STUDY ON SURFACE OPTIMIZATION IN CNC*

BY

PRATIK PATIL♣

Ajeenkya D Y Patil University, Pune, Maharashtra, India.

pratik.patil@adypu.edu.in

SNEHA SARODE

Ajeenkya D Y Patil University, Pune, Maharashtra, India.

sneha.sarode@adypu.edu.in

ABSTRACT

Surface finish plays a vital role in the quality of product. It is necessary to have good surface finish to improve the quality standards of any product. This review paper represents the study of Surface Optimization in CNC. Study on various CNC machining techniques using different techniques such as MMR optimization, Response surface methodology, Principle component analysis, grey relation analysis and Taguchi method was carried out. The parameters that effect surface roughness were optimized based on the analytical reports of the inputs given and its response on surface finish.

KEYWORDS

CNC Milling, Surface Optimization, Surface Roughness.

I.INTRODUCTION

In modern manufacturing the main focus is on increasing the quality standards of product, it is done by achieving high dimensional accuracy and surface finish. All the geometric irregularities on the solid surface of the material are called as texture, this texture contains of waviness, lay and flaws. All of these parameters which are caused by fine irregularities during the machining process contribute in the surface roughness of material. In modern industries the main goal of the manufacturers is on improving the quality of the product while reducing the production time. In order to reduce the time required for production computer numeric control machines (CNC) were implemented from past few years. Surface finish of the product highly contributes in the quality of product. The way all the surface roughness are formed is very complex and process dependent [1]. The controllable parameters in CNC machining such as spindle speed, depth of

* Received 22 September 2021, Accepted 09 October 2021, Published 24 October 2021
♣ Corresponding Author

cut and feed rate influence the final surface finish. There are various methods via which the parameters that effect the surface finish can be studies and optimized to achieve desirable surface finish of the final product.

II.LITERATURE REVIEW

[1]Hardik B Patel, Satyam P Patel 'A Review paper for Optimization of surface Roughness and MRR in CNC Milling'

This paper focus on optimization of surface roughness created while machining using CNC machining. It does it by reviewing numerous machining parameters which includes spindle speed, feed rate, depth of cut and insert nose radius. This study includes processing

the machining parameters on a specimen of hard steel material, further emerging a mathematical model using the design of matrix. CNC stored all the instructions in the form of program in a micro-computer that is attached to the machine. This computer handles all the control of machine in a logical form, making the machine more flexible than earlier traditional machining. This study considers of experimenting numerous attempts using surface response methodology and finding the result on surface of hard steel. After experimenting this procedure we can easily conclude which set of parameter gives best results on surface and which has the worst surface finish[1].

[2]B. Sidda Reddy, J. Suresh Kumar and K. Vijaya Kumar Reddy 'Optimization of surface roughness in CNC end milling using response surface methodology and genetic algorithm'

In this research the surface roughness minimization is carried out using the following techniques:

1.Design of Experimental method.

2.Response Surface Methodology (RSM).

3.Genetic algorithm.

Using these techniques it is intended to achieve the lowest surface roughness and optimal conditions. They conclude the experiment using Taguchi's L50 orthogonal array in association with design of experiments (DOE), the machining parameters considered were Nose radius (R), Cutting speed (V), feed (f), axial depth of cut (d), and radial depth of cut (rd). An analytical response surface model of surface roughness was progressed using Response surface methodology (RMS). The following results of response surface model were accommodate with genetic algorithm (GA) for obtaining optimum machining parameters [2].

[3]Mandeep Chahal, Vikram Singh, Rohit Garg, Sudhir Kumar 'Surface Roughness Optimization Techniques of CNC Milling' Surface Roughness is typically used as an index to determine the surface finish for continuous improvement of quality [3]. A large number of publications by

numerous authors reflect the interest in this technique. Reviews of literature on surface roughness optimization have been done in the previous research paper by a few authors. However, considering the contributions in recent times, a more complete review is attempted here. In this paper, the authors have reviewed the literature in a way that would benefit authors and academicians to take a closer look at the growth, expansion, and applicability of this method. The authors have examined various papers and have proposed a dissimilar scheme of classification. In addition, convinced gaps that would provide hints for further research in this field have been recognized.

[4]Naveen Bansal, Gyanender Ghanghas 'Optimizing Technique for Surface Roughness of CNC Milling'

Developing of surface roughness is directly incorporated with improving the quality of product which is completely modest looking at the development of industries. Currently many researchers are contributing in CNC milling machines and its optimization techniques. Whereas very few of the engineers show an interest in surface optimization techniques. This paper clarifies the selected area and it is assumed this will be very helpful to the students and new researchers in this field. The author also gives clues and suggests arears in which further efforts for research can be done by the future researchers [4].

[5]B.Radhakrishnan, S.Tharun Kumar, P.Sankarlal, P.Ramakrishnan, S.Sarankumar 'Optimization of CNC Machining Parameters for Surface Roughness in Turning of Aluminium 6063 T6 with Response Surface Methodology'

The above paper signifies optimization of surface roughness obtained in CNC by turning procedure using numerous machining parameters. The study in this case was done on aluminum 6063. The machining was carried out using a CCMT tool. The range of parameters were set for selected material before performing the machining procedure. Initially three machining parameters were examined using design of experiment methodology, parameters considered were the cutting speed, feed rate, and depth of cut, on an aluminum alloy 6063 T6 and the correlative surface roughness was obtained. Then a surface response model was built using the response surface methodology (RMS) to fit the correlation between the procedure parameters and the obtained surface roughness. The results of the experiment wear confirmed by using the one-way ANOVA. After performing the following procedure the results for surface roughness under various sets of process parameters were obtained and used for predicting optimum surface roughness. The results of the following experiments were used for

enhancing the main factors affecting the surface finish in the aluminum metal using RSM (response surface methodology) with correlation with ANOVA methodology.

III.CNC MILLING

CNC milling or computer numeric control milling is a machining process that implies rotating multipoint cutting tools which are controlled by the computers and used to remove material from the workpiece and produce a custom-designed part. CNC milling can be utilized for machining different materials such as metal, plastic, wood, and glass. As CNC uses multiple tools all the materials can be custom designed and manufactured under one roof with the precision of CNC machining. CNC machines are capable of doing multiple operations like drilling, turning, boring, etc. CNC uses conventional machining technique i.e. the material is removed from a workpiece with the help of cutting tools hence it is said that CNC is a mechanical machining process. This article is focused on parameters that effect the surface finish of the final product, which are the controllable parameters of the CNC milling machining. CNC machines are very flexible and can easily be programmed to get a desirable output product by running different programs.

IV.OVERVIEW OF CNC MACHINING PROCESS.

CNC milling machining process operates to remove material from the solid block of material and cut it to shape like most CNC machining processes. It utilizes computerizes panel which operates the electronics. Alike all CNC machining processes it follows same basic production stages, including:

- Designing a CAD model
- Converting the CAD model into a CNC program
- Setting up the CNC milling machine
- Executing the milling operation

The CNC milling process starts with the creation of a 2D or 3D CAD part design. Then the accomplished design is exported to a CNC-compatible file format and converted by CAM software into a CNC machine program which dictates the activities of the machine and the movements of the tooling across the work piece. Before the operator runs the CNC program, they prepare the CNC milling machine by affixing the workpiece to the machine's work surface (i.e., worktable) or workholding device (e.g., vise), and

attaching the milling tools to the machine spindle. The CNC milling process employs horizontal or vertical CNC-enabled milling machines—depending on the specifications and requirements of the milling application—and rotating multi-point (i.e., multi- toothed) cutting tools, such as mills and drills. When the machine is ready, the operator launches the program via the machine interface prompting the machine to execute the milling operation. Once the CNC milling process

is initiated, the machine begins rotating the cutting tool at speeds reaching up to thousands of RPM. Depending on the type of milling machine employed and the requirements of the milling application, as the tool cuts into the workpiece, the machine will perform one of the following actions to produce the necessary cuts on the workpiece:

1.Slowly feed the workpiece into the stationary, rotating tool

2.Move the tool across the stationary workpiece

3.Move both the tool and workpiece in relation to each other

As opposed to manual milling processes, in CNC milling, typically the machine feeds moveable workpieces with the rotation of the cutting tool rather than against it. Milling operations which abide by this convention are known as climb milling processes, while contrary operations are known as conventional milling processes. Generally, milling is best suited as a secondary or finishing process for an already machined workpiece, providing definition to or producing the part's features, such as holes, slots, and threads. However, the process is also used to shape a stock piece of material from start to finish. In both cases, the milling process gradually removes material to form the desired shape and form of the part. First, the tool cuts small pieces i.e., chips off the workpiece to form the approximate shape and form. Then, the workpiece undergoes the milling process at much higher accuracy and with greater precision to finish the part with its exact features and specifications. Typically, a completed part requires several machining passes to achieve the desired precision and tolerances. For more geometrically complex parts, multiple machine setups may be required to complete the fabrication process. Once the milling operation is completed, and the part is produced to the custom- designed specifications, the milled part passes to the finishing and post-processing stages of production

V.CNC MILLING MACHINE OPERATION.

CNC Milling is a machining process appropriate for producing high accuracy, high tolerance parts in prototype, one-off, and small to medium production runs. While parts are typically produced with tolerances ranging between +/- 0.001 in. to +/- 0.005

in., some milling machines can achieve tolerances of up to and greater than +/- 0.0005 in. The versatility of the milling process allows it to be used in a wide range of industries and for a variety of part features and designs, including slots, chamfers, threads, and pockets [1]. The most common CNC milling operations include:

- Face milling
- Plain milling
- Angular milling

- Form milling

VI. Surface optimization techniques that can be used :

1.Taguchi Method

Taguchi defined the quality of the product in terms of the effect that it would make on the environment and society from the time the product was manufactured and sourced to customer. Taguchi method use different technique it used signal-to-noise ratio (S/N) to define the quality characteristics, as S/N ratio is a measurable variable it rather than standard deviation, as it is known that the decrease in mean also creates a decrease in standard deviation. It can be said that the mean can easily be controlled by targeting standard deviation, and the standard deviation cannot be minimized first [6].

2.PCA (Principle Component Analysis)

Taguchi's Orthogonal Array (OA) provides a well- balanced set of experiments (with less number of experimental runs), and Taguchi's signal-to-noise ratios (S/N), which are desired output for Logarithmic functions. Principal Component Analysis (PCA) is provide a patterns in form of correlated data, and present the data in such a way that we easily finds their Similarities and differences [7]. The main advantage of PCA is the data can be compressed that once the Patter ns in data have been identified. The procedure involved in PCA are discussed below:

1.Getting some data

2.Normalization of data

3.Calculation of covariance matrix.

4.Interpretation of covariance matrix

3.RSM (Response Surface Methodology)

RSM is a technique used for empirical model building. This methodology implies design of experiment with the objective to optimize a response which is an output variable which is influenced by several independent variables which are input parameters. In this process series of test runs, in which changes in input variables are made in order to identify its influence om the output response generated and finding the reasons for changes. Initially RSM was developed for model experimental responses and now implemented for modeling of numerical experiments.

4.Artificial Neural Networks

An Artificial Neural Network (ANN) is an information processing paradigm that is inspired by the way biological nervous systems process information [3]. The complexity of real neurons when modeling artificial neurons is highly abstracted. These basically consist of inputs (like synapses)

and then computed by a mathematical function which determines the activation of the neuron. As inputs are multiplies by weights. Another function computes the output of the artificial neuron.

5.ANOVAS Approach

ANOVA is an experimental approach used for determining influence of given input parameters on the experimental results obtained by design of experiment, thus it can be used for describing experimental data. ANOVA approach is used where there are two or more data inputs and used for comparing the output data to determine best output possible.

6.Grey Relationship Analysis

The grey relational theory provides an efficient management upon the uncertainty, multi-input and discrete data [8]. On the other hand, the grey relational analysis reveals the necessary information of the interactions among parameters. The first step of parameter design is to switch the quality characteristic to S/N ratio (signal-to-noise ratio). There are three categories of performance characteristics in the analysis of the S/N ratio that is, the lower the better, the higher the better, and the nominal the better.

CONCLUSION

Many of the researchers have studies very limited aspects of the CNC milling machining. All the effects of the machining parameters can easily be studies on the surface finish and its roughness. The experimental outputs of the process parameters give an accurate and exact output and makes the study more effective rather than the mathematical derived outputs that we see. The RSM model can be interfaced with an effective GA and the optimum values of the process parameters can be evaluated. RSM is an efficient and effective method for optimizing surface roughness in a milling operation. In Response surface machining setting the optimum settings for the parameters such as surface roughness and the peak to value it can be concluded using the statistical analysis that: 1. The value for the lowest surface roughness obtained was for the

parameters set as speed = 1400rpm, feed rate given 0.1 mm/min and the depth of cut 0.7 mm which gives the value of Ra = 0.85. 2. The value for the worst i.e highest surface roughness obtained was for the parameters set as speed = 1800rpm, feed rate given 0.2 mm/min and the depth of cut 1.1 mm which gives the value of Ra = 1.84. 3. The value for the lowest Rz obtained was for the parameters set as speed = 1400rpm, feed rate given 0.1 mm/min and the depth of cut 0.7 mm which gives the value of Rz = 4.41. 4. The value for the highest Rz obtained was for the parameters set as speed = 1400rpm, feed rate given 0.2 mm/min and the depth of cut 0.1

mm which gives the value of Rz = 7.79. Which says that the best values for Ra & Rz were obtained for the same setting parameters which were speed = 1400rpm, feed rate given 0.2 mm/min and the depth of cut 0.1 mm.

REFERENCES

[1]Hardik B Patel, Satyam P Patel 'A Review paper for Optimization of surface Roughness and MRR in CNC Milling'

[2]B. Sidda Reddy, J. Suresh Kumar and K. Vijaya Kumar Reddy 'Optimization of surface roughness in CNC end milling using response surface methodology and genetic algorithm'

[3]Mandeep Chahal, Vikram Singh, Rohit Garg, Sudhir Kumar 'Surface Roughness Optimization Techniques of CNC Milling'

[4]Naveen Bansal, Gyanender Ghanghas 'Optimizing Technique for Surface Roughness of CNC Milling'

[5]B.Radhakrishnan, S.Tharun Kumar, P.Sankarlal, P.Ramakrishnan, S.Sarankumar 'Optimization of CNC Machining Parameters for Surface Roughness in Turning of Aluminium 6063 T6 with Response Surface Methodology'

[6]Julie Zhang, Joseph Chen "Surface Roughness optimization in an end milling operation using Taguchi design method"

[7]Sanjit Moshat et al "Optimization of Cnc end milling process parameters using PCA based Taguchi Method"

[8]Anish Nair, P Govindan "Optimiztion of CNC End Milling Of Brass Using Hybrid Taguchi Method Using PCA and GREY relational analysis"