Available online at www.ijapie.org

International Journal of Advanced Production and Industrial Engineering

IJAPIE-SI-MM 515 (2017) 93–100

Special Issue on

MATERIALS & MANUFACTURING

Optimisation of Cutting Parameters on Surface Roughness in Turning: A Review

Yashwant Koli*, Prashant Kumar Singh ,Vipin, Ranganath M. S.
(Department of Mechanical Engineering, Delhi Technological University, Delhi110042, India)
**Email: yashwantkoli5@gmail.com*

Abstract : *The literature review of these papers serves various goals. First it focuses on the work that has been done on turning during these recent years or the advancement that has been done in this field. Secondly it will helpful to the researcher who wishes to work further on this topic or wishes to know the effects of cutting parameters on SR in turning on different alloys. This analysis through this article will help the researcher to find the existing gap on this issue and outline the future direction for the researchers through this review analysis. Total 140 papers published were selected, categorized and analyse and gap in the work been identified to suggest for future analysis. The research will be helpful for researchers, academicians and practitioners for better understanding in the field of turning.*

Keywords: *Turning; surface roughness; cutting parameters*

I. INTRODUCTION

Today economic machining with good dimensional accuracy has become the main concern for the production companies .The machining can be either on turning, milling, drilling In a turning operation Fig.1, it is significant task to select cutting constraints for achieving high cutting performance. However, this does not confirm that the selected cutting constraints have best or near best cutting performance for a specific machine and environment.(B.Ackroyd)[1]

Cutting constraints are imitated on roughness, surface quality and dimensional nonconformities of the product. Surface roughness is used to regulate and to estimate the quality of a product, is one of the chief quality characteristics of a turning product.

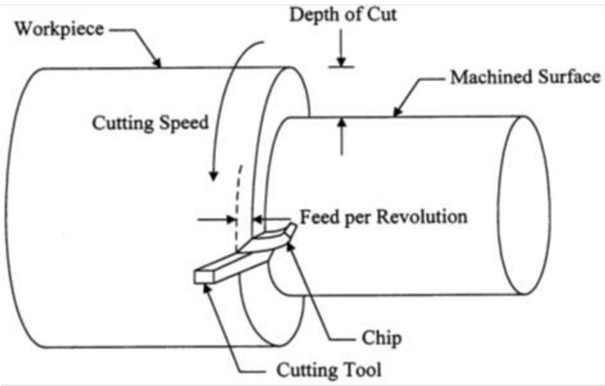

Fig.1. Basic turning operation(W.H. Yang et al.) [4]

According to (M.Nalbant et al.) [2]“Surface roughness can be defined as the measure of the quality of a product and also it is the factor that significantly effects manufacturing cost. It can further also be describes the geometry of the machined surfaces that combined with the texture of the surface”.

In today’s manufacturing industry, dimensional accuracy and surface finish are the very important point of concern. Thus, activity and characterizing the surface end is thought of because the predictor of the machining performance (Reddy and Rao) [3].

The papers review in this review paper has been selected form the journals and conference conducted. The papers are reviewed in this review paper has been selected as follow.

First the papers to be reviewed were selected from January 1995 to December 2015. Basic scholarly search engine 'Google Scholars' and 'Science Direct' were used. First the keywords 'surface roughness in turning' was used to search the papers. About 140 papers published from various journals and conferences were reviewed.

Fig.2, explains the experimental scheme for optimizing the surface roughness in turning operation. Initially, perform the basic turning operation on work piece with different cutting parameters then measure surface roughness with the help of surface measurement device. Then for enhancing the roughness both the cutting constraints and the measured surface roughness is inserted in the computer. With the assistance of different technique it gives the preferred optimal output.

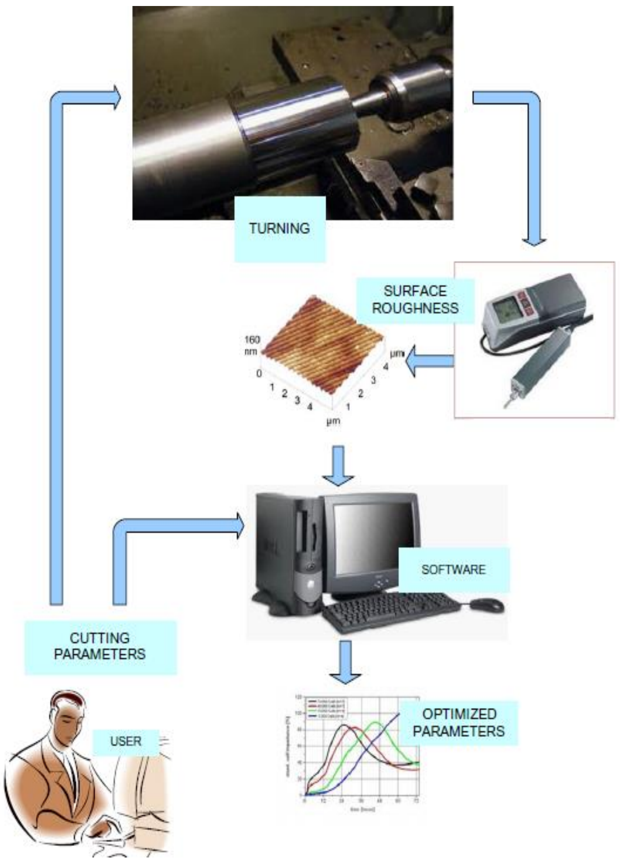

Fig.2. Experimental scheme (IlhanAsilturk et al.) [5]

I. SURFACE ROUGHNESS

Surface properties such as roughness are judicious to the purpose competence of machine components. Augmented understanding of surface generation instruments can be used to enhance machining process and to increase component function ability. Surface roughness is tougher to manage and track than physical dimensions are, because relatively many causes affect surface roughness. Some of these causes can be controlled and some cannot. Manageable process constraints include feed, cutting speed, tool geometry and tool setup. Other factors, such as tool, work piece, tool wear and degradation and tool material inconsistency cannot be controlled as easily.

TABLE I.
Cutting Parameters

Cutting parameters	**Units**
Cutting speed	(m/min)
Feed rate	(mm/rev)
Depth of cut	(mm)

II. TECHNIQUES

- TAGUCHI METHOD : Taguchi's parametric design is the operational tool for robust design it proposals a simple and organized qualitative ideal design to a comparatively low cost. The Taguchi method of off-line (Engineering) quality control encompasses all stages of product/process development. However the key component for attaining great value at low cost is Design of Experiments.

- ANOVA : Since there are a great number of variables governing the process, some mathematical simulations are required to represent the process. However, these models are to be developed using only the significant parameters influencing the process rather than including all the parameters. In order to achieve this, statistical analysis of the experimental results will have to be processed using the analysis of variance ANOVA is a computational method that allows the estimation of the comparative assistances of each of the control aspects to the overall calculated response. ANOVA can be beneficial for defining effect of any given input constraint from a series of experimental outcomes by design of experiments for machining process and it can be used to translate experimental data.

- ANN : ANN is an interconnected gathering of simple managing elements, units or nodes, whose functionality is loosely built on animal neuron. The processing capability of the network is kept in the inter-unit linking strengths, or weights, attained by a method of adaptation to, or learning from, a set of training patterns. In its most general form, ANN is a machine that is planned to model the way in which the brain implements a specific task or function of interest; the network is frequently executed by using electronic constituents or is simulated in software on a digital computer.

III. LITERATUREREVIEW

TABLE II

CLASSIFICATION AMONG DIFFERENT RESEARCHERS AND THEIR RESEARCH

Researchers	**Tool Material**	**Work piece Material**	**Techniques**	**Key Findings**
JANG.D.et al. [6]	Carbide	AISI 1020	On Line	The roughness along the work piece without chatter, has specific frequency components that are determined by the feed marks in the lower frequency range. They are narrowly related to the natural frequencies of a machine tool structure.
Davim. J et al. [7]	Cemented Carbide	Free Machining Steel	ANN	The roughness is highly sensitive to both cutting speed and feed rate whereas depth of cut has the least effect. The surface roughness has a tendency to reduce with the increase in cutting speed and also with the reduction in feed rate.
I.A. Choudhury et al.[8]	Uncoated Tungsten Carbide	EN 24T	Factorial Design	Effect of feed is much more pronounced than the effects of cutting speed and depth of cut, on the roughness. Though, a higher cutting speed improves the surface finish.
W.H. Yang et al. [4]	Uncoated Tungsten Carbide	S45C	Taguchi Method	The tool life and surface roughness from increases to about 250% from the initial cutting parameters to the optimal cutting parameters
M. Nalbant et al. [2]	TiN Coated	AISI 1030	Taguchi Method	Greater insert radius (1.2 mm), low feed rate (0.15 mm/rev) and low depth of cut (0.5 mm) leads to better surface roughness. The surface roughness improves to about 335% form initial cutting parameters to the optimal cutting parameters
IlhanAsilturk et al. [5]	Coated Carbide	AISI 4140	Taguchi Method	Optimum cutting conditions which correspond for the smaller surface roughness in hard turning method were found to be 120 m/min for the cutting speed, 0.18 mm/rev for the feed rate and 0.4 mm for the depth of cut.
HamdiAouici et al. [9]	CBN 7020	AISI H11	ANOVA	Feed rate and work piece hardness have major statistical influences on the surface roughness. Lower feed rate and the high cutting speed lead to best surface roughness.

S. Ramesh et al. [10]	Round Coated Carbide	Titanium Alloy (gr5)	ANOVA	The order of importance was feed, followed by depth of cut and cutting speed. Feed has a great effect on roughness.
Upadhyay.V et al. [11]	Uncoated Cemented Carbide	Ti–6Al–4V alloy	ANN	Surface roughness within reasonable accuracy.
Günay.M et al. [12]	CBN	High-alloy white cast iron (Ni-Hard)	Taguchi Method	The most significant variable for Ni-Hard with 62 HRC was found the feed rate while the variable that was the most significant for Ni-Hard with 50 HRC was the cutting speed.
Bouacha.K et al. [13]	CBN	AISI 52100	ANOVA	The surface roughness is highly affected by feed rate, whereas the cutting speed has a negative effect and the depth of cut a negligible influence.
N.R. Abburi et al. [14]	TiN-Coated Carbide	Mild Steel	ANN	Reducing the ranges and increasing the number of training data is expected to improve the accuracy of the surface roughness.
B.Y. Lee et al. [15]	Tungsten Carbide	S45C	Polynomial Network	The accuracy of the surface roughness can be predicted once the image of the turned surface and turning conditions (cutting speed, feed rate, and depth of cut) are given.
JanezKopac et al. [16]	Cermet	C15 E4	Taguchi Method	A higher cutting speed results in a smoother surface
P.V.S. Suresh et al. [17]	TiN-Coated tungsten carbide	Mild steel	GA	Surface quality can be greatly controlled using Genetic Algorithms
Shinn-Ying Ho et al. [18]	Tungsten Carbide	S45C	ANFIS	The advantages of the proposed method are non-contact measurements, ease of automation, and high accuracy
Tugrul Ozel et al. [19]	CBN	AISI 52100	ANN	The developed prediction system is found to be capable of accurate surface roughness prediction.

W.S. Lin et al. [20]	Carbide	S55C	Regression analysis	Feed rate is the significant factor that affects the roughness, where increasing feed rate will increase the roughness, while a regression multiplier proves that the cutting speed does not have a major impact on surface roughness.
O.B.Abouelatta et al. [21]	Cemented Carbide	Free cutting Steel	Mathematical Model	The maximum height roughness parameter depends greatly on the rotational cutting speed.
K.A. Risbood et al. [22]	TiN-Coated Carbide	Steel	ANN	Artificial neural networks can be used to find out the effective estimates of surface finish.
M.Y. Noordin et al. [23]	Coated Carbide	AISI 1045	ANOVA	The ANOVA revealed that feed is the most significant factor influencing the surface roughness.
D.I. Lalwani et al. [24]	Coated Ceramic	MDN250	ANOVA	Good surface roughness can be achieved when cutting speed and depth of cut are in range (93m/min and 0.2mm) and feed rate is at low level of (0.04mm/rev).
M. Anthony Xavior et al. [25]	Carbide	AISI 304	ANOVA	Coconut oil was found to be a better cutting fluid than the conventional mineral oils in reducing surface roughness.
Jeffrey D. Thiele et al. [26]	CBN	AISI 52100	ANOVA	The effect of work piece hardness and edge geometry interaction on the surface roughness was found to be very significant. The effect of edge hone on the surface roughness decreased with increase in work piece hardness
Davim. J et al. [27]	PCD	GFRP	ANOVA	The roughness increases with the feed rate and decreases with the cutting velocity. The feed rate has the highest physical and statistical effect on surface roughness.
A.Kohli et al. [28]	Carbide	Mild Steel	ANN	The experimental value is close to the most likely estimate and within the upper and lower estimates
Tugrul Ozel et al. [29]	CBN	AISI H13	ANOVA	Honed edge geometry and lower work piece surface hardness resulted in better surface roughness.

Eyup Bagci et al. [30]	MTT3000	GFRP	ANN	It was found that the maximum test errors were 6.30% and 6.36% by comparing roughness values predicted from ANN model with those predicted RSM.
Dilbag Singh et al. [31]	Ceramic	AISI 52100	ANOVA	Feed is the governing factor affecting the surface roughness.
Ahmet Hasçalhk et al. [32]	CNMG 12040-833	Ti-6Al-4V	Taguchi Method	Feed rate is the key factor that has the highest importance on the roughness and it is about 1.72 times more vital than depth of cut. The cutting speed does not seem to have much of an influence on the roughness.
Surjya K. Pal et al. [33]	HSS	Mild Steel	ANN	The predicted surface roughness from the neural network model is very close to the measured values.
Vishal S. Sharma et al. [34]	Coated Carbide	Adamite	ANN	Surface roughness is positively influenced with feed and it shows negative trend speed and depth of cut.
Hardeep Singh et al. [35]	Carbide	EN-8	Taguchi Method	The feed has the variable effect on surface roughness. It is interesting to note that spindle speed, feed rate and depth of cut for Material Removal Rate have increasing trend.
Ranganath M.S. et al. [41]	HSS	Aluminium 6061	ANOVA	The minimum surface roughness is obtained at 1.2mm depth of cut, 156rpm speed and 0.05mm/rev feed rate.
Ranganath M.S. et al. [42]	CNMG	Aluminium 6061	Taguchi Method	The optimal roughness is obtained at 1900rpm speed, 0.25mm depth of cut and 0.12mm/rev feed rate.
Ranganath M.S. et al. [43]	Carbide	Aluminium 6061	ANN	The surface roughness value increases as the feed and depth of cut increases and as spindle speed increases the roughness value decreases.

IV. ANALYSIS

The number of papers reviewed on turning is shown in fig 3. It shows in which year how many papers are published on turning which are reviewed.

Fig 4.gives the percentage distribution of the optimization technique used in the reviewed papers. With the help of the chart it can be stated that ANN, ANOVA and Taguchi techniques are used more than others.

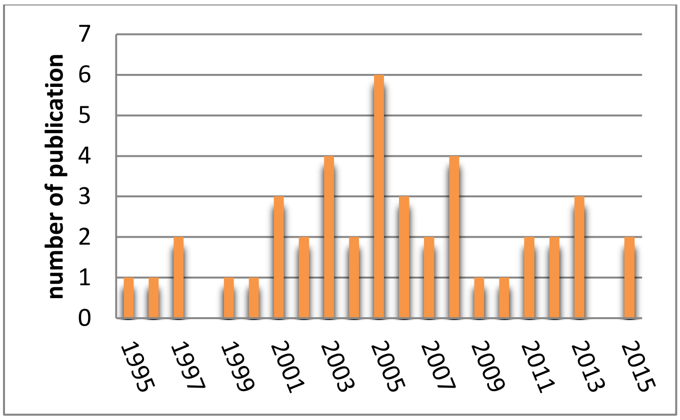

Fig 3. Total papers reviewed

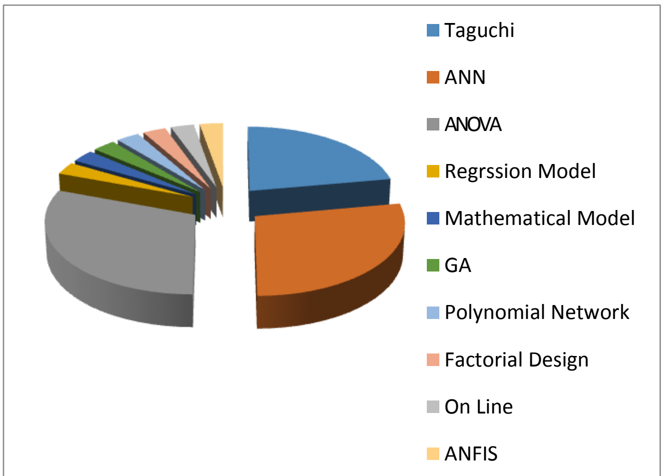

Fig 4. Percentage distribution of optimization technique

V. DİSCUSSİON AND CONCLUSİON

This literature review covers a brief literature of many areas of research; the current work presented a review of the different methodologies that are used for forecasting the surface roughness.

GAs and other optimization technique could be ideally used in conjunction with the developed models for the prediction of surface roughness(P.G. Benardos et al.) [36].

(Thomas M. et al.) [37] Concludes that the feed rate and also the tool nose radius square measure the variables that manufacture the foremost vital effects on surface roughness, followed by the cutting speed.

Dry machining of steel caused most tool wear and surface roughness and wet machining didn't show considerable improvement (N.R. Dhar et al.) [38].

It is observed that depth of cut and feed variables have a negative influence on the surface roughness average as increasing any of the two previous variables means increasing the roughness parameter. On the other hand, thereis an optimum value of cutting speed that provides a minimum value of surface roughness (I. Puertas Arbizu et al.) [39],(Davim. J et al.) [40].

This paper concludes that roughness increases with the feed rate and decreases with the cutting velocity. The best roughness was attained at the lower feed rate and the maximum cutting speed whereas depth of cut has negligible influence. This literature review not only presents the present scenario but also frame guideline for future research.

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