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ANALYSIS OF CNC MILLING PARAMETERS FOR ALUMINUM AA6063 BY USING TAGUCHI DESIGN

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Abstract- This paper analyze the CNC milling parameters for aluminum alloy. The objective of this work is to optimize the output milling parameters in CNC machining. The material used for the experiment was Aluminum AA6063. The experiments were done by using Taguchi design of experiment and the final results are evaluated there by identified the optimized milling parameters. Generally in milling process is carried out in CNC machine with multiple milling cutters to remove all the materials for the required profile. The operation involves linear and circular interpolation to obtain the required profile. The speed and feed are the two major input parameters and the diameter of the tool and depth of cut are considered as secondary input parameters. It provide an opportunity to carry out the calculation in the basic output parameters like machining time, material removal rate and surface roughness. Finally optimized values of output parameters were concluded.

Keywords**:** Pocket Milling, Machining Time, Material Removal Rate, Surface roughness.

I. INTRODUCTION TO POCKET MILLING

Milling is an operation of removing excess material by plunging a rotating cutter onto a stationery work piece. Pocket milling is one of the critical operations employed in industrial applications to produce internal recess for accommodating certain parts into it. Such pocket milling operation is widely found in various industrial applications. Accurate pockets are highly essential to have a perfect fit. In recent times computer numerical controlled (CNC) machine tools have been implemented to utilize full automation in milling and they provide greater improvements in productivity, increase the quality of the machined parts and also its require less operator input. Basic drawback found in CNC machine is the production cost.

A.Principle of Milling Operation

The work piece is holding on the work table of the machine.

The table movement controls the feed of work piece against the rotating cutter. The cutter is mounted on a spindle or arbor and revolves at high speed. As the work piece advances the cutter teeth remove the metal from the surface of work piece and the desired shape is produced. There are many operations are involved in milling are end milling, chamfer milling, face milling, drilling, boring, counter boring, counter sinking, reaming and tapping. The end milling process is widely used in industry because of its versatility and efficiency. The applications of the end milling process can be found in many industries ranging from large aerospace manufacturers to small tool and die shops. Reasons for its popularity include the fact that it may be used for the rough and finish machining of such features as slots, pockets, peripheries and faces of the components. A pocket milling can be defined as any machining which removes all the material located inside a preset boundary between two horizontal planes. It is one of the critical operations employed in industrial applications to produce internal recess for accommodating certain parts into it. Such pocket milling operation is widely found in various applications. Accurate pockets are highly essential to have a perfect fit. In recent time computer numerical controlled (CNC) machine tools have been implemented to utilize full automation in milling and they provide greater improvements in productivity, increase the quality of the machined parts and also its require less operator input. The basic drawback found in CNC machine is the production cost.

B. Importance of AA6063 Aluminum Alloy

The importance of aluminum alloy in one word: versatility. More than any other material aluminum has the capability of being extruded into complex shapes to exact tolerances. Other metals such as steel can be extruded but they require enormous pressure to pass through the die rendering all but a few simple extrusions uneconomic. It can be formed into literally thousands of unique profiles, each one able to meet a number of specific structural and aesthetic requirements

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AA6063 is an aluminum alloy majorly with magnesium and silicon as the alloying material. It has generally good mechanical properties and is heat treatable and wieldable. It is similar to the British aluminum alloy HE9. Aluminum alloys with a wide range of properties are used in engineering structures. The major advantages of AA6063 aluminum alloy are having good mechanical strength with high thermal resistance property. The Other advantages are Light in weight, Superior corrosion resistance, High toughness and resistance to low ductility fracture even at low temperature and having very good ability to fabricate. The disadvantages are higher initial cost and low strength comparative to steel.

II.PROBLEM DESCRIPTION

The optimization of machining parameters is important part in pocket milling operation. The selection of appropriate process parameters is one of the most important factors are to be considered for the effective machining. From this literature survey further more scopes exists to improve the machining by using suitable tool path. Hence the tool travel length, machining time and surface finish are the major machining parameters to achieve an effective machining. AA 6063 aluminum alloy material is chosen for experiment which is applied majorly in aero space, automobile industries and High Speed Steel (HSS) is selected as tool material.

1. Machining parameters like spindle speed, feed rate, depth of cut, tool idle travel, cutting fluids were considered.
2. Machining allowances like cutter radius compensation, tool offset & tool retract are essential for parameter optimization.
3. Tool size selection was taken in to consideration.
4. Machining economy in terms of above parameters also has considered.

The scope of this work is to analyze the CNC milling parameters of milling operation with minimum machining time , maximum material removal rate and enhanced surface finish, thereby reducing production cost.

III.EXPERIMENTAL SETUP

For this experiment the whole work can be done by a 3 Axis CNC Vertical Milling Machine were used for machining Model-DMV320;Table Size(mm)-450*160; Stroke X/Y/Z(mm)-600/450/500;SpindleSpeed(rpm)-100-2500rpm; Lubrication Used -Servo-Grade68.

3-AXIS VERTICAL MACHINING CENTRE

A. Cutting Tool Material

Cutter Make	ADDISON
Cutter Type	Flat end mill cutter – C08410D
Tool Material	HSS
Tool Diameter	8mm ,10mm , 12mm
Helix Angle	27˚ -33˚ RH

B. Material Selection

AA 6063 aluminum alloy specimens of 75 × 75 mm and 19 mm thickness were used in the present study. The work piece material is mounted onto the machine table to provide maximum rigidity. The work piece material is parallel to the machine table and perpendicular to the machine's spindle head. The experiment was performed by using servo 68coolant.

Chemical Composition of AA6063 aluminum alloy (wt. %)

Al	Cr	Cu	Fe	Mg	Mn	Si	Ti	Zn
96.9 -97.8	0.1	0.1	0.6	0.4 -0.9	0.3	0.3-0. 7	0.2	0. 2

C. Design Variables

Input Parameters –

N – Spindle Speed (rpm)
f - Feed rate (mm/min)
d - Depth of cut (mm)
TD –Tool Dia (8mm , 10mm , 12mm)

Output Parameters–

t_m *- Machining time (min)*
MRR-Material Removal Rate (gm/sec)
R_a *- Surface roughness (µm)*

D. Process Variables Used in Experimentation

Parameter	Unit	Level1	Level2	Level3
Speed	rpm	300	600	1200
Feed	mm/min	100	400	1000
Depth Of Cut	mm	1	1.5	3
Tool Dia	mm	8	10	12

E. Experimental Work

The objective of this work is to optimize the output parameters with appropriate speed, feed and depth of cut for achieving minimum machining time, maximum material removal rate and maximum surface finish. The Taguchi design was used to create machining inputs and to evaluate the performance of the response variables such as machining

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time, MRR and surface roughness based on experimental results. The experiments were conducted with pocket milling operation by applying the input parameters like speed, feed, depth of cut. The CNC vertical machining center was used for machining. The CNC machine program was written as per the drawing for the profile dimensions. Before machining, the simulation of machining is carried out as per the generated program.

MACHINING SPECIMEN

F. Evaluation Of Output Parameters

1. Machining Time (t_m) can be directly taken from the machine.

2. Material Removal Rate (MRR)

The material MRR is expressed as the ratio of the difference of weight of the work piece before and after machining to the machining time and density of the material.

$$MRR= W_B-W_A/(t_m)+\rho$$

Where

W_B – Weight of the work piece before machining
W_A – Weight of the work piece after machining
t_m – Machining Time
ρ – Density Of the AA6063

3. Surface Roughness (R_a)

Surface roughness test has done for 9 jobs were taken by using the portable surface roughness tester.

PORTABLE SURFACE ROUGHNESS TESTER

IV.EVALUATION AND ANALYSIS

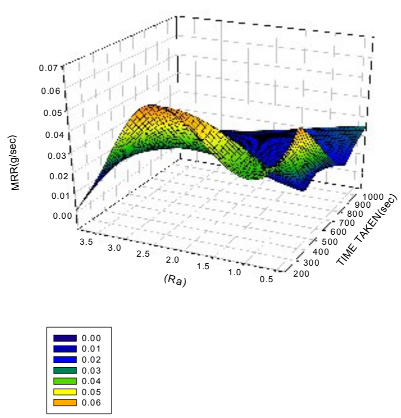
The design of experiment was used to create a model of output parameters. The Speed and Feed rate and depth of cut are chosen as process variables with three factorial designs. The significance of the parameter was found and it is developed for machining time and surface roughness. By using Taguchi design the performance for the experimental results were evaluated and analyzed.

TOOL DIA (mm)	SPEED (rpm)	FEED (mm/min)	DEPTH OF CUT (mm)	MACHINING TIME (sec)	MATERIAL REMOVAL RATE (gms/sec)	SURFACE ROUGHNESS (μm)
8	300	100	1	524	0.013359	3.848
8	600	400	3	780	0.015385	0.779
8	1200	1000	1.5	194	0.051546	2.764
10	300	400	1.5	516	0.023256	3.007
10	600	1000	1	235	0.042553	0.515
10	1200	100	3	1080	0.012037	2.814
12	300	1000	3	300	0.053333	0.369
12	600	100	1.5	540	0.012963	0.669
12	1200	400	1	215	0.027907	3.242

V.RESULTS AND DISCUSSION

The influences of cutting speed, feed rate and depth of cut have been assessed by conducting experiments. The variation of experimental Machining time , Material Removal Rate and Surface roughness values under varying input parameters were tabulated. It was observed from the charts representing the variation of experimental Machining time, Material Removal Rate and Surface roughness under different feed rate and spindle speed.

3D CONTOUR GRAPH



It was found that the surface roughness decreases with increase in spindle speed and increases as feed rate increases where as depth of cut will have lesser influence on the surface roughness. Also found that the machining time increases with decrease in feed rate and decreases with increase in feed rate where as spindle speed will not have an influence with machining time.

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VI.CONCLUSION

The approach to this paper is the analysis of CNC milling parameters to achieve a optimized values of above said output parameters based on experimental results of machining time, material removal rate and surface roughness majorly with respect to speed and feed rate. The evaluation has done for machining by Taguchi design.

The feed rate is a dominant parameter that the surface roughness increases rapidly with the increase in feed rate and decreases with an increase in spindle speed and machining time decreases with an increase in feed rate and increases with decrease in feed rate where as considering the same depth of cut.The performance evaluation has been done for experimental results with Taguchi design. The maximum MRR can be obtained by increasing the depth of cut. The type of chip formation is also based upon the selection of feed, speed and depth of cut. The spindle speed of the machine is not influenced with the machining time. This work can be extended to other pocket geometries using more tool paths with different cutting tools and work piece materials. The same problem can be elaborated with optimization technique to find the optimal solutions and the computer-aided process planning can also be adopted.

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