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# Optimization of Cutting Parameters on Surface Roughness and Cutting Force in Turning Mild Steel on Conventional Lathe: A Review

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***Abstract :*** This literature review explores the impact of cutting parameters specifically cutting speed, feed rate (FR), & depth of cut (DOC) on surface roughness as well as cutting force in the turning of mild steel on conventional Lathe machines. These factors are critical in optimizing machining quality, efficiency, and tool life in industrial manufacturing. The study employs the Taguchi technique to examine variations and enhance the quality of manufactured products and engineering designs. The review examines recent studies to understand how each parameter influences surface finish and cutting force independently, as well as the interactions between parameters that often yield complex effects on machining outcomes. Cutting speed depends on material & cutting conditions, although FR & DOC always impact surface roughness as well as cutting force. In several reviews, signal-to-noise ratio was employed to analyze turning operation performance; Additionally, this paper discusses the measurement techniques and the use of statistical and computational models including ANOVA (Analysis of Variance), RSM (Response Surface Methodology), & DOE (Design of Experiments) in analyzing and predicting optimal cutting conditions. Identified gaps in the current literature include limited parameter ranges, lack of comprehensive interaction studies, and limited exploration of advanced tool materials and lubricants. This review concludes by recommending future research to address these gaps, intending to improve machining performance and efficiency through optimized parameter selection

***Key words****:* Taguchi Method, Feed rate, Depth of cut, Spindle speed, Turning, Surface roughness.

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## I. Introduction

Globally, lathe machine turning operations face key challenges in achieving precision, efficiency, and sustainability. Lathe machine parameters perform crucial functions market by directly influencing the quality, efficiency, and cost-effectiveness of machined components. Key parameters like FR, DOC determine surface finish, & cutting speed, dimensional accuracy, as well as production speed, that are critical for industries like automotive, aerospace, and heavy machinery. Optimized lathe parameters lead to high-quality, precise parts that meet strict tolerances, enhancing product value and reliability.

LATHE MACHINE:

Figure no.1

A lathe machine is a multipurpose instrument that is mostly employed to rotate a workpiece against a cutting tool to shape along with process a variety of materials, especially metals. It's one of the oldest machine tools, with applications in various fields, including manufacturing, metalworking, and woodworking.

CONSTRUCTION:

The construction of a lathe machine involves several essential components, each contributing to its functionality such as Bed, Headstock, Spindle, Chuck, Tailstock, Carraige, Apron, Lead Screw and Feed Rod, Speed and Feed Controls, Electric Motor & Coolant System.

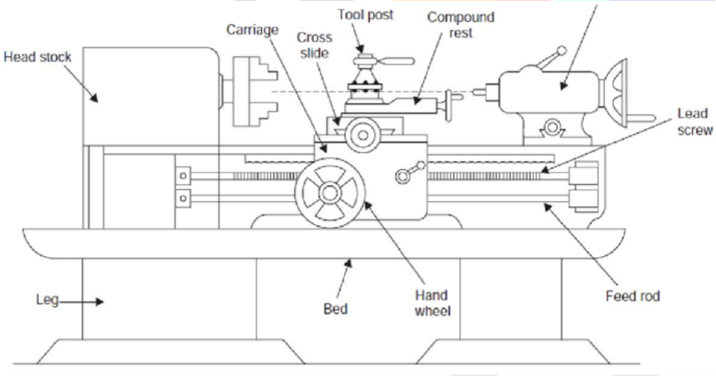



Fig.no.2 [1]

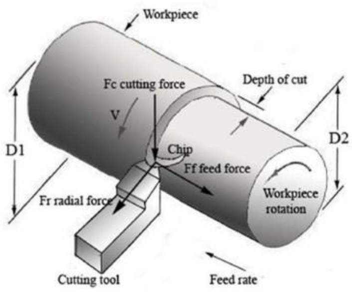
WORKING PRINCIPLE:

A lathe machine works by rotating a workpiece held in a chuck or collet, while a stationary cutting tool is applied to it. Cutting tool could remove material while shaping workpiece by rotating it. The cutting tool moves along different axes (longitudinal, cross, or angular) to perform various operations, such as turning, facing, boring, and threading. The operator can adjust parameters including FR, spindle speed, dimensions, achieving desired shapes, & DOC for controlling surface finishes, & machining process.

Lathe machine is used primarily for shaping and machining materials, especially metals, by rotating a workpiece against a stationary cutting tool. It can perform a wide variety of operations such as that are crucial in manufacturing, research, and production of precise parts. A lathe machine can perform operations such as turning, facing, drilling, boring, threading, knurling, parting, grooving, taper turning, and chamfering.

TURNING:

Figure no.3 [1]




The chemical composition of mild steel (low-carbon steel) generally falls within the following range:

1) Sulphur (S): ≤ 0.05%
2) Manganese (Mn): 0.25–0.70%
3) Carbon (C): 0.05–0.25%
4) Silicon (Si): ≤ 0.30%
5) Phosphorus (P): ≤ 0.05%
6) Remaining Iron (Fe) is major constituent.

A lathe machine's turning procedure entails rotating workpiece while employing a stationary cutting tool to remove material from its exterior. This usually reduces the diameter that shapes the workpiece into a cylindrical shape, as depicted in Fig.3 [1]. Depending on desired shape, cutting tool could be fed longitudinally or at an angle resulting in a variety of profiles, including

straight, tapered, or contoured surfaces. Tool moves along length of rotating workpiece. This operation is commonly used for creating shafts, rods, and other cylindrical components.

A single-point cutting tool on a lathe rotates the workpiece while removing material from its surface with its sharp point to shape it. This process is known as turning. Typically mounted cutting tool onto tool post that fed along the length of the workpiece to cut away material, reducing its diameter or producing specific shapes.

The tip of single-point cutting tool is positioned at the desired cutting point on the rotating workpiece that is fixed to the tool post. The tool moves along the length of the workpiece (longitudinal feed) or perpendicular to it (crossfeed) to remove material and shape the workpiece. Along workpiece tool moves, material is progressively sheared off, creating a smooth, cylindrical surface. Adjustment of these parameters like FR, Cutting Speed,& DOC is essential for operation.

## II. LITERATURE REVIEW

This chapter includes a list of references to previous research, highlighting the areas that researchers have focused on in their work.

DIFFERENT VIEWS:

As per study by Arumugam and Ragoth Singh in 2013 [2], turning is a widely used machining process in the manufacturing industry. In terms of design, material hardness is a crucial property for ensuring safety and reliability. Primary aim of current study is investigating impact of FR, spindle speed, & DOC on changes in material hardness on the machined surface during turning. Forged steel EN353 was selected for this study to assess hardness. The Taguchi method was applied, and the Rockwell hardness tester was used to assess the hardness, with cutting parameters varied throughout the experiment.

As per study by Bharat Sharma in 2020 [3], This research paper examines how various machining parameters, like FR, DOC, & spindle speed, affect cutting forces during a turning operation on a lathe machine. The authors use a dynamometer to measure these forces and then analyze their findings to identify optimal cutting parameters for minimizing cutting force. Ultimately, the paper's goal is to improve machining efficiency and tool life by understanding the complex relationship between machining variables and the resultant forces generated. Objective of the study in determining how to reduce the cutting force.

As per study by Satish Kumar and R Bishnoi in 2019 [4], optimized turning parameters using the Taguchi Method. They investigated how various turning parameters, including FR, rotational speed, tool nose radius, & DOC, influence high carbon steel surface roughness. An L8 Taguchi design was employed for experiment design and parameter optimization, involving eight experiments with four factors, each at two levels. The findings highlighted that tool nose radius significantly impacts surface roughness, emerging as the most influential factor with a contribution of 99.58%.

Ankit Dogra, Dharampal, Sunil Kumar, Hartaj Singh, and Vishal Singh in 2016 [5] stated, conducted experiments with EN8 material specimens to examine various machining parameters impact on tool wear. Primary objective had been assessing how cutting parameters and workpiece characteristics impact tool wear during EN8 material machining. They identified workpiece material quality as a key factor affecting tool wear, spindle speed, alongside DOC, & FR. Experimental design was structured using the Taguchi Technique, employing an L9 orthogonal array & ANOVA for analyzing turning conditions. A coated tool has been employed for machining process.

A. Elanthiraiyan, G. Haripriya, S. Sathiyaraj, & V. Srikanth Pari in 2015 [6] research concluded, explored surface roughness optimization, a critical factor in conventional machining. They focused on optimizing parameters in the turning process for steel alloys for achieving an improved surface finish. FR, speed, & DOC were analyzed as machining parameters in study, with Taguchi method employed for determining optimal levels for each. Through statistical analysis, optimal feed, speed, & DOC ranges determined in minimizing surface roughness, which was then applied in a real-time experimental model. EN8 steel employed as work material in study, along with a tungsten carbide-tipped tool.

K. K. Bhosale, N. S. Bagal, V. P. Patil, P. G. Inamdar, and V. V. Mane in 2017 [7] research aimed at surface roughness optimization in conventional turning of medium carbon steel EN8 applying Taguchi Method. For improving surface quality, three performance criteria have been selected: DOC, FR, & cutting speed. Taguchi analysis employed for determining the primary parametric impacts on surface roughness across three levels as well as factors in an experimental design utilizing an L9 orthogonal array. A 95% confidence level was used to perform ANOVA. According to the results, in conventional turning, cutting speed had greater impact on surface roughness than FR & DOC.

Pon. Azhagiri, B. Suresh, B. Kumarakurubaran, & T. Senthil Kumar 2016 [8] research conducted experiments for investigating cutting parameters impact—cutting speed, DOC, & FR —on surface roughness and material removal rate (MRR) during the turning of EN8 steel. Cutting speeds of 1000, 1250, & 1500 rpm, FR s of 0.1, 0.2, & 0.3 mm/rev, as well as depths of cut of 0.3, 0.4, & 0.5 mm were all employed in experiments. The experimental arrangement was designed using the Taguchi method, and the effects of cutting settings on response variables have been assessed utilizing an orthogonal array as well as ANOVA. The association with cutting parameters and performance measurements, including machining time, surface roughness, as well as MRR, was modeled by applying multiple regression analysis.

A study by G. Akhtar, C.H. Che Haron, and J.A. Ghaniet in 2008 [9], demonstrated that enhancing quality & productivity across companywide activities can significantly improve design quality. They emphasized Taguchi's parameter design as a crucial instrument for robust design, providing straight-forward & methodical approach for optimizing designs for quality, performance, & cost. Cutting parameters in turning operations had been meticulously optimized by employing Taguchi optimization approach.

Taguchi optimization approach was applied to bending parameters in a 2010 study by Sijo M.T. & Biju Ann [10], that emphasized turning factors such as cutting velocity, FR, DOC, tool nose radius, & material stiffness, each at two levels. Contrary to the DOC along with material hardness, the investigation demonstrated that FR, cutting velocity, as well as tool nose radius had a slight impact on surface roughness.

Dr. S.S. Chowdhary, S.S. Khedkar, and N.B. Borkaret in 2011 [11], explored how manufactured products' performance can be assessed using multiple quality characteristics and experimental techniques. To optimize crucial procedure parameters, involving speed, FR, DOC, as well as nose radius of a single-point cutting tool, they designed an optimization model following Taguchi method. Taguchi L9 orthogonal array has been selected for this investigation for organizing experimental design. For purpose f enhancing performance while limiting MRR & surface roughness, an ideal combination of cutting speed, DOC, & lower feed levels is required, according to an analysis of trial data.

## III. TAGUCHI' METHOD:

Multiple regression analysis, response surface methodology (RSM), & artificial neural networks (ANN) combined with optimization algorithms including genetic algorithms (GA), fuzzy regression models, & swarm intelligence are typical approaches for modeling along with process optimization in this process. Typically, these methods rely on single objective functions for optimization. A major limitation, however, is that they require substantial data to build an accurate model, increasing both experimental costs and time. For example, an experiment involving four factors, each with three levels, would require 81 trials to capture all possible combinations, providing 100% accurate results [12]. In contrast, the Taguchi method's orthogonal array reduces the required trials to just nine, achieving approximately 99.96% accuracy [13]. This reduction drastically lowers the number of experiments while maintaining similar accuracy. The Taguchi Method employs specially designed, highly fractionated factorial experiments derived from balanced orthogonal arrays. These designs allow researchers to efficiently explore the entire experimental region of interest. Also, in Taguchi method's experimental design and analysis process consists of several steps, though design of experiments (DOE) can sometimes be complex, time-consuming, and challenging to scale when more process factors are involved. In this approach, ANOVA can be performed to identify the significant parameters in the turning process.

## CONCLUSION:

Taguchi technique effectively employed during this study enhanced toughness & hardness of engineering materials by optimizing machining parameters during the turning process. Emphasizing the importance of achieving an optimal surface finish in machining, the research utilized the signal-to-noise ratio to assess performance parameters. Taguchi technique employed in determining optimal spindle speed, FR, & DOC for turning mild steel.

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