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Optimization of Different Workout Variables Throughout CNC Turning of ASTM 316 Deploying ANOVA

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Abstract*: Blueprint of examination regarding ANOVA remains developed and executed for evaluating effect of various workout variables like V, F and D on surface unevenness throughout CNC turning of ASTM 316 steel using coated carbide insert. 3D graphs through momentous surface unevenness got developed and utilized for evaluating average surface unevenness through ideal design situations. Evidently, text interface impressions are extraneous. Research findings through different mathematical analyses provided the effective guideline for choosing appropriate machine settings to realize surface unevenness within the stipulated limit during stated turning operation. Ideal machining situations got determined to minimize the surface unevenness of same. Current research evidently divulges that multicoated carbide inserts performed marvelously at optimum workout variables combination of V = 150 m/min, F = 0.10 mm/rev with D = 0.4 mm. Ultimate range of Ra with Rz are 0.16 µm ≤ Ra ≤ 0.52 µm and 1.4 µm ≤ Rz ≤ 3.1 µm, respectively. Besides, Ra is below recommended safety limit 1.5 µm (i.e. Ra < 1.5 µm) for turning using coated carbide inserts. 3D surface plots got developed with changing 2 variables and fixing third one. Wholly, both unevenness variables (Ra and Rz) increase with F. Also, both unevenness variables (Ra and Rz) decrease with increase in V. But, D got quite insignificant impact on both unevenness variables (Ra and Rz). Probability plot of Ra is depicted for trialing statistical cogency of representations. Residuals discrepancies appear along approximately linear route.

***Index Terms*: Surface Unevenness, CNC Turning, ASTM 316 Steel, ANOVA, Workout Variables, Workpiece.**

I. INTRODUCTION

Metal machining stands as the ultimate noteworthy practice for removal of undesirable material in manufacturing of any kind of modules. It is a machining practice where finished surface of preferred shape and size gets produced through detachment of superfluous materials stratums in shape of chips using wedge like device termed as cutting tool. Metal cutting practice remains influenced through relative motion between workpiece and cutting tool. Metal cutting remains as forming practice occurring in cutting structural modules through supply power generating determined fracture of stratum actuality detached. Here, fracture occurs owing to collective/net stress covering bending stress.

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Crucial aim of cutting practices (typical situations as established in figures 1-3) stand to transform workpiece for getting segment of desired geometry and surface quality using cutting tool through supreme concert throughout its epoch. In machining practices, the major concern of customer requirements is surface unevenness quality. Surface unevenness remains primarily an outcome of process parameters like tool parameters/tool geometry (edge geometry, rake angle, nose radius, etc.) and workout variables/cutting conditions (V, F, D, etc.). Numerical or experimental evaluations on materials processing remain extant in collected works [1-7]. Computational and experimental researches stand also designated [8-44].

Present exploration remains as examining the influence of workout variables on surface unevenness throughout dry turning of ASTM 316 steel with multicoated carbide tool. Study includes determination of top variables for getting ideal unevenness using ANOVA. In addition, workout variables (i.e. V, F and D) got correlated with routine results (R_a with R_z).

II. EXPERIMENTAL DETAILS

A. Sample Preparation from Work Materials

ASTM 316 steel sample bars of 90 mm length and 50 mm diameter got heated up to appropriate austenitizing temperature of 918 ºC and kept at that temperature for about 25 minutes to realize desired modifications in crystalline structure. Subsequently, oil quenching of stated sample. Then, tempering by reheating the stated sample up to a pre-calculated temperature of 398 ºC (just below lower critical temperature limit) for about 1.5 hours. Thereafter, air cooling for removing residual stresses aimed at structural homogenization.

B. Cutting Inserts

Multicoated inserts attached to tool holder got utilized in present practice. Cutting geometry of the same is as stated: clearance angle = 5º, rake angle = −5º, cutting edge inclination = −5º, major cutting edge angle = 92º besides nose radius = 0.7 mm. Overall cases, both back rake and side rake are equal to −6º.

All inserts intended for current experimentations got same geometry (with negative rake angle).

Figure 1. CNC turning practice

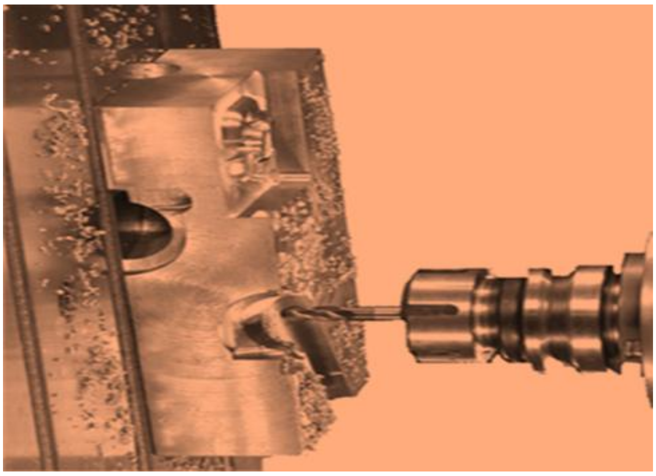

Figure 2. CNC milling practice

Figure 3. CNC grinding practice

III. EXPERIMENTAL TECHNIQUES

Experiments got accomplished for examining effect of V, F and D on surface unevenness (R_a or R_z). For that ANOVA is used through above stated parameters at three different levels mentioned in Table 1. CNC turning (with speed limit 3000 rpm and power limit 15 kW) operations got performed for generating investigational data in dry situation. Initially, thin layer from workpiece sample surface got removed and then a hole got drilled on sample face for providing support at tailstock as demonstrated in figure 4.

Surface unevenness (R_a or R_z) of turned surface got measured expending a surface unevenness tester. Critical surface unevenness $R_a < 1.5$ µm is adopted for surface finish in present CNC turning.

Table 1. Workout variables with levels.

Workout Variables	Levels		
	1	2	3
D (mm)	0.3	0.4	0.5
F (mm/rev)	0.1	0.15	0.2
V (m/min)	90	120	150

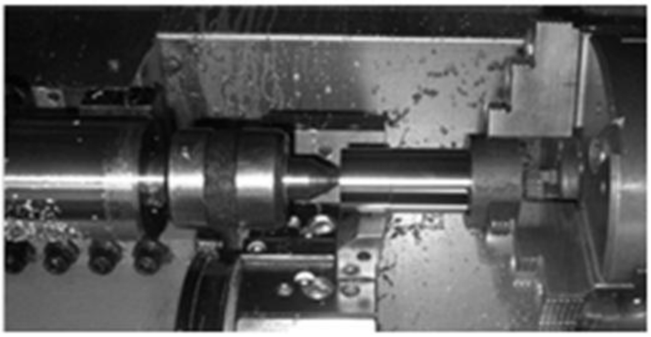

Figure 4. Photograph of cutting region

IV. RESULTS AND DISCUSSIONS

A. Illustration of Investigational Outcomes with Different Workout Variables

Course of investigation regarding ANOVA stands developed and executed for evaluating effect of various workout variables like V, F and D on surface unevenness throughout CNC turning of ASTM 316 steel using coated carbide insert. Trials summarizes the experimental outcomes/observations aimed at surface unevenness parameters (DOF, SS, MS, F-value, P and C). Lowest/least magnitudes/levels of surface unevenness measures (R_a = 0.4 µm with R_z = 1.8 µm) got observed at F = 0.1 mm/rev, V = 150 m/min with D = 0.4 mm. Highest/uppermost magnitudes/levels of surface unevenness measures (R_a = 2.4 µm with R_z = 9.8 µm) got enumerated at F = 0.2 mm/rev, V = 90 m/min with D = 0.4 mm. Evidently, text interface impressions are extraneous. Stated impressions remain unconnected in lieu of abating surface unevenness, R_a with R_z.

B. Elucidation of 3D Surface Plots

3D surface plots (for instance illustrated in figures 5 and 6) for momentous surface parameters (R_a and R_z) got developed and utilized for evaluating average surface unevenness through ideal design situations.

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Useful levels of momentous surface parameters (R_a and R_z) got established for providing lesser magnitude of unevenness. F level-1 with V level-3 (F_1V_3) usually provides smaller unevenness magnitudes. While surface unevenness (R_a) remains considered an estimated average stands at F_1V_3 level (i.e. while the two best momentous parameters stay at their superior level). Ultimately, estimated average R_a limit/range with peak confidence level is $0.16\ \mu m \leq R_a \leq 0.52\ \mu m$. Likewise, while surface unevenness (R_z) remains apprehensive, appraised average stands at F_1V_3 level. Lastly, estimated average R_z limit/range with peak confidence level is $1.4\ \mu m \leq R_z \leq 3.1\ \mu m$. However, practice of evaluating average value rests on additivity existence pertaining to factorial influences meant for accuracy predictions.

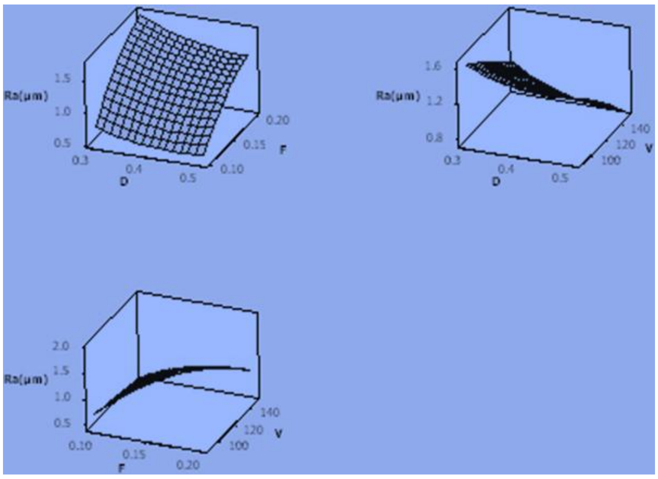

Figure 5. 3D surface plots of R_a

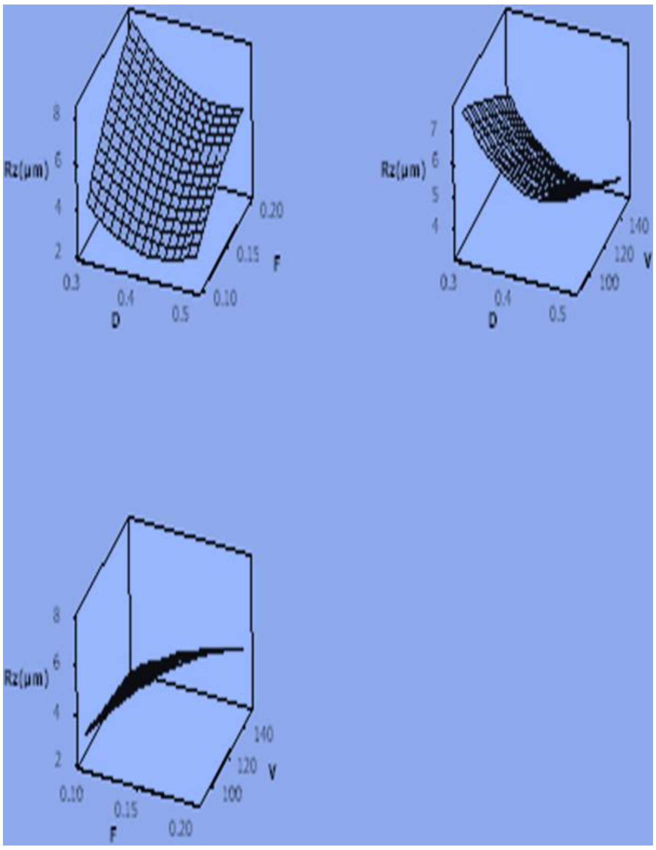

Figure 6. 3D surface plots of R_z

3D surface plots of both figures 5 and 6 got developed with changing 2 variables and unchanging third one. Wholly, both unevenness variables (Ra and Rz) increase with feed (F). Additionally, both unevenness variables decrease with V. However, D got quite insignificant impact on both unevenness variables (Ra and Rz).

C. Depiction of Probability Plot of R_a

Figure 7 demonstrates the probability plot of R_a for trialing the statistical cogency of the representations. Residuals variations seem along approximately linear path. Errors got scattered customarily for unevenness variable R_a. Wholly, variables stand within specified level as evident from stated illustration. Hereafter, stated variables reap healthier outcomes during imminent forecasts. Stated depiction leads no recognizable decoration/erection existing inside the facts. Thus, error exploration lacks in showing any exemplary shortfall.

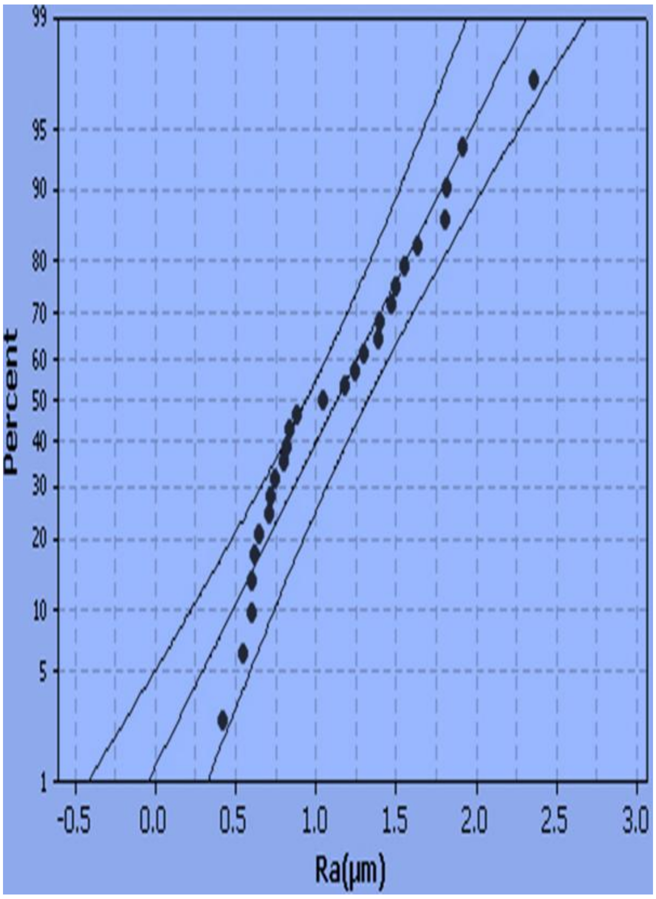

Figure 7. Probability plot of R_a

V. CONCLUSION

Course of investigation regarding ANOVA stands developed and executed for evaluating effect of various workout variables like V, F and D on surface unevenness throughout CNC turning of ASTM 316 steel using coated carbide insert. 3D graphs through momentous surface unevenness got developed and utilized for evaluating average surface unevenness through ideal design situations. Evidently, text interface impressions are extraneous. Research findings through different mathematical analyses provided the effective guideline for choosing appropriate machine settings to realize surface unevenness within the stipulated limit during stated turning operation. Ideal machining situations got determined to minimize the surface unevenness of same. Current research evidently divulges that multicoated carbide inserts performed marvelously at optimum workout variables combination of V = 150 m/min, F = 0.10 mm/rev with D = 0.4 mm. Ultimate range of R_a with R_z are $0.16\ \mu m \leq R_a \leq 0.52\ \mu m$ and $1.4\ \mu m \leq R_z \leq 3.1\ \mu m$, respectively. Besides, R_a is below recommended safety limit 1.5 µm (i.e. $R_a < 1.5\ \mu m$) for turning using coated carbide inserts. 3D surface plots got developed with changing 2 variables and fixing third one. Wholly, both unevenness variables (Ra and Rz) increase with F. Also, both unevenness variables (Ra and Rz) decrease with increase in V. But, D got quite insignificant impact on both unevenness variables (Ra and Rz). Probability plot of R_a is depicted for trialing statistical cogency of representations. Residuals variations seem along nearly linear path.

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