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Optimization of Cutting Parameters to Reduce the Surface Roughness by Taguchi Method: A Review

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ABSTRACT

In the modern world manufacturing industry demand best Production rate and machining processes along with customer satisfaction. Also high level of surface finish is also one of the important aspect of machining processes. The goal of this review paper is to optimization of machining processes such as milling, Drilling, Turning etc. by the application of Taguchi method. We found various research work on different factors such as Depth of cut, cutting speed and feed under different types of materials to enhanced machining process and to improve the surface finish. This paper represents a review of various approaches to improve the machining processes, which will help the researchers & industrialists to find out the new way of machining.

Keywords: Taguchi, surface finish, machining, optimization

Introduction

Productivity play a great role in today's Industry, Todays manufacturing industry demand best production rate and enhanced machine capability. In today's world customer satisfaction is obtained by quality of product. As product quality is the top most priority for any industry. Aside from quality, there is a criterion known as productivity, which is linked to profit and the organization's goodwill. The industry sector is concentrating on improving production and part quality. All components of each process must be checked in order to achieve this goal. A desired machined part parameter is selected and compared to the required degree.

In this paper we present Taguchi's parameter design offers a systematic approach for optimization of the parameters in order to minimize the surface roughness in Face Milling operation.component that has a significant impact on manufacturing costs. The quality of the surface has a substantial impact on the turning performance, since a high-quality turned

Surface roughness is an important indicator of a product's technological excellence and a surface improves fatigue strength, corrosion resistance, and creep life. Surface roughness also has an impact on surface friction, light reflection, lubricant retention, and electrical and thermal contact resistance. As a result, the intended surface roughness value for a particular part is usually specified, and specific techniques are used to attain the given finish.

Review Review

Various studies are carried out over the last decade to show optimization of machining processes. We found various research work on different factors such as Depth of cut, cutting speed and feed under different literature using Taguchi method.

1. **P Georgeet al 2021,** In this research workTaguchi approach (S/N ratio and ANOVA) was used to optimise CNC dry milling parameters for martensitic stainless steel (MSS) grades AISI 410 and AISI 420. The tests are designed using a L9 orthogonal array with three levels of spindle speeds and feeds with a constant depth of cut. Surface roughness was studied in relation to machining parameters. For both MSS grades 410 and 420, the rank obtained for spindle speed clearly reveals that spindle speed is the most significant factor impacting surface roughness than feed rate, as shown in the response table for S/N ratios.The percentage contribution of spindle speed to surface roughness is higher than feed, according to ANOVA data. Cutting characteristics were found to be optimal at a spindle speed of 1500 rpm and a feed rate of 30 mm/min.
2. **Y.D. Chethanet al 2019,** In this research paper Acoustic emission (AE) and machine vision signals were used to determine the ideal cutting settings, which might potentially characterise the status of tool wear, and the results are presented in this study. Nimonic 75 is produced using a titanium-coated carbide insert, and Taguchi's L27 array is used for parametric optimization. During the experiment, the spindle speed, feed, and cutting depth were changed, and the tabulated data in terms of AE and machine vision signals were evaluated further.
3. **Mohamed ZakariaZahafet al 2021,** The goal of this reseach is to calculate Statistical analysis, mathematical modelling, and optimization of machined surface roughness (Ra) and workpiece displacements (D) observed during shoulder and contour milling of AISI 52100 bearing steel are part of this experimental investigation. Using a TiAlN coated carbide inserts tool, dry end mill annealed and quenched/tempered conditions. The influence of cutting settings considered as input variables, surface roughness, and level of work piece throbs/ displacements considered as reaction factors recorded during machining were investigated using a Taguchi experimental plan of 27 tests. Analysis of variance and mathematical regression models were used to show the extent to which each cutting parameter affected the milled surface roughness and

displacements. This study show that how the radial depth of cut affects shoulder, groove, and contour milling when the Axial depth of cut is strong while the Radial depth of cut is weak.

4. **Patricio Quitiaquezet al 2022,** The goal of this research is to identifies a geometry that is suited for high-speed steel cutting tools used in turning and facing operations. Different angles were addressed in the Polyamide PA-6 material, such as the tip, free, attack, and nose radius angles, which allowed for clean machining with the least amount of roughness. The Taguchi method was used in this study, with orthogonal layouts being used for each stage of the corresponding variance analysis , ANOVA. The study allowed for the selection of the best variable for each parameter in order to propose the lowest possible roughness ; the nose angle 45˚, 6˚free, 8˚attack, and nose radius 0.7 mm were determined for the turning tool.
5. **N.S. Patel et al 2021,** In this research work Day by day, in the new era of manufacturing science, machining techniques are being evaluated. Achieving a high level of surface quality is an important aspect of any machining operation. This work presents a literature review on Taguchi technique, Analysis of Variance (ANOVA), Response Surface Methodology (RSM), and other methods for parametric optimization of various machining processes such as drilling, reaming, milling, turning, and so on.
6. **P. Rasagopalet al 2020,** In this research the effects of machining settings on surface roughness and cutting force were examined. Using the stir-casting process, three reinforced composites were created by combining three SiC and boron carbide (B4C) compositions. Milling operations with various cutting parameters were used to machine the produced composite material. The Mitutoyo Surftest SV-2100 Column-type surface roughness tester was used to determine the roughness of the machined surfaces. Cutting forces were measured in the y-direction. The Taguchi method was also used to optimize and analyse the outcomes. The acquired experimental results show that feed rate, cutting speed, and depth of cut on surface roughness, as well as cutting force, are the most critical machining parameters.
7. **P.M. Gopal et al 2017,** The current study looks at how material and machining parameters affect cutting force, surface roughness, and temperature when using a carbide tool to end mill Magnesium (Mg) Metal Matrix Composite (MMC). Powder metallurgy was used to reinforce Cathode Ray Tube (CRT) panel glass, an intensifying E-waste, and Boron Nitride (BN) particles in a magnesium hybrid composite. The milling studies were carried out using an L27 orthogonal array that was developed with CRT glass particle size and weight percentage, tool diameter, speed, feed, and cut depth as input process parameters.Grey Relational Analysis (GRA) and Techniques for Order Preferences by Similarity to Ideal Solution were used to achieve multi-objective optimization (TOPSIS). Both techniques produced similar optimum parameter conditions, such as 10m particle size, 5% reinforcement, 8mm diameter tool, 710rpm speed, 20mm/min feed, and 0.5mm depth of cut, resulting in 139.48N in-feed force, 63.92N cross-feed force, 42.6N thrust force, 68.96℃ temperature, and 0.198m surface roughness.
8. **J. Santhakumaret al 2017,** The aim of this research is that by machining Titanium Alloy Grade 5 (Ti6Al4V) using Titanium Aluminium Nitrate (TiAlN) Nano coated tools and altering their coating thickness, the Taguchi technique and Grey relational analysis are utilised to analyse the effect of tool coating thickness. On the CNC vertical machining centre, the pocket milling operation is performed using the L9 orthogonal array with three levels and four factors design. The experiment's machining input parameters were tool coating thickness, spindle speed, feed rate, and depth of cut. After the machining process, different output characteristics such as cycle time, tool wear, surface roughness, material removal rate, and micro hardness were discovered.
9. **Jay Airaoet al 2017,** The purpose of this research is to determine the surface roughness of SUPER DUPLEX 2507 stainless steel in both dry and wet machining conditions. Three levels of cutting speed, feed rate, and constant axial depth of cut were used in dry and wet milling studies. In both dry and wet machining conditions, the effects of various cutting settings on surface roughness are studied. The link between surface roughness and cutting parameters was discovered using multiple regression analysis. The feed rate, followed by cutting speed, is the most important component that determines surface roughness, according to the regression equation. It is also concluded that surface finish obtained in wet machining is much better compared to dry machining.

10. **M. Balajiet al 2017,** The current study looks at how cutting parameters such as cutting speed, feed rate, and helix angle affect tool life. Drilling AISI304 steel with carbide drill bits was used in the experiments. The Taguchi orthogonal array of L8 was used to design the experiments, and the tests were run using two sets of cutting parameters. By measuring the amplitude of drill bit vibration and surface roughness, the impacts of cutting settings were investigated.The drillbit vibration data was collected online using a Laser Doppler Vibrometer (LDV), and the acousto optic emission (AOE) signals were processed using a high-speed Fast Fourier Transform analyzer. Significant cutting parameters impacting drill bit vibrations and surface roughness were identified using Taguchi and Analysis of Variance methods. According to the results of the experiments, the vibration of the drill bit increases as the tool wears. Cutting parameters that produce the best surface roughness are 25℃ helix angle, 12mm/min feed rate, and 800rpm spindle speed. 25 degrees of helix angle, 10mm/min feed rate, and 600 rpm spindle speed are the optimal cutting parameters for vibration acceleration.

11. **ŞenerKarabulutet al 2014,** In this research work the influence of milling parameters on surface roughness and cutting force utilizing an uncoated carbide insert were explored, which used powder metallurgy to generate AA7039/Al2O3 metal matrix composites. The milling tests were carried out utilizing an L18 21 x 32 mixed orthogonal array and the Taguchi design of experiment method. Analysis of variance was used to investigate the impact of the cutting parameters on surface roughness and cutting force (ANOVA).The findings of the investigation revealed that material structure had the greatest impact on surface roughness, while feed rate had the greatest impact on cutting force. As milling Al2O3 particle-reinforced aluminium alloy composites, surface roughness values improved by 196 percent to 312 percent when compared to AA7039 aluminium. Surface roughness and cutting force were predicted using artificial neural networks (ANN) and regression analysis. With a mean squared error of 2.25 percent and 6.66 percent, respectively, ANN was able to forecast surface roughness and cutting force.

12. **Jihong Yan et al 2013,** This paper present manufacture in a sustainable manner, it is necessary to reduce energy use. Metal cutting operations were formerly primarily optimized based on economic and technological factors, with little regard for the environmental dimension. It is critical to increase production rate and cutting quality while minimizing the environmental impact of manufacturing. The cutting parameters in the milling process are optimized using a multi-objective optimization method based on weighted grey relational analysis and response surface methodology (RSM) in order to analyse trade-offs between sustainability, production rate, and cutting quality. Three objectives are optimised at the same time: surface roughness, material removal rate, and cutting energy.
13. **Fabrício José Pontes et al 2012,** This paper presents a study of the applicability of radial basis function (RBF) neural networks for Roughness Average (Ra) prediction in the turning process of SAE 52100 hardened steel, using Taguchi's orthogonal arrays as a tool to construct network parameters. Experiments were carried out with training sets of various sizes in order to compare the performance of the best network found in each trial. The number of radial units, the algorithm for selecting radial centres, and the algorithm for selecting the spread factor of the radial function were all taken into account. Artificial neural networks (ANN) models were found to be capable of accurately, precisely, and affordably predicting surface roughness. The findings revealed that important network design elements have a considerable impact on network performance for the task at hand. The research concludes that the design of experiments (DOE) methodology is a superior strategy for designing RBF networks for roughness prediction than the most prevalent trial and error method.
14. **G.Ugrasenet al 2015,** This research present WEDM (Wire Electrical Discharge Machining) is a specialised thermoelectric machining technology that can precisely machine components with changing hardness or complex forms. The current research focuses on the optimization of wire EDM process parameters. As a work material, HCHCr was used. Different process parameters based on Taguchi's L27 orthogonal array were used to machine this work material. The pulse-on, pulse-off, current, and bed speed were all changed. Surface roughness, volumetric material removal rate, and accuracy are the response variables for the analysis. ANOVA was used to determine the size of factor effects. A verification experiment was also carried out to ensure that the optimum settings were performing as expected.

15. **Girish Kant et al 2014,** In this research work Sustainable development challenges have made energy and environmental issues relevant to all industries around the world. However, the ever-increasing demand for quality from clients has resulted in a superior surface polish and, as a result, higher energy usage. Machine tools have a usually low energy efficiency, especially during discrete part manufacture. This work presents a multi-objective predictive model for machining power consumption and surface roughness minimization that employs grey relational analysis, principal component analysis, and response surface approach to determine the best machining parameters. The analysis of variance (ANOVA) test was used to determine the statistical significance of the suggested prediction model.To reduce power consumption and surface roughness, the obtained findings show that feed is the most important machining parameter, followed by depth of cut and cutting speed. The shop floor personnel can use the generated response surface contours to determine and employ the ideal combination of machining parameters for the current situation. The power consumption of machine tools during non-cutting idling time will be reduced as peak demand is reduced through optimization.

16. **Patricia Munoz-Escalonaet al 2014,** This paper present that Surface roughness, which plays a major role in wear resistance, ductility, tensile, and fatigue strength for machined parts, is an important feature of surface quality in engineering. This paper describes a study that involved the creation of a geometrical model for predicting surface roughness when face milling with square inserts. The model is based on a geometrical examination of the tooltrail that was left on the machined surface and recreated. The Taguchi approach was used to validate the model with experimental data acquired for high-speed milling of aluminium alloy (Al 7075-T7351) utilising a wide range of cutting speeds, feed per tooth, axial depth of cut, and varied values of tool nose radius (0.8 mm and 2.5 mm).The surface roughness of the milled surfaces was measured with a non-contact profilometer to determine the experimental roughness. When tool flank wear is not taken into account, the proposed model can be utilised for any combination of material workpiece and tool, and it can be used with any tool diameter, number of teeth, and tool nose radius. When compared to experimental data, the results demonstrate that the constructed model performed exceptionally well, with over 98 percent accuracy in predicting surface roughness.

Conclusion:

The literature review found that feed rate is the most dominant and important parameter for surface roughness in almost all the machining processes, whether it is drilling, milling, turning or reaming. For the drilling process, feed rate and spindle speed were the positively influential parameters on the surface roughness; for turning, it was feed rate with cutting speed and depth of cut. The combination of high feed rate and radial depth with low cutting speed and axial depth was most efficient and gave better surface roughness for milling operation.

REFERENCES:

[1] Pramod George, D. Philip Selvaraj“ Cutting parameter optimization of CNC dry milling process of AISI 410 and 420 grade MSS”, Materials Today: Proceedings 42 (2021) 897–901

[2] Y.D. Chethan , H.V. Ravindra , Y.T. Krishnegowda “ Optimization of machining parameters in turning Nimonic-75 using machine vision and acoustic emission signals by Taguchi technique” Measurement 144 (2019) 144–154

[3] Mohamed ZakariaZahaf, MohieddineBenghersallah "Surface roughness and vibration analysis in end milling of annealed and hardened bearing steel" Measurement: Sensors 13 (2021) 100035

[4] PatricioQuitiaquez, Juan Cocha, William Quitiaquez , Xavier Vaca "Investigation of geometric parameters with HSS tools in machining polyamide 6 using Taguchi method" Materials Today: Proceedings xxx (xxxx) xx

[5] N.S. Patel, Priyansh L. Parihar, Jay S. Makwana "Parametric optimization to improve the machining process by using Taguchi method: A review" Materials Today: Proceedings xxx (xxxx) xx

[6] P. Rasagopal ,P. Senthilkumar , G. Nallakumarasamy , S. Magibalan "A study surface integrity of aluminum hybrid composites during milling operation" jmaterreste chnol . 2 0 2 0;9(3):4884–4893

[7] P.M. Gopal, K. Soorya Prakash "Minimization of Cutting Force, Temperature and Surface Roughness through GRA, TOPSIS and Taguchi techniques in End Milling of Mg Hybrid MMC" MeasurementS0263-2241(17)30713-3

[8] J. Santhakumar,U.Mohammed Iqbal , M. Prakash " Taguchi-Grey Relational Based Multi-Response Optimization on the Performance of Tool Coating Thickness in Pocket Milling" Materials Today: Proceedings 5 (2018) 13422–13428

[9] Jay Airao,,Bhavesh Chaudhary,VivekBajpai , Navneet Khanna " An Experimental Study of Surface Roughness Variation in End Milling of Super Duplex 2507 Stainless Steel " Materials Today: Proceedings 5 (2018) 3682–3689

[10] M. Balaji, B.S.N. Murthy , N. Mohan Rao " Optimization of Cutting Parameters in Drilling Of AISI 304 Stainless Steel Using Taguchi and ANOVA " Procedia Technology 25 (2016) 1106 – 1113

[11] ŞenerKarabulut" Optimization of surface roughness and cutting force during AA7039/Al2O3 metal matrix composites milling using neural networks and Taguchi method " MeasurementS0263-2241(15)00053-6

[12] Jihong Yan, Lin Li" Multi-objective optimization of milling parameters e the trade-offs between energy, production rate and cutting quality " Journal of Cleaner Production xxx (2013) 1- 10

[13] Fabrício José Pontes , Anderson Paulo de Paiva , Pedro Paulo Balestrassi , João Roberto Ferreira " Optimization of Radial Basis Function neural network employed for prediction of surface roughness in hard turning process using Taguchi's orthogonal arrays " Expert Systems with Applications 39 (2012) 7776–7787

[14] G.Ugrasena , H.V.Ravindra , G.V.Naveen Prakash , Y.N.Theertha Prasad " Optimization of process parameters in wire EDM of HCHCr material using Taguchi's technique " Materials Today: Proceedings 2 (2015) 2443 – 2452

[15] Girish Kant, Kuldip Singh Sangwan" Prediction and optimization of machining parameters for minimizing power consumption and surface roughness in machining " Journal of Cleaner ProductionS0959-6526(14)00801-4

[16] Patricia Munoz-Escalona, Paul G. Maropoulos " A geometrical model for surface roughness prediction when face milling Al 7075-T7351 with square insert tools" journal of Manufacturing Systems xxx (2014) xxx–xxx