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Literature Review on Optimal Cutting Parameters of Trochoidal Machining Based On Taguchi Method

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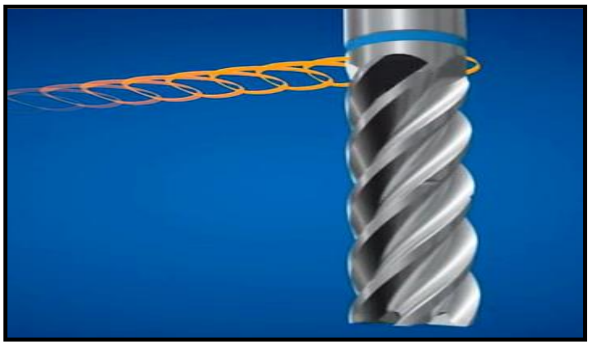
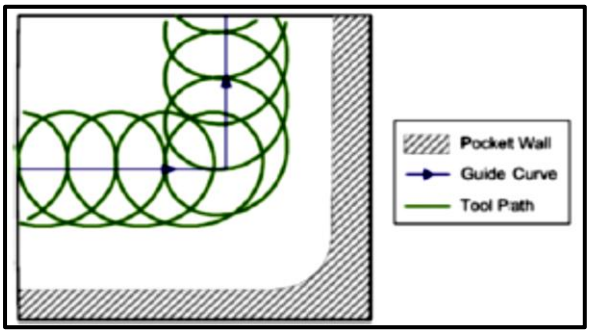
ABSTRACT:The aim of this paper is to review Trochoidal Machining technique used in High Speed Machining and Taguchi Method of optimization. The Taguchi method is used to find the best process parameters and Improved quality results. Taguchi technique investigates the variation in experiments, and generally approach of system, parameter and acceptance aim have been significant in improving man-made quality worldwide. The present work focused by using L 9 (3^2) Orthogonal Array (OA) on the processing steps to get the optimal values with the help of main effects plot. This technique meets the current needs of industry owing to its shorter design cycles and improved quality of design. This method helps to find out optimal condition for a process. This optimal condition gives optimized parameters which can be used to achieve better surface finish of End Milling process by Trochoidal Machining.

KEYWORDS:Taguchi Method, Orthogonal Array, High Speed Machining, Trochoidal Machining.

I. INTRODUCTION

The high speed machining is highly efficient type of machining, where it is possible to reach large volumes of machined material per unit time. The high speed machining thus brings us a possibility of production cost and energy savings. Trochoidal milling is a process where the tool path continuously re-crosses itself as the tool feeds through an outline of constant radius arcs. This process uses circular milling and slicing so that the forces on the tool are kept relatively constant. Trochoidal machining is therefore appropriate to use in high speed machining (HSM). Trochoidal milling makes it possible to mill a complete pocket using one unique trochoidal profile which reduces machining time and costs and increases the part accuracy.Also, tool overloads due to full-immersion milling are reduced and the behaviour of the machine tool is improved, giving an increased tool life and better surface roughness.

Figurea. Trochoidal Milling

Paper is organized as follows. Section II describes literature review from past papers to understand the work performed on Trochoidal. After understanding different methods, the experimental plan to implement Taguchi Method is explained in Section III. Section IV presents optimization by Taguchi method, this experimental results showing results by main effect plot .Finally, Section V presents conclusion.

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II. LITERATURE REVIEW

Abram Pleta and Laine Mears [2016], they represent gas turbine, aerospace and nuclear industries as dependent upon nickel-based super-alloys to enable industries to continue to innovate. Nickel-based super-alloys thrive in these elevated temperature applications, where their great resistance to creep and corrosion is coupled with remarkably high strength values. Trochoidal milling has been identified to extend tool life and reduce machining time in the milling of aluminium. However in nickel-based super-alloys it remains largely unexplored. This work aims to understand the cutting force behaviour of milling nickel-based super-alloys using this alternative milling technique.

Prasad Patil1, Ashwin Polishetty, Moshe Goldberg1, Guy Littlefair and Junior Nomani1 [2014], they have researched on Titanium usage for aerospace and its alloys. Most of the aerospace components made up of wall structure involves lot of pocket slot milling since those components are monolithic components, eliminating need to manufacture multiple pieces for assembly into one final part. The increasing complexity of titanium parts used in aviation industry, increasing demand for productive manufacturing methods like trochoidal milling. This research aims at evaluating its potential in slot milling for Ti6Al4V component by conducting experiments on 5-axis CNC machine. This study focuses on Productivity, Quality and Machine tool Dynamics.

Vikas Pare1, Geeta Agnihotri, C.M. Krishna [2013], they have evaluated surface roughness as a very important criteria for end milling operation. They have used GSA which is inspired by Law of gravity, for optimization of surface roughness. They have conducted experiments by varying the input parameters at two levels each and three levels for speed. MATLAB software has been used for writing code for GSA and results indicate that GSA proves to be effective in this optimization problem. TheOptimum Result obtained by GSA method is Speed-7132 Rpm, Feed-120.8 mm/min, Depth of Cut-0.3 mm and Step over ratio- 0.6 shows resultant surface roughness value as 0.1986 Ra in micron.

I. Szaloki1, S. Csuka1, S. Csesznok, S. Sipos dr.[2012], They have used milling technology to machine surfaces with grooves and scallops, repeating cuttings (zigzag surfaces) with a new, alternative method: it is the so-called trochoidal milling, carried out in different kinematic ways.. They have examined and compared with analyzing the results of the tests, planned and carried out systematically. For machining grooves, having a greater depth (ap>d), additional cuts are necessary in order to achieve economical general milling, but these can be the obstacle to the economical machining. But in case of trochoidal milling methods, applying the same cutting conditions (w, ap, bw etc. have constant values), the tool wear has decreased to a significant extent. In addition, almost the whole working part of the tool can be used and it can result in the increase of chip volume, detached with one tooth.

Baohai Wu1, Chengyu Zheng1, Ming Luo1 and Xiaodong He1 [2012], their experiment onNickel-based super-alloy is used in aero engine parts such as blade and blisk. As this material has high hardness and high strength at high temperature, it's difficult to machine nickel-based alloy. In order to reduce tool wear, Trochoidal milling strategy is studied by them. With trochoidal tool path strategy, tool load can be reduced and the tool has enough time to be cooled under high cutting temperature. Tool immersion angle in trochoidal milling is smaller than slot milling, thus the tool load can be reduced. Experiment results show that tool flank wear with normal slot milling is about four times larger than that with Trochoidal milling.

Ahmad Hamdan & Ahmed A. D. Sarhan & Mohd Hamdi [2011], they have used High-speed machining (HSM) as a key technology in rapid tooling and manufacturing applications. They have compared traditional machining with High-speed machining. They have studied the demand for high quality focusing extensively to analyses and predict surface roughness and cutting force. The optimization method applied in high speed machining of stainless steel using coated carbide tool is to achieve minimum cutting forces and better surface roughness. The Taguchi optimization method is the most effective method to optimize the machining parameters, in which a response variable can be identified. The standard orthogonal array of L9 (3^4) was employed in this research work and the results were analyzed for the optimization process using signal to noise (S/N) ratio response analysis and Pareto analysis of variance (ANOVA) to identify the most significant parameters affecting the cutting forces and surface roughness. Finally, conformation tests were carried out to investigate the improvement of the optimization. The result showed a reduction of 25.5% in the cutting forces and 41.3% improvement on the surface roughness performance.

Bassoli E; Minetola P; Salmi A. [2010], their research addresses optimization of finishing performances on tool steel extrusion dies. They have carried Milling tests on semi manufactured parts to ensure adherence to standard industrial technological chain, varying cutting parameters towards the field of high-speed machining (HSM). The Dimensional tolerance is determined on die lands. The land surface roughness is measured through a multiscale approach and modelled as a function of cutting speed and feed. The cutting speed of 200m/min and feed per tooth of 0.16 mm/rev. provides minimum roughness with very narrow standard deviation. The minimum surface roughness was around 0.5µm.

Jana Novakova, Lenka Petrkovska, Josef Brychta, Robert Cep and Lenka Ocenasova [2009], their contribution deals with high speed machining parameters. High speed machining is a highly effective method of machining with the following goals: increasing of machining productivity, increasing of quality of the machined surface, improving of machining economy, improving of ecological aspects of machining. The best tension parameter was achieved for the transport speed Vf 24 m/min. Lower surface tension values were achieved during high speed cutting in comparison with cutting using lower speeds. The effect of high speed cutting has been confirmed in this case.

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III. EXPERIMENTAL PLAN

Taguchi methods is a statistical approach developed to enhance the quality of manufactured goods and more recently it is applied to engineering, biotechnology, marketing and advertising also. In most quality control situations, the goal is to produce output as uniformly near a target value as possible and the reduction of variation is now regarded. To understand the workings of Taguchi methods is aimed at the manufacturing situations concerning quality characteristics of interest. These three are: large values are better, smaller values are better, target values are better. Taguchi method employsa systematic approach to the robust design by increasing performance quality and decreasing the cost.Two major tools used to optimize the process parameter are signal to noise ratio and orthogonal array.

1. Orthogonal Array

It is a type of experiment wherever the columns for the independent variables are orthogonal to one another. By using an orthogonal array of standard procedure can be used for a number of experimental situations. To describe an orthogonal array, one must identify:

- Number of factors to be studied.
- Levels for each factor.
- The specific two-factor interactions to be estimated.
- The special intricacy that would be encountered in running the experiment.

2. Steps for using Taguchi Method

- Identify the main function, Side effects, and failure mode.
- Identify the noise factors, testing conditions, and quality Characteristics.
- Identify the objective function to be optimized.
- Identify the control factors and their levels.
- Select the orthogonal array matrix experiment.
- Conduct the matrix experiment.
- Analyze the data, predict the optimum levels and Performance.
- Perform the verification experiment and plan the future Action.

In present investigation design of experiment was performed as L9 orthogonal array was chosen, which has 9 rows and 2 columns as shown in Table 1. And therefore, using Minitab17 Software data can be analysed.

Table a. Experimental layout using L9 (3)2 orthogonal array

L9(3^2) Experimental	Level 1	Level 2
1	1	1
2	1	2
3	1	3
4	2	1
5	2	2
6	2	3
7	3	1
8	3	2
9	3	3

IV. OPTIMIZATION BY TAGUCHI METHOD

In the case of multi-objectives optimization observations are reduced to perform analysis by:

- Determine factor influence (Main Effect).
- Determine optimum condition and estimate performance.
- Calculate confidence interval of optimumperformance.
- Finally, the process parameters can be verified by confirmation test.

1. Main Effects

A main effect plot is a plot of the mean response values at each level of a design parameter or process variable. One can use this plot to compare the relative strength of the effects ofvarious factors. The sign and magnitude of a main effect would tell us the following:

- The sign of a main effect tells us of the direction of the effect, i.e. if the average response value increases or decreases.
- The magnitude tells us of the strength of the effect.

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In this type Smaller is better present the main effect graph. The average effects of percentage of the material at level 1, 2, and 3 respective values as average at the points are A1, A2, A3, B1, B2 and B3. The average values of levels at; L1, L2 of given particle size as shown in Figure b.

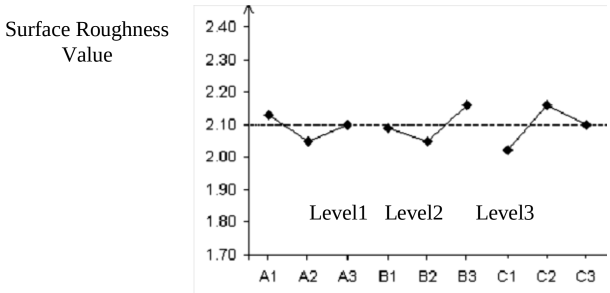

Figure c. Main Effect Plot

2. Optimum Conditions & Performances

The optimum condition is determined based on the quality characteristic selected for the analysis. It is a common practice to only include the significant factor in calculating:

- Total contribution from, all factors
- Current grand average of performance
- Expected result, at optimum condition

The optimum condition and performance can be obtained by these results and which can be verified by various tests.

V. CONCLUSION

The Taguchi method is suitable for industrial use, but it can also be used for scientific research purposes. It emphasizes a mean performance characteristic value close to the target value rather than a value within certain specified limits, thus improving the product quality. In present study, design of experiment by L9 orthogonal array has been described by considering two factors and three levels to analyze the influence of process parameters by using main effects, analysis of variance and to get the optimal conditions. Thus best parameters within the experiment will results for optimal condition. Finally, the optimum combinations of parameters will be achieved by confirmation tests to verify that experimentally obtained results are true.

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