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A Review of the Optimization of Turning Parameters on Various Steel Grades

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Abstract

The impact of cutting parameters in the turning process primarily affects the surface roughness, material removal rate cutting forces and tool wear. The rising competition to increase productivity with high quality surface finish has formed the need to choose high quality machining tool. The significant cutting parameters in turning process are commonly cutting speed, depth of cut, feed rate and spindle speed these are the factors that affect the surface roughness and material removal rate of the finished material. The purpose of this study is to evaluate the work on optimizing turning parameters during turning operations on various steel grades. The key input parameters in separate publications were cutting speed, feed rate, and depth of cut, whereas the output parameters were cutting forces, tool wear, surface roughness, and material removal rate. Various researchers have investigated Taguchi and RSM (Response surface methodology) techniques for parameter creation and optimization. In order to determine whether input parameters had a substantial impact on performance characteristics, researchers utilised ANOVA (Analysis of variance) in their study. In their individual studies, researchers used the Signal to Noise (S/N) ratio to quantify the variances in experimental data. This study was mainly focused on determining the most prompting input parameter for good or undesired outcome; nonetheless, the primary goal was to pick optimal parameters for enhanced surface quality and low material loss rate.

Keywords: **surface roughness; material removal rate; Taguchi; ANOVA; RSM**

1. Introduction

The problems of today's machining industries are mostly focused on achieving high quality in terms of work dimensional accuracy and surface polish. Geometric imperfections are the focus of surface texture. The quality of a surface is a critical component in estimating the productivity of a machine tool and machined items. Manufacturers in the manufacturing industry focus on the product's quality and productivity. There are several elements that influence surface roughness and material removal rate (MRR), including cutting circumstances, tool variables, and work piece variables. Cutting conditions include speed, feed, and depth of cut, as well as tool variables such as tool material, nose radius, rake angle, cutting edge geometry, tool vibration, tool overhang, tool point angle, and so on, and work piece factors such as material hardness and mechanical qualities. Taking all of the factors that govern the surface roughness and material removal rate for a certain procedure is quite difficult. It is quite difficult to select the cutting parameters in a turning operation in order to achieve a high surface finish and material removal rate. In the current production setup, metal cutting optimization techniques are required for manufacturing processes to respond successfully to a high degree of competitiveness and rising demand for quality goods in the market [1]. This research explains how cutting speed, feed rate, spindle speed, and depth of cut affect surface roughness and material removal rate while turning various steel grades on a computer numerical control machine with various types of tools and inserts. This article also discusses the many sorts of optimization techniques that are utilised in optimization.

2. Optimization Techniques

Optimization denotes to the art and science of assigning infrequent resources to the best possible effect [2]. For Optimization we are applying two types of tools they are Response Surface Methodology (RSM) and Taguchi Technique.

2.1 *Response Surface Methodology (RSM)*

Response Surface Methodology (RSM) is a collection of mathematical and statistical tools that are useful for the modeling and examination of complications in which an output response of interest is influenced by several input variables and our goal is to optimize (minimize or maximize the response depending on the need) the response [3].

2.2 *Taguchi's Approach*

Taguchi's parametric method is a powerful tool for creating sturdy designs. It provides us with a basic and structured qualitative ideal design at a reasonable cost. The most notable advantage of this strategy is that it saves both time and money by identifying the significant components. [4].

2.3 *ANOVA*

It's also known as analysis of variance. It is a statistical technique that uses the F-test to determine whether or not the means of more than two set values are equal. It is a statistical technique that may be used to adjust the percentage contribution of components based on the results of the Taguchi experiment. This computation employs the Taguchi method's S/N ratio [5].

3. Literature Review

A brief review of status of research work carried out by various investigators is presented in Table 1.

Table 1: The Influence of Cutting Speed, Feed, and Depth of Cut on Surface Roughness and Material Removal Rate

S. No.	YEAR	AUTHOR	Material	Cutting Tool	Input Parameters	Method
1	1907	Taylor F W [6]	metal turning	Single point tool	Cutting Speed, feed and depth of cut	Experimental
2	1950	Gilbert W W [7]	metal turning	Single point tool	Cutting speed	Experimental
3	1998	W.H, Yang and Y.S. Tarng [8]	S45-C steel bars	Tungsten Carbide Cutting Tools	Cutting Speed, feed and depth of cut	Taguchi method
4	2002	Suresh P.V.S et.al. [9]	Mild Steel	CNMG Cutting Tool	Cutting Speed, feed, depth of cut and nose radius	RSM
5	2005	Tugrul O Zel, Yigit Karpat [10]	AISI H13 steel	CBN inserts	Cutting Speed, feed, workpiece hardness and edge preparation	regression model
6	2005	Tugrul O Zel et.al. [11]	AISI H13 steel	CBN inserts	Cutting Speed, feed, workpiece hardness and edge preparation	ANOVA
7	2007	S. Thamizhmanii et al. [12]	SCM440 alloy steel	Coated Carbide tool Al2O3 + TiC with tin coating	Cutting Speed, feed and depth of cut	Taguchi method
8	2009	B. Frides et.al. [13]	Aluminium alloys	carbide cutting tools	Cutting Speed, feed and depth of cut	ANFIS model and RSM
9	2009	Muammer Nalbant [14]	AISI 1030 steel	Coated and Uncoated tool	Cutting Speed, feed, coating method and	Taguchi Method

					coating material	
10	2010	Ali Riza Motorcu [15]	AISI 8660	P.V.D. coated ceramic cutting tool	Cutting Speed, feed, depth of cut and nose radius	Taguchi & ANOVA
11	2010	D. Philip Selvaraj and P. Chandramohan [5]	AISI-304 Austenitic Stainless Steel	Multilayered coated and uncoated carbide tool	Cutting Speed, feed and depth of cut	ANOVA
12	2010	R. Ramanujan et.al. [16]	Al-15 steel	Central Composite Design	Cutting Speed, feed and depth of cut	L27 Taguchi Method
13	2010	S. Delijaicov et.al. [17]	AISI 1045 Steel	Steel	Cutting Speed, feed and depth of cut	Experimen tal
14	2010	Vipin Kumar Sharma [1]	AISI-1060 Steel	Multilayered coated and uncoated carbide tool	Cutting Speed, feed and depth of cut	Taguchi method and RSM
15	2012	H.K. Dave et al. [18]	Various grades of EN materials	TiN coated cutting tools	Workpiece material, Cutting Speed, feed and depth of cut	ANOVA
16	2012	L B Abhang, M Hameedullah [19]	EN-31 Alloy steel	tungsten carbide inserts	Feed, depth of cut and lubrication temperature	ANOVA and RSM
17	2012	F. Puh et.al. [20]	AISI 4142 Steel	PCBN tools	Cutting Speed, feed and depth of cut	L9 Taguchi Method, ANOVA
18	2012	K. Adarsh kumar et.al. [21]	EN-8 Steel	cemented carbide inserts	Cutting Speed, feed and depth of cut	Multiple regression analysis and ANOVA

19	2013	S.B. Salvi et.al. [22]	20MnCr5 steel	Ceramic TNGA160404	Cutting Speed, feed and depth of cut	Taguchi method and ANOVA
20	2013	Mustafa Gunay and Emre Yucel [23]	high-alloy white cast iron (Ni-Hard)	ceramic and cubic boron nitride (CBN)	Cutting tool, Cutting Speed, feed and depth of cut	Taguchi method and ANOVA
21	2013	Ashvin J. Makadia and J.I. Nanavati [24]	AISI-410 steel	TiN coated carbide	Cutting Speed, feed, depth of cut and tool nose radius	RSM
22	2013	C.J. Rao .et. al 2013 [25]	Al2O3+TiC matrix (KY1615)	AISI 1050 steel	Cutting Speed, feed and depth of cut	L27 Taguchi Technique
23	2013	Harish Kumar [2]	Different Steel Grade	Multilayered coated and uncoated carbide tool	Feed rate, spindle speed and depth of cut	Taguchi Technique
24	2014	Surendra Kumar Saini and Sharad Kumar Pradhan [26]	8011 Aluminium Alloy	carbide cutting tool	Spindle Speed, feed and depth of cut	L27 Taguchi Analysis
25	2014	Nithyanandan T et.al. [4]	AISI-304 Stainless Steel	Tungsten Carbide Insert	Cutting Speed, feed and depth of cut	Taguchi Technique
26	2014	Sayak Mukherjee et.al. [27]	SAE 1020	carbide cutting tool	Cutting Speed, feed and depth of cut	L25 Taguchi Analysis
27	2014	Mittal P Brahmbhatt [28]	EN-9 Steel	MTCVD multicoated carbide inserts	Cutting Speed, feed and depth of cut	Taguchi Technique
28	2014	Murat Sarikaya and Abdulkadir Gullu [29]	AISI 1050 Steel	Uncoated tool	Cooling condition, Cutting Speed,	L16 Taguchi Method,

					feed and depth of cut	ANOVA and RSM
29	2014	Puneet Saini [30]	20MnCr5 Steel	PVD and CVD coated tool	Cutting Speed, feed and depth of cut	RSM
30	2014	Govindan P and Vipindas M P [31]	EN-24 Steel	Ceramic coated tool,	Cutting Speed, feed and depth of cut	Taguchi Technique
31	2015	Supriya Sahu and B.B Choudhury [32]	AISI-4340	TiN Coated carbide tool	Cutting Speed, feed and depth of cut	Taguchi Technique
32	2015	Hemant Jain et.al. [33]	Inocel-645	Carbide coated tool	Spindle Speed, feed and depth of cut	Taguchi analysis
33	2015	G.M.Sayeed Ahmed [34]	Mild Steel	HSSS Tool	Cutting Speed, feed and depth of cut	L9 Taguchi Technique
34	2015	Girish Kant and Kuldip Singh Sanghwan [35]	AISI 1060 Steel	Single tool carbide tool	Flank wear, Cutting Speed, feed and depth of cut	Artificial Neural Network
35	2016	D. Rajasekhar Reddy and AV Hari Babu [36]	EN-31 alloy steel	CVD and PVD coated carbide tool	Cutting tool, 18Cutting Speed, feed and depth of cut	Taguchi based grey relation energy
36	2016	Suraj R. Jadhav and Aamir M. Shaikh [37]	EN-24 alloy steel	PVD coated TiAlN inserts and uncoated carbide inserts	Spindle Speed, feed and depth of cut	Experimen tal
37	2017	Chandan Kumar [3]	AISI-202 steel	TiAlN coated carbide insert	Cutting Speed, feed and depth of cut	RSM

38	2017	Jitendra Kumar Verma and Amit Sharma [38]	16MnCr5 steel	TNMG160408 Insert	Spindle Speed, feed and depth of cut	L27 Taguchi Method
39	2017	Rahul R Deshpande and Reena Pant [39]	EN-8 Alloy Steel	uncoated insert	Cutting Speed, feed and depth of cut	Experimental
40	2017	Jitendra Kumar Verma, et.al. [40]	16MnCr5 steel	TNMG160408 Insert	Spindle Speed, feed and depth of cut	Grey Relation Analysis
41	2017	Ravi Aryan et.al. [41]	HSS	carbide and cobalt tool	Spindle Speed, feed and depth of cut	Taguchi analysis
42	2017	Praveen Kumar et.al. [42]	EN-31 Steel	Tungsten Carbide Insert	Spindle Speed, feed and depth of cut	RSM
43	2017	Santosh Kumar et.al. [43]	EN-45 Steel	Plain carbide tool	Cutting Speed, feed and depth of cut	Taguchi method and regression analysis
44	2018	M. Vijay Kumar et.al. [44]	EN19 Steel	Carbide tip tool	Lubrication, Spindle Speed, feed and depth of cut	L18 Taguchi and ANOVA
45	2018	Rakesh Kumar Gadekula et.al. [45]	High Carbon High Chromium Steel (HCHCR)	Carbide tip tool	Spindle Speed, feed and depth of cut	Taguchi technique
46	2019	B.Radha Krishnan and M Ramesh [46]	IS2062 E250 Steel	Coated carbide cutting tool	Spindle Speed, feed and depth of cut	Taguchi analysis and ANOVA
47	2019	Amardeep Kumar and Shard K Pradhan [47]	EN – 24 Steel	CBN	Cutting Speed, feed and depth of cut	Taguchi, ANOVA, regression techniques

						and genetic algorithms
48	2019	Syed Irfan et.al. [48]	EN45 Steel	Carbide cutting tool	Lubrication, Spindle Speed, feed and depth of cut	Taguchi analysis and ANOVA
49	2019	S.P. Palaniappan [49]	Aluminium 6082	Tungsten carbide cutting tool	Cutting Speed, feed and depth of cut	L27 Orthogona l Array
50	2020	C. Veera Ajay and V.Vinoth [50]	Aluminium 6061 Steel	Central Composite Design	Cutting Speed, feed and depth of cut	RSM
51	2020	Rudra Patel et.al. [51]	EN8D Carbon steel	Carbide Insert	Cutting Speed, feed and nose radius	Taguchi Analysis and ANOVA
52	2020	M. Vinoth Kumar [52]	AA2024 steel	Uncoated insert	Cutting Speed, feed and depth of cut	Taguchi Technique
53	2020	Mustafa Gunay, Mehmet Erdi Korkmaz [53]	Nimonic 80A	coated carbide tools	Cutting Speed, cutting environment, feed and depth of cut	RSM
54	2020	K.M.Senthikumar , et.al. [54]	Inconel 718	coated carbide inserts	Spindle Speed, feed and depth of cut	Taguchi method
55	2020	A.Arunnath and P.Haza SyedduMasooth [55]	SCM440 Steel	uncoated carbide and TiCN/Al2O3 /TiN coated carbide tool	Cutting Speed, feed and depth of cut	S/N Ratio and ANOVA
56	2021	Mahshad Javidikia et.al. [56]	AA 6061-T6 Steel	Central Composite Design	Cutting Speed, feed, depth of cut and different turning	ANOVA and RSM

					environment	
57	2021	Vishwanath Panwar et.al. [57]	EN-36 Alloy steel	TNMG160404 Insert	Spindle speed, Feed rate and Cutting Width	RSM
58	2021	Sundar Singh Sivam Sundarlingam Paramasivam et.al. [58]	EN 8 Steel	Coated Insert	spindle speed, feed speed, cutting depth, environment and insert corner radius	L16 Taguchi Technique and ANOVA
59	2021	Praveen Kittali et.al.	EN 1A Steel	Uncoated cutting tool	Spindle Speed, feed and depth of cut	Taguchi Technique
60	2021	Ramneek Singh [59]	Brass 63/37	CNMG120408	Spindle Speed, feed and depth of cut	L27 Taguchi Technique and ANOVA
61	2021	Ravi Kumar Panthangi et.al.	LM9 Aluminium alloy	CVD Coated cutting tool	Cutting Speed, feed and depth of cut	L9 Taguchi Technique
62	2021	Rudra Patel et.al.	EN8D carbon steel	Carbide Insert	Cutting Speed, feed and Nose radius	L27 Taguchi Method and ANOVA
63	2021	S. Kolappan et.al. [60]	AA2014/TiC (Titanium carbide) composites	Tungsten carbide cutting tool	spindle speed, feed and cutting depth	L16 Taguchi Method

4. Conclusion

According to a survey of the literature, spindle speed, depth of cut, feed, and cutting speed are the cutting parameters that most researchers have focused on in their studies, while ignoring other characteristics such as nose radius, tool signature, and cutting tool coating thickness. Surface roughness and material removal rate are two frequent output factors (MRR). According to the findings of this literature study, surface roughness is mostly reliant on cutting speed and feed rate when performing the operation, with DOC being the least relevant characteristic. The depth of cut and feed rate has a major impact on material removal rate.

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