International Journal of Research Publication and Reviews, Vol 4, no 5, pp 3404-3411 May 2023

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Study of Favorable Surface Roughness in a Lathe, Drilling, Milling Machine

Dr. A.K. Madan[1], Prateek Yadav [2], Raj Kulhari [3]

[1]Professor, Mechanical Engineering department, Delhi Technological University, New Delhi
[2, 3] Student, Mechanical Engineering, Delhi Technological University, New Delhi

ABSTRACT

The objective of this paper is to evaluate the effect of different machining parameters on the surface roughness of Hardox 600 (hard and tough steel with high wear resistance and hardness of 600 HBW) in the milling process using the Taguchi optimization method. The selected process parameters are feed rate, spindle speed, the depth of cut, and radial immersion. Based on the number of parameters and their levels L_9, an orthogonal array of the Taguchi was chosen. Surface roughness data were collected for nine experiments. Signal to noise *(S/N)* ratio and analysis of variance calculation were conducted to determine the optimum level and percentage of contribution of each parameter. Furthermore, the mathematical model was created to determine the predicted value of *S/N* ratio, and the experiments were implemented to justify the mathematical model. It is found that the margin error for the mathematical model and the experimental result was 5.5%, resulting from any uncontrollable parameters affecting the machining process. It is also identified that the radial immersion was the most significant parameter with 45.33% of contribution in the milling procedure of steel with high hardness (Hardox 600). Hence, the surface roughness was mostly influenced by radial immersion (D), followed by the depth of cut (C), spindle speed (B), and finally, feed rate (A) respectively based on the level of their significance. The optimal level of the selected parameters for the minimum surface roughness value is the radial immersion at level 1, depth of cut at level 1, spindle speed at level 2, and feed rate at level 2.

Keywords: Taguchi optimization, Surface roughness, machining parameters

INTRODUCTION

.Milling process is used to remove material with the help of a rotating cutter. This process of machining is generally used by the industries, and by cutting away the material which is unnecessary. The aim of this paper is to get optimum surface roughness, by identifying certain parameters of the machine. Surface roughness is defined as the fine irregularities of surface texture. Also surface roughness takes place due to the tool chip interface and feed marks in machining process. The quality of surface plays an important role in evaluating productivity of machine tool and machined parts. Several parameters of milling process are there like speed of cutting, feed rate, cutting depth, rate of material removal (MRR) etc. which play a crucial role in surface roughness. A suitable method of optimization is needed to find optimum value of parameters for cutting and minimizing surface roughness. Taguchi method will be used in this report for finding optimum roughness and Taguchi's orthogonal array should be used to determine the parameter's settings. ANOVA will be used for result analysis

FACTORS AFFECTING SURFACE ROUGHNESS

Surface roughness occurs from tooth marks left when machining a surface. The tool marks are affected by the different factors that are present in the cutting operation. Some of these factors are: tool geometry, workpiece material, and cutting conditions. The quality of the surface finish in milling operations has been related to: tooth spacing, feed per tooth, diameter of the cutter, method of milling, difference in teeth heights of the cutter, chatter conditions, favorable conditions for the formation of built-up edge, and arbor deflections. The effect of these variables on surface roughness, as stated by various researchers, are discussed in the following sections.

Feed It has been observed that, in general, surface finish deteriorates when feed rate is increased.

Cutting Speed Cutting speed is another factor of great importance in the cutting process. It takes direct action on chip formation, forces, and temperature; therefore, the kind of chip obtained depends on the cutting speed, and the kind of chip formed affects surface finish.

Depth of Cut Previous investigations on the effect of depth of cut on surface finish indicate that as depth of cut increases, surface roughness also increases.

Tool Material It has been observed that surface roughness varies with tool material. The key to producing better surface finish with any tool is the wear resistance at high cutting speed. High speed steel produces good surface finish when moderate cutting speeds are used.

Tool Wear For a fixed set of conditions, surface roughness changes more or less proportionally to the cutting time. Flank wear changes the tool form, resulting in changes in the expected surface finish and dimensional accuracy of the workpiece.

Cutter Diameter From the geometry of the cutting process in milling operations, that surface roughness is related to the cutter 25 diameter. The general observation is that as cutter diameter increases the surface finish improves.

Helix Angle surface roughness varies with helix angle for different feed rates. Some improvement in surface finish is obtained by increasing the helix angle at lower feed rates. At higher feed rates, better finish is obtained when a large helix angle is used. Other causes of variation in surface finish, related to the tool in milling operations are: 1. Variation in tooth spacing, which is determined by the manufacturer of the tool. 8 2. Variation in the distance of the cutting edge of the teeth from the center of the cutter rotation. It produces high and low teeth in the cutter, due to inaccuracies in cutter sharpening.

Method of Milling The method of milling influences the peak-to-valley height. Martellotti showed that improved surface finish is obtained in peripheral milling with up-milling. In down-milling, the negative sign in the denominator indicates that the peak-to-valley height is greater than for up-milling. The cutting forces are generally higher than in up-milling. He also showed that in down-milling, the specific and mean cutting pressures are higher than in up-milling. It is possible that these increases in force and pressure deteriorate surface finish in down-milling.

Workpiece Material The relation between the Brinell hardness number and roughness has been investigated using steel. In general, roughness decreases as the Brinell hardness number increases. Very little attention has been devoted to the effect of workpiece material in milling operations using surface finish as the response.

Chatter Chip formation is also affected by vibration produced in machining operations. In milling operations, chatter is a condition of resonant vibration in which the cutter and the workpiece move with respect to each other at a frequency of one or more elements of the machine. When this condition has been established, the interaction of the cutter and workpiece sustains the vibration at this frequency. Chatter conditions can vary with the number of teeth on the cutter. Chatter is one cause of poor surface finish. Its occurrence can be minimized by locating the cutter and workpiece as close as possible to the spindle, or by variation of the cutting conditions.

Cutting Speed and Feed Interaction Often, the combined effect of two or more factors is different from that of each factor alone. Therefore, the consideration of two or more factor interactions can be important in determining cutting conditions that allow the best surface finish. The combined effect of cutting speed and feed on surface finish has been investigated for fine turning and the results indicate that better surface finish is obtained with a combination of large cutting speed and low feed . However, no investigation has been done on the combined effect of cutting speed and feed on surface roughness in the case of end milling operations. Cutting Speed-Depth of Cut Interaction It was stated that for a turning operation, an increase in both the cutting speed, as well as depth of cut, improves the surface finish. However, a combined increase of both of these variables beyond certain limits may cause poor surface finish due to vibration. At higher cutting speeds, and at smaller feeds, if the depth of cut is increased, a 29% increase in cutting force will occur. For end milling operations, the combined effect of cutting speed and depth of cut on surface finish has not been investigated.

Depth of Cut-Feed Interaction An increase in depth of cut has been found to improve the surface finish in the case of turning operations, but an increase in feed would deteriorate the surface finish. The size of the chip cross-sectional area has a dominating effect on surface roughness. For larger chips, the surface roughness is increased, due to higher friction, at the tool-chip interface; the contrary occurs for smaller chips. For best results, with respect to surface finish, a combination of a relatively large depth of cut and a small feed should be used for turning operations.

TECHNIQUES BY WHICH SURFACE ROUGHNESS REDUCES

- **A comparison of machining performance with different cooling methods**

Ceramic cutting tools are widely used particularly in high-speed machining of difficult-to-machine materials. However, using cutting fluid with these ceramic tools significantly reduces tool life. Therefore, the inclusion of a cooling/lubrication method into the process to improve the machining performance of ceramic tools will make machining efficiency much more effective. One cutting tool type suitable for material that is difficult to machine is the ceramic cutter. Ceramic cutters have been widely used in metal cutting for more than 100 years. Features like high hardness, high heat resistance, high wear resistance and low chemical affinity are some of the reasons that ceramic cutters are widely used for high-temperature alloys. Moreover, their longer tool life compared to carbide tools is another of their important features. The rising demand of manufacturers for more accurate machining, higher speed and highly finished surfaces has increased the interest in ceramic cutters. However, ceramic cutters are also very fragile and thermal shocks shorten their life. Therefore, it is not recommended that cutting fluid be used with these cutters although including cutting fluid in the process is an important necessity for users who want to increase production efficiency. It is known that ceramic tools are extensively used to increase process efficiency in the high-speed machining of superalloys and especially hard materials. This method, especially for hard materials, results in a high cutting tool wear rate and thus a lower tool life and negatively affects the surface quality For this reason, it is important to include a cooling method in the system in order to increase process efficiency, but at the same time to consider the impact on human health and the environment.

- **Cooling/lubrication conditions**

Three types of cooling conditions were chosen for the machinability experiments:

1. Dry
2. Traditional (wet)

3. Minimum quantity lubrication (MQL)

- **Evaluation of experimental results for tool wear**

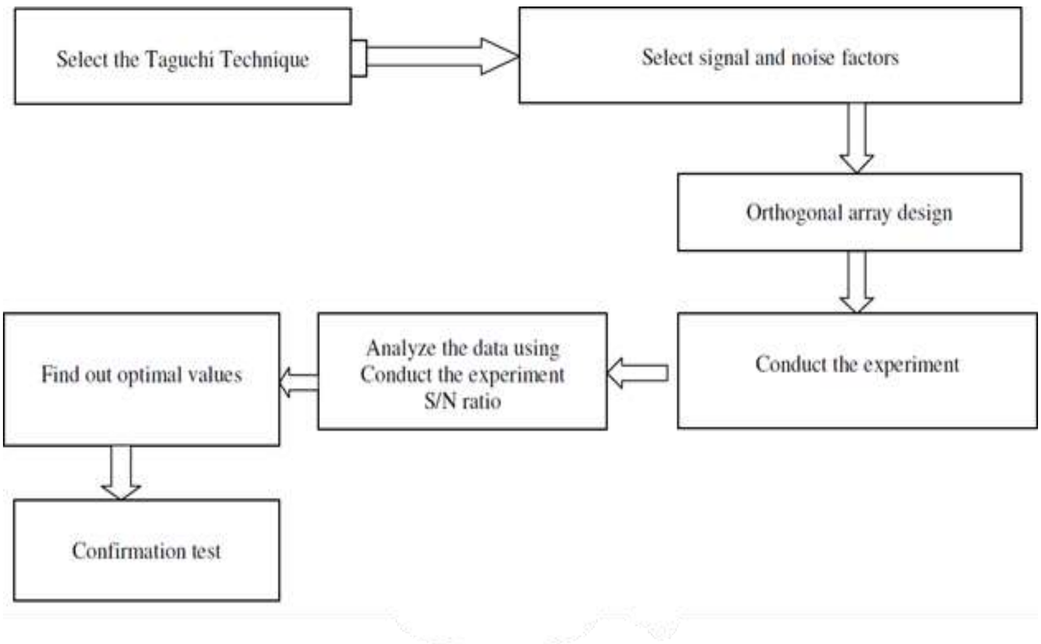
The machining parameters comprised three different cooling/lubricating methods (dry, wet and MQL), three different cutting speeds (500, 600 and 700 m/min) and three different feed rates (0.02, 0.04 and 0.06 mm/rev). Analysis of variance was used to determine the effects of the machining parameters on tool wear and surface roughness. In addition, a regression analysis was conducted to identify the relationship between the dependent and independent variables. The lowest wear was again achieved by using the MQL system, while the highest wear resulted from the wet machining. The wet machining caused 64.37% higher tool wear than the dry machining, while the MQL caused 9.20% lower wear than the dry machining. This can be explained by the low thermal shock resistance of the ceramic tools. However, the MQL system had the priority of lubrication rather than cooling and therefore created a film layer at the tool/chip interface which resulted in better lubrication and had an important effect on reducing tool wear compared to the traditional cooling. According to the experimental results, the minimum quantity lubrication method was identified as the best cooling method for minimum tool wear and surface roughness.

- **Machinability of titanium alloy through laser machining: material removal and surface roughness analysis**

Laser milling is a competent precision process especially when the work material is hard-to-machine such as titanium alloys. Titanium and its variants are considered as the materials of the present and future because of their use in numerous industrial sectors such as aeronautics, biomedical, chemicals, shipbuilding, and automobiles. Titanium alloys have remarkable properties including high strength-to-weight ratio, low thermal conductivity, low density, better toughness, and excellent corrosion resistance as compared with other materials. Due to these properties, machining of titanium is considered as cumbersome especially through conventional processes in which rapid tool wear and serious adhesion are the significant issues.

PROBLEM FORMULATION AND RESEARCH OBJECTIVES

1. ***Taguchi Method-*** It is a statistical method which was developed to improve the quality of manufactured goods and to reduce the occurrence of defects and failures in the same. It gauges quality as a calculation of loss associated with a product. Loss in a product is defined by variations in its function and the negative side effects that may result from the product. Loss from variation in function is a comparison of how much each unit of the product differs in the way it operates. The greater the variance, the more significant the loss in function and quality. This denotes how usage has been impacted by defects in the product.



2. ***Taguchi Orthogonal Array-*** Taguchi Orthogonal Array (OA) design is a type of general fractional factorial design. It allows one to consider a selected subset of combinations of multiple factors at multiple levels.

Run	Control Factors					
	Spindle Speed (rpm)	Feed rate (mm/min)	Depth of cut (mm)	Coolant flow (lit/min)	Surface Roughness (µm)	S/N ratio (dB)
1	1500	800	0.4	0	2.0450	-6.2139
2	1500	1000	0.8	30	0.8053	1.8808
3	1500	1200	1.2	60	2.9128	-9.2860
4	2000	800	0.8	60	0.6866	3.2659
5	2000	1000	1.2	0	2.3710	-7.4986
6	2000	1200	0.4	30	0.4220	7.4938
7	2500	800	1.2	30	0.4398	7.1358
8	2500	1000	0.4	60	1.0468	-0.3968
9	2500	1200	0.8	0	1.2810	-2.1509

L9 Orthogonal Array

3. ***ANOVA- Short for Analysis of Variance:*** It helps in finding out whether the differences between groups of data are statistically significant or not. From its name we know that it works by analyzing the levels of variance within the groups through samples taken from each of them. In the context of this paper, it is used to quantify and identify the source of results of different trial from different trial runs (different cutting parameters).

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Spindle speed (rpm), N	2	3.44 17	3.4417	1.7208	2.11	0.322
Feed rate (mm/rev), f	2	7.23 95	7.2395	3.6197	4.43	0.184
Depth of cut (mm), d	2	2.65 64	2.6564	1.3282	1.63	0.381
Error	2	1.63 47	1.6347	0.8173		
Total	8	14.9 723				
S = 0.904071		R-Sq = 89.08 %		R-Sq (adj) = 56.33%		

ANOVA Table

Research Papers Used:

1) Raj R. A., Parun T., Sivaraj K. and Kannan T.T.M. (2013). Optimization of milling parameter of EN8 using Taguchi Methodology. International Journal of Mechanical Engineering and Robotics Research, 2, 202-208

2) Ribeiro João, Lopes Hernâni, Queij Luis and Figueired Daniel (2016). Optimization of Cutting Parameters to Minimize the Surface Roughness in the End Milling Process Using the Taguchi Method. Periodica Polytechnica Mechanical Engineering, 61(1), 30-35.

3) Verma Narendra Kumar and Sikarwar Ajeet Singh (2015). Optimizing Turning Process by Taguchi Method under Various Machining Parameters. International Research Journal of Engineering and Technology (IRJET), 2(6), 307-312

4) Sumesh A.S. and Melvin Eldho Shibu (2016). Optimization Of Drilling Parameters for Minimum Surface Roughness Using Taguchi Method. IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), 12-20

5) Thakre Avinash A. (2013). Optimization of Milling Parameters for Minimizing Surface Roughness Using Taguchi 's Approach. International Journal of Emerging Technology and Advanced Engineering, 3(6), 226-230

Important information from the research papers

1) This paper focuses on the usage of Taguchi method and ANOVA to analyse and optimize the turning operation to improve the quality of the finished product. The material used here for the processes is AISI 1045 steel and the tool used here is a coated cemented carbide tool.

Herein, various parameters like the maximum material removal rate (MRR) and minimum surface roughness were taken into account to arrive at a definite conclusion. Since the above-mentioned parameters are derived from values like spindle speed, feed rate and depth of cut, these values had to be calculated and recorded as shown in Table No. 1 and Table No. 2, for surface roughness and MRR respectively.

Usage of the CNC lathe machine pushed them to calculate the S/N ratio (signal/noise ratio) which is defined as a value which compares the level of a desired signal to the level of background noise. Here, the reason we use the S/N ratio is because we want to compare two different types of values- controllable and uncontrollable values. The controllable value here would be signal and the uncontrollable one would be the background noise. Since we

$$\eta = -10\log\left[1/n\left(\sum Yi^2\right)\right]$$

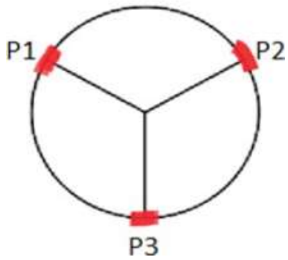
need to minimize the surface roughness and maximize the material removal rate, Smaller-the-Better is used for surface roughness and Bigger-the-Better is used for material removal rate. The formula used for S/N ratio is:

The last step of Taguchi parameter design is to verify and predict the improvement of response (surface roughness) using optimum methods (combination of cutting parameters). The predicted optimal value (ηopt) can be calculated by:

$$\eta_{opt} = m + \sum_{j=1}^{n} \left[(m_{i,j})_{\max} - m\right]$$

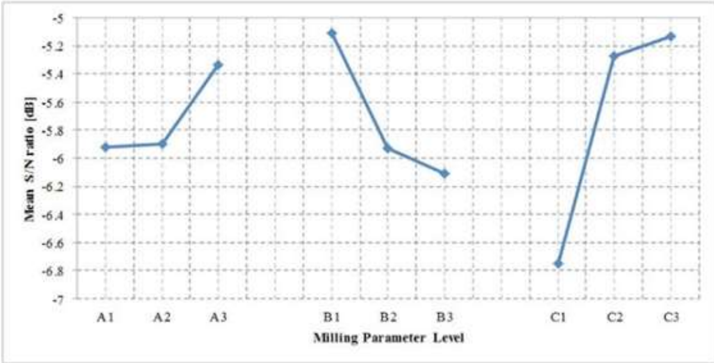
In the end, the future scope was discussed wherein, it was suggested that instead of using only 3 parameters, one can enhance the accuracy by taking more parameters into account, such as, nose radius, cutting conditions etc.

2) This paper mainly focuses on the usage of L9 orthogonal array in the Taguchi method to optimize the CNC end milling operation which is carried out by ANOVA analysis identify the significant factors affecting the surface roughness. The study was carried-out by machining a hardened steel block (steel 1.2738) with tungsten carbide coated tools. Here, three levels of the cutting parameters selected for this study are shown in Table 1. The experimental design for the three cutting parameters using the L9 orthogonal array is presented in Table 2 and Table 3 tells us about the chemical composition of the workpiece i.e., steel 1.2738. The roughness was measured along of cylinder axial direction and in three equi- distance orientations separate by 120º angle (P1, P2, P3) as shown in figure. the Table 4 is presented



the average of the surface roughness measurements in the three directions (Ra_P1, Ra_P2, Ra_P3) and the computed signal-to-noise S/N by using the formula: - $\eta = -10\log\left[1/n\left(\sum Yi^2\right)\right]$ The Taguchi analysis procedure can be described in four steps. In the first, is implemented the evaluation signal-to- noise ratio and allows to define the level of variation for each parameter. This is followed by a comparison of arithmetic mean surface roughness among all the tests. The third is based on analysis of variance, which is used to define the influence of each parameter.

Fig. 3 shows the S/N ratio response graph for Ra. One gets a high S/N ratio for smaller variance of surface roughness around the desired value. Nevertheless, the relative importance among the milling parameters for the surface roughness still required to be identified so optimal combinations of the milling parameter levels can be determine more accurately using an ANOVA analysis.



The experimental results confirm the prior parameter design for the optimal cutting parameters with the multiple performance characteristics in milling operations. The optimal solution for minimizing the surface roughness value is A3B1C3 i.e., cutting speed of 250 m/min, the feed rate of 0.075 mm/t and the depth of cut of 0.312 mm leading to average surface roughness of 1.662 μm. Therefore, radial depth of cut is the most significant factor of surface roughness with contribution of approximately 64%.

3. This paper focuses on the analysis and optimisation methods of different milling parameters using the Taguchi method and ANOVA (Analysis of Variance). The material used here for the processes is EN8 steel. The machine used here was the universal milling machine with maximum spindle speed 1440 rpm and 25 kw drive motor without using cutting fluids.

It is important to know about the material on which the experiments are being performed, so in Table 1 and Table 2, we can see the chemical composition and mechanical properties of EN8 steel.

Values like cutting speed, feed rate and depth of cut as shown in Table 3 and Table 4 were observed in order to calculate the material removal rate and the surface roughness.

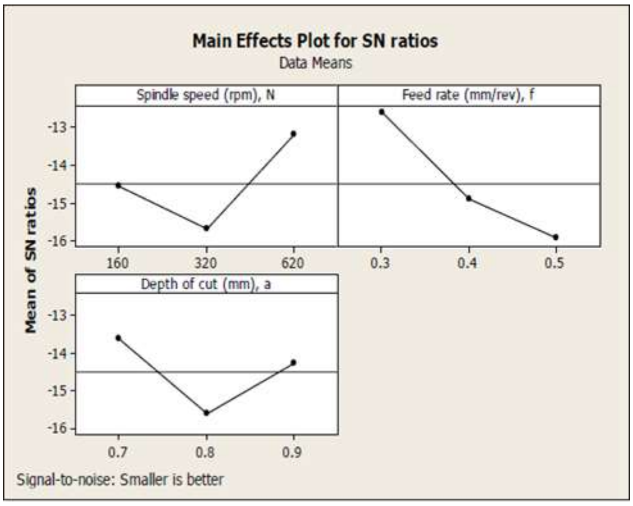
With the help of Minitab 15, main effects plot for S/N ratios were plotted, from which, it was deduced which factor has a higher impact on the surface roughness of the finished product. The higher the deviation/lesser the angle between the two lines of the graph, more will it affect the surface roughness. Here, X axis represents change in level of the variable and y axis represents the change in the resultant response. From the graphs, it is clearly visible that the feed rate has the lowest deviation in its graphs and thus has the highest significance in terms of surface roughness.

Also, in the main effects plots, if the line for a particular parameter is near horizontal, then the parameter has no significant effect. On the other hand, a parameter for which the line has the highest inclination will have the most significant effect.

Another important parameter to know exactly about the predictions made by the Taguchi method is the S/N ratio (signal/noise). It gives insight and contributes as a significant factor while calculating the surface roughness and is observed and calculated in Table 5.

ANOVA is another method which is employed for knowing about the surface roughness and is calculated in Table 6 using parameters like DOF (Degree of Freedom), S (sum of square), V (Variance) F (variance ratio) and P (significant factor).

In the end, various conclusions were drawn out from the experiments like the different values of parameters from which low surface roughness is obtained and which operations on the milling machine can provide the best accuracy on the workpiece made out of EN8 steel.



4) This paper focuses on the optimization of drilling parameters using the Taguchi technique to obtain minimum surface roughness (Ra) and usage of L9 orthogonal array on a radial drilling machine to conduct a number of drilling experiments. The machine used here was Radial Drilling Machine. However,

various parameters like the maximum material removal rate (MRR) and minimum surface roughness were considered to arrive at a definite conclusion. The material used here is Cast Iron and the tool used is made up of HSS- High Speed Steel. The basic composition of HSS is 18% W, 4% Cr, 1% V, 0.7% C and rest Fe. Table 1 shows the chemical composition of the type of cast iron used. We have used Surftest to measure to measure the shape or form of components. A profile measurement device is usually based on a tactile measurement principle. With the help of Taguchi method we have experimentally concluded the data as shown in table 3. One repetition for each of 9 trials was completed to measure Signal to Noise ratio (S/N ratio) given in Table 4 as shown.

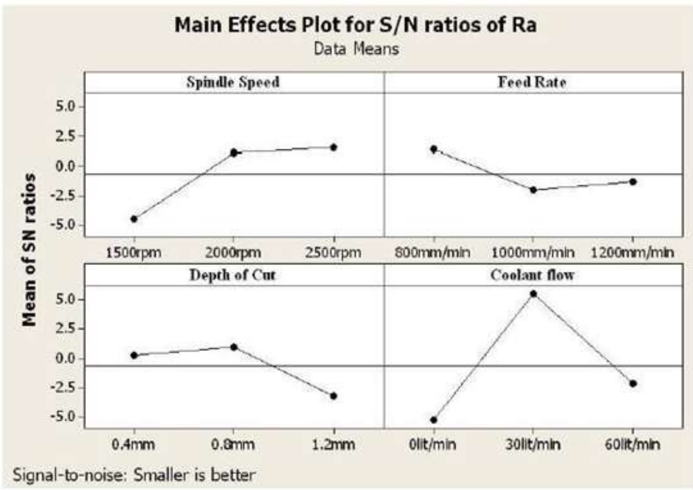
Table 4. Roughness values and S/N ratio's values for the experiments

Trial No.	Speed (RPM)	Feed (mm/rev)	Drill diameter (mm)	Surface Roughness		Mean Surface Roughness	S/N Ratio
				1	2		
1	80	0.1	4	0.65	0.68	0.665	3.54136
2	80	0.125	8	0.77	0.78	0.775	2.21379
3	80	0.15	12	0.99	1.10	1.045	-0.394339
4	160	0.1	8	0.89	0.83	0.86	1.30475
5	160	0.125	12	0.93	0.95	0.94	0.536951
6	160	0.15	4	0.75	0.77	0.76	2.38298
7	250	0.1	12	0.84	0.86	0.85	1.41102
8	250	0.125	4	0.99	1.05	1.02	-0.175759
9	250	0.15	8	0.86	0.88	0.87	1.20904

From these tables researcher concluded that the optimal solution for minimizing the surface roughness value is A1 B1 C1 i.e., spindle speed of 80 rpm, feed rate 0.1 mm/rev and 4mm drill diameter. The surface roughness value and S/N ratio of the combination are 0.665 µm and 3.54 respectively.

It is found that the drill diameter is the most significant factor for determining surface roughness and its contribution to surface roughness is 38.3%. But another control parameter had a great impact on determining the surface roughness which is feed rate contributing approximately 34% to the result.

5. This paper focuses on the usage of Taguchi method and ANOVA to analyze and optimize the turning operation to improve the quality of the finished product on a CNC turning machine. The material used here for the processes is AISI 1045 steel and the tool used here is a coated cemented carbide tool. The orthogonal array, signal to noise ratio (S/N) and analysis of variance were employed to find the maximum material removal rate (MRR) and minimum surface roughness. Table 1 here focuses on the factor and levels for selected machining parameters which are to be used in the Taguchi orthogonal array. Here since the L9 orthogonal array is used, there are 4 different factors which are considered and each factor is assigned 3 different levels. A new factor is taken into account here, known as coolant flow which is measured in lit/min. When the experiments were conducted on Agni, BMV45 TC24 with FANUC controller, several graphs of surface roughness and waviness profiles were obtained which help in finding the S/N ratio for each of the levels of the considered factors.



The quality characteristic for surface roughness is smaller-the-better for which equation 1 is used to calculate the signal to noise ratios (η) where yi is the value of quality characteristics at ith experiment, n is number of runs for an experiment. The experimental data for surface roughness and calculated signal- to-noise ratio for all nine combinations are shown in table 2.

After making the table for the orthogonal array, wherein the S/N ratio was calculated using the provided parameters with the help of Minitab 15, graphs pertaining to the main effects plot for S/N ratio with respect to surface roughness were plotted.

From these graphs, the researcher concluded that the optimal solution for minimizing the surface roughness value is A3 B1 C2 D2 i.e. spindle speed of 2500 rpm, feed of 800 mm/min, 0.8 mm depth of cut, 30 lit/ min coolant flow. The surface roughness value for this combination was found to be 0.357µm. With the help of Taguchi method, it was concluded that coolant flow was observed to be the main controller of the surface roughness with a contribution of approximately 60%. The second most important factor was found to be spindle speed with a contribution of approximately 22%.

CONCLUSION

The main objective of the five research papers which were referred to, was to analyse the surface roughness on different materials using milling machine. The review process included different comparison studies between the 5 research papers on the following bases.

• 2 papers- identical

• 1 paper- one extra factor (end milling)

• 1 paper- drilling instead of milling

• 1 paper- lathe/turning instead of milling

The first two papers focus on the exact objective of the topic, the only major difference being in the material used. This gave us an idea about the factors and methods to be used. The two papers which did not perform the operation on the milling machine, rather the lathe and drilling machine, gave us an idea whether the machine plays a major or important role in the surface roughness with respect to the finished work piece. The last paper which included an extra factor gave us a new perspective regarding the factors which can be considered.

The factors which were initially used for analysing the surface roughness were cutting speed, spindle speed, depth of cut and feed rate. Later on, a new factor, called coolant flow was considered and as opposed to the prior results of cutting speed being the most important factor, coolant flow turned out to be the most important factor.

All the researchers of the 5 research papers used the Taguchi method, which contains 7 different steps, for their respective analyses, followed by different statistical methods like ANOVA and Fisher's F Ratio. Taguchi method is a statistical method used to optimise the parameters of a process and in turn control the quality of a product. The main reason this method was used because it considers both the control as well as the noise/uncontrollable factors which leads to better precision and accuracy in the outcomes. Here, the L9 orthogonal array was used which includes 4 factors and 3 levels each. Here the 4 factors are as listed before. The ANOVA method (Analysis of Variance) is a statistical tool which was employed to quantify and identify the source of results of different trials from different trial runs.

To conclude the review work done by us based on the 5 research papers, the common factors which were used by majority of the researchers were-

• Cutting speed

• Feed rate

• Depth of cut

Out of all these 3 factors, the major share of the controlling factors for surface roughness turns out to be cutting speed. Also, from this review we can conclude that any further research in this area will revolve more around these 3 selected parameters.

REFERENCES

1. K. Senthil Kumar, J.S. Senthilkumaar & A. Srinivasan, "Reducing surface roughness by optimising the turning parameters".,2012; page (79-86)
2. SZYMON WOJCIECHOWSKI1, MICHA" WIECZOROWSKI , AND THOMAS MATHIA, "Surface Roughness Analysis of Hardened Steel After High-Speed Milling".,2011;page(386-395)
3. S. Bharathi Raja, N. Baskar, "Application of Particle Swarm Optimization technique for achieving desired milled surface roughness in minimum machining time".,2012; page (5982-5989)
4. Çagrı Vakkas Yıldırım, Turgay Kıvak, Fehmi Erzincanlı, "Tool wear and surface roughness analysis in milling with ceramic tools of Waspaloy: a comparison of machining performance with different cooling methods".,2019; page (2-15)
5. Amjad Hussain & Madiha Rafaqat & Mazen Zaindin, "Machinability of titanium alloy through laser machining: material removal and surface roughness analysis".,2019; page (1-20)