughness for turning of HSS (M2) material.

Material-High speed steel [M2]

Result-cutting speed-250rpm, depth of cut-0.15mm, feed rate-0.75mm/min, surface roughness-0.80µ.

Bhateja et al. [10], election of various process and performance parameters after parameter selection aims to study various techniques for the optimization for that purpose literature review and industrial survey is conducted. After this next objective is to study the process and machining parameters for the performance characteristics of turning operation on CNC using different grades of Tungsten Carbide and with varying properties & surface roughness testing of work piece material to be carried out after machining. After testing optimization and compare the Effect of cutting parameters on surface roughness of different selected geometry on EN-24 alloy steel by using empirical approach i.e. Taguchi Analysis using Statistical Software. In the end also aims to calculate Tool Wear Rate (TWR) & Material Removal Rate (MRR) related with the performance parameters based upon the experimental investigation.

Material-EN24 Alloy steel

Result- cutting speed-1800rpm, feed rate-0.2mm/rev, depth of cut-1mm, surface roughness-035µ.

Garg et al. [11], Machining of medium Brass alloy is very difficult. There are a number of parameters like cutting speed, feed and depth of cut etc. which must be given consideration during the machining of medium Brass alloy. This study investigates the effects of process parameters on Material Removal Rate (MRR) in turning of C34000. The single response optimization problems i.e. optimization of MRR is solved by using Taguchi method. The optimization of MRR is done using twenty seven experimental runs based on L'27 orthogonal array of the Taguchi method are performed to derive objective functions to be optimized within the experimental domain When the MRR is optimized alone the MRR comes out to be 8.91. The optimum levels of process parameters for simultaneous optimization of MRR have been identified.

Material-medium brass alloy C (340000).

Result-The best setting of input parameters for defect free turning maximum material removal rate within the selected range is as follows: cutting speed 55m/min, feed rate 0.35mm/rev, depth of cut 0.2mm.

Sharma and Bhambri. [12], the optimization of two response parameters (Surface roughness and Material Removal Rate) by three machining parameters (cutting speed, feed rate and depth of cut) is investigated in high speed turning of H13 in dry conditions. Taguchi's L'18 orthogonal array and analysis of variance (ANOVA) are used for individual optimization. The simultaneous optimization is done by Grey Relational Analysis approach. The different levels of all machining parameters are used and experiments are done.

Material-AISI H13

Result-cutting speed-210m/min, feed 0.1mm/rev, depth of cut 1.0 mm MRR 535.71MM/S, surface roughness 0.48µ.

Kamala et al. [13], in this paper Taguchi method has been employed with L25 (5^3) Orthogonal Array for three parameters namely Speed, Feed and Depth of cut. For each of these parameters five different levels have been identified and used to perform the turning parameters for maximization of material removal rate on an EMCO Concept Turn 105CNC lathe. The material selected for machining was SAE 1020 with carbide cutting tool. The MRR is observed as the objective to develop the combination of optimum cutting parameters. This paper proposes an optimization approach using orthogonal array for the maximized MRR and the result from this study confirms the same.

Material-Mild steel 1020.

Result-cutting speed 5 m/s, feed rate 5mm/rev, depth of cut 4mm, MRR 4492.06 mm/min SN ratio 73.048918 (dB).

Kaladhar, et al. [14], in this work, AISI 304 austenitic stainless steel work pieces are turned on computer numerical controlled (CNC) lathe by using Physical Vapors Deposition (PVD) coated cermet insert (Ticn- TiN) of 0.4 and 0.8 mm nose radii. The results revealed that the feed and nose radius is the most significant process parameters on work piece surface roughness. However, the depth of cut and feed are the significant factors on MRR. Optimal range and optimal level of parameters are also predicted for responses.

Material-SS304

Result-cutting speed 170rpm, feed0.25mm/rev, and depth of cut 2.0mm, surface roughness's 0.90µ.

Saravanakumar, et al. [15], Therefore, by optimizing input parameters such as cutting speed, feed rate, and depth of cut, etc., the output parameters like surface finish and metal removal rate can also be optimized for economical production. Machining process is done in Computer Numerical Control (CNC) turning lathe. Several techniques are available for optimizing the input parameters to get optimized output parameters and in this research genetic algorithm is used. The chemical composition and hardness test are carried out for Inconel 718 material. Number of experiments had been conducted with suitable combinations of input parameters. Relationship between material removal rate and input parameters and between surface roughness and input parameters are arrived through Minitab software.

Material- Inconel 718.

Result- Population 100, Current generation 52 Optimization value Cutting speed= 79.9m/min, feed rate=0.15mm/rev, depth of cut=0.1mm Best fitness for minimization of surface roughness is 0.69 µm

3. Future Scope

Material is widely used in industries for the different application e.g. uses for shear blades, needle valves & surgical equipment cutlery, steam strap, hydraulic components, vapour conduction, etc. and few worked on quality parameters like MRR, surface roughness for facing, power consumption, geometric tolerance like circularity, cylindricity, perpendicularity, etc. Taguchi approach help to determine optimal parameter condition for required output with help of lesser number of experiment (with help Orthogonal Array) & ANOVA approach help to determine which parameters are most significant.

An even better method can be used for parameter optimization where in the values of the accuracy of surface finish which can be got for different material with the help of different variation in parameter can be up to a range of one hundredth of a micron.

Purpose of review paper

Study the research work done on the material stainless steel (SS420) and Identify the scope of machining using the research aspects to redefine the present parameters of machining and their implementation for enhancing quality and optimize the process parameters.

4. Conclusions

In the project, we have performed a full experiment process of the process parameters influencing the surface roughness on a metal after CNC turning. In our work process we have identified the values of the optimum process parameters to get the minimum surface roughness. The paper reviews the effect of various machining parameter on the performance parameter during turning operation. In the turning operation the machining parameter spindle speed, feed, depth of cut play major role in deciding performance parameter such as surface roughness, tool wear, material remove rate.

In most of the industries the turning process parameters and surface roughness on the job/work piece depends upon the skill, experience and mentality of the operators therefore it is very necessary to optimize the turning process parameters, so that minimum surface roughness can be attain to obtain the maximum surface roughness. Optimization operation is one of the important goals of manufacturing systems, also it simple to use and are increasingly used to solve inherently inflexible problems quickly. From previous studies and papers, it is clearly that the genetic algorithm is one of the best population searches and its variants have been extensively used. However, many studies are concentrated on optimization of surface roughness, tool wear and material removal rate.

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