A Review on Multi Objective Optimization of CNC End Milling Parameters for Machining Aluminium Alloy(Al2024-T4) by Using Expert System

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Abstract: - The present works defines the effects of various milling machine parameters such as spindle speed, feed rate, and depth of cut. It is an approach to determine the best cutting parameters leading to minimum surface roughness and maximum material removal rate. Machining process has characteristics that describe their performance relative to efficient use of machine tools by setting optimum cutting parameters. The traditional optimization techniques are not suitable because milling machining operation is highly constrained in manufacturing industries. CNC end milling is the most important milling operation, widely used in most of the manufacturing industries due to its capability of producing complex geometric surfaces with responsible accuracy and surface finish along with flexibility and versatility. In order to improve the quality & productivity the present study highlights the optimization of CNC end milling process parameters to provide best results to the manufacturers to obtain quality product. Defining the cutting parameters directly related to the high productivity of machine. The optimal selection of the machining parameters for the particular material is main challenge to the manufacturers to increase the production. In metal cutting operation cutting parameters are the dominant factors while machining the manufacturers has that challenge to perform the operation within the particular range of the material so that the productivity should be increased. Quality and productivity are two important but conflicting criteria in any machining operations. An improvement in quality results in increasing machining time thereby, reducing productivity. Machining conditions are set on CNC machines as per standard handbook, which are far from reality.

Keywords*:-CNC End Milling Process, Cutting Parameters, Multi Objective Optimization, Optimization Techniques Methodology*.

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I. INTRODUCTION

CNC end milling is the most important milling operation, widely used in most of the manufacturing industries due to its capability of producing complex geometric surfaces with responsible accuracy and surface finish along with flexibility and versatility. In order to improve the quality & productivity the present study highlights the optimization of CNC end milling process parameters to provide best results to the manufacturers to obtain quality product. Defining the cutting parameters directly related to the high productivity of machine. The optimal selection of the machining parameters for the particular material is main challenge to the manufacturers to increase the production. In metal cutting operation cutting parameters are the dominant factors while machining the manufacturers has that challenge to perform the operation within the particular range of the material so that the productivity should be increased. Quality and productivity are two important but conflicting criteria in any machining operations. in order to ensure high productivity, extent of quality is to be compromised . An improvement in quality results in increasing machining time thereby, reducing productivity. Machining conditions are set on CNC machines s per standard handbook, which are far from reality. In today's manufacturing world, there is a vital need to optimize milling machining for this operation, particularly when NC machines are employed .due to these reasons optimization of machining process parameters is the key component in manufacturing environment.

II. 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. Milling is a versatile and useful machining operation. In case of end milling operation, metal is usually removed from a work piece by a multiple cutting point tool [1]. It is the most fundamental and commonly encountered material removal operations in manufacturing industries .Its versatility to generate complex geometric shapes in variety of materials at high quality. Due to the advances in machine tool, CNC, CAD/CAM, cutting tools and high speed machining technologies the volume and importance of milling have increased [5].

In end milling machining it produces flat and complex shapes with the use of multi-tooth cutting tool, which is called a milling cutter and the cutting edges are called teeth. 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 tool is looks like a stubby twist drill with a flattened end instead of a point [7]. A end mill can cut a work piece either vertically, like a drill, or horizontally using the side of the end mill to do the cutting. This horizontal cutting operation imposes heavy lateral forces on the tool and the mill, so both must be rigidly constructed. By making a series of horizontal cuts across the surface of a work piece, the end mill removes layers of metal at a depth that can be

accurately controlled to about one thousands of an inch (.001") [7].

III. CUTTING PARAMETERS

Increasing productivity, decreasing costs, and maintaining high product quality at the same time are the main challenges manufacturers face today. The proper selection of machining parameters is an important step towards meetings these goals and thus gaining a competitive advantage in market [8], it is necessary to find the optimal cutting parameters. Cutting process has many constraints that must be satisfied for a meaningful optimization of 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 means the resources which are utilizing the process should be used effectively and efficiently at minimum cost & maximum output. In optimization, we focus on different parameters which govern the process. In present scenario, it is a matter of great concern in industry to achieve a good quality product at minimum cost [4].

The independent variables for optimal cutting parameters are

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

The output parameters

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

IV. MULTI-OBJECTIVE OPTIMIZATION

Multi objective problems are special in the sense that they have not a unique solution. The family of solutions of a multi objective optimization problem is composed of all those elements search space, which such are, that the corresponding objectives cannot be all simultaneously improved [13]. Finding the optimal process parameters to achieve the desired level of response. MOO is used for the solving of problems with two or more objectives to be satisfied simultaneously. The objectives may be conflict to each other and expressed in different units. The multi objective optimization problem general formulation consists of a number of objectives with a number of inequality and equality constraints. The maximize objective function is to be converted into minimization type by multiplying negative without loss of generality. 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. OPTIMIZATION TECHNIQUES

DESIGN OF EXPERIMENTS (DOE):-

The study of most important variables affecting quality characteristics and a plan for conducting such experiments is called the design of experiments. G. Taguchi (1959) of Japan, by developing the associated concept of linear graph, was able to device numerous variants based on the OA design, which can easily be applied by an engineer or a scientist without acquiring advanced statically knowledge for working out the design and analysis of even complicated experiments (Ross J. Philip, 1989). Design of experiments is statistical technique that is used to determine the relationship between the different factors of input variables that affects a process and the output or response of that process. Design of experiments involves designing a set of experiments, in which all relevant factors are varied systematically. When the results of these experiments are analyzed, they help to identify optimal conditions, as well as details such as the existence of interactions and synergies between factors. When applied to product or process design, the technique helps to seek out the best design among the alternatives [2].

TAGUCHI METHOD:-

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

The steps of an effective designed experiment

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

Step-2: define the process objective, or more specifically, a target value for a performance measure of the process.

Step-3: define the quality characteristics(s) and measurement system (s).

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

Step-5: select control and noise factors.

Step-6: select levels for the factors.

Step-7: create orthogonal arrays for the parameter design indicating the number of and conditions for each experiment.

Step-8: conduct the experiments indicated in the completed array 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.

VI. METHODOLOGY

DEFINITION OF PROBLEM

In this experimentation an attempt is made to find out the optimum process parameters of CNC END MILLING on Al (2024-T4) plates. Process parameters considered are cutting speed, depth of cut, feed rate. Each process parameter is considered at three levels with one trial on each specimen. Trials are conducted and the response characteristics are studied.

In this experimentation Taguchi L9 orthogonal array is employed to analyze experimental results of machining obtain from 9 experiments for finish machining individually by varying for process parameters i.e. spindle speed(s), feed(f), depth of cut(d), width of cut(w). 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.

FACTORS AND LEVELS FOR SELECTED MACHINING 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 1

Taguchi Array L9 (33) approach

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

TABLE 2

MATERIAL SELECTION:-

Aluminum Alloy Al (2024-T4)

CHEMICAL COMPOSITION

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

TABLE 3

KEY PROPERTIES

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 orthopedic equipments

VII. CONCLUSION

A new approach for optimization of the cutting conditions for end milling which is presented here. This paper discussed optimization techniques used for CNC END milling machine to find optimal cutting parameter conditions during machining process for the material Al (2024-T4). All above discussed optimization processes and methodology were suitable and had the potential to be applied for cutting parameters optimization problems during machining. These techniques that are being applied successfully in industrial applications for optimal selection of process parameters with economic production cost in the area of machining for making the process insensitive to any uncontrollable factors such as environmental variables.

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