INTERNATIONAL JOURNAL OF PROGRESSIVE RESEARCH IN ENGINEERING MANAGEMENT AND SCIENCE (IJPREMS)

www.ijprems.com
editor@ijprems.com

Vol. 04, Issue 04, April 2024, pp: 1071-1074

e-ISSN : 2583-1062

Impact Factor: 5.725

A REVIEW PAPER ON OPTIMIZING CUTTING PARAMETERS IN TURNING OPERATIONS THROUGH THE TAGUCHI METHOD FOR MULTI-OBJECTIVES PURPOSE

Kalpana[1], Yogesh Mishra[2], Ramnarayan Sahu[3]

[1,3]Research Scholar, Master of Technology (APS) Department of Mechanical Engineering, NIIST, Bhopal, India.

[2]Assistant Professor, Department of Mechanical Engineering, NIIST, Bhopal, India.

ABSTRACT

This review paper delves into the optimization of cutting parameters in turning operations with a focus on achieving multi-objective goals using the Taguchi Method. Turning, as a fundamental machining process, plays a pivotal role in the manufacturing industry, and efficient parameter optimization is crucial for enhancing productivity and product quality. The Taguchi Method, recognized for its efficiency in experimental design and optimization, is applied to address multiple objectives simultaneously. The paper systematically reviews the existing literature on the application of the Taguchi Method in turning operations, emphasizing its effectiveness in optimizing critical cutting parameters such as cutting speed, feed rate, and depth of cut. The multi-objective nature of the optimization process involves balancing conflicting goals such as minimizing tool wear, maximizing material removal rate, and achieving superior surface finish.

Keywords: Turning, Cutting, Optimizing, Tools, Pivoted and Taguchi.

1. INTRODUCTION

The optimization of cutting parameters is a multifaceted challenge, as it involves the delicate balance of conflicting objectives such as minimizing tool wear, maximizing material removal rate, and achieving superior surface finish. The traditional trial-and-error approach is both time-consuming and resource-intensive, necessitating the adoption of systematic optimization methods to streamline the process. The Taguchi Method, rooted in statistical principles, provides a structured framework for experimentation and optimization, enabling researchers and engineers to navigate the complex terrain of turning operations with greater precision. This review paper aims to synthesize and critically analyze the existing body of knowledge surrounding the application of the Taguchi Method in optimizing cutting parameters for turning operations. By exploring the rich tapestry of literature, this review seeks to unveil the method's effectiveness in concurrently addressing multiple objectives, thereby advancing the field's understanding and application of precision machining techniques. Through a systematic examination of case studies and experimental results, the paper will shed light on the method's versatility in optimizing crucial parameters like cutting speed, feed rate, and depth of cut. Furthermore, this introduction sets the stage for a comprehensive exploration of advancements, challenges, and future prospects in the integration of the Taguchi Method with cutting-edge technologies, such as numerical simulations and artificial intelligence, to further refine the optimization process. By navigating through this review, researchers, practitioners, and industry professionals will gain insights into the Taguchi Method's role in shaping the future of turning operations, propelling the industry towards increased efficiency, reduced waste, and enhanced product quality, as shown in figure 1.

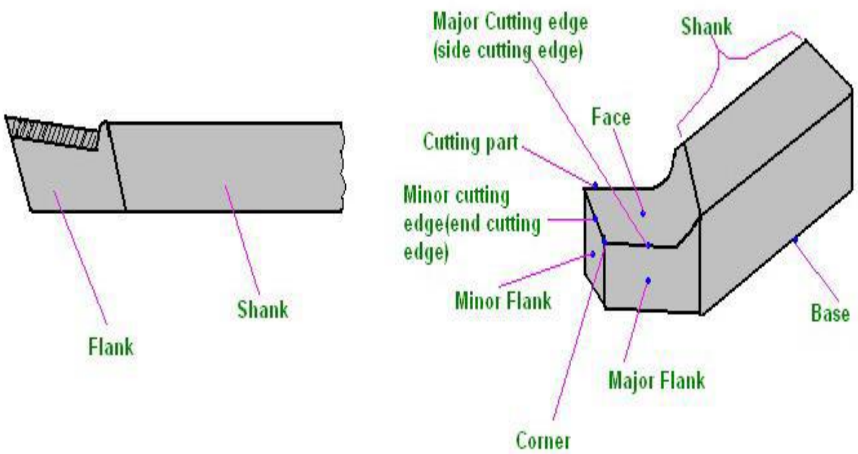

Figure 1 Nomenclatures of Single Point Cutting Tool

2. LITERATURE REVIEW

Literature reviews are integral components of academic research papers, theses, dissertations, and scholarly articles. They serve to situate the research within the existing body of knowledge, demonstrate the researcher's familiarity with prior work, and justify the need for new investigations.

Zhou et al. (2023) investigated on tool life criteria in raw turning. A new tool-life criterion depending on a pattern-recognition technique was proposed and neural network and wavelet techniques were used to realize the new criterion. The experimental results showed that this criterion was applicable to tool condition monitoring in a wide range of cutting conditions. **[1]**

Lin et al. (2023) adopted an abdicative network to construct a prediction model for surface roughness and cutting force. Once the process parameters: cutting speed, feed rate 44 and depth of cut were given; the surface roughness and cutting force could be predicted by this network. Regression analysis was also adopted as second prediction model for surface roughness and cutting force. Comparison was made on the results of both models indicating that adductive network was found more accurate than that by regression analysis. **[2]**

Feng and Wang (2023) investigated for the prediction of surface roughness in finish turning operation by developing an empirical model through considering working parameters: work piece hardness (material), feed, cutting tool point angle, depth of cut, spindle speed, and cutting time. Data mining techniques, nonlinear regression analysis with logarithmic data transformation were employed for developing the empirical model to predict the surface roughness. **[3]**

Suresh et al. (2023) focused on machining mild steel by TiN-coated tungsten carbide (CNMG) cutting tools for developing a surface roughness prediction model by using Response Surface Methodology (RSM). Genetic Algorithms (GA) used to optimize the objective function and compared with RSM results. It was observed that GA program provided minimum and maximum values of surface roughness and their respective optimal machining conditions. **[4]**

Lee and Chen (2023) highlighted on artificial neural networks (OSRR-ANN) using a sensing technique to monitor the effect of vibration produced by the motions of the cutting tool and work piece during the cutting process developed an on-line surface recognition system. The authors employed tri-axial accelerometer for determining the direction of vibration that significantly affected surface roughness then analyzed by using a statistical method and compared prediction accuracy of both the ANN and SMR. **[5]**

Kohli and Dixit (2022) proposed a neural-network-based methodology with the acceleration of the radial vibration of the tool holder as feedback. For the surface roughness prediction in turning process the back-propagation algorithm was used for training the network model. The methodology was validated for dry and wet turning of steel using high speed steel and carbide tool and observed that the proposed methodology was able to make accurate prediction of surface roughness by utilizing small sized training and testing datasets. **[6]**

Pal and Chakraborty (2022) studied on development of a back propagation neural network model for prediction of surface roughness in turning operation and used mild steel work-pieces with high-speed steel as the cutting tool for performing a large number of experiments. The authors used speed, feed, depth of cut and the cutting forces as inputs to the neural network model for prediction of the surface roughness. The work resulted that predicted surface roughness was very close to the experimental value. **[7]**

Sing and Kumar (2022) studied on optimization of feed force through setting of optimal value of process parameters namely speed, feed and depth of cut in turning of EN24 steel with TiC coated tungsten carbide inserts. The authors used Taguchi's parameter design approach and concluded that the effect of depth of cut and feed in variation of feed force were affected more as compare to speed. **[8]**

Ahmed (2022) developed the methodology required for obtaining optimal process parameters for prediction of surface roughness in Al turning. For development of empirical model nonlinear regression analysis with logarithmic data transformation was applied. The developed model showed small errors and satisfactory results. The study concluded that low feed rate was good to produce reduced surface roughness and also the high speed could produce high surface quality within the experimental domain. **[9]**

Abburi and Dixit (2022) developed a knowledge-based system for the prediction of surface roughness in turning process. Fuzzy set theory and neural networks were utilized for this purpose. The authors developed rule for predicting the surface roughness for given process variables as well as for the prediction of process variables for a given surface roughness. **[10]**

Al-Ahmari (2021) developed empirical models for tool life, surface roughness and cutting force for turning operation. The process parameters used in the study were speed, feed, depth of cut and nose radius to develop the machinability model. The methods used 48 for developing aforesaid models were Response Surface Methodology (RSM) and neural networks (NN). **[11]**

Thamizhmanii et al. (2021) applied Taguchi method for finding out the optimal value of surface roughness under optimum cutting condition in turning SCM 440 alloy steel. The experiment was designed by using Taguchi method and experiments were conducted and results thereof were analyzed with the help of ANOVA (Analysis of Variance) method. The causes of poor surface finish as detected were machine tool vibrations, tool chattering whose effects were ignored for analyses. The authors concluded that the results obtained by this method would be useful to other researches for similar type of study on tool vibrations, cutting forces etc. The work concluded that depth of cut was the only significant factor which contributed to the surface roughness. **[12]**

Natarajan et al. (2021) presented the on-line tool wear monitoring technique in turning operation. Spindle speed, feed, depth of cut, cutting force, spindle-motor power and temperature were selected as the input parameters for the monitoring technique. For finding out the extent of tool wear; two methods of Hidden Markov Model (HMM) such as the Bar-graph Method and the Multiple Modeling Methods were used. A decision fusion centre algorithm (DFCA) was used for increasing the reliability of this output which combined the outputs of the individual methods to make a global decision about the wear status of the tool. Finally, all the proposed methods were combined in a DFCA to determine the wear status of the tool during the turning operations. **[13]**

Objectives:

- To systematically review and synthesize existing literature on the application of the Taguchi Method for optimizing cutting parameters in turning operations.
- To analyze the effectiveness of the Taguchi Method in concurrently addressing multiple objectives, including minimizing tool wear, maximizing material removal rate, and achieving superior surface finish in turning operations.
- To examine case studies and experimental results that demonstrate the versatility of the Taguchi Method in optimizing critical cutting parameters such as cutting speed, feed rate, and depth of cut.

3. METHODOLOGY

Establish specific criteria for selecting studies, including the relevance of the Taguchi Method, the diversity of cutting parameters considered, and the focus on multi-objective optimization in turning operations. Exclude studies that do not align with the core objectives of the review.

Extract pertinent information from selected studies, including details on experimental setups, cutting parameters investigated, Taguchi experimental designs employed, and outcomes related to multi-objective optimization. Create a comprehensive database of key findings from each study.

Systematically categorize the extracted data to identify common trends, variations, and emerging patterns across different studies. Group findings based on the specific cutting parameters optimized, the objectives targeted, and the Taguchi Method's application variations.

In-depth analysis of case studies illustrating the application of the Taguchi Method in turning operations. Evaluate the experimental designs, methodologies employed, and the effectiveness of the Taguchi Method in achieving multi-objective optimization. Discuss the implications of each case study's results. Identify challenges and limitations associated with the application of the Taguchi Method in turning operations for multi-objective optimization. Explore issues related to experimental design complexities, parameter interactions, and practical implications in real-world manufacturing scenarios.

4. CONCLUSION

In the pursuit of optimizing cutting parameters in turning operations with a multi-objective purpose through the Taguchi Method, this review has synthesized and critically examined a wealth of literature.

The comprehensive analysis of diverse studies and case examples has provided valuable insights into the effectiveness of the Taguchi Method in achieving simultaneous optimization of critical parameters such as cutting speed, feed rate, and depth of cut.

In conclusion, this review not only underscores the current state of knowledge regarding the Taguchi Method's application in turning operations but also highlights avenues for future exploration.

The fusion of traditional optimization techniques with modern computational tools holds the potential to shape the future of precision machining, driving advancements in efficiency, quality, and overall manufacturing performance.

5. REFERENCES

[1] Zhou Q., Hong G. S. and Rahman M., (2023), "A New Tool Life Criterion for Tool Condition Monitoring Using a Neural Network", Engineering Application Artificial Intelligence, Volume 8, Number 5, pp. 579-588.

[2] Lin W. S., Lee B. Y., Wu C. L., (2023), "Modeling the surface roughness and cutting force for turning", Journal of Materials Processing Technology, Volume 108, pp. 286-293.

[3] Feng C. X. (Jack) and Wang X., (2023), "Development of Empirical Models for Surface Roughness Prediction in Finish Turning", International Journal of Advanced Manufacturing Technology, Volume 20, pp. 348–356

[4] Suresh P. V. S., Rao P. V. and Deshmukh S. G., (2023), "A genetic algorithmic approach for optimization of surface roughness prediction model", International Journal of Machine Tools and Manufacture, Volume 42, pp. 675–680.

[5] Lee S. S. and Chen J. C., (2023), "Online surface roughness recognition system using artificial neural networks system in turning operations" International Journal of Advanced Manufacturing Technology, Volume 22, pp. 498–509.

[6] Kohli A. and Dixit U. S., (2022)," A neural-network-based methodology for the prediction of surface roughness in a turning process", International Journal of Advanced Manufacturing Technology, Volume 25, pp.118–129.

[7] Pal S. K. and Chakraborty D., (2022), "Surface roughness prediction in turning using artificial neural network", Neural Computing and Application, Volume14, pp. 319–324.

[8] Singh H. and Kumar P., (2022), "Optimizing Feed Force for Turned Parts through the Taguchi Technique", Sadhana, Volume 31, Number 6, pp. 671–681.

[9] Ahmed S. G., (2022), "Development of a Prediction Model for Surface Roughness in Finish Turning of Aluminium", Sudan Engineering Society Journal, Volume 52, Number 45, pp. 1-5.

[10] Abburi N. R. and Dixit U. S., (2022), "A knowledge-based system for the prediction of surface roughness in turning process" Robotics and Computer-Integrated Manufacturing, Volume 22, pp. 363–372.

[11] Al-Ahmari A. M. A., (2021)," Predictive machinability models for a selected hard material in turning operations", Journal of Materials Processing Technology, Volume, 190, pp. 305–311.

[12] Thamizhmanii S., Saparudin S. and Hasan S., (2021), "Analysis of Surface Roughness by Using Taguchi Method", Achievements in Materials and Manufacturing Engineering, Volume 20, Issue 1-2, pp. 503-505.

[13] Natarajan U., Arun P., Periasamy V. M., (2021), "On-line Tool Wear Monitoring in Turning by Hidden Markov Model (HMM)" Institution of Engineers (India) Journal (PR), Volume 87, pp. 31-35.