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A Review Paper on Optimization of Surface Roughness and Material Removal Rate in CNC Turning of Al5083/SiC_p Using Taguchi Method

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ABSTRACT:

This review paper systematically explores the optimization of surface roughness and material removal rate (MRR) in the CNC turning process of Al5083/SiC_p composite material using the Taguchi Method. The study critically examines relevant literature to provide a comprehensive overview of the key factors influencing surface quality and machining efficiency in this specific machining operation. Various parameters such as cutting speed, feed rate, depth of cut, and tool geometry are analyzed in the context of their impact on surface roughness and MRR. The Taguchi Method, known for its efficiency in experimental design and optimization, is highlighted as a valuable approach to systematically enhance CNC turning processes for Al5083/SiCp. The review identifies trends, challenges, and gaps in existing research, offering insights into potential avenues for future investigations to further refine and optimize the machining parameters for improved surface quality and enhanced material removal rates in CNC turning of Al5083/SiCp composites.

Keywords: *CNC, MRR, Surface, Taguchi Method, Speed and Quality.*

Introduction:

The integration of advanced composite materials in industrial applications has gained significant momentum due to their unique combination of desirable properties. Among these, Aluminum 5083 reinforced with Silicon Carbide particles (Al5083/SiC_p) stands out for its enhanced mechanical and thermal characteristics, making it a preferred material in various engineering sectors. In the context of machining, CNC turning is a widely employed process for shaping components from Al5083/SiC_p composites. However, achieving optimal surface quality and material removal rates (MRR) in this complex machining operation necessitates a meticulous exploration of influential parameters. Surface roughness and material removal rate are critical factors that directly impact the performance and integrity of machined components. The interaction of cutting parameters such as cutting speed, feed rate, depth of cut, and tool geometry in CNC turning plays a pivotal role in determining the final surface finish and machining efficiency. Recognizing the multifaceted nature of these interactions, researchers have turned to advanced optimization techniques to enhance the precision and effectiveness of the machining process. Among the various optimization methodologies, the Taguchi Method has emerged as a robust and widely applied approach for experimental design and parameter optimization in manufacturing processes. This method systematically explores the influence of multiple factors with minimal experimental trials, providing a cost-effective and time-efficient means to optimize machining parameters. In the context of CNC turning of Al5083/SiC_p, the application of the Taguchi Method offers a promising avenue for achieving superior surface finish and maximizing material removal rates, as shown in figure 1.

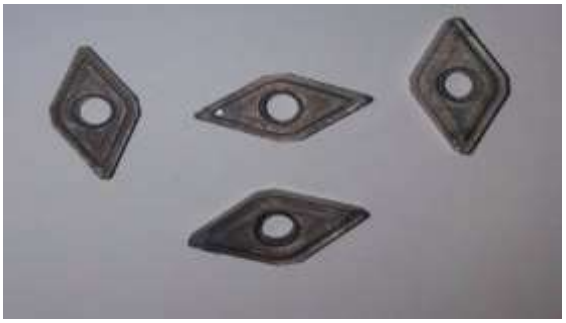

Figure 1 Al5083/SiC_p Material

Literature Survey:

A literature review is a piece of academic writing demonstrating knowledge and understanding of the academic literature on a specific topic placed in context. A literature review also includes a critical evaluation of the material; this is why it is called a literature review rather than a literature report.

J.S. Senthil kumar et.al (2023) used Inconel 718 to improve surface unpleasantness and flank wear in complete turning. Slicing examinations were coordinated by the full factorial structure under dry cutting conditions. Taguchi's optimization examination shows that the components level, its criticalness to affect the surface harshness and flank wear for the tuning and defying structures. Attestation tests were aimed at a perfect condition to make an assessment between the preliminary outcomes anticipated from the referenced connections.[1]

H. Yanda et. al (2023) investigate the effect of the cutting pace, feed rate and profundity of cut on material departure rate (MRR), surface harshness, and tool life in customary turning of adaptable cast iron FCD700 assessment using TiN shrouded cutting tool in dry condition. The machining condition parameters were the cutting rate of 220, 300 and 360 m/min, feed pace of 0.2, 0.3 and 0.5 mm/fire up, while the profundity of cut (DOC) was kept consistent at 2 mm. The effect of cutting condition (cutting pace and feed rate) on MRR, surface unpleasantness, and tool life were examined and researched. Preliminaries were coordinated reliant on the Taguchi plan of examinations (DOE) with symmetrical L9 exhibit, and after that sought after by optimization of the results using Analysis of Variance (ANOVA) to find the most outrageous MRR, least surface unpleasantness, and most noteworthy tool life. [2]

D. Mittal et.al (2023) investigates the effect of technique parameters in turning of Titanium grade 2 on conventional machine. Three parameters specifically pivot speed, profundity of cut and feed rate are varied to look at their effect on material removal rate and tool disillusionment. The preliminaries are driven using each factor thus approach. In addition, a few sporadic examinations are in like manner passed on to inspect the wonder of tool frustration. The assessment reveals that material ejection rate is truly influenced by all the three methodology parameters. At any rate the effect of shaft speed and feed rate is more when stood out from profundity of cut. A perfect extent of data parameters has been separated as a definitive outcome for finishing further investigate.[3]

S. Pahda, S. et.al (2022) analyzed surface harshness by considering the cutting parameters like cutting velocity, feed rate and profundity of cut. The CNC turning machine is used to direct tests experimentation is EN-8 steel with 150 mm length and 35 mm separation over. Taguchi technique has been used for organizing and optimization of the examination. Moreover, Minitab 16 writing computer programs is in like manner being used to lead ANOVA test to predict the immensity level for singular parameter and it has been found that the cutting rate is most gigantic parameter. [4]

M. Vellibor et.al (2022) presented Taguchi solid parameter plan for displaying and optimization of surface unpleasantness in dry single-point turning of infection moved blend steel 42CrMo4/AISI 4140 using TiN-secured tungsten carbide installs. Three cutting parameters, the cutting speed (80, 110, 140 m/min), the feed rate (0.071, 0.196, 0.321 mm/fire up), and the profundity of cut (0.5, 1.25, 2 mm), were used in the preliminary. All of various parameters was taken as steady. The typical surface unpleasantness (Ra) was picked as an extent of surface quality.[5]

S. Khrais et. al (2021) develop a various backslide model for surface roughness as a segment of cutting parameters during the turning of fire cemented medium carbon steel with TiN-Al_2O_3-TiCN secured increases. An exploratory course of action of work and sign to-racket extent (S/N) were used to relate the effect of turning parameters to the workpiece surface total the process of utilizing Taguchi strategy. The effects of turning parameters were thought about by using the assessment of distinction (ANOVA) procedure. Surveyed parameters were feed, cutting pace, and profundity of cut. [6]

Aswathy V G et. al (2021) In recent years, the rapid technology development in industry sector, especially in aviation industry has been increasing. So that we need more capabilities in the micro-scale manufacturing process, especially micro-milling process which can produce good surface roughness and high complexity parts. In this study, the effect of machining parameters to the surface roughness investigated by using Inconel 718 material with cutting tool diameter 1 mm, carbide material with coating TiAlN. The machining process was performed in low-speed machining category. There are three variations of spindle speed (3.000, 7.000, 10.000 RPM) and also feed rate (0.5, 1, 2 mm/s) with constant depth of cut 10 µm.[7]

Saurabh Singhvi et. al (2020) The challenge of recent machining industries is reduce lead time and increase production rate in order to maintain their competitiveness. This paper investigates the machinability of mild steel in turning process perform on conventional lathe machine. Two parameters like tool rake angle and feed are varied to investigate their effect on material removal rate. An attempt has been made to model the one response variable using Taguchi an ANOVA method. These are techniques of great practical importance in a lot of applications of statistical conclusion in a reliable way. Taguchi L9 orthogonal array is used for experimental design. The main aim of this work is save power and useful production time during manufacturing of product. [8]

Amritpal Singh et. al. (2020) The hard-turning process is steadily finding its place in modern manufacturing technology and with advance cutting tool materials it can be applied as alternative machining process to grinding providing a more economical way to finish hard surfaces. The main concerns of hard turning are tooling cost and the effect of process on machinability characteristics. The poor selection of process parameters may cause excessive tool wear and increased surface roughness. Hence there is a need to find the right parameters to achieve the right dimensional accuracy, good surface and maximum material removal rate. This paper reviews the effects of various process parameters such as cutting speed, depth of cut and feed rate on the response parameters such as surface roughness, material removal rate and chip reduction coefficient. Through this study main cutting parameters which affect the turning operation are discussed. [9]

Objectives of Research Work:

The objective is to systematically optimize CNC turning parameters for Al5083/SiCp composite, enhancing surface roughness and material removal rate using the Taguchi method.

- Surface roughness optimization.
- Material removable rate optimization.
- Taguchi method implementation.

Methodology:

- Turning of Al5083/SiC_p rod has been performed on a CNC machine using Taguchi Method.
- Taguchi based Design of experiments has been used to find out optimum number of experiments to be conducted to achieve the said objectives.
- Surface roughness of machined surface has been measured using a surface analyzer during experimentation.
- Material removal rate has been evaluated using high precision balance by weighing samples before and after experimentation.
- Analysis has been carried out using analysis of variance (ANOVA). The significance of the regression model and significant model term i.e spindle speed, feed and depth of cut are clearly highlighted.

Conclusion:

In conclusion, this review paper has provided a comprehensive overview of the optimization efforts directed towards surface roughness and material removal rate in CNC turning of Al5083/SiCp utilizing the Taguchi Method. The synthesis of existing literature has highlighted the significance of key machining parameters such as cutting speed, feed rate, depth of cut, and tool geometry in influencing the final surface quality and machining efficiency of this composite material.

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