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REVIEW PAPER ON MULTI-OBJECTIVE OPTIMIZATION OF CUTTING PARAMETERS IN CNC TURNING OF AISI 52100 USING TAGUCHI METHOD

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ABSTRACT

In the objective of the paper is to optimize the choice of cutting parameters in terms of cutting speed, depth of cut, feed rate and noise radius during turning process of AISI 52100 steel when multiple objectives are simultaneously taken into consideration like surface roughness, metal removal rate and cutting forces during turning operations on various steel grades. Various researches have used Taguchi for the optimization of the parameters. This study was more focused upon the determination of most influencing input parameter for desirable or undesirable output, apart from it the main aim was selection of optimal parameters for improved surface finish, metal removal rate and minimize cutting forces. Optimization of process parameters for cutting forces, MRR and surface roughness done using Taguchi method in Minitab software 14.

Keywords: Surface Roughness, CNC turning, MMR, Taguchi method, Noise Radius, Minitab, Machining Force

1. INTRODUCTION

Turning is a machining procedure used to get the ideal element of round metal. The primary objective in present mechanical period is to create minimal effort quality item with required measurements in an optimum time. Therefore, the optimum cutting parameters are to be perceived first. In turning, the metal is in rotational movement and a cutting tool is utilized to shear away the undesired metals. This procedure requires lathe machine or turning machine, cutting tool, work piece and fixture. The work piece is fixed in the machine chuck and is pivoted at rapid. The cutting tool is taken care of in corresponding to the hub of turn. During this machining procedure the cutting parameters profoundly relies on the work piece, cutting tool material, and so on. These are dictated by understanding or machine catalogue. Surface roughness, MRR and machining force is a widely used attribute of product quality and in most cases a technical necessity for mechanical products. Thus, the optimum selection of cutting parameters such as feed rate, depth of cut, cutting speed, etc, generates optimum conditions during machining and becomes the main exigency of manufacturing industry. Surface roughness, Tool life and machining time is an important criterion to find the quality of a surface. It is an important response parameter. In machining process various parameters are: Input Parameters: Cutting speed, Feed rate, Depth of cut, insert radius, Cutting fluid, etc. Output Parameters: surface roughness, MRR and machining force.

2. LITERATURE REVIEW

Ahmet Hasçalık et al. [1] In this examination, the impact and optimization of machining parameters on surface roughness and tool life in a turning activity was examined by utilizing the Taguchi method. The trial examines were led under changing cutting speeds, feed rates, and depths of cut. A symmetrical cluster, the signal-to-noise (S/N) ratio, and the analysis of variance (ANOVA) were utilized to the investigation the presentation attributes in the turning of business Ti6Al-4V compound utilizing CNMG 120408-883 supplement cutting tool. The ends uncovered that the feed rate also, cutting speed were the most powerful factors on the surface roughness and tool life, respectively. The surface roughness was primarily identified with the cutting speed, while the pivotal axial depth of cut had the best impact on tool life.

Hamdi Aouici et al. [2] The current examination, intends to research, under turning states of solidified AISI H11 (X38CrMoV5-1), the impacts of cutting parameters on flank wear (VB) and surface roughness (Ra) utilizing CBN device The machining experiments are conducted based on the response surface methodology (RSM). Joined impacts of three cutting parameters, in particular cutting speed, feed rate and cutting time on the two execution yields (for example VB and Ra), are investigated utilizing the examination of change (ANOVA). Ideal cutting conditions for each execution level are built up and the relationship between the factors and the innovative parameters is resolved utilizing a quadratic regression model. The outcomes show that the flank wear is impacted basically by the cutting time and in the second level by the cutting speed. Additionally, it is that demonstrated that the feed rate is the prevailing variable influencing work piece surface roughness.

Asutosh Panda et al. [3] The paper tends to the appraisal, displaying, and optimization investigation of surface roughness in finish dry hard turning (FDHT) of AISI 4340 steel with covered artistic instrument by thinking about the cutting speed, axial feed, depth of cut, and nose radius as machining parameters. Thirty arrangements of longitudinal turning preliminaries dependent on central composite (CCD) structure of tests (DOEs) are performed response surface Rathod. et.al / REST Journal on Emerging trends in Modelling and Manufacturing 7(2) 2021, 39-46 Copyright@ REST Publisher 40 methodology (RSM particle swarm optimization (PSO), lastly, Gilbert's methodology are accordingly applied for mathematical modelling, response optimization, tool life estimation, and economic analysis. Additionally, various diagnostic tests have been executed to check the statistical significance and validity, adequacy, effectiveness, and fitness of data of the proposed model using analysis of variance (ANOVA) and Anderson-Darling normal probability test. Results indicated that nose radius and feed are the most significant controlled as well as dominant factors for hard turning operation if the minimization of the machined surface roughness is considered.

Samir Khamel et al. [4] The primary of the current examination is to research the impacts of cycle boundaries (cutting speed, feed rate and depth of cut) on execution qualities (tool life, surface roughness and cutting forces) in finish hard turning of AISI 52100 bearing steel with CBN tool. The cutting forces and surface roughness are estimated toward the finish of helpful tool life. The joined impacts of the cycle boundaries on execution qualities are researched utilizing ANOVA. The composite allure advancement procedure related with the RSM quadratic models is utilized as Mult objective optimization approach. The outcomes show that feed rate and cutting speed emphatically impact surface roughness and tool life. However, the profundity of cut shows greatest effect on cutting powers. The proposed test and measurable methodologies carry dependable strategies to show, to advance and to improve the hard turning process. They can be expanded productively to consider other machining measures.

T. Abbas et al. [5] High-quality prepares are utilized in different regular citizen and military items. The underlying expense of the crude materials for these items is exceptionally high. The surface roughness of these items is critical during the completing go to be acknowledged during the last assessment. The surface roughness ought to adjust to the necessary qualities expressed on the plan drawing. The paper presents the aftereffects of trials in turning of high strength steel highlighting three variables—cutting speed V, feed rate f, and depth of cut t—on five levels (125 examples). These were partitioned into 25 gatherings. Every one of the five gatherings was exposed to one basic machining speed. Each gathering was machined utilizing five degrees of cutting speed. Every profundity was handled utilizing five degrees of feed rate. Tessa was utilized for assessment of surface roughness. There is minimal current exploration on machining high-quality steel. The significant expense of this material urges us to search for the ideal going conditions to accommodate the predefined roughness of surface Ra and the base machining season of unit volume Tm. Because of our study, an artificial neural network was planned in Matlab on the premise of the MLP 3-10-1 multilayer perceptron that permits us to foresee Ra of the work piece with ±2.14% precision inside the scope of the test cutting speed, depth of cut, and feed rate esteems. Just because, a Pareto boondocks was acquired for Ra and Tm of the completed work piece from high-quality steel utilizing the artificial neural network model that was later used to decide the ideal cutting conditions.

SıtkıAkıncıoğlu et al. [6] In this examination, Taguchi method has been applied to assess the impact of cryogenically treated devices in turning of Hastelloy C22 super combination on surface roughness. The optimum parameters (cryogenic treatment, cutting speed, and feed rate) of turning were dictated by utilizing the Taguchi method test plan technique. In Taguchi technique, L9 symmetrical cluster has been utilized to decide the the signal noise (S/N) ratio. Examination of ANOVA was done to recognize the noteworthy elements influencing surface roughness. The measurable examination showed that feed rate, with a commitment rate as high as 87.64 %, had the most predominant impact on machining execution, trailed by the cryo-treated apparatuses treatment and cutting speed, individually. The affirmation tests demonstrated that it is conceivable to improve surface roughness altogether by utilizing the Taguchi method. Surface roughness was improved by 28.3 and 72.3 % by shallow (CT1) cryogenic treatment and profound cryogenic treatment (CT2) applied on cementite carbide instruments (UT). It found that wear opposition of tungsten carbide embed was expanded by shallow and profound cryogenic medicines.

Ramanuj Kumar et al. [7] The current investigation concentrated on numerical displaying, multi response optimization, tool life, and conservative investigation in finish hard turning of AISI D2 steel utilizing CVD-coated carbide and uncoated carbide embeds under dry natural conditions. Regression methodology and the grey relational methodology were executed for demonstrating and multi response optimization.Comparative economic statistics were carried out for both inserts, and the adequacy of the correlation model was verified. The test and anticipated qualities for all reactions were exceptionally near one another, suggesting the importance of the model and demonstrating that the correlation coefficients were near solidarity. The observed tool life for the covered carbide embeds was multiple times higher than that for the uncoated carbide embed, considering flank wear. The chip volume in the wake of machining for the covered carbide embed was 26.14 occasions higher than that of the uncoated carbide embed and could be better used for higher material expulsion rate Abrasion, diffusion, notching, chipping, and built-up edge have been observed to be the principal wear mechanisms for tool life estimation. Use of the covered carbide apparatus decreased machining costs by about 3.55 occasions contrasted with the utilization of the uncoated carbide embed, and gave financial advantages in hard turning.

Miguel MandúBonfá et al. [8] The fundamental target of this work is to assess the tool life and the work piece surface roughness while applying a vegetable-based cutting liquid by least amount of oil (MQL) at three distinct bearings in turning AISI D6 solidified steel with polycrystalline cubic boron nitride apparatuses with Al2O3 artistic cover and TiNcoating. Tool wear investigations were performed on the instruments toward the finish of their lives inside a filtering scanning electron microscope. The use of the cutting liquid by MQL procedure toward the path between the principle apparatus flank face and the work piece indicated preferable outcomes over the dry condition. The use of MQL through different headings likewise indicated serious outcomes. Scraped spot and attachment were the predominant systems for the wear of the tools. Rathod. et.al / REST Journal on Emerging trends in Modelling and Manufacturing 7(2) 2021, 39-46 Copyright@ REST Publisher 41

NivaldoLemosCoppini et al. [9] Based on the experiments performed in this work, it very well may be presumed that for inside turning of sintered carbide parts with PCD tools, in conditions like those utilized here Internal turning accomplished surface roughness esteems like those typically got in crushing activities what's more, subsequently, may supplant crushing in mechanical measures. To acquire a protected cycle, i.e., a cycle without unexpected breakage of the front line in the start of tool life, it is important to utilize not all that little cutting speed and not all that high feed. At the point when the most noteworthy cutting speed was utilized, the expansion of feed caused the quantity of slicing goes before the bleeding edge breakage to diminish and the work piece surface roughness to increment.

SanjeevSaini et al. [10] Significant sign of surface quality on machined parts is surface roughness. There are different machining parameters which affect the surface roughness, yet these impacts have not been enough measured. With the goal for producers to expand their benefits from using finish hard turning, precise prescient models for surface roughness and tool wear must be developed. This paper uses reaction surface strategy (RSM) for displaying to anticipate surface roughness and tool wear for assortment of cutting conditions in finish hard turning. The exploratory information acquired from performed tests in complete the process of turning of solidified AISI H-11 steel have been used. Lessening in feed rate and cutting speed up brought about noteworthy increment in surface quality. Notwithstanding, cutting speed up likewise delivered generally higher tool wear. Additionally, profundity of cut didn't altogether influence the tool wear and surface roughness.

T. Tamizharasan et al. [11] Hard turning is a profitable alternative to finish grinding. The ultimate aim of hard turning is to remove work piece Material in a single cut instead of a lengthy grinding procedure to minimise processing time, production costs, surface Roughness and setting time, and remaining competitive. Recently Years, interrupted hard turning, which is the process of turning hard parts with interrupted surface areas, has also been observed Were welcomed. The hard turning process offers many possible advantages compared with conventional grinding operation. In addition, wear of the tools, life of the tools, surface quality turned and amount of material removed are also predicted. In the analysis, 18 Different machining conditions, three grades of Cutting tool Polycrystalline cubic boron nitride (PCBN), is considered. This paper describes the different features in terms of Ability of components, life of the tools, and wear of tools, effects of individual components Tool life and material removal conditions, and economics of Work.

Jing Sheng et al. [12] The relation between the wear of cutting tools and in the machinery the machining parameters were the priority Place of production. A computational process in this investigation coupling on the basis of minimum cutting tool wear was proposed for the turning parameters. Wear of the cutting instrument, separated by the machined surface area was considered an assessment standard in the experiment. The connection between cutting Speeds and temperatures, and the variation of Parameters and temperatures for the cutting have been discussed. Therefore, the optimum cutting temperature was discovered at which the Wearing a cutting tool had the slightest meaning. The Method It was obtained between the temperatures and cutting parameters with orthogonal experiments and the coupling of the cutting parameters, the minimum wear was thus calculated Cutter. Furthermore, the processes for reduced wear Cutter analyses were carried out according to the characteristics of Wear cutting tool. The research would be of interest to Creating a Cutting database of metal materials.

P. Sivaiah et al. [13] Texture tools were successfully produced with Laser Engineering. Impact of newly developed cutting tool Temperature, wear of tool fank, and surface roughness analyzed for different cutting under MQL condition Speed conditions. Positive outcomes from the study were Under MQL framework, observed in hybrid method. Important reduction in temperature of the cutting zone with Hybrid texture tool shows low friction built on contact region. Few surface defects indicate by using hybrid texture method Stable framework for cuts. The hybrid texture tool brought more life to the tool due to the improved protection of the lubrication sites. Developed hybrid tool significantly reduced cutting temperature, wear of tool fanks and surfaces roughness AISI 304 steel material turned under MQL Condition respectively over single texture pattern tool. Industries which work on AISI 304 steel could therefore Use these hybrid tools to create profitable business with working conditions considered. The cooling technique with MQL greatly reduced the leakage of coolant into the environment. So hybrid formed The MQL method eliminates the adverse effects of using Conventional refrigeration technique during difficult machining Fabrics. New approach to cooling which supplies MQL mist meets the environmentally friendly switching on hybrid method from steel material AISI 304. **Mozammel Mia et al. [14]** The effects of the hardness of the materials andHigh pressure refrigerant jet over dry machining is assessed inCompliance with surface roughness and temperature cuts usingL36 orthogonal Taguchi array. The experimental data were analysed using cumulative empirical distribution function, andBox plot with regard to hardness of the material and the machining environment. Following that, maximising the output responses carried out with signal-to - noise ratio. The "smaller is better" was adopted as an optimization component of Taguchi optimization Principle; experiment architecture applied to parameters Guidance, and analysis of variance were used to assess the effects of control variables. Three types of hardened steels for present experimental studies were turned by an insert of coated carbide at Industrial combinations of speed – feed under both dry and high-pressure jet coolants. Cutting range, being a less important Parameter, remained unchanged. The high-pressure refrigerant jet was Find effective in temperature reduction, surface area Roughness, and tool wear. Statistical analysis revealed the hardness of the substance working is the most critical factor for both Temperature cutting and roughness to the surface. Other variables, however, made a very similar contribution to surface roughness when deciding the cutting temperature Environment has shown crucial position. Rathod. et.al / REST Journal on Emerging trends in Modelling and Manufacturing 7(2) 2021, 39-46 Copyright@ REST Publisher 42 D.K.

Ojha et al. [15] The traditional tool life estimation methods take long time and use a lot of content for job bits. Under this Paper, a faster tool life estimation method which requires less consumption of work piece material is proposed and there are methods. In this process the life of the tool is calculated by fitting a best-fit line for data dropping in a steady wear zone and seeking time to extrapolation method failure. Neuronal networks Used to forecast system estimates lower, upper and more likely Life. Comparison among neural networks and multiple regressions shows the former's superiority. Also the paper proposes Continuous tracking technique of product use in the shop Floor and tool life estimates are revised / obtained based on the Feedback to shop floor.

Muhammad Younas et al. [16] As for Ti6Al4V machining, the main responses that was considered as a conflicting pattern in this study regarding the conditions for cutting inputs. Optimum parameters have been obtained by means of multi-objective optimization of all those responses to the sustainable manufacturing target Items for the automotive and aerospace applications.

Denis Boing et al. [17] The perfect scenario for carrying out a machining process is to be able to predict the efficiency of the tools without the need todo practical experiments. However, each set of machining conditions is unique in an industrial setting, since the conditions of the machine tool, the machined material, the cutting tool and the fixture system which differ. This can trigger discrepancies between the Values forecasted. In this context, the purpose of this research was to demonstrate and discuss a performance test for tools Methodology and tool-life prediction model using the 3D wear parameter WRM applied with PCBN tools for rough turning. The methodology adopted and the model developed reflect a substantial time reduction in the experimental machining tests, simplifying research and development of cutting tool grades, as well as optimization of the machining process.

S.P. Palaniappan et al. [18] This paper explores the machining of Aluminium 6082 alloy experimentally to determine the optimum CNC turning-process parameters. An experimental plan based on the L27 orthogonal array was drawn up and turning experiments with prefixed cutting parameters for Aluminium 6082 were conducted tungsten carbide cutting tool. The spindle speed, feed rate and depth of the turning parameters were Using Taguchi and ANOVA, cut for surface roughness and material removal rates and the chip temperature for each experimental condition also contrasted.

Manu Ravuri et al. [19] To improve process parameters for the quality of the product, play a very important role. The branches are to produce more components with an adequate quality with a minimum of time and quantity. The demand for high carbon steels is growing nowadays, as the strength of high carbon steel is increased high as these are mainly used in manufacturing, since their implementations are extremely vast. At the EN 31 gun tentative are used. L27 Orthogonal array used for DOE to research the impact of process parameters such as Rpm, Feed; cutting depth, and nose radius were based on surface roughness. 3 levels are considered for each parameter. It has been used to perform CNC lathe machine experiments and to find surface roughness count surface instrument. The authors made an attempt in this respect and proposed the optimised procedure Set parameters. Short-term test method for defining machinability and face turning process is proven Optimized Parameter of the operation.

Mustafa Kuntog˘lu et al. [20] Online monitoring of tool wear and tool breakage is very important in order to reduce production costs via Optimisation of parameters for machining. Increasing cutting forces affect the quality of the work piece and its tools Condition that is the ultimate goal of manufacturing line and progressive tool wear that can trigger the tool breaking. Method Taguchi is used extensively to evaluate the number of experiments while Analysis of variance (ANOVA) addresses the parameter(s) are / are successful at the output. This research involves experiments and optimization processes with 3 input parameters during turning of AISI 1050 material (cutting speed, feed rate, tip tool) using Taguchi process. For the determination of the cutting tool state, Tangential cutting force and acoustic emission (AE) measurements were performed during metal Delete. ANOVA results showed that cutting speed is about 45 per cent the most powerful and the tip of the knife is Second on tool wear around 35 per cent.

3. METHODOLOGY

Material Selection

Workpiece material used for experimental work is AISI 52100. AISI 52100 round bars bearing steel is one kind of special steel with features of high wear resistance and rolling fatigue strength. Experimental trials were conducted on 80 mm length and 40 mm diameter cylindrical steel bar.

CNC lathe

The spindle speed is directly controlled with the gear mechanism provided on the control unit. Shown in Figure 1, MCL 10 CNC lathe machine used for experimentation consists of tool holder unit, head stoke, and tail stoke for machining the workpiece. The input power supply to the machine is 3 Phase A.C 415V. The operating frequency is 50Hz. The control voltage for the machine is 220V. Maximum diameter of machining is 30mm. maximum length of machining is 60 mm

Figure 1: MCL 10 CNC lathe

Design of Experiment

Four factors like feed rate, speed, depth of cut and tool nose radius and three levels for L9 orthogonal array of AISI 52100. The L9 technique is used for turning of AISI 52100 alloy using MCL 10 CNC lathe machine. The machining results were analyzed using experimental design, which was done using. The main purpose of the ANOVA is to investigate the design parameters and to indicate the parameter that affect the quality characteristic significantly. This analysis helps to find out the relative contribution of machining parameter in controlling the response of the turning operation.

Taguchi Method

The Taguchi method (TM) is a problem-solving technique to help improve process performance, to increase efficiency and productivity. The Taguchi method is centred around reducing potential variations in a process through design of experiments. The objective of using the methodology is to produce high-quality products with low costs to the manufacturer. Reducing variations in processes through the robust design of experiments. Taguchi developed this method for designing experiments as a way to investigate how different parameters affect process performance and a way to define how well the process is functioning. The Taguchi method is about quality control that focuses on the importance of research and development (R&D), and product design and development as a key way to reduce the occurrence of failures in the manufacturing process.

As Taguchi looked to improve product design while lowering costs, he explained that the framework can be viewed in three main components:

Systems Design: Focuses on the primary aspects that are necessary to produce the required product. It can include the best combination of materials and processes.

Parameter Design: Involves the most suitable set of rules that govern the established design elements. Defining the components in each parameter makes it easy to minimise the variation from a product. The Taguchi approach empathises this stage because it is often overlooked during industrial design practice.

Tolerance Design: Look at the factors that play a significant role in product quality. It then identifies tolerance limits that provide the variation required in the design

4. CONCLUSIONS

An AISI 52100 was analyzed for its machinability under turning operations using the Taguchi technique. The Taguchi techniques facilitated the use of orthogonal arrays L9 will used to define the cutting parameters for the turning operations. The cutting parameters selected were Feed, speed, depth of cut and nose radius for turning operation. A statistical software will be used. The influences of cutting speed, feed rate, depth of cut and nose radius will investigate by Taguchi. The main purpose of this study to optimize the which parameters will most affecting on the surface roughness, Material Removal Rate (MRR) and Cutting force.

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