International Journal of Applied and Structural Mechanics
ISSN: 2799-127X
Vol: 04, No. 02, Feb-Mar 2024
http://journal.hmjournals.com/index.php/IJASM
DOI: https://doi.org/10.55529/ijasm.42.8.17

Experimental Analysis of Surface Roughness of Steel by Considering Variable Cutting Parameters for Turning

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Received: 01 November 2023 **Accepted:** 19 January 2024 **Published:** 02 March 2024

***Abstract:** This paper presents results of experiment conducted in order to analysis of surface roughness of steel by considering variables cutting parameters for turning. Surface roughness measurement is a critical aspect of quality control in manufacturing processes, particularly in the context of lathe and milling machine operations. This abstract provides an overview of the methods, tools, and significance of surface roughness measurement in turning processes. It explores the key techniques, such as stylus profilometry and optical interferometry that are commonly employed for assessing surface roughness. The abstract also highlights the importance of surface roughness measurement in ensuring product quality, functionality, and performance. Furthermore, it emphasizes the relevance of this research in optimizing machining processes, enhancing product aesthetics, and reducing material waste. This investigation contributes to the field of precision manufacturing by presenting an in-depth analysis of surface roughness measurement in lathe machine applications, offering valuable insights for industry professionals and researchers alike.*

***Keywords:** Cutting Speed, Depth of Cut, Feed Rate, Turning, and Surface Roughness.*

1. INTRODUCTION

In the field of precision manufacturing, achieving the desired surface finish is of paramount importance. Surface roughness not only influences the aesthetics of a product but also significantly affects its functionality, durability, and performance. Among the various machining processes, lathe and milling machines are commonly employed to shape and

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refine workpieces, making them essential tools in the pursuit of high-quality surface finishes. This project aims to delve into the realm of surface roughness measurement as a critical component of the manufacturing process. Accurate and efficient surface roughness measurement techniques are vital for ensuring that products meet the stringent quality standards demanded by modern industries. By harnessing the capabilities of lathe and milling machines for this purpose, we intend to explore innovative approaches and methodologies for precise surface roughness assessment.

Many cutting factors, such as cutting speed, feed rate, depth of cut, tool geometry, and the material characteristics of the workpiece and cutting tool, all have an impact on surface roughness in steel machining. The theoretical understanding of how these parameters affect surface roughness is crucial for optimizing machining processes.

By understanding the theoretical principles behind these cutting parameters and their effects on surface roughness, machinists and engineers can employ optimization techniques such as experimental design, mathematical modeling, and simulation to enhance machining efficiency and quality. Additionally, advancements in cutting tool technology and machining strategies continue to drive improvements in surface finish and overall productivity in steel machining applications.

2. RELATED WORK

1. Vajpayee, Surface Roughness Analysis in Turning: A Comprehensive Study In the peer-reviewed paper ELSEVIER, Wear, 70 (1981), certain aspects of quality control and solution are elucidated. Specifically, it is stated that because surface finish evaluation instruments are expensive and complex, theoretical equations that can roughly predict the amount of surface roughness under specific cutting conditions are necessary. A novel method is suggested to enhance the degree of finish, which is typically attained by making a finishing cut following a roughing cut. On the other hand, compared to the traditional roughing and finishing cut procedure, this technique—which is predicated on the overlapping of cuts—can shorten the amount of time needed for machining to reach the necessary degree of finish.
2. Surface roughness influencing parameters in the turning process by C.L. He, W.J. Zong, and J.J. ZhangThis paper presents a thorough assessment of the parameters that influence surface roughness during the turning process as well as theoretical modelling techniques. First, based on their modelling procedures, surface roughness modelling techniques are divided into theoretical and empirical solutions. The definitions of surface roughness characteristics are then examined using the ISO standard as a guide. Additionally, the benefits and drawbacks of these theoretical models of surface roughness are discussed, along with the associated difficulties. Lastly, a discussion of upcoming theoretical modelling projects for surface roughness is had.
3. A overview of surface roughness prediction in machining open overlay panel is linked by the author. According to the study evaluated by Benardos, G.-C. Vosniakos, the general manufacturing issue may be characterised as the attainment of a set product quality with given equipment, cost, and time restrictions. This paper explains various components of the quality control and solution. The purpose of this work is to provide an overview of

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the many approaches and procedures used to forecast surface roughness. As a consequence, the production process may become more competitive and productive, and it can also minimise the need to reprocess the machined workpiece in order to meet technical requirements.

4. O.B. Abouelatta, J. Mádl: Surface roughness prediction based on cutting parameters in turning operations: a systematic study For many turned workpieces, the surface finish quality is a crucial prerequisite throughout the machining process. Finding a relationship between surface roughness and cutting vibrations is the main goal of this work. Additionally, mathematical models for the projected roughness parameters based on cutting parameters and machine tool vibrations are derived. The commercial software programmes MATLAB, BC++, and SPSS were utilised to gather and analyse the measured findings. Predicting roughness parameters as a function of cutting parameters may benefit from the procedure.
5. A Review of V. D. Kandure, Prof. A. H. Karwande's 2017 Optimisation of Cutting Parameters of Various Engineering Materials for Surface Roughness in Turning ProcessThe product's surface roughness and machining time are the two key aspects that are impacted by the cutting parameters throughout the turning process. When considering the product's quality, surface roughness is a crucial component. The surface quality of the completed material is affected by many critical cutting factors in the turning process, including cutting speed, feed rate, depth of cut, and spindle speed. This article examines the Taguchi method's cutting parameter optimisation in the turning process.
6. A. Kumar's "ANN BASED PREDICTION OF SURFACE ROUGHNESS IN TURNING," published in 2012.During a machining process, one of the most specific client requirements is surface roughness, which is an indication of surface quality. The ideal cutting parameters (speed, feed, and depth of cut) are necessary for the effective operation of machine tools.Consequently, in order to minimise surface roughness, an appropriate optimisation technique that can identify the ideal cutting parameter values must be found. The optimisation of the turning process parameter is nonlinear and severely limited.
7. Research on Optimising Turning Parameters on Different Steel Grades by Rajeev Kumar, Nishant Verma, and Sachin Chauhan This article, an attempt is made to evaluate the optimisation of several parameters such surface roughness, MRR, and tool wear during turning operations on various steel grades. Some of the solution and quality control elements are described. Cutting speed, feed rate, and depth of cut were the turning input parameters in different publications, and surface roughness, cutting forces, tool wear, and MRR were the turning output parameters. Taguchi and RSM techniques have been utilised in several studies for parameter design and optimisation. It was discovered that RSM was a more prevalent approach for both designing the trials and analysing their results. The primary goal of this study was to pick the ideal parameters for increased productivity and better surface quality, but it was also primarily focused on identifying the input factors that had the most influence on desired or unwanted output.
8. Impact of Feed Rate, Bulk Texture, and Cutting Speed on Nitrogen Alloyed Duplex Stainless Steel Surface Finish During Dry Turning Philip Selvaraj, D., and Chandramohan, Palanisamy This paper presents experimental work done on the dry

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turning of cast duplex stainless steels (ASTM A 995 Grade4A and ASTM A 995 Grade5A) utilising cutting tools made of cemented carbide coated in TiC and TiCN. Three different feed rates (0.04, 0.08, and 0.12 mm/rev) and five different cutting speeds (80, 100, 120, 140, and 160 m/min) were used in the turning trials, which had a constant depth of cut (0.5 mm). The effects of feed rate and cutting speed on the machined surface roughness were examined. Texture analysis (Bulk) was also done to look at how preferred orientation affected the final surface roughness.The result demonstrates that surface roughness first lowers to a certain extent before rising as cutting speed increases.

9. Cutting parameters' effects on surface finish and cutting force during a turning operationOpen overlay panel links provided by the authorP. Srihar, D. Nageswara Rao Dr. b, and C.J. Rao Dr. a: in This paper investigates the effects of feed, speed, and depth of cut on surface roughness and cutting force while utilising a ceramic tool with an Al_2O_3+TiC matrix (KY1615) and an AISI 1050 steel work material with a 484 HV hardness. The studies were conducted using a Johnford TC35 Industrial type CNC lathe. The Taguchi approach (L27 design with three levels and three components) was used to conduct the experiments. The analysis of variance using a modified technique has been applied. The results have shown that feed rate has a significant impact on cutting force and surface roughness. Cutting force is greatly affected by depth of cut, while surface roughness is mostly unaffected.
10. Analysis of the residual stresses produced by turning the Author links open overlay panel in Inconel 718TM Sharman, A.R.C.; Hughes, J.I.; Ridgway, K.- A series of nickel-based superalloys, which includes Inconel 718, is widely used in the hot sections of gas turbine engines by the aerospace industry. The effects of varying operating conditions on tool life during the machining of nickel-based superalloys have been extensively documented in the literature; on the other hand, the effects on the residual stress development and the surface integrity of the machined workpiece have received less attention. A greater comprehension of the ways in which operational parameters impact surface integrity is necessary for the acceptance of new cutting tool materials, geometries, and techniques. First, a review of earlier studies on the surface integrity acquired during Inconel 718 turning is conducted. Following this, a variety of studies evaluating the effects of modifying the content, shape, and degree of wear.

Experimental Set Up:

The material employed in this experiment was a commercial AISI 1020 steel round bar that measured 220 mm in length and 50 mm in diameter.This study developed a mathematical model based on an experimentally driven regression-analyzed technique to estimate the surface roughness of a milled workpiece. Machine test results provided the training data needed for prediction models. In order to carry out an extensive analysis, the parameters for cutting, depth of cut, and spindle speed were chosen such that they fell between low speed, rough machining, high speed, and finish machining. Specifically, based on the cutter's machining stability, the stable region's cutting depth and spindle speed were chosen to guarantee machining in a stable condition with a greater removal rate.

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Fig:-1 Lathe machine with attached job


Fig:-2 the job contacts with the tool bit


Fig:-3 Sand paper in contact with the job

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Fig 4:- Surface roughness measurement tester.

3. METHODOLOGY

1. **Preparation:** The turned steel surface was cleaned and free from any debris or contaminants that could affect the measurement accuracy.
2. **Selecting the Measurement Area:** Choosen the specific area of the turned steel surface where we want to measure the roughness. This area was considered as representative of the overall surface finish.
3. **Calibration:** Calibrate the roughness tester according to the manufacturer's instructions for maintaining the accurate measurements by setting the appropriate parameters for the specific measurement environment.
4. **Setting Measurement Parameters:** Set the measurement parameters on the roughness tester. This was included selecting the appropriate evaluation length (cutoff length), sampling length, and filtering parameters based on the surface characteristics and standards being followed.
5. **Performing the Measurement:** Place the roughness tester probe on the selected measurement area of the turned steel surface to ensure that the probe makes proper contact with the surface. Initiate the measurement process according to the instrument's instructions.
6. **Data Collection:** Allow the roughness tester to scan the surface and collect data on the surface profile. The instrument was typically record parameters such as Ra (average roughness), Rz (average maximum peak-to-valley height), Rq (root mean square roughness), and other relevant parameters depending on the instrument's capabilities.
7. **Analysis and Interpretation:** Once the measurement is complete, analyze the data collected by the roughness tester. Review the surface roughness parameters to assess the quality of the turned steel surface. Compare the measured values with any specified tolerances or quality standards to determine if the surface meets requirements.

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8. **Documentation:** Record the measured surface roughness values along with any relevant details such as measurement location, date, and operator information

Observation:

Table 1 RPM_1= 274

		Depth of cut(mm)	Roughness
F1(mm)	0.1209	0.75	2.570
F2(mm)	0.0645	0.6	2.504
F3(mm)	0.0322	0.5	2.074

Table 2 RPM 2 = 186

		Depth of cut(mm)	Roughness
F1(mm)	0.1183	0.75	2.621
F2(mm)	0.0591	0.6	2.582
F3(mm)	0.0298	0.5	2.474

Table 3 RPM 3 = 124

		Depth of cut(mm)	Roughness
F1(mm)	0.1167	0.75	3.201
F2(mm)	0.0584	0.6	3.013
F3(mm)	0.0292	0.5	2.478

Table 4 DEPTH OF CUT = 0.75 MM

RPM	ROUGHNESS
124	3.201
186	2.621
274	2.570

Where,
F = feed, F1 = feed 1, F2 = feed 2, F3 = feed 3
RPM_1, RPM_2, RPM_3 = 274,186,124

4. RESULTS AND DISCUSSION

Developing prediction model of surface roughness using Response surface method:- Roughness criteria have been widely used in industry and research community. It can be

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represented by several parameters. Following curves have been considered for rpm 186 (Fig.5 & Fig.6) & depth of cut 0.75 mm (Fig.7).

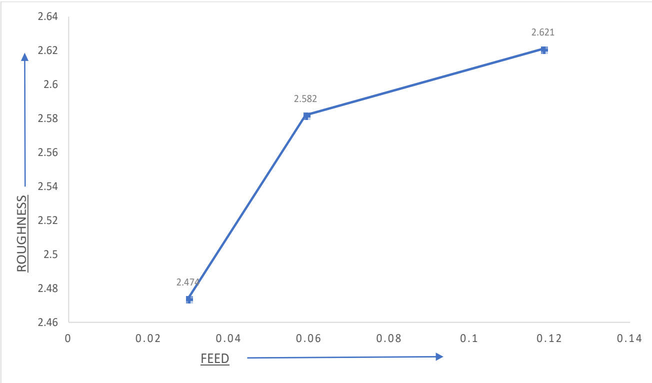

Figure: - 5 shows that the surface roughness decreases with decreasing the feed rate for a fixed cutting speed (186 rpm)

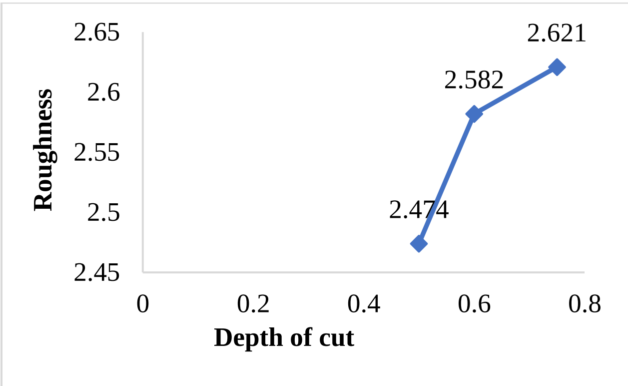

Figure: - 6 shows that the surface roughness decreases with decreasing the depth of cut for a fixed cutting speed (186 rpm)

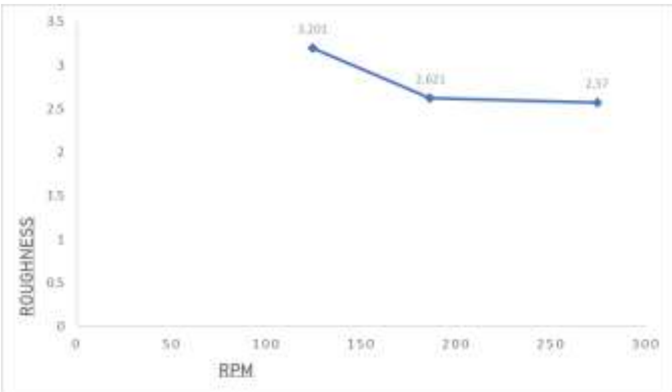

Figure: - 7 shows that the surface roughness decreases with increasing the cutting speed for a fixed depth of cut (0.75 mm)

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5. CONCLUSION

Based on the conclusion provided, it seems that when the feed rate & depth of cut is decreased, the surface roughness value also drops for a fixed cutting speed. Additionally, an increase in RPM causes the surface roughness to decrease for a fixed depth of cut. This suggests that adjustments in feed rate, RPM, and depth of cut can influence surface roughness in machining processes.

Future scope:
More research work should carry out for further development of the present work. Some of the areas are –

- The work & tool material can be changed
- The work can be carried out through other machining processes.
- Temperature can be considered for carrying out the present work.

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