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STUDY OF FAVORABLE SURFACE ROUGHNESS IN MILLING MACHINE AND ITS OPTIMIZATION

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ABSTRACT

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.

1. INTRODUCTION

Milling is a metal removal operation. In milling operation metallic particles are removed by means of a rotating multipoint cutter which is geared up on the Arbor of the milling system. The types of features are fashioned through milling machine on an element by means of cutting away the unwanted material. Milling machine is having certain essential components, which can be its column, saddle, base, table, knee, arbour, over-arm and spindle. In milling process, positive elements perform a very crucial position inclusive of work-piece, fixture, and cutter which are wished in milling system. The work held in a fixture, connected to a table of milling device. Three table moves are possible in a Milling machine i.e., crosswise, vertical, and longitudinal however rotational or swivel movement are also located with respect to the table in some cases. In improving manner of Milling, a completely essential function is performed by the first-class of surface. The fatigue energy, corrosion resistance, or creep life is improved by way of a good surface. Surface roughness impacts some of practical attributes of components, which include, friction among contacted parts, parts wearing, mirrored image of light transmission of warmth, distributing capability and lubricant holding a, capability of load bearing, coating or fatigue resisting and so on. consequently, the chosen of procedures should be right all through the operation and the preferred completed floor is exact. for maximum floor roughness, Taguchi method can be used to optimize the manner parameter.

Taguchi technique: To optimize parameters of a procedure and improve the additives satisfactory, which can be synthetic Taguchi approach is used which is absolutely statistical approach. Taguchi and Konishi have advanced the Taguchi method. by and large To enhancing the manufactured goods (development of manufacturing method) pleasant, Taguchi approach was advanced. At a later level its software of this technique turned into multiplied to diverse other engineering fields, like Biotechnology etc. Taguchi's efforts were stated statisticians in particular inside the improvement of designs for studying variant. favoured results are successfully carried out through cautious choice of manipulate elements and divide them into manage and noise elements. manage elements need to be decided on that it eliminates the impact of noise issue. proper manage elements are recognised via Taguchi method and surest effects of the system are attain by this approach. To behaviour a hard and fast of experiments orthogonal array (OA) are selected. To statistics and expect the satisfactory of additives produced, outcomes of these experiments are used.

ANOVA: The assessment of reaction significance in percent (%) for every parameter of orthogonal array, evaluation of variance (ANOVA) is used. it's miles used to quantify and identify the source of consequences of different trial from specific trial runs (i.e. one-of-a-kind reducing parameters). The ANOVA is basically a way in which the variations most of the extraordinary agencies are tested. to begin with Prof. R.A. Fisher turned into the person who use this time period and later it was evolved through Prof. Snedecor and lots of others. The primary property of ANOVA is that the entire sum of the squares (total version) is identical to the sum of the SS (sum of the squares of the deviations) of all condition parameters and the errors components.

2. LITERATURE REVIEW

Raj R.A. et al. focused on the usage of Taguchi method and ANOVA to analyze 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 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:

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

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 (η_{opt}) can be calculated by:

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

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.

Ribeiro João focused 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: -

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

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%.

Verma Narendra Kumar et al. focused on the analysis and optimization 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.

Thakre Avinash A. et al. focused 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 the 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%.

Sumesh A.S. et al. focused 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.

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.

3. CONCLUSION

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.

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