International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 02 | Feb 2019 www.irjet.net p-ISSN: 2395-0072

Review on Optimization of Vertical Milling Process Parameters of EN24 by Using ANOVA and ANN Technique

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Abstract - *Metal cutting is one of the most significant manufacturing processes in the area of material removal , Generally metal cutting defined as the removal of metal chips from a workpiece in order to obtain a finished product with desired attributes of size, shape, and surface roughness. Milling is the machining process of using rotary cutters to remove material from a workpiece by advancing (or feeding) in a direction at an angle with the axis of the tool. The objective of this study is to develop a better understanding of the effects of spindle speed, cutting feed rate and depth of cut on the surface roughness and to build a multiple regression model. Such an understanding can provide insight into the problems of controlling the finish of machined surfaces when the process parameters are adjusted to obtain a certain surface finish. Taguchi matrix will be created from process parameters selection and selecting the best performing parameter using ANOVA technique.*

Key Words: *Metal Cutting Process, Vertical Milling Cutter, Taguchi Matrix, ANOVA Technique*

1. INTRODUCTION

Machining is any of various processes in which a piece of raw material is cut into a desired final shape and size by a controlled material-removal process. The processes that have this common theme, controlled material removal, are today collectively known as subtractive manufacturing, in distinction from processes of controlled material addition, which are known as additive manufacturing. Exactly what the "controlled" part of the definition implies can vary, but it almost always implies the use of machine tools (in addition to just power tools and hand tools).

Milling is the machining process of using rotary cutters to remove material from a workpiece by advancing (or *feeding*) in a direction at an angle with the axis of the tool. It covers a wide variety of different operations and machines, on scales from small individual parts to large, heavy-duty gang milling operations. It is one of the most commonly used processes in industry and machine shops today for machining parts to precise sizes and shapes. Milling can be done with a wide range of machine tools. The original class of machine tools for milling was the milling machine (often called a mill). After the advent of computer numerical control (CNC), milling machines evolved into machining centers (milling machines with automatic tool changers, tool magazines or carousels, CNC control, coolant systems, and enclosures), generally classified as vertical machining centers (VMCs) and horizontal machining centers (HMCs). The integration of milling into turning environments and of turning into milling environments, begun with live tooling for lathes and the occasional use of mills for turning operations, led to a new class of machine tools, multitasking machines (MTMs), which are purpose-built to provide for a default machining strategy of using any combination of milling and turning within the same work envelope. The milling process removes material by performing many separate, small cuts. This is accomplished by using a cutter with many teeth, spinning the cutter at high speed, or advancing the material through the cutter slowly; most often it is some combination of these three approaches. The speeds and feeds used are varied to suit a combination of variables. The speed at which the piece advances through the cutter is called feed rate, or just feed; it is most often measured in length of material per full revolution of the cutter.

The four key mechanical inputs i.e. process parameters in metal removal operations are:

1) Feed:

Feed is the rate at which the tool is moved into the part or the part into the tool. Feed is measured in feet, inches or millimeters per time period.

2) Speed:

Speed is the rate of rotation of the spindle where the tool is held. It is measured in revolutions per minute (RPMs).

3) Depth of cut:

When setting the depth of cut, the workpiece should be brought up to just touch the revolving cutter. After a cut has been made from this setting, measurement of the workpiece is taken. At this point, the graduated dial on the traverse feed is locked and used as a guide in determining the depth of cut. When starting the cut, the workpiece should be moved so that the cutter is nearly in contact with its edge, after which the automatic feed may be engaged. When a cut is started by hand, care must be taken to avoid pushing the corner of the workpiece between the teeth of the cutter too quickly, as this may result in cutter tooth breakage. In order to avoid wasting time during the operation, the feed trips should be adjusted to stop the table travel just as the cutter clears the workpiece.

4) Cooling:

Cooling medium used in lathe machine affects the roundness i.e. surface smoothness of material along with speed, feed, and depth of cut. The turning with cooling was showed that roundness value was lower than dry-cutting. It means that the turning with cooling was the better process for quality of mild steel. Moreover, increasing cutting speed in dry cutting would be increasing roundness quality of workpieces. On the other hand, on cooling cutting with high cutting speed was not increasing roundness quality of mild steel. Furthermore, increasing feed rate in cooling turning would be decreasing roundness quality but in dry-cutting was not different.

Manipulating the feed, speed and depth of cut can maximize the benefits of a particular cutting fluid and can increase productivity. However, like most decisions, the choice of feed, speed and depth of cut must be based on the customer's objectives. What is their goal in this application? Do they want to manufacture parts faster or maximize tool life? How important is the surface finish and dimensional accuracy of the part? Answers to these questions will drive their decisions on feeds, speeds and depth of cut.

1.1 Surface Roughness

With the more precise demands of modern engineering products, the control of surface texture together with dimensional accuracy has become more important. It has been investigated that the surface texture greatly influences the functioning of the machined parts. The properties such as appearance, corrosion resistance, wear resistance, fatigue resistance, lubrication, initial tolerance, ability 'to hold pressure, ,load carrying capacity, noise reduction in case of gears are influenced by the surface texture. Whatever may be the manufacturing process used, it is not possible to produce perfectly smooth surface. The imperfections and irregularities are bound to occur. The manufactured surface always departs from the absolute perfection to some extent. The irregularities on the surface are in the form of succession of hills and valleys varying in height and spacing. These irregularities are usually termed as surface roughness, surface finish, surface texture or surface quality. These irregularities are responsible to a great extent for the appearance of a surface of a component and its suitability for an intended application.

Factors Affecting Surface Roughness

- Vibrations
- Material of the work piece
- Type of machining
- Rigidity of the system consisting of machine tool, fixture cutting tool and work
- Type, form, material and sharpness of cutting tool
- Cutting conditions i.e., feed, speed and depth of cut
- Type of coolant used

Reasons for Controlling surface finish

- To improve the service life of the components
- To improve the fatigue resistance
- To reduce initial wear of parts
- To have a close dimensional tolerance on the parts
- To reduce frictional wear
- To reduce corrosion by minimizing depth of irregularities
- For good appearance
- If the surface is not smooth enough, a turning shaft may act like a reamer and the piston rod like a broach. However, as already explained perfectly smooth surface is not always required, the requirement of surface texture depends upon the specific application of the part.

1.2 Material Used:

Mild steel is one of the most common materials used for machine part building. There are different requirements of the surface finish and hardness of the mild steel as per application. It is usual practice to manufacture the product using simple machinery and then performing quality checks for the required hardness and surface finish value, in case of not meeting the acceptance criteria the work pieces are rejected. In this project work we will study the relation between different machining parameters on the surface roughness and hardness of the plain milling work piece of mild steel using ANOVA technique to avoid lot rejections in the quality check phase. Low carbon steel, also known as mild steel, contains 0.05 % to 0.26 % of carbon (e.g. AISI 1018, AISI 1020 steel). These steels are ductile and have properties similar to iron. They cannot be modified by heat treatment. They are cheap, but engineering applications are restricted to non-critical components and general paneling and fabrication work. These steels cannot be effectively heat treated. Consequently, there are usually no problems associated with heat affected zones in welding process. The surface properties can be enhanced by carburizing and then heat treating the carbon-rich surface. High ductility characteristic results in poor Machinability.

2. LITERATURE SURVEY

Mohammed T. Hayajneh[1] presented a paper on **"A Study of the Effects of Machining Parameters on the Surface Roughness in the End-Milling Process".** In this paper, a series of experiments has been conducted in order to begin to characterize the factors affecting surface roughness for the end-milling process. The effect of spindle speed, feed rate, depth of cut on surface roughness of aluminum samples was studied. The model generated, which includes the effect of spindle speed, feed rate, depth of cut, and the any two-variable interactions, predicts surface roughness reasonably well. The deviation between predicted and measured surface roughness values was within an error band of about 12%. The machining parameters investigated influenced the surface finish of the machined workpiece significantly. In general, the study shows that cutting feed is by far the most dominant factor of those studied. The most important interactions, that effect surface roughness of machined surfaces, were between the cutting feed and depth of cut, and between cutting feed and spindle speed.

Abhishek Dubey [2] presented a paper on **"A Parametric Design Study of End Milling Operation using Grey Based Taguchi Method".** This paper presents the multiple response optimization of end milling parameter using grey based taguchi method. Experiments were designed and conducted based on L27 orthogonal array design .The milling parameter were spindle speed, depth of cut, feed rate and pressurized coolant jet and the response was surface roughness. EN31, high carbon alloy steel which achieves a high degree of hardness and compressive strength and abrasion résistance. The present work is focused to study the effect of process parameter such as speed, feed rate, and depth of cut, pressurized coolant jet on surface roughness in end milling of EN31 steel. Surface roughness values were recorded for each experiment. The feed rate was identified as the most influential process parameter on surface roughness. The results obtained by Grey relational method were compared with that of the optimal condition obtained.

Rajesh Kumar presented **[3] "Modeling and optimization of end milling parameters on aluminum 6061 alloy using GRA based Taguchi method coupled with PCA"** in this method The optimization of end milling parameters with multiple performance characteristics (high MRR, low Ra) for the machining of Al6061 was carried out. The optimum conditions for obtaining higher grey relational grade such as C1S2F3D2, (Coolant emp. on, speed 765Rpm, feed 50mm/min, Depth of cut 0.8mm) were obtained. ANOVA study has been carried out to obtain the significant factors for MRR, Ra and GRG. It is found that feed and depth of cut are the most influential factor for MRR. Further, Coolant Employment, feed and depth of cut are significant factors for Ra and Coolant Employment, feed is most affecting parameters for GRG. After conducting the confirmation test with the optimal level of end milling process parameters, it has been found that GRA based Taguchi method coupled with PCA is best suitable for solving the quality problem of machining in the end milling of Al-6061 alloy.

Wasim Khan worked on **[4] "Optimization of End Milling Process Parameters for Minimization of Surface Roughness of AISI P20 Steel"** The optimal sets of process parameters were obtained for performance measures using Taguchi design of experiment methodology. From the analysis of variances, the most significant factor was concluded spindle speed and also from main effects plot of process parameters to the output response factor as a surface roughness. The spindle speed also shows the minimum values of S/N ratio -13.6608 in S/N ratio graph regarding to process parameters. The ranks obtained in Analysis of variance as follows, 1st rank to spindle speed, 2nd rank to feed rate and 3rd rank to depth of cut in both analysis (response Table for Means and : Response Table for Signal to Noise Ratios: Smaller is better). The confirmation test is taken and comparison made between the predicted value of surface roughness which is obtained from regression analysis equation and the actual value of surface roughness which is obtained from practical experiment process.

P. R. Periyanan [5] presented work on "A study on the machining parameters optimization of micro-end milling process" this paper focuses the Taguchi technique for the optimization in micro-end milling operation to achieve maximum metal removal rate (MRR) considering the spindle speed, feed rate and depth of cut as the cutting parameters. An orthogonal array, signal-to-noise (S/N) ratio and Pareto analysis of variance (ANOVA) are employed to analyze the effect of these milling parameters. The analysis of the result shows that the optimal combination for higher metal removal rate (MRR) is medium cutting speed, high feed rate and high depth of cut. Using Taguchi method for design of experiment (DOE), other significant effects such as the interaction among milling parameters are also investigated. The study shows that the Taguchi method is suitable to solve the stated problem. Based on the verification experiment it is concluded that the percentage of error of response was less.

R. Ramanujam [6] presented study on **"Multi-Response Optimization Using ANOVA and Desirability Function Analysis: A Case Study in End Milling of Inconel Alloy"** The present study investigated the parameter optimization of end milling operation for Inconel 718 super alloy with multi-response criteria based on the Taguchi method and desirability function analysis. Experimental tests were carried out based on an L9 orthogonal array of Taguchi method. The influence of machining factors cutting speed, feed rate and depth of cut were analysed on the performances of surface roughness and material removal rate. The optimum cutting conditions are obtained by Taguchi method and desirability function. The analysis of variance (ANOVA) is also applied to investigate the effect of influential parameters. A regression model was developed for surface roughness and material removal rate as a function of cutting velocity, feed rate and depth of cut. Finally, the confirmation experiment was conducted for the optimal machining parameters, and the betterment has been proved.

A. R. Lande [7] presented topic called **"Gray Relational Based Analysis of Al-6351"** In the present study, experiments are conducted on aluminium 6351 materials to see the effect of process parameter variation in this respect. An attempt has also been made to obtain Optimum cutting conditions with respect to roughness parameters and Material removal rate .In order to carry out the multi objective optimization Gray relational analysis is used which gives gray relational grade and from the analysis it can be concluded that feed is the most significant parameter for the combined objective function while, speed is the least significant parameter.

Harshraj D. Wathore [8] presented paper called **"Investigation of Optimum Cutting Parameters for End Milling of H13 Die Steel using Taguchi based Grey Relational Analysis"** This paper presents the study of the parameter optimization of end milling operation for H13 die steel with multi-response criteria based on the Taguchi L9 orthogonal array with the grey relational analysis. Surface roughness and material removal rate are optimized with consideration of performance characteristics namely cutting speed, feed rate and depth of cut. A grey relational grade obtained from the grey relational analysis is be used to solve the end milling process with the multiple performance characteristics. Additionally, the analysis of variance (ANOVA) is to be applied to identify the most significant factor. Finally, confirmation tests are performed to make a comparison between the experimental results and developed model.

Bhargav Patel [9] worked on **"Parametric Optimization of Temperature during CNC End Milling of Mild Steel Using RSM"** In the present work; response surface methodology has been used for design of experiments during CNC end milling of mild steel material. Temperature measurement during end milling process is carried out using Cr-Al thermocouple to study the effect of various process parameters on temperature during machining. Optimization of process parameters such as cutting speed, feed and depth of cut has been carried out by ANOVA analysis using MINITAB 14.0 software. The results show the importance of parameters to optimize the temperature requirement. Conclusions made from contour plots and response surface diagrams are critically discussed.

3. CONCLUSION

Most of the work is done for the study of machining parameters feed, speed and the depth of cut for end milling process and their effect on surface roughness. In this machining parameters are studied so as to know their effect on the surface roughness of the machined workpiece of different materials. This study said that machining parameters of milling process affect the surface finish of the workpiece. So study can be conducted for the optimization of these machining parameters for vertical milling process of EN24 so as to improve the surface finish by using ANOVA and ANN method.

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