

Analysis On Multi Objective Optimization of CNC End Milling Machining Parameters of (Al 2024-T4)

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Abstract : The present works defines the approach to determine the best cutting parameters leading to minimum surface roughness and maximum material removal rate by using various milling machine parameters such as spindle speed, feed rate, and depth of cut. The performance of machining processes is relative to efficient use of machine tools by setting optimum cutting parameters. CNC end milling is now tremendously used in milling operation, due to its capability of producing complex geometric surfaces with accuracy and surface finish along with flexibility and versatility. The present study highlights the best results to the manufacturers to improve the quality & productivity of the product. Defining the cutting parameters directly related to the high productivity of machine. Cutting parameters are the dominant factor in machining processes. The manufacturer has challenge to perform the cutting operation within the particular range of the material so that the quality & productivity should be increased. Quality and productivity are two important but conflicting criteria in any machining processes. An improvement in machining quality results is increasing machining time thereby, reducing productivity.

Index Terms: CNC End Milling, Cutting Parameters, MOO, Literature Survey, Optimization Techniques Methodology.

I. INTRODUCTION:-

CNC end milling is the most important milling process, mostly used in the manufacturing industries due to its capability of producing complex geometric surfaces with responsible accuracy and surface finish along with flexibility & versatility. The present study gives the best results to the manufacturers to obtain quality product. Defining the cutting parameters directly related to the high productivity of machine. Defining optimal cutting machining parameters for the particular material is main challenge to the manufacturers to increase the production. In metal cutting processes cutting parameters are the dominant factors while machining. Quality and productivity are two important but conflicting criteria in any machining processes. An improvement in quality results is the increasing machining time thereby, reducing productivity. Machining conditions are set on CNC machines as per standard handbook, which are far from reality. In today's manufacturing, there is a vital need to optimize milling machining for the particular operation, most of when NC machines are employed. Because of all these reasons the optimization of machining process parameters is the key component in manufacturing industries.

II. CUTTING PARAMETERS:-

Increasing productivity, decreasing costs, and maintaining high quality production are the main challenges that manufacturers face today. The proper selection of machining parameters is an important step towards meeting these goals and thus gaining a competitive advantage in market [8]. The cutting processes have many constraints that must be satisfied for a optimization machining process [2]. For the efficient use of the machine tool it is important to find the optimum cutting parameters before a part is put into production [1]. Cutting parameters are the resources which are utilized for the process to be used effectively and efficiently at minimum cost & maximum output. In optimization we focus on different parameter which governs the process. In present scenario, it is a matter of great concern in industry to achieve a good quality production effectively & efficiently [4].

The independent variables for optimal cutting parameters are

- | | |
|------------------------------------------------------|----------------------------------|
| 1. Cutting speed | 3. Depth of cut (radial & axial) |
| 2. Feed (per tooth, per revolution or per unit time) | 4. Tool diameter & tool length |
| | 5. Tool materials |

The output parameters

- | | | |
|--------------------------|--------------------|-------------------|
| 1. Surface roughness | 4. Productivity | 7. Machining time |
| 2. Material removal rate | 5. Quality | 8. Cutting Forces |
| 3. Tool life | 6. Machining speed | |

III. END MILLING PROCESS:-

Milling is a multipurpose and useful machining operation. It is a process of using rotary cutters to remove material from a work piece advancing in a direction at an angle with the axis of the tool. In case of end milling operation, metal is usually removed from a work piece by a multiple cutting point tool [1]. Due to the advances in machine tool, CNC, CAD/CAM, cutting tools, versatility to generate complex geometric shapes in variety of materials at high quality and high speed machining technologies the volume and importance of milling process has increased [5].

In end milling machining the axis of rotation of the cutting tool is perpendicular to the direction of feed, either parallel or perpendicular to the machined surface. The end milling similarly looks like a stubby twist drill with a flattened end instead of a point [7]. An end mill can cut a work piece either vertically or like a drill, or horizontally using the side of the end mill cutter. The horizontal cutting operation imposes heavy lateral forces on the tool and the mill, so both must be rigidly structured [7].

IV. MULTI-OBJECTIVE OPTIMIZATION:-

Multi objective problems are special in the sense that they have not a unique solution; it is the finding of the optimal process parameters to achieve the desired level of response. The family of solutions of a multi objective optimization problem is composed of all those elements search space, that the corresponding objectives cannot be all simultaneously improved [13]. The MOO is used to convert maximized function into minimization by multiplying negative without loss of generality type. A perfect objective solution that simultaneously optimizes each objective function is almost impossible. A reasonable solution to multi objective problems is to investigate a set of solutions. Each set satisfies the objectives at an acceptable level without being dominated by any other solution [11].

V. LITERATURE SURVEY:-

1. Jatin, Pankaj Sharma [14]. Was carried out Effect of machining parameters on output characteristics of CNC milling using Taguchi optimization technique. In this paper found that the higher the cutting speed less will be the surface roughness. With the decrease of feed rate surface roughness also decreases. It is observed that the increased value of depth of cut will decrease the value of surface roughness.

2. M. Janardhan [11]. Was carried out "Multi-objective optimization of cutting parameters for surface roughness and metal removal rate in surface grinding using Response Surface Methodology". A plan of experiments has prepared to test the influence of cutting speed, feed rate and depth of cut on the output parameters. It is found that the surface roughness and MRR parameters greatly depend on work piece materials. A response surface optimization is attempted using Minitab software for output responses in surface grinding.

3. K.-D. Bouzakis [5]. Was carried out "Multi objective optimization of cutting conditions in milling using GA". It is found that roughing or finishing. Optimum machining parameters obtained from this procedure can be intended for use by commercial CAD-CAM systems or directly by CNC machines.

4. Azlan Mohdzain [3]. Was carried out "Non conventional approaches for optimizing of cutting parameters in machining process: A Review". From the review it can be concluded that all the non-conventional approaches were suitable and had the potential to be applied for cutting parameters optimization problems during machining.

5. K. Sundara Murthy [15]. Was carried out "Optimization of end milling parameters under minimum quantity lubrication using principal component analysis and grey relational analysis" In this paper taguchi method is proposed to optimize the machining parameters of Al6063 under maximum quantity lubrication. It is found that the machining parameters are the most significant. The proposed GA based ANN hybrid prediction model has excellent agreement with experimental values, with errors of only 3.3%.

6. M. R. Soleymani Yazdi [16]. Was carried out "Modelling and optimization of milling process by using RSM and ANN methods". It is found that the speed and feed are the most significant factors in surface roughness model. The depth of cut feed rate and their interaction are significant in the material removal rate model. The MLP network and RSM provide a very good process modelling. In addition, the former provided the better data coverage value. The excellent accuracy (nearly null error) of the RSM optimization procedure is observed during rough machining and finishing.

7. Prajina N. V. [13]. Was carried out "Multi response optimization of CNC end milling using Response Surface Methodology & desirability function" It is found that feed has significant effect on cutting force & it has to be kept minimum for least force & better surface finish and machining time. Cutting speed has significant effect on machining time and surface roughness. Speed has to keep maximum for combined optimization of forces, roughness, and machining time. With less power good surface finish is obtained at minimum time if cutting speed is kept maximum and depth of cut minimum.

8. PR. Periyanan [17]. Was carried out "A study on the machining parameters optimization of micro-end milling process. In this experimental work, it is found that the use of medium value of spindle speed, higher value of depth of cut and higher value of feed rate is recommended to obtain the maximum MRR value in micro end milling process.

VI. OPTIMIZATION TECHNIQUES:-

Taguchi Method: -Dr.Genichi Taguchi a Japanese management consultant developed an efficient methodology to optimize quality characteristic and is widely being applied now days for continuous improvement and off line quality control of any manufacturing production process or product [2].

Steps of an effective designed experiment

Step-1: Define the problem(s) or area(s) of concern.

Step-2: Define the process objective, a target value for a performance measure of the process.

Step-3: Define the quality characteristics(s) & measuring system characters (s).

Step-4: Determine the design parameters / factors affecting the selected quality characteristics.

Step-5: Select control & noise factors.

Step-6: Select levels for the factors.

Step-7: Define orthogonal array for the parameter indicating the number & conditions for each experiment.

Step-8: Conduct the experiments indicated in OA to collect data on the effect on the performance.

Step-9: Complete data analysis and interpret results for determining the effect of the different parameters on the performance & measure.

Step-10: Conduct conformation experiment.

Design of Experiments (DOE):-

The study of most important variables which are affecting to quality characteristics & so the plan for conducting such experiments is called the design of experiments. G. Taguchi (1959) of Japan introduced this technique and also developed the associated concept of linear graph, it was able to device numerous variants based on the orthogonal array design, which can easily be applied by an engineer or a researcher without gaining advanced statistical knowledge for working out the design and analysis of even complicated experiments (Ross J. Philip, 1989). Design of experiments involves designing a set of experiments, in which all the relevant factors are varied systematically. When the results of these experiments are analyzed, they help to identify optimal conditions, as well as the details such as the existence of interactions and synergies between factors. When this experimental technique is applied to product or process design, the technique helps to seek out the best design among the alternatives [2].

Methodology

Definition of Problem

The study find the optimum cutting process parameters of CNC End milling for machining Al (2024-T4) plates. Parameters considered are cutting speed, depth of cut, feed rate. Each parameter is considered at 3 levels with one trial on each specimen. Trials were conducted and the response characteristics are studied.

In this experimentation the L9 orthogonal array is selected based on the DOF. Here for 3 parameters each at 3 levels (DOF=2+2+2) so the total DOF=6 hence, the number of DOF for orthogonal array should be greater than or equal to the number of DOF required. ANOVA has been performed and compared with Taguchi method.

Material Composition:-

Aluminium Alloy Al (2024-T4)

TABLE 1: Chemical Composition of Material

Component	Wt%
Al	90.7-94.7
Cr	Max.0.1
Cu	3.8-4.9
Fe	Max 0.5
Mg	1.2-1.8
Mn	0.3-0.9
Si	Max 0.5
Ti	Max 0.15
Zn	Max 0.25

Properties of Material

1. Higher strength
2. Better creep resistance

3. Excellent mechanical properties
4. Excellent corrosion properties
5. Superior oxidation resistance
6. Good fabric ability

Application

1. Aircraft fittings, missile parts, hydraulic valves
2. Gears and shafts, bolts, clock parts, computer parts
3. Couplings fuse parts, munitions, nuts, pistons
4. Rectifier parts, worm gears, fastening device
5. Veterinary and orthopaedic equipments

TABLE 2: Selected Factors & Levels of Parameters

FACTORS/LEVELS	Units	1	2	3
Spindle Speed (A)	Rpm	800	900	1000
Feed Rate (B)	mm/rev	0.25	0.28	0.30
Depth of Cut (C)	Mm	0.5	1	1.5

TABLE 3:L9 Array (33) approach

TRIALS	A	B	C
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

CNC Machine:-

TABLE4: CNC Machine Specifications

Machine	Flex Mill MTab
L*W*H	2030*1435*1210
Slides	Linear Motion, Guide Ways
Tool Shank	BT30
Max Tool Dia.	16 mm
Max Tool Length	40 mm
Programmable feed rate	0-5000 mm/min
Lubrication	Centralized
Programmable spindle speed	150-4000 rpm
Table Size	480*180
Travel (XYZ)	250*150*200 mm

VII. CONCLUSION:-

This paper briefs about a new approach of optimization for the cutting conditions of CNC end milling machine during machining process for the material Al (2024-T4). Above discussed optimization process & methodology is much suitable & have the potential

to be applied for cutting parameters optimization problems during actual industrial machining process. These technique is being applied successfully in industries for optimal selection of process parameters with economic production cost& effectively, efficiently in the area of machining.

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