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Analysis and Optimization of Surface Roughness in Turning of Wet & Dry Condition of Alloy Steel Using Taguchi Method

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1.0 Abstract:

This research aims to analyze and optimize the primary reason for the present manufacturing businesses is to deliver ease, excellent items in brief time. They are centered around accomplishing high caliber, in term of part exactness, surface completion, high creation rate and so on. Thus, the determination of ideal cutting parameters is a significant issue for each machining procedure to diminish the machining costs and increment the nature of machining items. Present postulation manages the cutting of Alloy Steel under wet and dry condition utilizing CNC machine. Taguchi technique is utilized to Plan the test format. The impact of cutting condition (shaft speed, feed rate and depth of cut) on surface roughness are examined and dissected. The CNC turning machine is utilized to direct trials dependent on the Taguchi plan of analyses (DOE) with orthogonal L9 cluster. Ideal cutting parameters for every exhibition measure are gotten utilizing Taguchi systems. The orthogonal exhibit, sign to clamor proportion and investigation of difference were utilized to discover least surface roughness. Ideal outcomes are at last checked with the assistance of affirmation tests.

Keywords: *Turning, Orthogonal array, roughness, spindle, Taguchi Method, Signal-to-noise.*

2.0 Introduction:

Manufacturing implies change of crude materials into completed products for the fulfillment of human needs. To change the crude material distinctive manufacturing processes are applied due to which the shape, size and physical properties of given material are adjusted.

2.1 Turning Process:

Turning is a type of machining, a material evacuation process, which is utilized to create rotational parts by cutting ceaselessly undesirable material as appeared in figure1.1. The turning process requires a turning machine or machine, work piece, installation, and cutting device. The work piece is a piece of pre-molded material that is secured to the apparatus, which itself is attached to the turning machine, and permitted to pivot at high speeds. The cutter is typically a solitary point cutting instrument that is additionally secured in the machine, albeit a few tasks utilize multi-point devices. The cutting device feeds into the pivoting work piece and cuts away material as little chips to create the ideal shape.

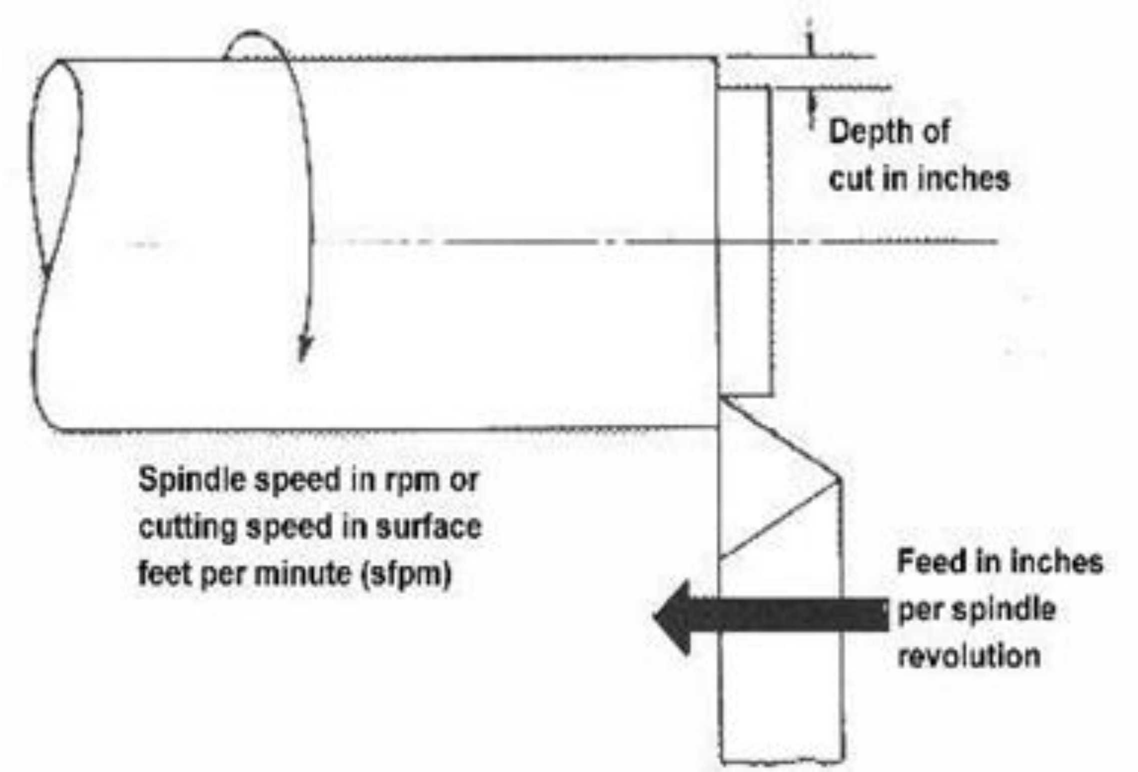

Figure 2.1 Turning Process

Turning is used to convey rotational, commonly axisymmetric, parts that have various features, for instance, holes, grooves, strings, decreases, diverse distance across steps, and even formed surfaces. Parts that are related absolutely through turning normally incorporate sections that are used in constrained sums, perhaps for models, for instance, hand crafted shafts and clasp. Turning is in like manner routinely used as a helper process to include or refine features parts that were produced using a substitute process. Because of the high resistance and surface completes the process of that turning an offer, it is perfect for adding correct rotational features to a section whose fundamental shape has recently been encircled.

2.2 Cutting Tool Materials

Choosing the proper cutting device material for a particular application is vital in accomplishing proficient activities. Expanding sliding velocity to build profitability is just conceivable to a restricted degree as this abbreviates the instrument life, expanding apparatus re-pounding/substitution costs and expanding interference to reaction. No single material meets all prerequisites. The properties required by cutting instruments mean tradeoff is required, for instances expanding hardness by and large outcomes in lower strength.

The Ideal cutting apparatus material ought to have the entirety of the accompanying attributes:

- Harder than the work it is cutting
- High temperature security
- Resists wear and heat stun
- Impact safe
- Chemically idle to the work material and cutting liquid

To successfully choose apparatuses for machining, a mechanic or architect must have explicit data about:

- The beginning and completed part shape
- The work piece hardness
- The material's rigidity
- The material's abrasiveness
- The sort of chip produced
- The work holding arrangement the power and speed limit of the machine instrument

Figure 2.2 Shapes of turning cutting tool

It is important to note, though, that the diameter of the work piece is reduced by two times the depth of cut because this layer is being removed from both sides of the work.

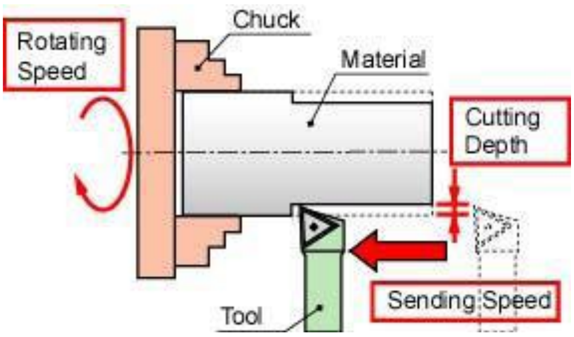

Figure 2.3 Process Parameters in Turning Operation

3.0 Literature Review:

Pytlak et.al (2021) developed a multi-criteria optimization method for hard turning of cemented 18 HGT [Poland standard of compound assistant steel] steel. CBN enhancements of wiper geometry were used. The model considered the going with parameters profundity of cut, feed and cutting velocity. Optimization criteria were generation cost, time per unit and resultant cutting force. Weighted goals procedure and Modified division technique was used to make Pareto sets of courses of action. To ensure low creation cost and low advantages of cutting forces a different leveled procedure was used. Sieben et al. (2010) used plan and assessment of PC tests (DACE) for the exploratory demonstrating of hard turning of AISI 6150 steel. PCBN tool was used hence. The different parameters picked were feed, profundity of cut and cutting rate. The DACE technique can be used to show complex non direct factors.[1]

Cappellini et al. (2020) used AISI 52100 circles to consider the improvement of white and dull layers in hard cutting. Thus, Polycrystalline Cubin Boron Nitride (PCBN) installs were used. The essayists found that as the temperature goes above austenizing temperature, the martensite is quickly smothered and white layer is formed. Cutting speed and feed rate were the parameters. The white layers surrounded were seen under Scanning Electron Microscope (SEM). It was furthermore considered that to be the tool wears the thickness of layers extended. As the speed extended or the feed rate extended thicker white layers were molded and progressively thin diminish layers were encircled.[2]

D. PhilipSelvaraj et. al (2020) used AISI 304 Austenitic treated steel to consider the effect of cutting parameters like cutting rate, feed rate and profundity of cut superficially unpleasantness. A plan of assessments subject to Taguchi's technique has been used to pick up the data. A symmetrical exhibit, the sign to uproar (S/N) extent and the assessment of contrast (ANOVA) are used to look into the cutting qualities of AISI 304 austenitic solidified steel bars using TiC and TiCN secured tungsten carbide cutting tool. Finally, the certification tests that have been finished to differentiate the foreseen characteristics and the preliminary regards assert its ampleness in the assessment of surface unpleasantness. [3]

R. Ramanujam et.al (2019) presents another technique for the optimization of the machining parameters on turning Al-15%SiCp metal network composites. Optimization of machining parameters was done by an examination called appealing quality limit assessment. Taguchi's L27 symmetrical cluster is used for preliminary arrangement. The machining methodology parameters, for instance, cutting velocity, feed rate and profundity of cut are streamlined with various execution considerations to be explicit surface harshness and power use. The perfect machining parameters have been recognized by a composite appealing quality worth got from charm work assessment as the introduction list, and important responsibility of parameters would then have the option to be managed by examination of progress. Certification test is similarly prompted endorse the test result. Exploratory results have shown that machining execution can be improved effectively through this strategy. [4]

J.S.Senthilkumaar et.al (2010) used Inconel 718 to improve surface unpleasantness and flank wear in complete turning. Slicing examinations were coordinated by the full factorial structure under dry cutting conditions. The effects of the machining parameters on the show evaluations surface unpleasantness and flank wear were investigated. The association between the machining parameters and the presentation measures were set up using the non-straight backslide examination. Taguchi's optimization examination shows that the components level, its criticalness to affect the surface harshness and flank wear for the tuning and defying structures. Attestation tests were aimed at a perfect condition to make an assessment between the preliminary outcomes anticipated from the referenced connections.[5]

H. Yanda et al (2010) investigate the effect of the cutting pace, feed rate and profundity of cut on material departure rate (MRR), surface harshness, and tool life in customary turning of adaptable cast iron FCD700 assessment using TiN shrouded cutting tool in dry condition. The machining condition parameters were the cutting rate of 220, 300 and 360 m/min, feed pace of 0.2, 0.3 and 0.5 mm/fire up, while the profundity of cut (DOC) was kept consistent at 2 mm. The effect of cutting condition (cutting pace and feed rate) on MRR, surface unpleasantness, and tool life were examined and researched. Preliminaries were coordinated reliant on the Taguchi plan of examinations (DOE) with symmetrical L9 exhibit, and after that sought after by optimization of the results using Analysis of Variance (ANOVA) to find the most outrageous MRR, least surface unpleasantness, and most noteworthy tool life. The perfect MRR was gotten when setting the cutting rate and feed rate at high characteristics, yet the perfect tool life was landed at when the cutting pace and feed rate were set as low as could be normal the situation being what it is. Low surface fulfillment was gotten at high cutting rate and low feed rate.[6]

D. Mittal et.al (2011) investigates the effect of technique parameters in turning of Titanium grade 2 on conventional machine. Three parameters specifically pivot speed, profundity of cut and feed rate are varied to look at their effect on material removal rate and tool disillusionment. The preliminaries are driven using each factor thus approach. In addition, a few sporadic examinations are in like manner passed on to inspect the wonder of tool frustration. The assessment reveals that material ejection rate is truly influenced by all the three methodology parameters. At any rate the effect of shaft speed and feed rate is more when stood out from profundity of cut. A perfect extent of data parameters has been separated as a definitive outcome for finishing further investigate.[7]

4.0 Methodology:

The objectives of the present work have just been mentioned in the foregoing section. Accordingly, the present examination has been done through the following plan of experiment.

1. Checking and preparing the Lathe prepared for performing the machining operation.
2. Cutting steel bars by control saw and performing initial turning operation on Lathe to get desired dimension (of diameter 45mm and length 145 mm) of the work pieces.
3. Performing straight turning operation under dry and wet conditions on specimens in various combinations of procedure control parameters like: spindle speed, feed and depth of cut.
4. Length of cut was kept steady at 50 mm for both dry and wet turning.
5. Measuring surface roughness and surface profile with the assistance of a convenient stylus-type profilometer, Tal surf (Taylor Hobson, Sturrock 3+, UK).

4.1 Material Used

6.

The material selected was ALLOY STEEL bars (of diameter 45 mm and length 145 mm) on the basis that it was suitable for most engineering and construction applications.

4.2 Alloy Steel

ALLOY STEEL is a low-cost alloy, medium-carbon steel with adequate strength and toughness characteristics, Alloy Steel is valuable for induction- or flame-hardened components. The hardness of bar is 187 HB.

Table 1 Chemical Composition of Alloy Steel in %

C	Si	Mn	P	I	Cu	Ni	Al
0.75	6.5	0.5	0.015	1.3	3.0	0.5	87.4

4.3 Applications

Automotive type applications. Axle and spline shaft are two examples of automotive components produced using this material where the turning is the prominent machining process used.

4.4 Work Piece Dimension

The diameter of bar is 45 mm and of length 145 mm. The size was measured with the help of digital vernier caliper. The experiment was done on a piece nine times of Aluminium Alloy bars having same composition to measure the value of surface roughness and to determine which value of cutting parameters will be optimum to minimize it.

Figure 4.1 Picture of work piece before machining

5.0 Result and Discussion:

TAGUCHI MAIN EFFECT PLOTS FOR SURFACE ROUGHNESS

Main effect plots for surface roughness for dry and wet turning are shown in the fig.5.2 and fig. 5.2 Main effect plot shows the variation of surface roughness with respect to Spindle speed, feed rate and depth of cut. X axis represents change in level of the variable and y axis represents the change in the resultant response.

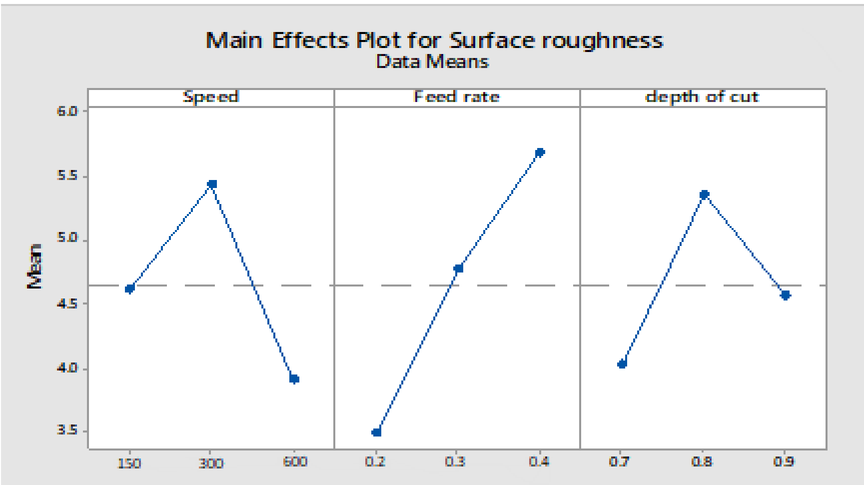

Figure 5.1Main effects plot for means for surface roughness for dry turning

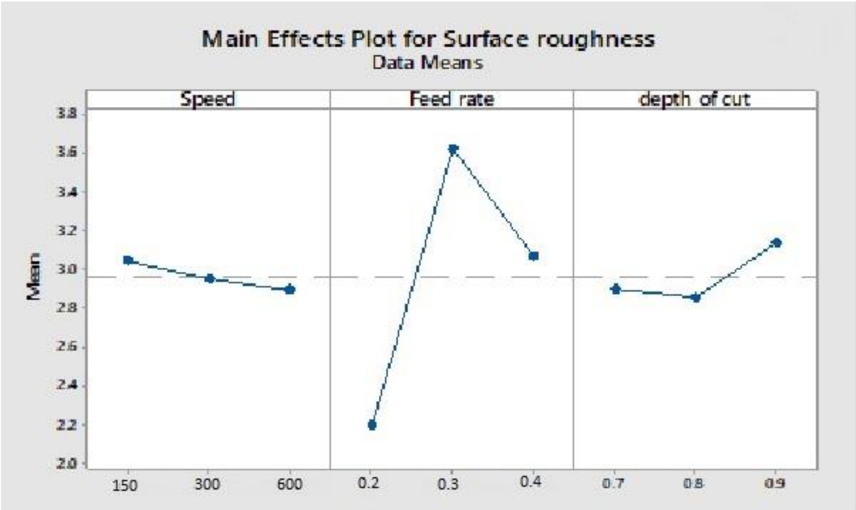

Figure 5.2 Main effects plot for means for surface roughness for wet turning

4.2 ANALYSIS OF S/N RATIO FOR SURFACE ROUGHNESS FOR DRY AND WET TURNING

The signal to noise ratios tells us about the variations present in the process. The values of all the results according to Taguchi array parameter design layout are presented in this section. The S/N ratios have been calculated to identify the major contributing factors for variation of force values. In this design situation, lower-the-better is used.

Table 1 Analysis of variance for S/N ratios for surface roughness (Ra) in Dry Turning

Source	DF	Adj SS	Adj MS	F	P	Percentage Contribution %
Spindle speed (rpm), N	2	14.561	7.28	1.75	0.363	19.67 %
Feed rate (mm/rev), f	2	35.606	17.803	4.29	0.189	48.44 %
Depth of cut (mm), d	2	15.025	7.513	1.81	0.356	20.44 %
Error	**2**	**8.307**	**4.154**			**11.3 %**
Total	**8**	**73.5**				**100 %**

Table 2 Response table for S/N Ratios of surface roughness (Ra) in Dry Turning

Level	Spindle Speed (rpm), N	Feed rate (mm/rev), f	Depth of Cut (mm), d
1	-12.51	-10.28	-11.41
2	-14.66	-13.46	-14.56
3	-11.63	-15.06	-12.83
Delta	**3.02**	**4.79**	**3.16**
Rank	**3**	**1**	**2**

Table 3 Analysis of variance for S/N ratios for surface roughness (Ra) in Wet Turning

Source	DF	Adj SS	AdjMS	F	P	Percentage Contribution %
Spindle speed (rpm), N	2	5.3878	0.01539	0.09	0.914	16.34 %
Feed rate (mm/rev), f	2	29.148	14.574	8.91	0.101	66.84 %
Depth of cut (mm), d	2	4.5985	0.4292	0.26	0.792	13.68 %
Error	**2**	**3.2715**	**1.6357**			**3.14 %**
Total	**8**	**33.586**				**100 %**

Table 4 Response table for S/N Ratios of surface roughness (Ra)in Wet Turning

Level	Spindle Speed (rpm), N	Feed rate (mm/rev), f	Depth of Cut (mm), d
1	-9.443	-6.836	-9.007
2	-9.260	-11.173	-9.023
3	-8.993	-9687	-9.667
Delta	0.451	4.338	0.66

Rank	3	1	2

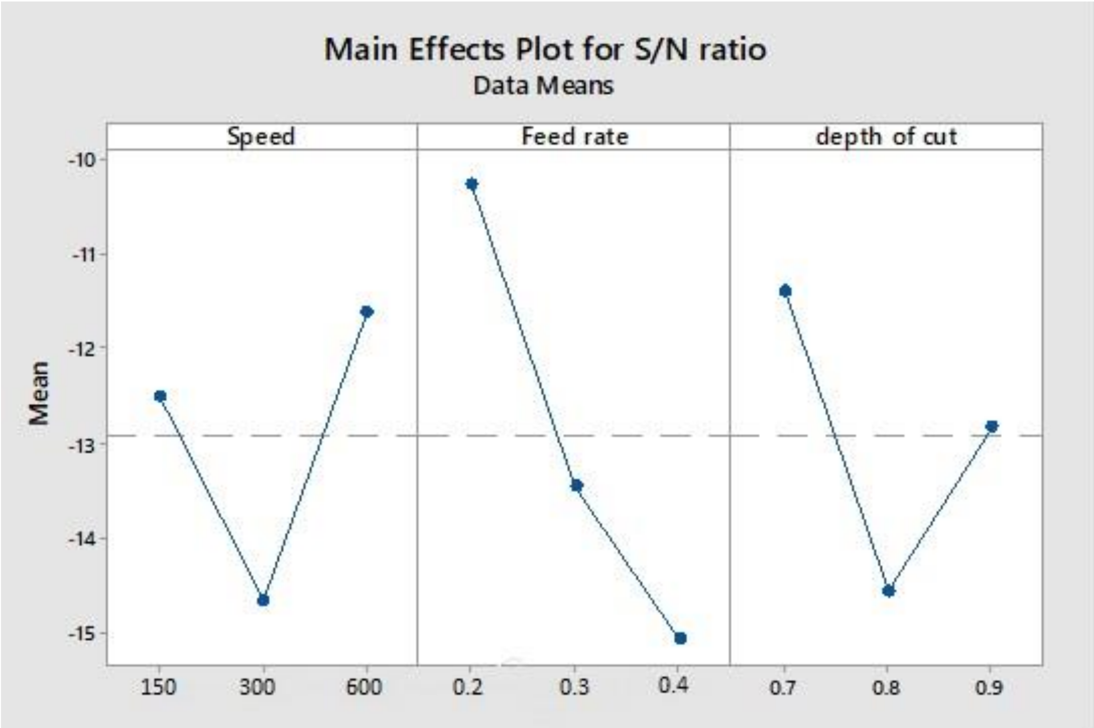

Figure 5.3 Main effects plot for S/N ratios for surface roughness in Dry Turning

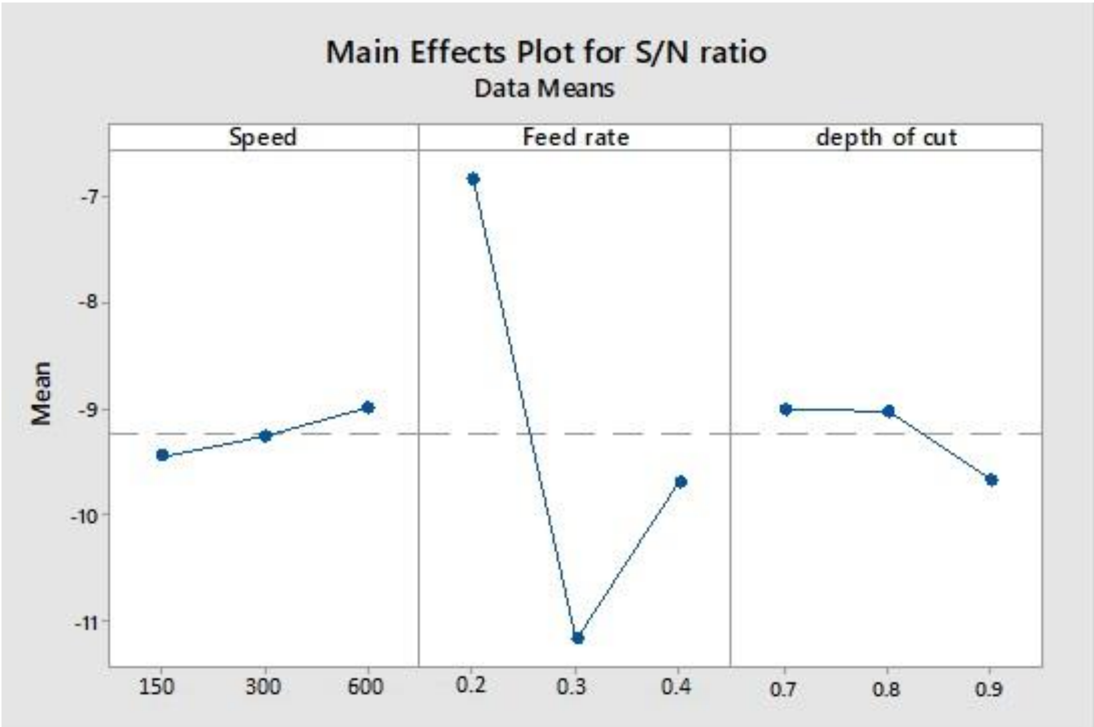

Figure 5.4 Main effects plot for S/N ratios for surface roughness in Wet Turning

6.0 Conclusion:

6.1 Conclusion from surface roughness in dry turning

The Surface roughness is mainly affected by feed rate, depth of cut and spindle speed. With the increase in feed rate the surface roughness also increases, as the depth of cut increases the surface roughness first increase and decrease and as the spindle speed increase surface roughness decreases. Also, it is observed from the S/N ratio graph that surface roughness minimizes at a combination of spindle speed = 300 rpm, feed = 0.4 mm/rev. and Depth of cut = 0.8 mm which gives a surface roughness of 2.18.

6.2 Conclusion from surface roughness in wet turning

The Surface roughness is mainly affected by depth of cut, feed rate and spindle speed. With the increase in depth of cut the surface roughness also increases, as the feed rate decreases and as the spindle speed increase surface roughness decreases. Also, it is observed from the S/N ratio graph that surface roughness minimizes at a combination of spindle speed = 160 rpm, feed = 0.4 mm/rev. and Depth of cut = 0.9 mm which gives a surface roughness of 2.10.

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