International Journal of Advance Research and Innovation
Vol. 4(1), Jan-Mar 2016, pp. 326-334
Doi: 10.51976/ijari.411648

Article Info
Received: 25 Jan 2016 | Revised Submission: 20 Feb 2016 | Accepted: 28 Feb 2016 | Available Online: 15 Mar 2016

Surface Texture Analysis in Milling of Mild Steel Using HSS Faceand Milling Cutter

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ABSTRACT

Surface finish influenced by the machining parameters on a milling machine. MOTIF-method is used for the evaluation of the primary profile. It is based on the envelope system and is suitable for alternative method to the mean line system. It determines the upper point of the surface profile and important for the functional behavior. The roughness and waviness can be evaluated directly from the surface profile curve. Cutting speed, feed rate and depth of cut effect was analyzed on the surface profile analysis. The experiments were conducted to study the machining parameter effects on milling of mild steel. The specimen was milled under different levels and analyzed R, Rx and Ar values.

***Keywords:** Surface Texture; Mild Steel; Milling,MOTIFs; Waviness; Roughness.*

1.0 Introduction

The surface finish is very important for the product, whichinfluence the functioning of a component. The qualityof the products depends upon the surface roughness.If the surface roughness increases, so it leads to decrease the quality of a product. It means that the surface roughness parameter should prefer forthe design of the component. The factor which influences the surface roughness is speed, feed rate and depth of cut. These cuttingparameters are very important for machining the material. The strategy involve in the selection of process parameters, neither guarantees forthe desired surface finish nor high metal removal rates. The geometry of a work piece includes their micro- and macro- geometrical deviations to the functional behavior and real geometry marks.The surface texture irregularities are mainly three type's roughness, waviness and lay.These geometrical errors can be easily detected by the instruments (e.g. taly surf). These may be induced by the vibration, hard material, chatter, heat treatment, etc.

The MOTIF-method is used to separate roughness and wavinessby means of unfiltered profiles. The MOTIF- method is a graphical evaluation with the complete description of roughness and waviness.It is based on the upper envelope line of the workpiece. It is a system of the primary profile evaluation and is suitable for an alternative to the mean line system. This method is used to determine the upper points of the surface profile and important for the functional behavior. Roughness and waviness can be evaluated directly from the diagram of the unfiltered profile. The MOTIF-method is well suited for technical inquiries onunknown surfaces and processes, functions related to the envelope of the surfaces and profiles with very close wavelengths for roughness and waviness.

The objective of the experiment is to predict the surface roughness to be obtained for the component of the milling operation. Surface finish is influenced by tool geometry, feed, cutting conditions and the irregularities of machining operations such as tool wear, chatter, tool deflections, cutting fluid and workpiece properties. The effect of cutting conditions (feed, cutting speed, axial–radial depth of cut and machining tolerance) is study in this work.

2.0 Literature Review

A considerable number of tribological studies have investigated the general effects of the speed, feedand depth of cuton the surface roughness. These studies are briefly discussed as: P.G. Benardos [2002] work on neural network modeling approach is

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presented for the prediction of surface roughness (Ra) in CNC face milling. The data used for the training and checking of the networks' performance derived from experiments conducted on a CNC milling machine according to the principles of Taguchi design of experiments (DoE) method. The factors considered in the experiment were the depth of cut, the feed rate per tooth, the cutting speed, the engagement and wear of the cutting tool, the use of cutting fluid and the three components of the cutting force. Using feedforward artificial neural networks (ANNs) trained with the Levenberg– Marquardt algorithm, the most influential of the factors were determined, again using DoE principles, and a 5_3_1 ANN based on them was able to predict the surface roughness with a mean squared error equal to 1.86% and to be consistent throughout the entire range of values.

Hasan Oktem [2006] used an approach for determination of the best cutting parameters leading to minimum surface roughness in end milling mold surfaces of an ortez part used in biomedical applications by coupling neural network and genetic algorithm. In doing this, design of experiments, neural network and genetic optimization technique are utilized in integrated purpose. A series of cutting experiments for mold surfaces in one component of ortez part are conducted to obtain surface roughness values. A feed forwardneural network model is developed exploiting experimental measurements from the surfaces in the mold cavity. The neural network model is trained and tested in MATLAB. Genetic algorithm coupled with neural network is employed to find optimum cutting parameters leading to minimum surface roughness without any constraint. For this purpose, a simulation model for the component of ortez part was created to determine the critical regions to be used in roughness measurements and to produce a plastic product. Additional measurements were performed to validate optimum values and their corresponding to the roughness value predicted by genetic algorithm with the values obtained from experiments in the mold cavity and on plastic product. From this, it is clearly seen that a good agreement is observed between the predicted values and experimental measurements.

Mohammed T. Hayajneh[2007]work on a set of experiments designed to begin the characterization of surface quality for the end-milling process have been performed. The objective of this study is to develop a better understanding of the effects of spindle speed, cutting feed rateand depth of cut on the surface roughness and to build a multiple regression model. Such an understanding can provide insight into the problems of controlling the finish of machined surfaces when the process parameters are adjusted to obtain a certain surface finish. The model, which includesthe effect of spindle speed, cutting feed rate and depth of cut, and any twovariable interactions, predicted the surface roughness values with an accuracy of about 12%.

Julie Z. Zhang[2007]study the Taguchi design application to optimize surface quality in a CNC face milling operation. Maintaining goodsurface quality usually involves additional manufacturing cost or loss of productivity. The Taguchi design is an efficient and effective experimentalmethod in which a response variable can be optimized, given various control and noise factors, using fewer resources than a factorial design. This study included feed rate, spindle speed and depth of cut as control factors, and the noise factors were the operating chamber temperature and the usage of different tool inserts in the same specification, which introduced tool condition and dimensional variability. An orthogonal array of L9(34)was used; ANOVA analyses were carried out to identify the significant factors affecting surface roughness, and the optimal cutting combination was determined by seeking the best surface roughness (response) and signal-to-noise ratio. Finally, confirmation tests verified that the Taguchi design was successful in optimizing milling parameters for surface roughness

Vipin and Harish Kumar [2009]used Response surface methodology for their investigations. The surface roughness models were developed for turning leaded gun metal under dry conditions. The models were developed in terms of cutting speed, feed rate and depth of cut obtained experimentally. The effects of cutting variables (cutting speed, feed and depth of cut) on surface roughness had beeninvestigated by Central composite Design.

Ranganath et al [2014]Surface texture is influenced by the machining, cutting parameters. The MOTIF-method is a system for the evaluation of the primary profile and based on the envelope system and is suitable as an alternative to the mean line system. The MOTIF-method determines the upper points of the surface profile, which have an importance for the functional behavior. Roughness and waviness can be evaluated directly based on the diagram of the unfiltered profile. The effects of cutting speed, feed rate and depth of cut on surface texture analysis have been studied. The experiments were conducted to study the effect of machining parameters on turning of mild steel. The total set of experiments carried out is 27. The specimen was turned under different levels and R, Rx and Ar values were analysed. Results obtained concluded that the Feed rate is the significant factor.

3.0 Experimental Work

A milling machine is a machine tool that removes metal as the work is fed against a rotating multipoint cutter. The milling cutter rotates at high speed and it removes metal at avery fast rate with the help of multiple cutting edges. Milling machine is used for machining flat surfaces, contoured surfaces, surfaces of revolution, external and internal threads, and helical surfaces of various cross- sections, etc. In the work, up-mailing is used to remove the metal in the form of small chips by a rotating cutter against the direction of travel of the workpiece.

Fig.1. Face Milling Cutter

Fig.2. Operating on Milling Machine

Fig. 3.Surface Roughness Measurement Instrument (Taylor Hobson Subtronics3+)

The Surtronic 3+ a portable is used for the measurement of surface texture and is suitable for use in both the workshop and laboratory.

Mild steel is used as a workmaterial, which is a common materialused in industry.Face milling cutter is used as tool with diameter (100mm),24 teeth, side (12.5mm) and arbor diameter 25mm.The milling machine model is **XW6032A**.

Table 1: The Process Parameters and their Levels

Process		Levels	
Parameter	1	2	3
Speed (m/min), V	565.48	724.92	1089.085
Feed rate (mm/min), f	20	32	45
Depth of cut (mm), d	0.5	0.75	1.00

4.0 Analysis and discussion

Fig. 4 V=565.74m/min,F=20mm/min., D=0.5mm

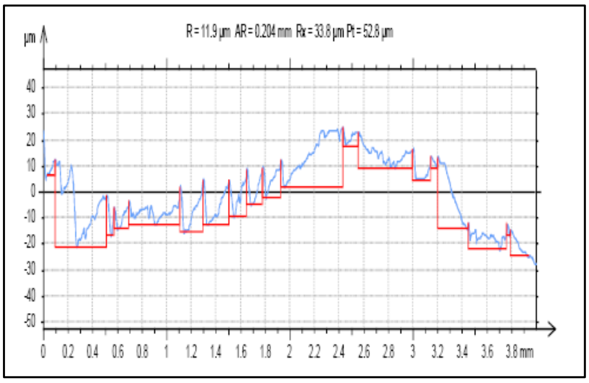


Fig. 5 V=565.74m/min,F=32mm/min.,D=0.5mm

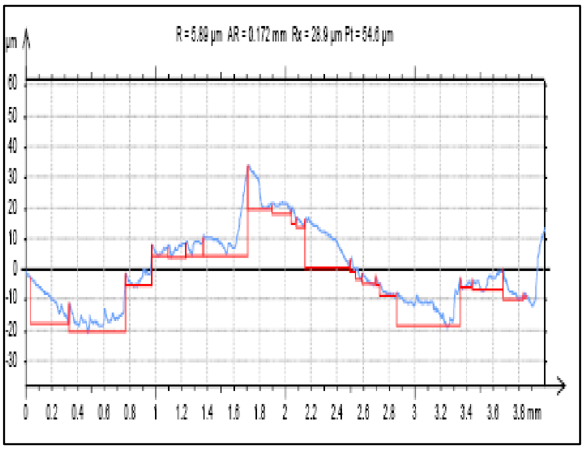


Fig. 6 V=565.74m/min,F=45mm/min.,D=0.5mm

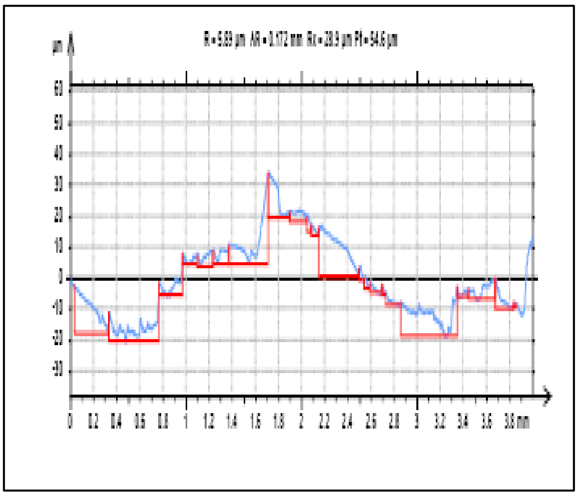


Fig. 7 V=775.273m/min,F=20mm/min,D=0.5mm

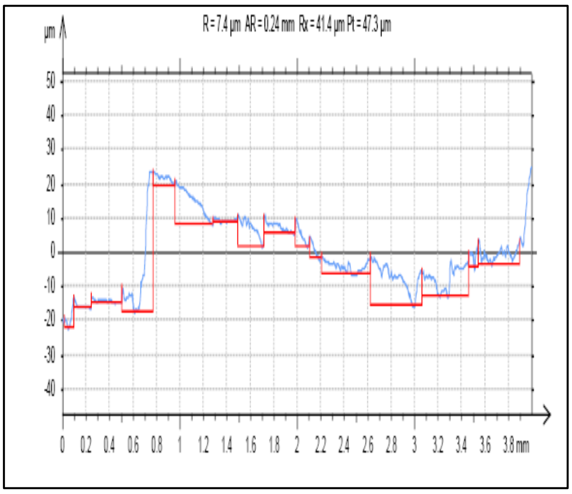


Fig. 8 V=775.273m/min,F=32mm/min.,D=0.5mm

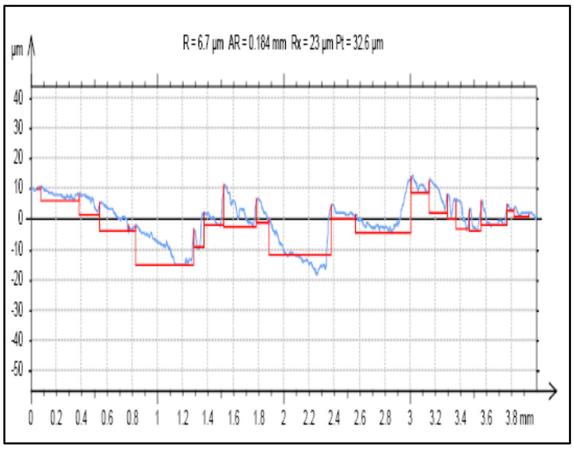


Fig. 9 V=775.273m/min,F=45mm/min.,D=0.5mm

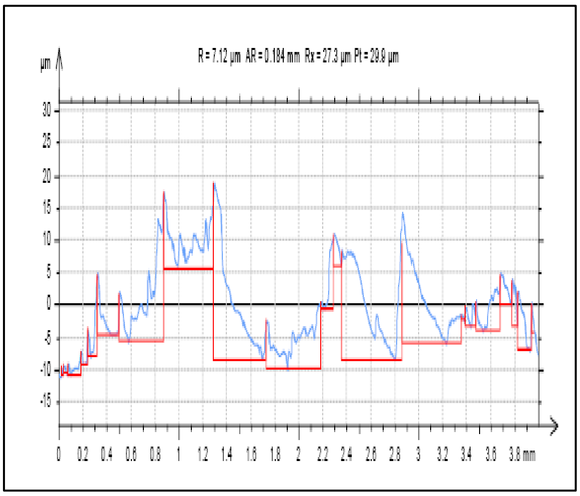


Fig. 10
V=1089.573m/min,F=20mm/min.,D=0.5mm

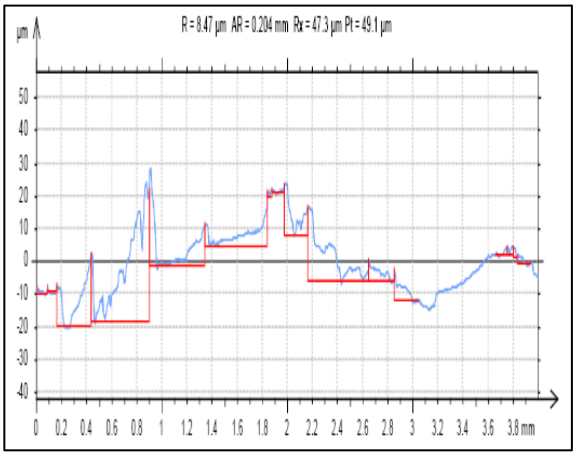


Fig. 11 V=1089.573 m/min, F=32mm/min., D=0.5mm

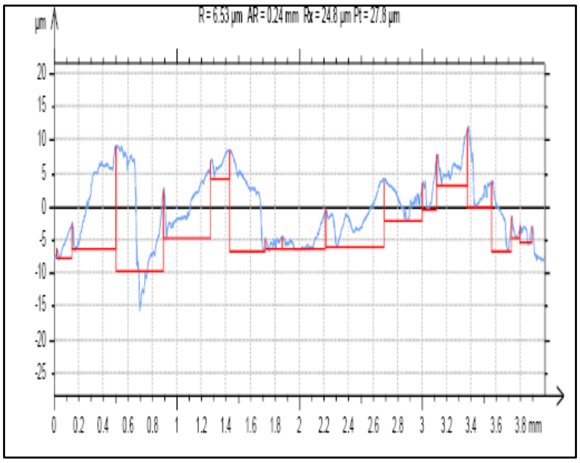


Fig. 12 V=1089.573m/min,F=45mm/min.,D=0.5mm

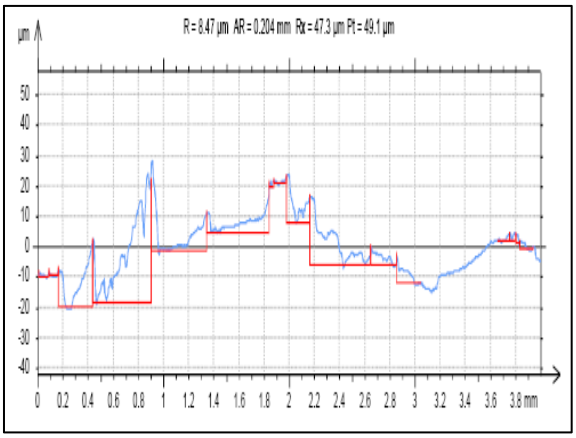


Fig. 13 V=565.74 m/min,F=20mm/min.,D=0.75 mm

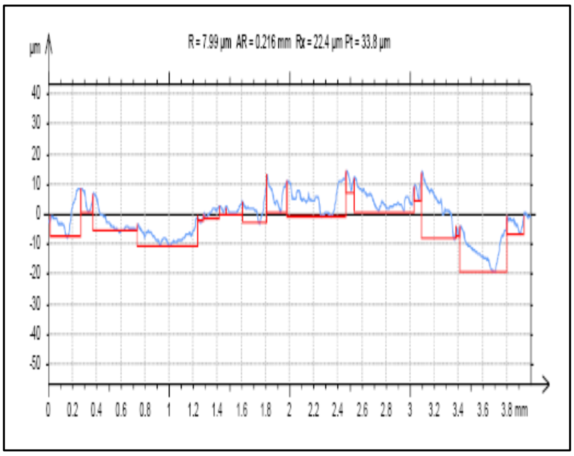


Fig. 14 V=565.74 m/min, F=32mm/min., D=0.75 mm

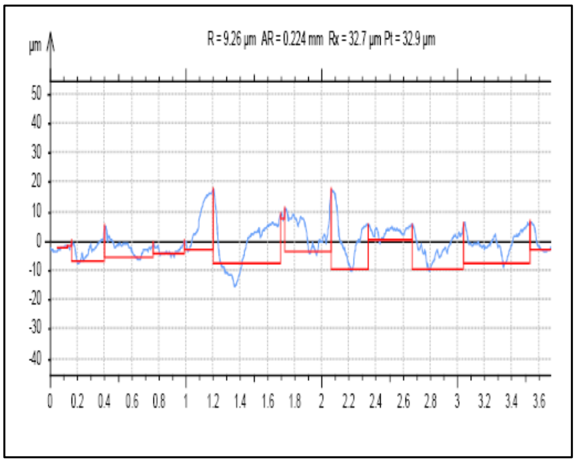


Fig. 15 V=565.74 m/min,F=45mm/min., D=0.75mm

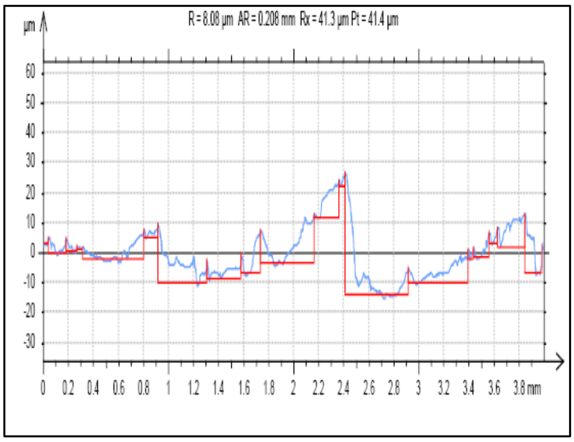


Fig. 16 V=775.273m/min,F=20mm/min, D=0.75mm

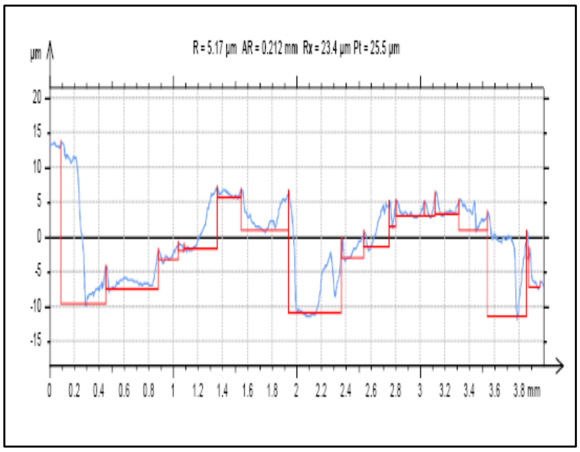


Fig. 17 V=775.273m/min, F=32mm/min, D=0.75 mm

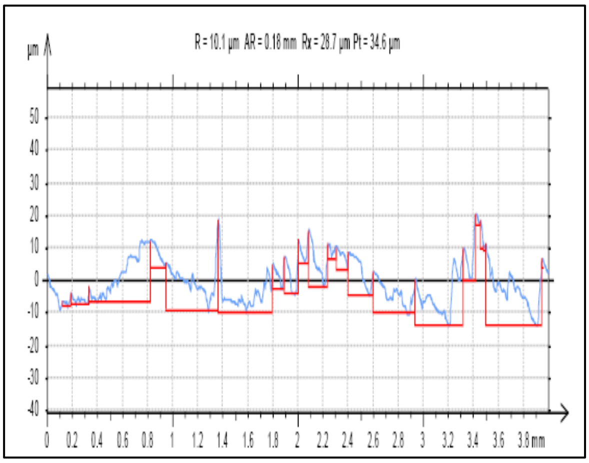


Fig. 18 V=775.273m/min,F=45mm/min, D=0.75 mm

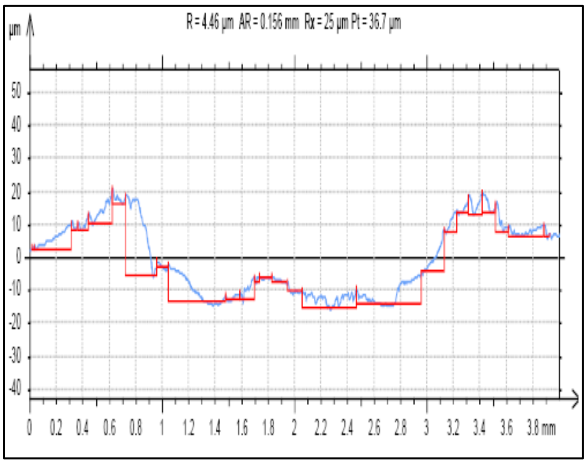


Fig. 19 V=1089.573m/min,F=20mm/min.,D=0.75mm

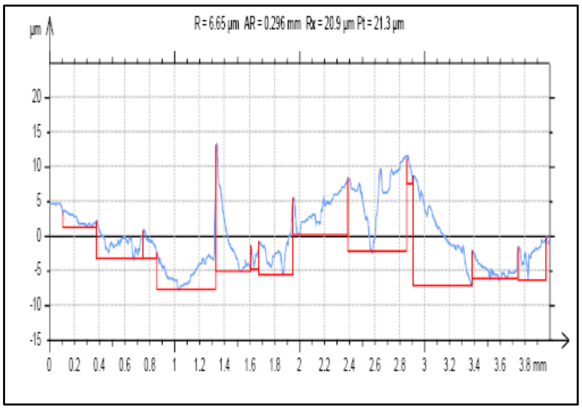


Fig. 20 V=1089.573m/min,F=32mm/min.,D=0.75mm

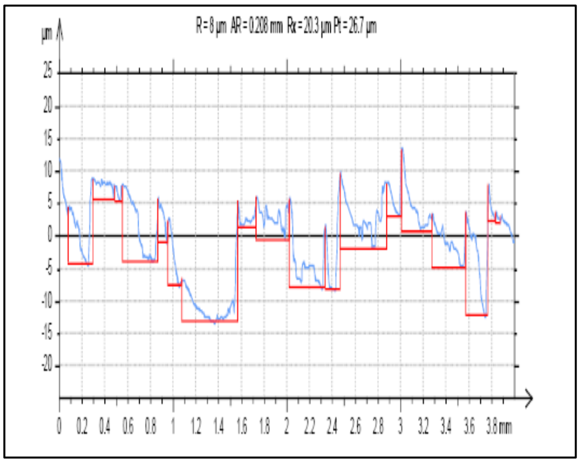


Fig. 21 V=1089.573m/min,F=45M/MIN.,D=0.75MM

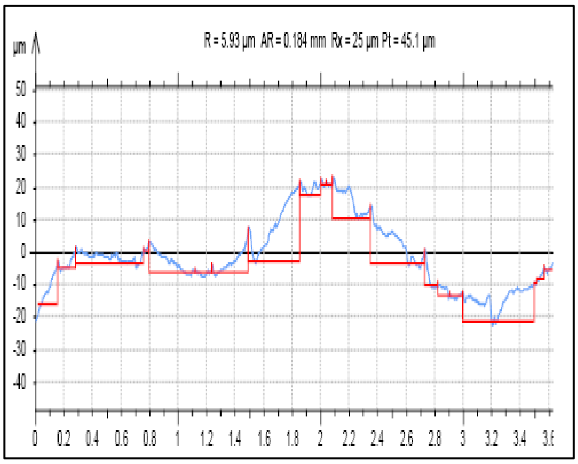


Fig. 22 V=565.74m/min,F=20mm/min.,D=1.00mm

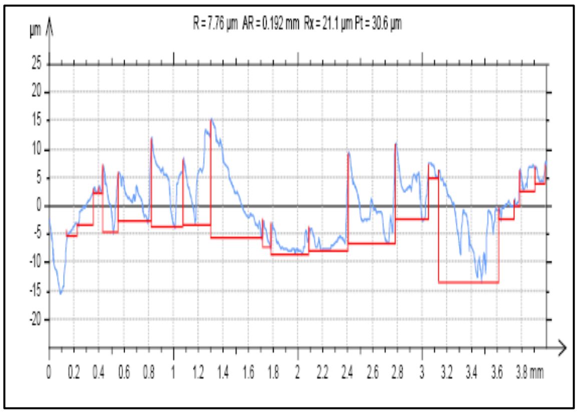


Fig. 23 V=565.74m/min, F=32mm/min., D=1.00mm

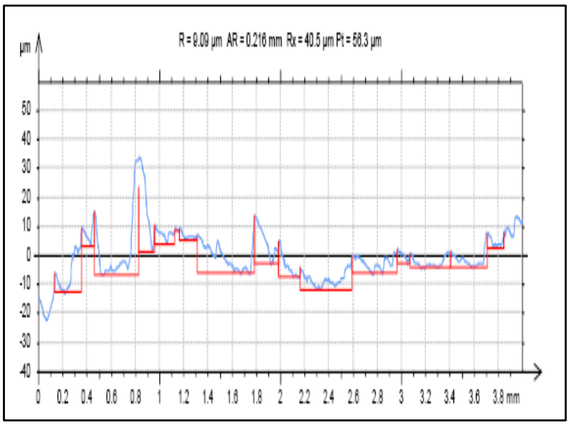


Fig. 26.V=775.273m/min, F=32mm/min., D=1.00mm

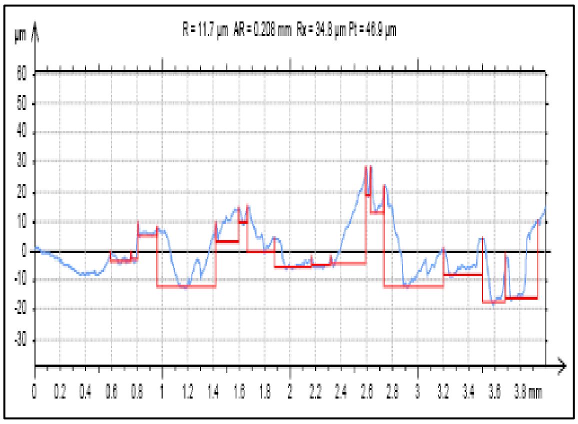


Fig.24.V=565.74m/min, F=45mm/min., D =1.00mm

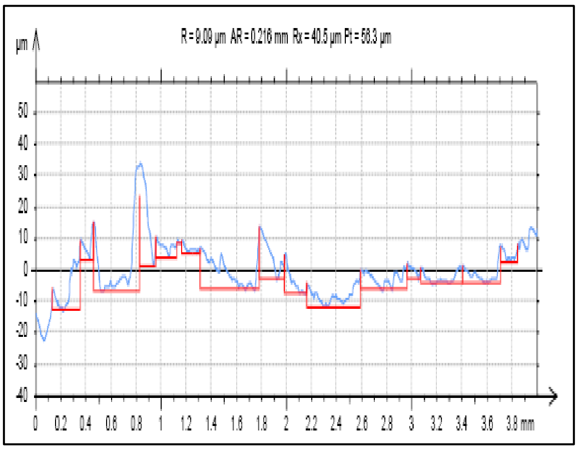


Fig. 27.V=775.273m/min, F=45mm/min.,D=1.00mm

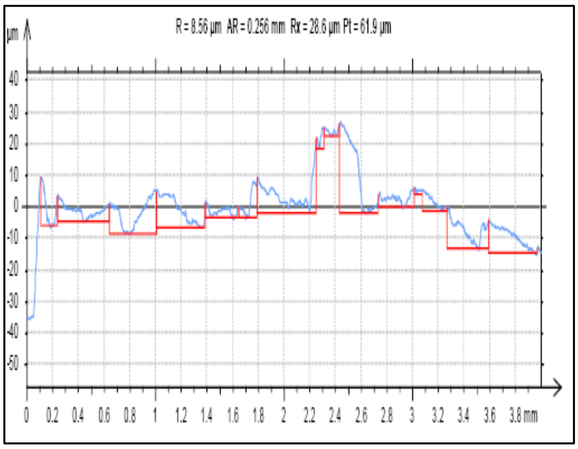


Fig.25. V=775.273m/min, F=20mm/min., D=1.00mm

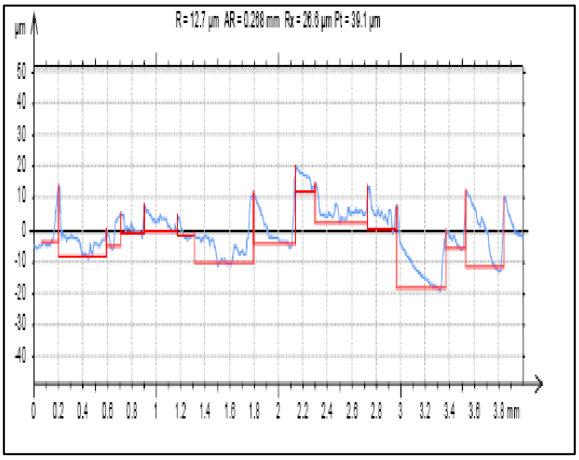


Fig. 28.V=1089.573m/min, F=20mm/min., D=1.00mm

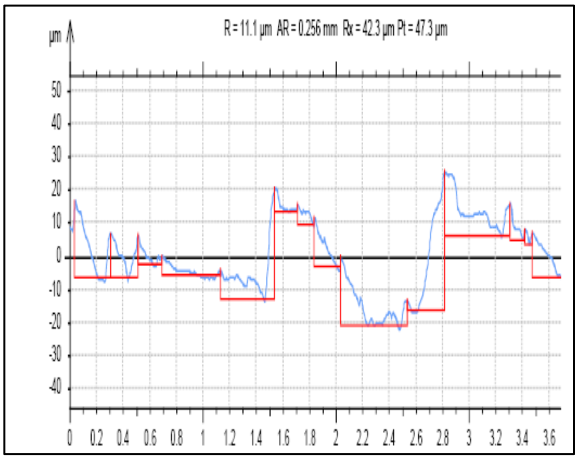


Fig. 29. V=1089.573m/min, F=32mm/min., D=1.00mm

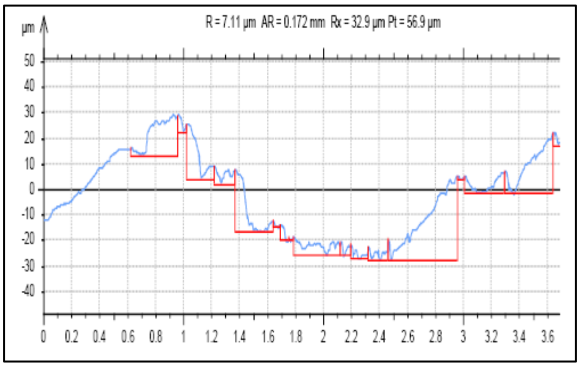
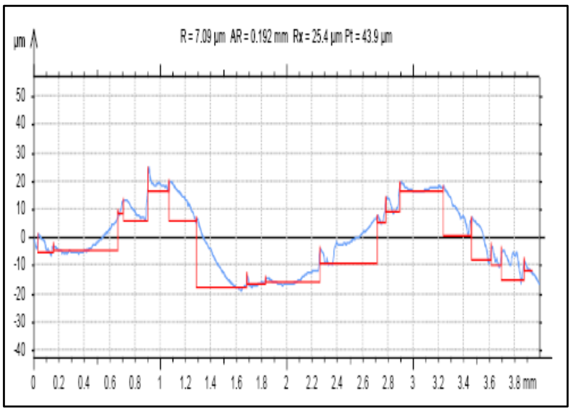
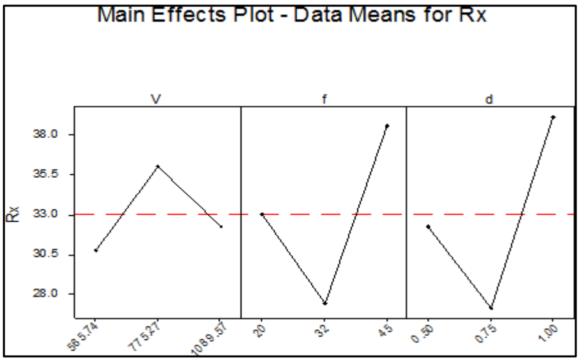


Fig. 30.V=1089.573m/min,F=45mm/min.,D=1.00mm



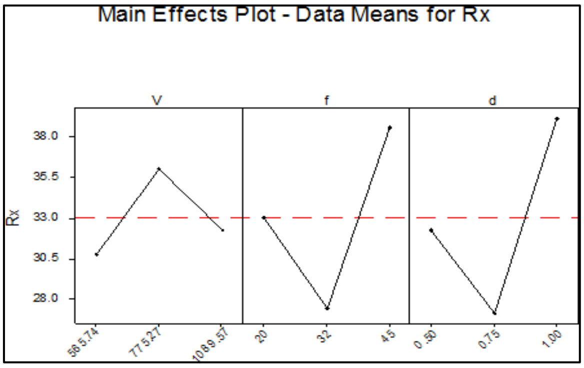
4.1 Roughness and waviness motifs (ISO 12085) for "R" parameters

R (Average depth of roughness motifs) increase for cutting speed upto 775.27m/min and than decrease with increase in cutting speed. R decrease for feed up to 32mm/min. and then increase with increase in feed.R decrease for depth of cut up to 0.50 mm and then increase with increase in depth of cut.



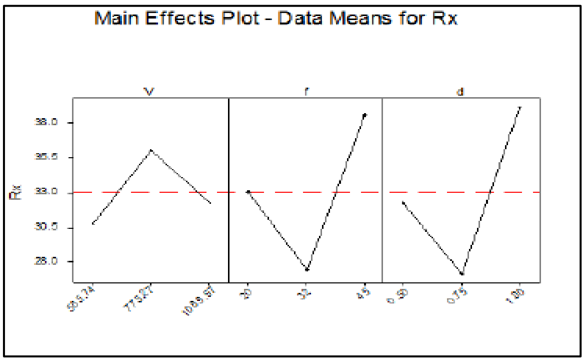
4.2 Roughness and Waviness Motifs (ISO 12085) for —ArParameters

Ar (Average spacingof roughness motifs) increase for cutting speed upto 775.27m/min and than decrease with increase in cutting speed. Ar decreasefor feed up to 32mm/min. and then increase with increase in feed. Ar increasesfor depth of cut up to 0.75 mm and then increase with increase in depth of cut.



4.3 Roughness and waviness motifs (ISO 12085) for "Rx" parameters

Rx (Maximum depth of roughness motifs) increase for cutting speed upto 775.27m/min and than decrease with increase in cutting speed. Rx decrease for feed up to 32mm/min. and then increase with increase in feed.R decrease for depth of cut up to 0.50 mm and then increase with increase in depth of cut.



5.0 Conclusions

The conclusions drawn from the results and graphs display clearly that

a Depth of cut is the significant factor. Optimum values of Rx are 775.27 m/min, 32mm/min and

0.75mm. Optimum values of Ar are 565.74 m/min, 32mm/rev and 0.50 mm. Optimum values of R (roughness) are 565.74 m/min, 32mm/rev and 0.5mm.

b The Feed rate is a significant factor. Optimum values of Ar are 775.27 m/min, 32mm/min and0 .50mm.

c Feed rate and depth of cut are significant factor. Optimum values of Rx are 775.27m/min, 32mm/min and 0.75mm.

Nomenclature

Parameter Description
Ra Parameter of roughness
The MOTIF (R & W) parameters
R Average depth of roughness motifs
Rx Maximum depth of roughness motifs
Ar Average spacing of roughness motifs
Wx Maximum depth of waviness motifs
Rsm Average spacing of waviness motifs
Pt Maximum depth of the raw profile
The “Rk” family of parameters
Rk Depth of the roughness core profile
Rpk Top portion of the surface to be worn away
Rvk Lowest part of the surface retaining the lubricant
MR1 Upper limit of the core roughness
MR2 Lowest limit of the core roughness

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