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# Analysis of Roughness and Waviness Motifs in Turning of Mild Steel Using Carbide Inserts

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## ABSTRACT

Surface roughness (SR) and waviness is influenced by the machining, cutting parameters. The MOTIF- method is a structure for the assessment of the key profile and established on the envelope system and is appropriate as a substitute to the mean line system. The MOTIF-method determines the upper points of the surface profile, which have significance for the functional behavior. Roughness and waviness can be evaluated directly based on the diagram of the unfiltered profile. The key objective is to analyze the effect of cutting speed, feed and depth of cut on the mild steel to know about the roughness and waviness in turning operation using carbide tool. Full factorial 27 tests are done to scrutinize the cutting features of mild steel bars. The specimen was turned under different levels of process parameters and values of R, Rx and Ar were analyzed. Results illustrate that the feed rate is the major factor.

**Keywords:** Mild steel, Turning, MOTIFs, Waviness and Roughness

## I. INTRODUCTION

In manufacturing industries, surface finish of a product is vital in defining the superiority. Suitable surface finish not only guarantees superiority, but also eases cost of manufacturing.

SR also affects numerous functional qualities of parts, such as wearing, heat transmission, and facility of sustaining a lubricant, coating and resisting fatigue. Commonly known model to establish the SR is $Ra = f^2/32r$, where f is the feed rate and r is the nose radius. Undoubtedly, feed rate and nose radius influence SR the most [1,2].

The MOTIF-method is a structure for the assessment of the key profile and established on the envelope system and is appropriate as substitute to the mean line system. The MOTIF-method controls the upper points of the surface profile, which have significance for the functional behavior.

SR and waviness can be evaluated directly based on the diagram of the unfiltered profile. SR and waviness are globally measured in industry with the help of stylus instruments, namely Surtronix3+. To isolated SR from waviness, the mean line system uses electronic filtering. The MOTIF-method (ISO 12085) offers a substitute assessment to isolated SR and waviness by means of unfiltered profiles. The MOTIF-method is a graphical assessment with the entire explanation of roughness and waviness with simply 7 parameters and the assessment based on the upper envelope line. The MOTIF-method finds out among these limits the horizontal and vertical properties of the vital profile irregularities without removal of important profile points. It is very well matched for technical inquiries on unknown surfaces and processes, functions associated with the envelope of the surfaces and profiles with very close wavelengths for roughness and waviness.

The intention of this experimental scrutiny is to establish the effects of cutting speed, feed rate and depth of cut in turning of mild steel and waviness MOTIFs. In experimental investigations, statistical design of experiments, L27 orthogonal array is used for accomplishing the experiments.

## II. LITERATURE REVIEW

J. Davim et al. [3] worked on surface roughness prediction models using artificial neural network (ANN) are developed to investigate the effects of cutting conditions during turning of free machining steel, 9SMnPb28k(DIN). I.A. Choudhury et al. [4] worked on the development of surface roughness prediction models for turning EN 24T steel (290 BHN) utilizing response surface methodology. W.H. Yang et al. [5] An orthogonal array, the signal-to-noise (S:N) ratio, and the analysis of variance (ANOVA) are employed to investigate the cutting characteristics of S45C steel bars using tungsten carbide cutting tools. M. Nalbant et al. [6] The orthogonal array, the signal-to-noise ratio, and analysis of variance are employed to study the performance characteristics in turning operations of AISI 1030 steel bars using TiN coated tools. IlhanAsilturk et al. [7] focuses on optimizing turning parameters based on the Taguchi method to minimize surface roughness (Ra and Rz). H. Aouici et al. [8] the effects of cutting speed, feed rate, workpiece hardness and depth of cut on surface roughness and cutting force components in the hard turning were experimentally investigated. Ramesh et al. [9] studies the effect of cutting parameters on the surface roughness in turning of titanium alloy has been investigated using response surface methodology. Günay.M et al. [10], focused on optimizing the cutting conditions for the average surface roughness (Ra) obtained in machining of high-alloy white cast iron (Ni-Hard) at two different hardness levels (50 HRC and 62 HRC). N.R. Abburi et al. [11] develops a knowledge-based system for the prediction of surface roughness in turning process. JanezKopac et al. [12] focuses on optimising the turning of raw workpieces of low-carbon steel with low cold pre-deformation to achieve acceptable surface roughness.

P.V.S. Suresh et al. [13], The experimentation was carried out with TiN-coated tungsten carbide (CNMG) cutting tools, for machining mild steel work-pieces covering a wide range of machining conditions. W.S. Lin et al. [14], an abductive network is adopted to construct a prediction model for surface roughness and cutting force. M.Y. Noordin et al. [15], The performance of a multilayer tungsten carbide tool was described using response surface methodology (RSM) when turning AISI 1045 steel. D.I. Lalwani et al. [16], In the present study, an attempt has been made to investigate the effect of cutting parameters (cutting speed, feed rate and depth of cut) on cutting forces (feed force, thrust force and cutting force) and surface roughness in finish hard turning of MDN250 steel [equivalent to 18Ni(250) maraging steel] using coated ceramic tool. J. Davim et al. [17], presents a study of the influence of cutting parameters on surface roughness in turning of glass-fibre-reinforced plastics (GFRPs). Dilbag Singh et al. [18], An experimental investigation was conducted to determine the effects of cutting conditions and tool geometry on the surface roughness in the finish hard turning of the bearing steel (AISI 52100). A. Hasçal et al. [19], the effect and optimization of machining parameters on surface roughness and tool life in a turning operation was investigated by using the Taguchi method. The experimental studies were conducted under varying cutting speeds, feed rates, and depths of cut. An orthogonal array, the signal-to-noise (S/N) ratio, and the analysis of variance (ANOVA) were employed to the study the performance characteristics in the turning of commercial Ti-6Al-4V alloy using CNMG 120408-883 insert cutting tools. V. S. Sharma et al. [20], machining variables such as cutting forces and surface roughness are measured during turning at different cutting parameters such as approaching angle, speed, feed and depth of cut. H. Singh et al. [21], an experimental study to investigate the effects of cutting parameters like spindle speed, feed and depth of cut on surface finish and material removal rate on EN-8. M. Thomas et al. [22], focus of this study is the collection and analysis of surface roughness and tool vibration data generated by lathe dry turning of mild carbon steel samples at different levels of speed, feed, depth of cut, tool nose radius, tool length and workpiece length. Ranganath M.S. et al. [23], investigates the parameters affecting the roughness of surfaces produced during the turning process for the material Aluminium 6061. Ranganath M.S. et al. [24], 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 specimen was turned under different levels and R, Rx and Ar values were analysed.

## III. EXPERIMENTAL PROCEDURE

Experiment was conducted on a LL20TL3 CNC lathe with work piece of 38 mm diameter and 300 mm long mounted between 3-jaw chuck and tailstock. Initially rough turning is done on CNC to remove scaling that is present on the surface of mild steel. The full factorial 27 experiments were performed according to the Taguchi DOE and surface is gauged by using instrument Surtronic 3+.With the aid of Minitab software, Taguchi and ANOVA are applied and results are obtained.

### Work piece material

Material was chosen to ensure consistency of an alloy, which is a Mild Steel made in the form of bars with the size of diameter 38mm and 300mm length so as to fit under the chuck. To more carefully replicate typical finish turning processes and to evade unnecessary vibrations due to work piece dimensional inaccuracies and defects, each work piece was rough-cut or rough-turning is done just prior to the measured finish cut.

### Cutting Tool Material

The cutting tool which is used for the present work was a carbide tip-CNMG 120408-THM-F. The fundamental properties of carbide tools have great hardness over a wide range of temperature; are very stiff (Young's modulus is nearly three times that of steel); exhibit no plastic flow (yield point) even on experiencing stresses of the order of 33300 kg/cm$^2$, have low thermal expansion compared with steel; relatively high thermal conductivity: and a strong tendency to form pressure weld at low cutting speed, these are weak in tension than in compression. Their high hardness at elevated temperature enable them to be used at much faster cutting speed ( 3 to 4 m/sec with mild steel) superior hot hardness and wear resistance.

**Table 1.** Cutting Parameters and their levels

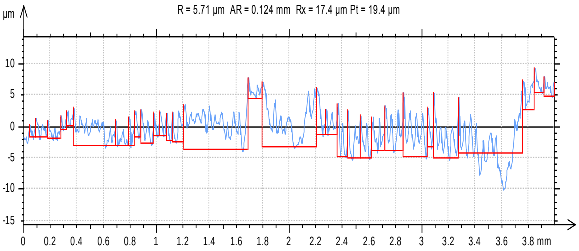
| Symbol | Cutting Parameters | Units | Level 1 | Level 2 | Level 3 |
|---|---|---|---|---|---|
| A | Speed (s) | m/min | 71.628 | 95.504 | 119.380 |
| B | Feed (f) | mm/rev | 0.04 | 0.14 | 0.24 |
| C | Depth of Cut (d) | mm | 0.2 | 0.4 | 0.6 |

## IV. ANALYSIS AND DISCUSSION

**Table 2.** Machining data for roughness and waviness motifs

| S.No. | S (m/min) | d (mm) | f (mm/rev) | R (µm) | Rx (µm) | Ar (µm) |
|---|---|---|---|---|---|---|
| 1. | 71.628 | 0.20 | 0.04 | 5.71 | 17.4 | 124 |
| 2. | 71.628 | 0.20 | 0.14 | 19.3 | 45.6 | 244 |
| 3. | 71.628 | 0.20 | 0.24 | 22.6 | 51.3 | 300 |
| 4. | 71.628 | 0.40 | 0.04 | 5.58 | 9.48 | 108 |
| 5. | 71.628 | 0.40 | 0.14 | 13.1 | 25.1 | 216 |
| 6. | 71.628 | 0.40 | 0.24 | 15.2 | 32.3 | 220 |
| 7. | 71.628 | 0.60 | 0.04 | 7.98 | 14.1 | 100 |
| 8. | 71.628 | 0.60 | 0.14 | 17.7 | 45.6 | 236 |
| 9. | 71.628 | 0.60 | 0.24 | 17.9 | 33.1 | 276 |
| 10. | 95.504 | 0.20 | 0.04 | 5.41 | 15.0 | 84.1 |
| 11. | 95.504 | 0.20 | 0.14 | 17.4 | 26.5 | 208 |
| 12. | 95.504 | 0.20 | 0.24 | 19.0 | 29.1 | 260 |
| 13. | 95.504 | 0.40 | 0.04 | 3.71 | 7.32 | 124 |
| 14. | 95.504 | 0.40 | 0.14 | 16.8 | 69.3 | 196 |
| 15. | 95.504 | 0.40 | 0.24 | 15.6 | 25.6 | 236 |
| 16. | 95.504 | 0.60 | 0.04 | 7.26 | 28.9 | 152 |
| 17. | 95.504 | 0.60 | 0.14 | 11.2 | 24.2 | 216 |
| 18. | 95.504 | 0.60 | 0.24 | 15.5 | 22.2 | 260 |
| 19. | 119.380 | 0.20 | 0.04 | 5.64 | 14.2 | 168 |
| 20. | 119.380 | 0.20 | 0.14 | 15.3 | 34.7 | 204 |
| 21. | 119.380 | 0.20 | 0.24 | 14.0 | 20.7 | 256 |
| 22. | 119.380 | 0.40 | 0.04 | 5.77 | 18.6 | 92.1 |
| 23. | 119.380 | 0.40 | 0.14 | 13.6 | 28.2 | 196 |
| 24. | 119.380 | 0.40 | 0.24 | 14.3 | 18.8 | 268 |
| 25. | 119.380 | 0.60 | 0.04 | 5.13 | 8.31 | 96.1 |
| 26. | 119.380 | 0.60 | 0.14 | 10.4 | 18.1 | 224 |
| 27. | 119.380 | 0.60 | 0.24 | 15.3 | 20.9 | 264 |

**Roughness and Waviness Motifs (ISO 12085)**

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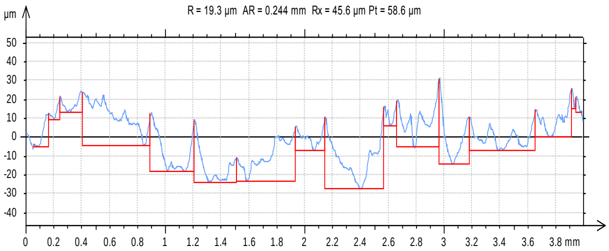


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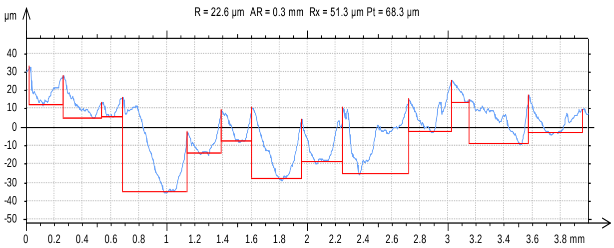


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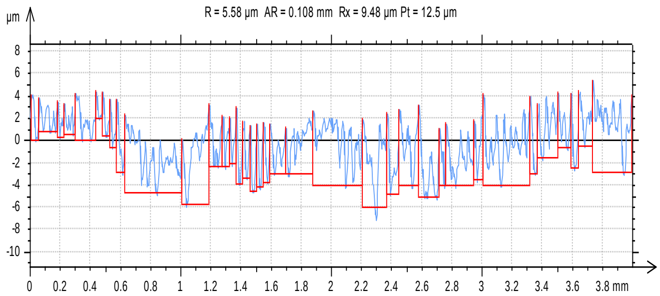


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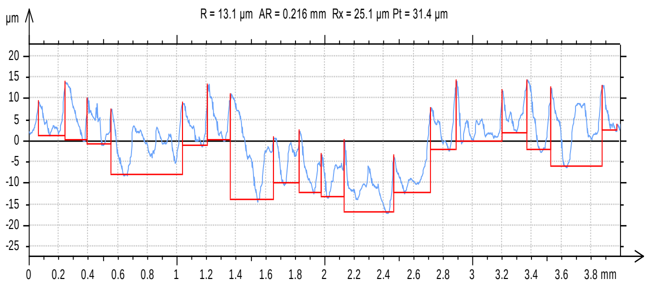


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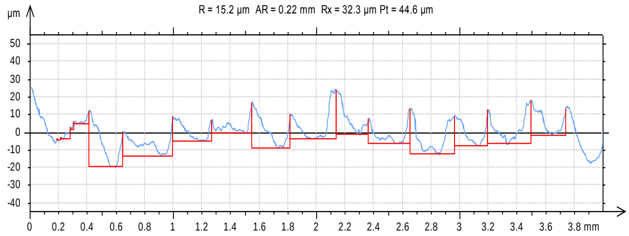


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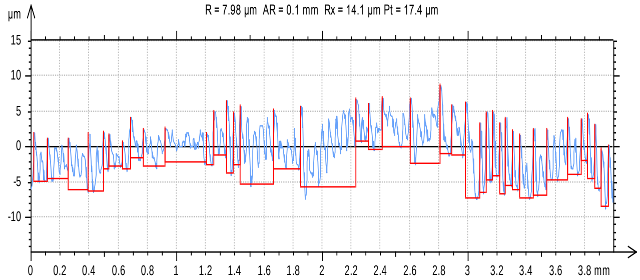


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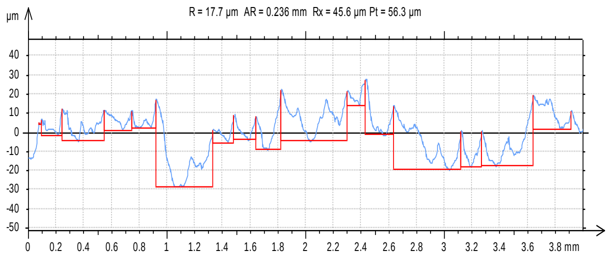


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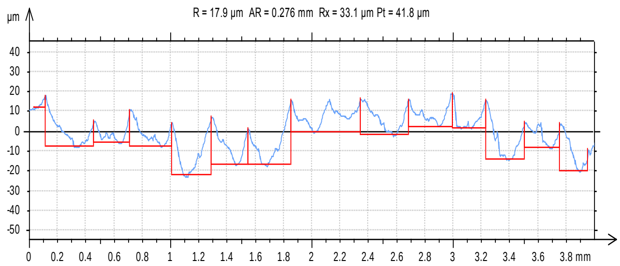


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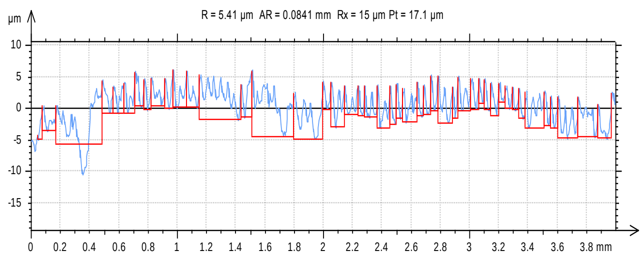


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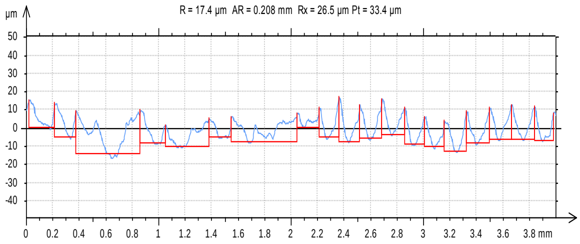


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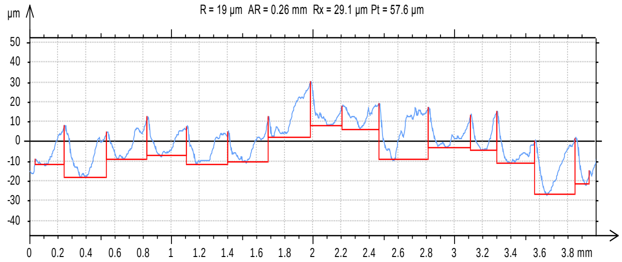


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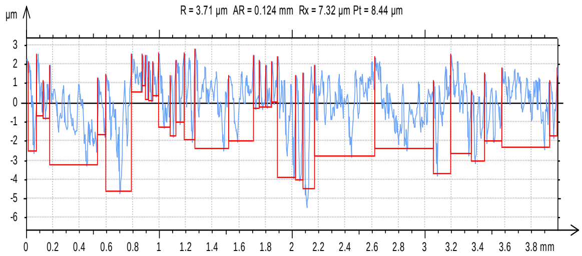


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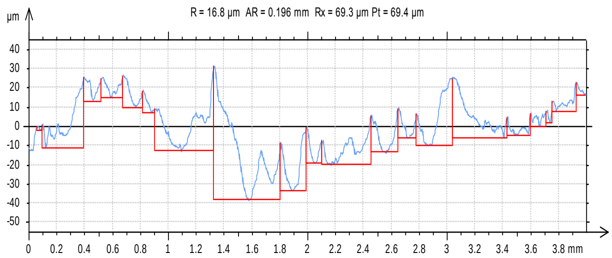


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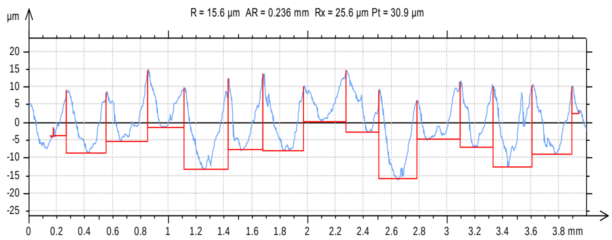


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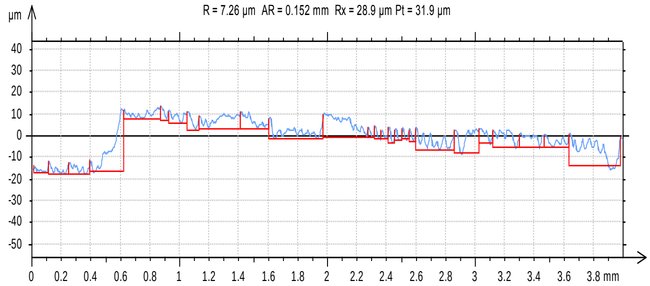


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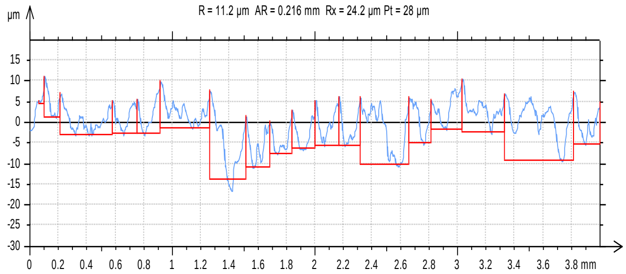


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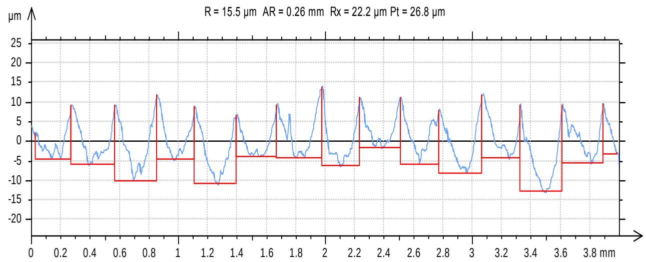


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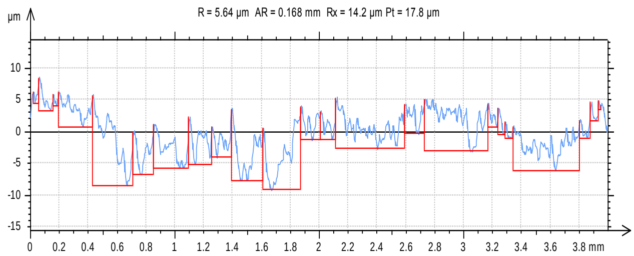


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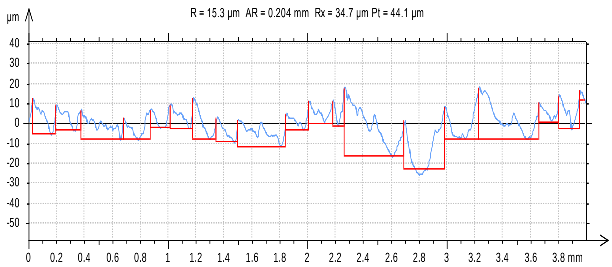


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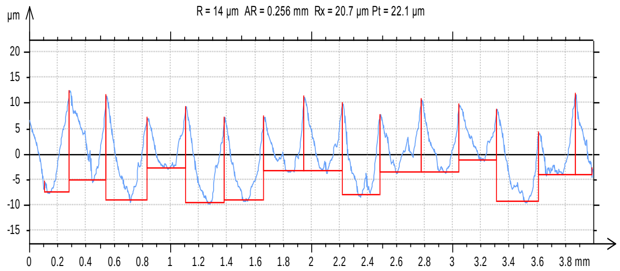


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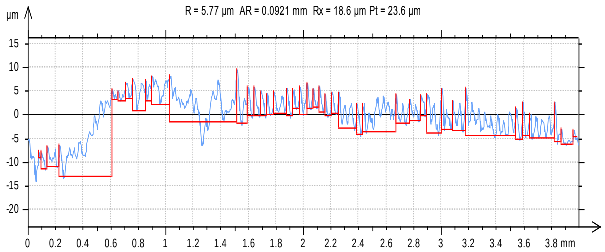


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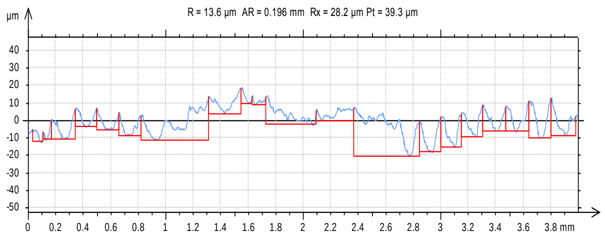


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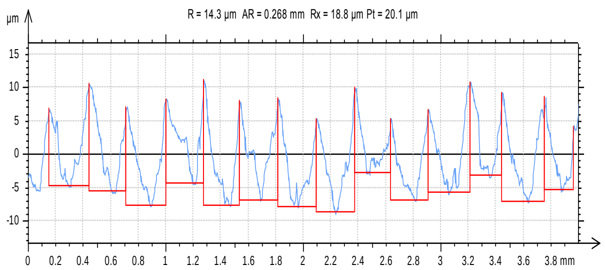


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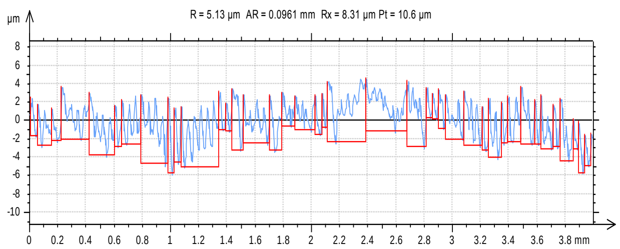


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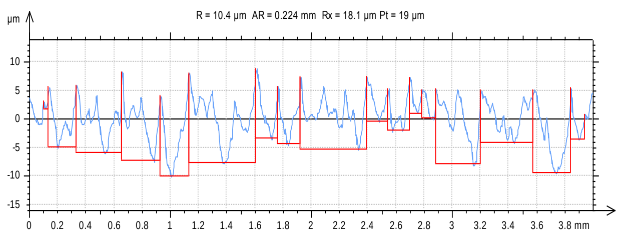


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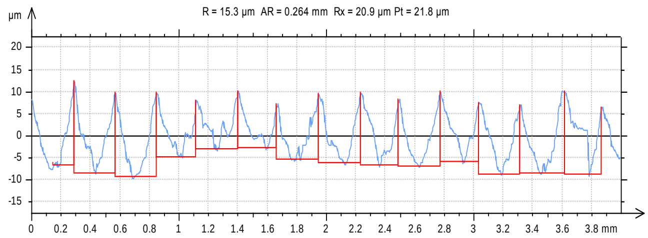


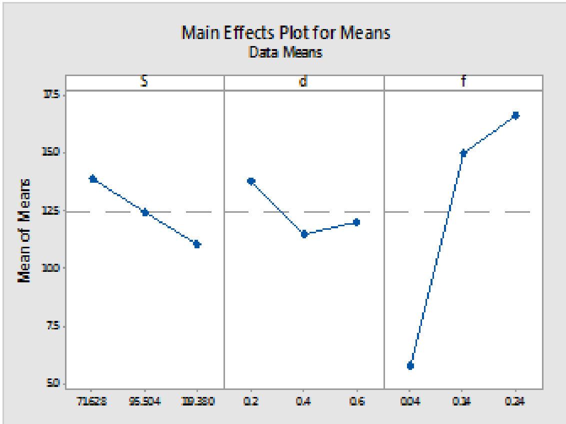

S=1000rpm, f=0.24mm/rev, d=0.60mm

**Roughness and Waviness Motifs (ISO 12085) for "R" Parameters**

R (Average depth of roughness motifs) decreases with increase in cutting speed.

R decreases upto 0.4mm and then increases with increase in depth of cut.

R increases with increase in feed.

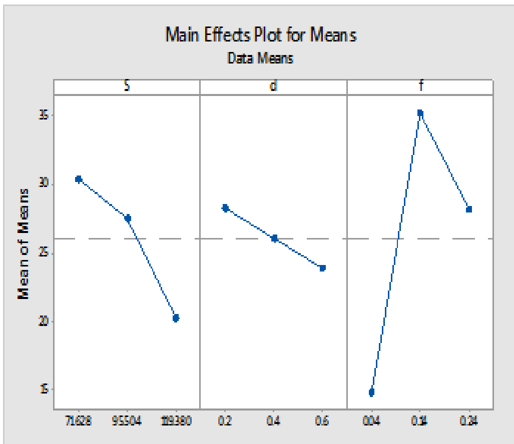



Main Effects Plot - Data Means for R

**Roughness and Waviness Motifs (ISO 12085) for "Rx" Parameters**

Rx (Maximum depth of roughness motifs) decreases with increase in cutting speed.

Rx increases upto 0.14mm/rev and then decreases with increase in feed.



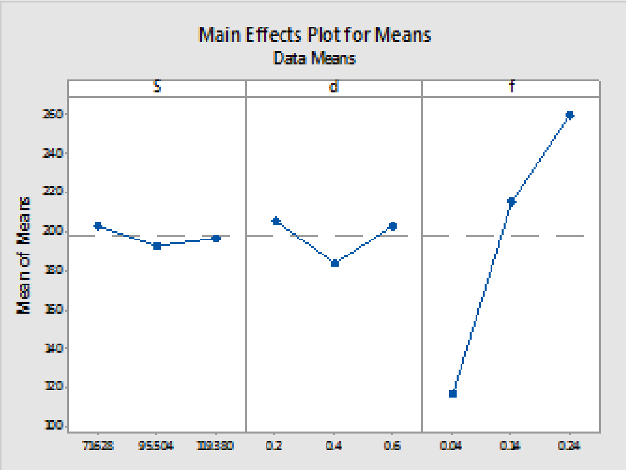

Main Effects Plot - Data Means for Rx

**Roughness and Waviness Motifs (ISO 12085) for "Ar" Parameters**

Ar (Average spacing of roughness motifs) decreases upto 95.504m/mimand then increases with increase in speed.

Ar decreases upto 0.4mm and then increases with increase in depth of cut.

Ar increases with increase in feed.




Main Effects Plot - Data Means for Ar

## V. CONCLUSIONS

The conclusions drawn from the results and graphs display clearly that feed rate is the significant factor.

- ✓ Optimum values of Rx are 119.380m/min, 0.04mm/rev and 0.6mm.
- ✓ Optimum values of Ar are 95.504m/min, 0.04mm/rev and 0.4mm.
- ✓ Optimum values of R are 119.380m/min, 0.04mm/rev and 0.4mm.

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