Tool Path Optimization of Pocketing Operation using CNC Milling Machine

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Abstract: In any manufacturing industries the major problem is to reduce the machining time of each operation so as to keep the cost low and high profit rate without sacrificing quality of the component... This paper presents a study on the reduction of machining time, focusing on Pocketing machining to minimise the time.. In this paper, the simulation model has been developed which develops the required machining time for each operation by specifying the exact tool and machining parameters. The Simulation Model is made in MasterCAM Software. Cutting Parameters used for machining are spindle speed, feed, tool diameter, plunge-rate, and depth of cut. Different toolpath generation methods are studied to select the best one to find out optimized cycle time Experimentation reveals that zigzag toolpath is more favourable than any other strategies for the machining of Pocketing Operation for minimum cycle time.

***Index Terms* – CNC Machine, Toolpath, Optimizatiom, machining strategies, Master CAM X18,**

I. INTRODUCTION

As indicated by Electronic industry Association (EIA), "CNC is a framework in which activities are constrained by the heading incorporation of numerical information sooner or later. The framework should naturally peruse probably some part of this information". CNC machining is an assembling procedure in which pre-modified PC programming directs the development of production line devices and hardware. The procedure can be utilized to deal with a scope of complex apparatus, from processors and machines to factories and switches. With CNC machining, three-dimensional cutting assignments can be consummate in a solitary arrangement of prompts. Another way to say "PC numerical control," the CNC procedure keeps running in qualification to and along these lines supplants — the constraints of manual control, where live administrators are expected to incite and direct the directions of machining devices by means of switches, catches and wheels. Tothe onlooker, a CNC framework may look like a normal arrangement of PC parts, yet the product projects and consoles utilized in CNC machining recognize it from every single other type of calculation. At the point when a CNC framework is enacted, the ideal cuts are customized into the product and directed to comparing devices and apparatus, which do the dimensional undertakings as determined, much like a robot. In CNC programming, the code generator inside the numerical framework will regularly accept systems are impeccable, in spite of the likelihood of mistakes, which is more prominent at whatever point a CNC machine is coordinated to cut in more than one course at the same time. The situation of a device in a numerical control framework is sketched out by a progression of data sources known as the part program. With a numerical control machine, programs are inputted by means of punch cards.

Fig.1 CNC Milling machin

On the other hand, the projects for CNC machines are sustained to PCs however little consoles. CNC writing computer programs is held in a PC's memory. The code itself is composed and altered by software engineers. Consequently, CNC frameworks offer far off progressively broad computational limit. The best part is that CNC frameworks are in no way, shape or form static, since more up to date prompts can be added to previous projects through changed code. Essentially, CNC machining makes it conceivable to pre-program the speed and position of machine instrument capacities and run them by means of.

II.OPTIMIZATION TECHNIQUES

Today many coordinated PC supported structure and fabricating (CAD/CAM) frameworks are accessible able to do creating machining Toolpath for different activities. In expansion these frameworks frequently don't produce ideal Toolpath in CNC machining tasks. For this streamlining of Toolpath the proposed procedures would be apply on machining task. The streamlining strategies of Toolpath are examined beneath:

2.1 Multiple cutting devices

There are at least two cutting device taken least machining time. Multi device slicing device is use to expand machining time as for single cutting device.

2.2 Cutting parameter

There are diverse Cutting Parameters, for example, shaft speed, feed, apparatus width, dive rate, and profundity of cut. Variety of cutting parameter gets settled outcomes for improvement.

2.3 Different shape

Toolpath Distinctive form Toolpath like 2D, chamfer 2D, Ramp, Remachining and Oscillating least process duration and broadcast appointment are mimicked for machining turbine sharp edge. There are two fundamental apparatus way designs ordinarily utilized in 2.5D end processing activities: heading parallel device ways and shape parallel instrument ways. The overall benefits of heading parallel and shape device According to an ongoing report, the best instrument way depends upon the geometry of the part, the machining qualities, furthermore, cutting conditions. The form parallel apparatus ways are referred to be rational as the instrument is dependably in contact with the material and subsequently diminishes inert time spent in lifting, situating, furthermore, diving of the instrument. Additionally, they keep up the steady utilization of either up-chop or down-cut processing methodology. Form parallel device ways are, along these lines, broadly utilized as cutting instrument ways. Heading parallel instrument ways, additionally generally alluded to as crisscross or Zig machining, are not favored for highlights with hard limits since cusps are abandoned along the hard edges amid unpleasant machining. The evacuation of these cusps requires an additional pass along these lines expanding the all out instrument way length.

2.4 Reduce Airtime

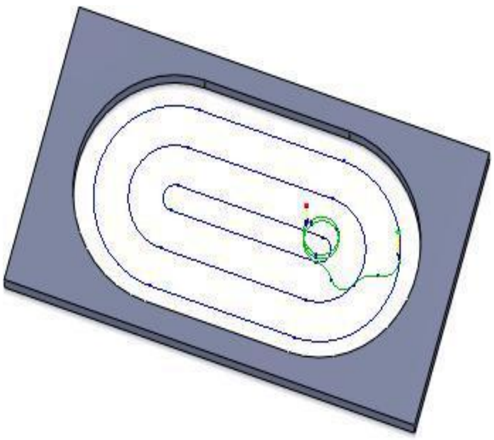
Broadcast appointment is characterized as the season of Toolpath when material is not evacuated at machining. The broadcast appointment is considered from completing of first slice to beginning of second cut. So, broadcast appointment is important to diminish for advanced the machining time.

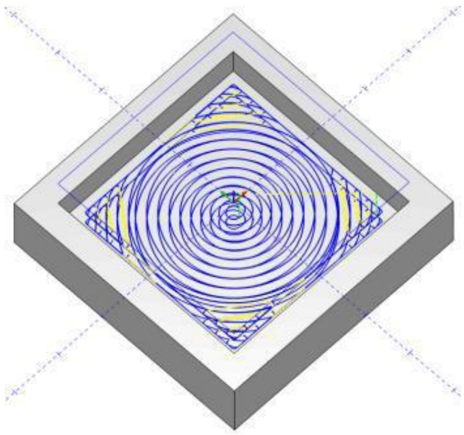
2.5 Retract

Withdraw use for second go of Toolpath after culmination of one go amid machining. Its advantage is that is no harm concerning clip. Taken minor withdraw gives decrease long what's more, time. In any case, pick alternative hold instrument down, while choosing parameter in MasterCAM. There is no decrease time concerning withdraw.

2.6 Plunge rate

Plunge rate is characterized as the feed when development of hardware is down inside and out at machining activity. Plunge rate is chosen as for feed rate according to standard. Plunge = ½ or ¾ feed. **1.9 Pocketing Operation** Milling of pocket is removal of material inside a closed area of the work piece flat surface at a certain depth using one or more tools. The important of the problem of pockets machining comes from the fact that 80% of work by milling is machining of pockets. Pocket milling has been regarded as one of the most widely used operations in machining. It is extensively used in aerospace and shipyard industries. In pocket milling the material inside an arbitrarily closed boundary on a flat surface of a work piece is removed to a fixed depth. Generally flat bottom end mills are used for pocket milling. Firstly roughing operation is done to remove the bulk of material and then the pocket is finished by a finish end mill. This type of path control can machine up to 80% of all mechanical parts. Since the importance of pocket milling is very relevant, therefore effective pocketing approaches can result in reduction in machining time and cost. Pocket milling can be carried out mainly by two tool paths, linear and non-linear.





III. MODELING AND SIMULATION

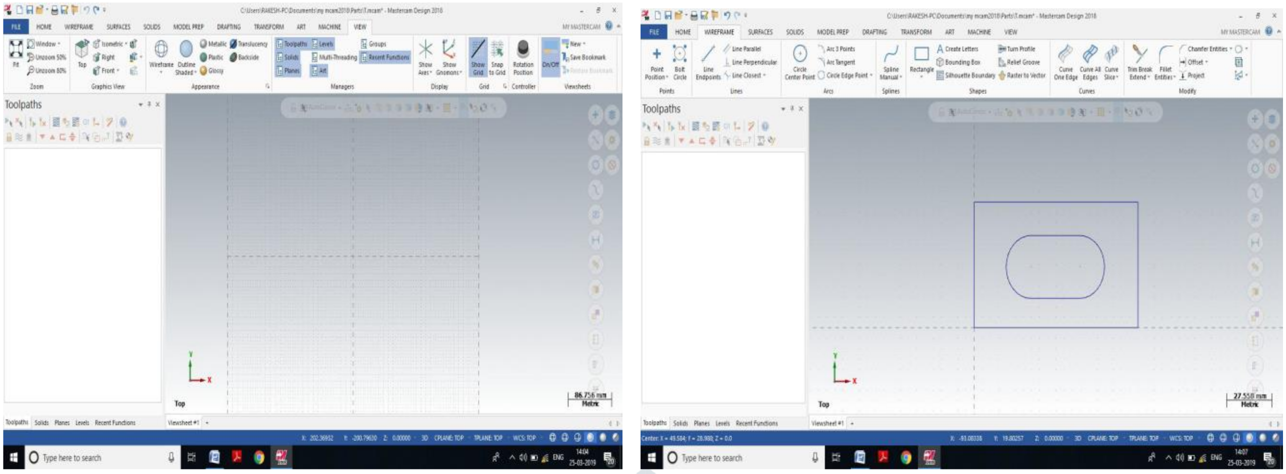


Fig 3.1 Draw 2D drawing in MasterCAM X18 Software

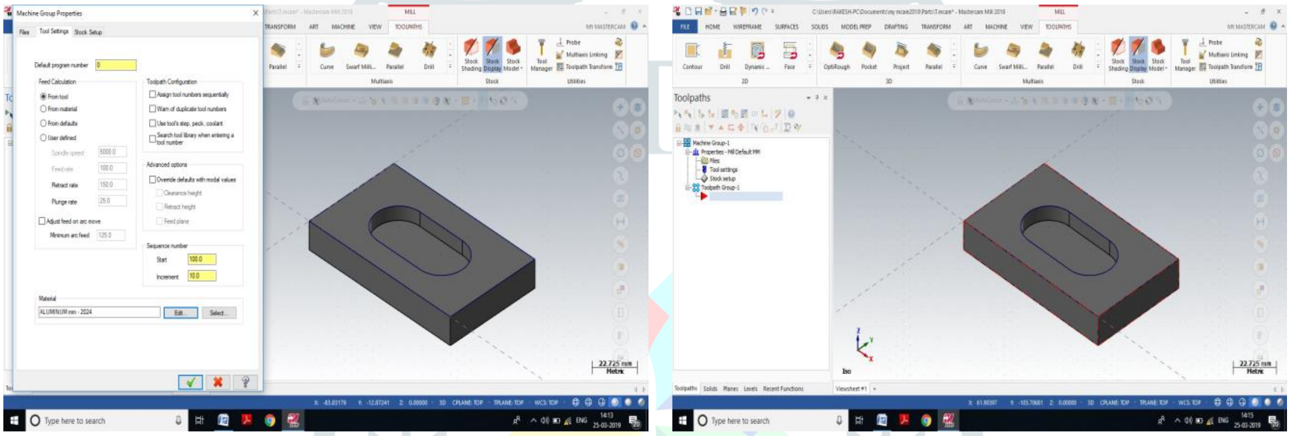


Fig 3.2 Material selection

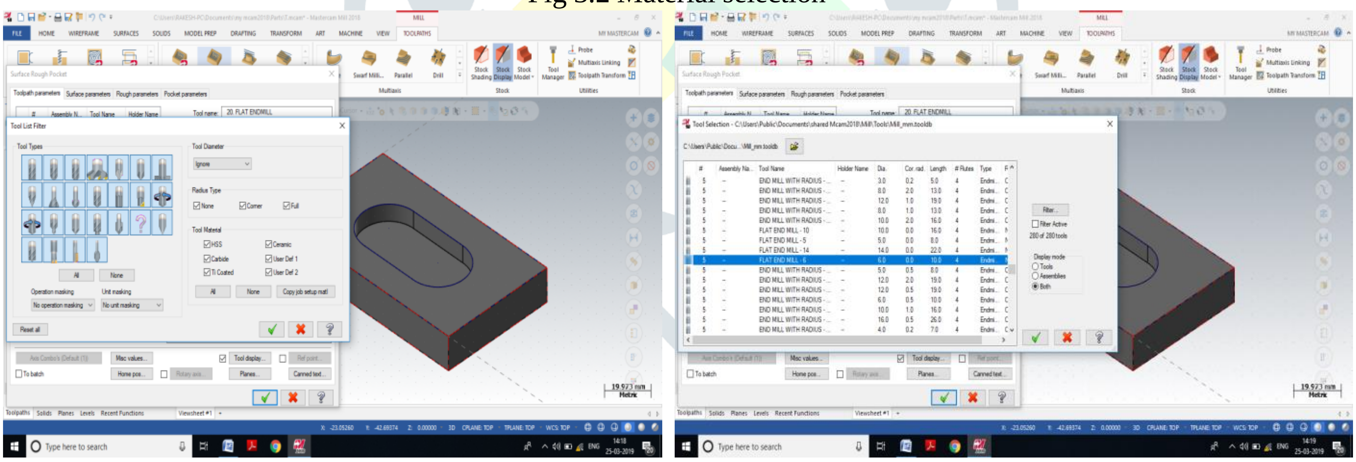


Fig 3.3 Selection of Flat Endmill Tool

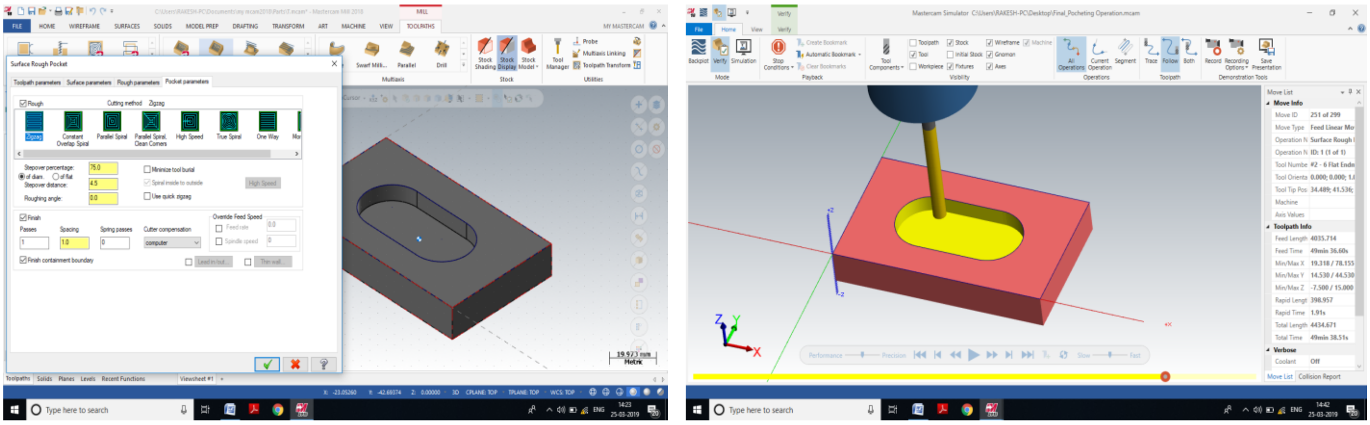


Fig. 3.4 Applied Zig-Zag Tool path and Simulation

MasterCAM X18 software simulation times of all the toolpaths are shown in below table II. Zig-zag toolpath gives minimum machining time which is 13min 2.98sec compare to other toolpath gives maximum machining times which is 20min 0.26sec (morph spiral toolpath).

Table 3.1: MasterCAM X18 Software Simulation Time

Sr. No.	Toolpath	MasterCAM X18 Software Simulation Time
1	Constant spiral	14m 11.54sec
2	Zig Zag	13min 2.98sec
3	Parallel Spiral	14min 26.17sec
4	High Speed	14min 32.85sec
5	One Way	13min 28.19sec
6	True spiral	19min 17.21sec
7	Parallel spiral, clean corner	14min 32.85sec
8	Morph Spiral	20min 0.26sec

IV. Experimental Setup

Computer Numerical Control (CNC) machining is a manufacturing process in which pre-programmed computer software dictates the movement of factory tools and machinery. It is the automated control of machining tools like drills, boring tools, lathes and 3D printers by means of a computer. The design is loaded into the computer which is attached to the CNC machine. The computer changes the design into a special code that controls the way the CNC cuts and shapes the material. Basically CNC is a specialized and versatile form of soft automation and its applications covers many kinds, although it was initially developed to control the motion and operation of machine tools. Performance is done on 3 axis vertical milling CNC machine. The program is run continuously in the machine and machine performs automatically. The cutting tool removes material from object according to the programmed fed. For the pocketing operation 8mm diameter Flat end mill is used to remove material speedily. The basic CNC process can be done into 3 steps. First different CAD model of the parts are designed. The machinists then turn the CAD file into a CNC program (G-code) and sets up the machine. Finally, the CNC system executes all machining operations with little supervision, removing material and creating the part.

4.1 Machine Specification

Table 4.1: MasterCAM X18 Software Simulation Time

Specifications	Units	XL Mill
Travels		
X Axis	Mm	225
Y Axis	Mm	150
Z axis	Mm	115
Distance between table top and spindle nose	Mm	70-185
Table		
Table Size	Mm	360*132
Spindle		
Spindle motor capacity	HP	0.5
Programmable spindle capacity	Rpm	150-4000
Spindle nose taper	-	BT 30
Accuracy		
Positioning accuracy	Mm	0.010

Repeatability	Mm	±0.005
Feed rate		
Rapid traverse X*Y*Z axis	m/min	1.2
Programmable feed rate X*Y*Z axis	Mm/min	0-1200
X Axis	Mm	225
ATC unit		
Tool storage capacity	Pcs	6
Max tool length	Mm	40
Max tool diameter	Mm	16
Slides		
Slides		Hardened ground guide ways
Ball screws X,Y,Z axis	Dia & Pitch	16 mm & 5 mm
CNC		
Control system		PC based 3 axis continuous path
Lubrication		
Lubrication system		Centralized lubrication system
Power sources		
Main supply		230V,Single phase, 50 Hz
Machine dimensions		
Height*length*Depth(W/o work bench)	Mm	1000*575*650
Machine weight(w/o work bench)	Kg	170
Training material		
Manuals :Construction manual, programming manual, operation manual, maintenance manual		
Work book: teachers workbook, students workbook		
Simulation software: CNC Train Simulation Software		
Operation Accessories		
Cam Software, offline programming software, Auto door, Hydro power vice, Work bench, 3 axis loading and unloading software, 6 station ATC, air compressor		
Features		
Compatible/Upgradable		FMS & CIM system

4.2 Material selection

Acrylic sheet is a material with unique physical properties and performance characteristics. Its weights half as much as the finest glass yet is equal to it in clarity and is up to 17 times more impact resistance. Expansion and contraction: Acrylic sheet responds to temperature changes by expanding or contracting at a far greater rate than glass.

Flexibility: Acrylic sheet is much more flexible than glass or many other building materials.

Chemical Resistance: Acrylic sheet has excellent resistance to attack by many chemicals. It is affected, in varying degrees, by benzene, toluene, carbon tetrachloride, ethyl and methyl alcohol, lacquer thinners, ethers, ketones and esters.

Electrical Properties: Acrylic sheet is an excellent insulator. Its surface resistivity is higher than that of most plastics.

Light transmission: Colorless acrylic sheet has a light transmittance of 92%. It is clearer than window glass and will not turn yellow. Acrylic sheet is also available in a large variety of transparent and translucent colors.

UV light Resistance: Acrylic sheet resists ultraviolet light degradation. Each acrylic sheet has a ten-year-limited warranty against yellowing and loss of light transmission.

Weather Resistance: Despite heat, cold, sunlight, and humidity acrylic sheet maintains its original appearance and color.

Safety: Acrylic is Shatter-resistant, Earthquake proof and burglar-resistant. Increase safety with windows glazed of acrylic.

Properties General Properties Relative Density 1.19 g/cm3 Rockwell Hardness M 102 Water Absorption 0.2% Mechanical Properties Tensile Strength 75 MPa Flexural Strength 115 MPa Thermal Properties Minimum and Maximum Service Temperature is -40C and 80C resp.

4.3 Cutting parameters:

Cutting parameters is selected from standard data of machining. Cutting parameters are also taken from cutting speed software which is shown in table. This software gives spindle speed and feed rate with respect to work piece material, tool material and tool diameter.

Table 4.2: Cutting Parameters

Sr No.	Operation	Tool Dia.	Spindle Speed(rpm)	Feed (mm/min)	Material
1	Pocket	6	2500	150	Acrylic

4.4 Machining:

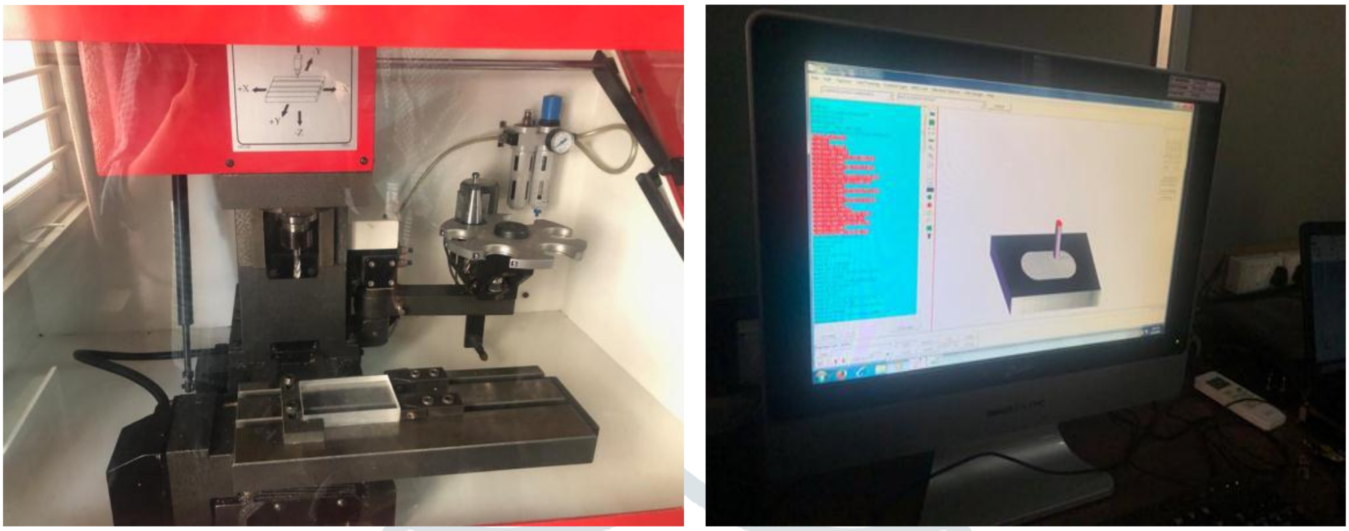


Fig. 4.1 Acrylic Raw material and CNC train simulator

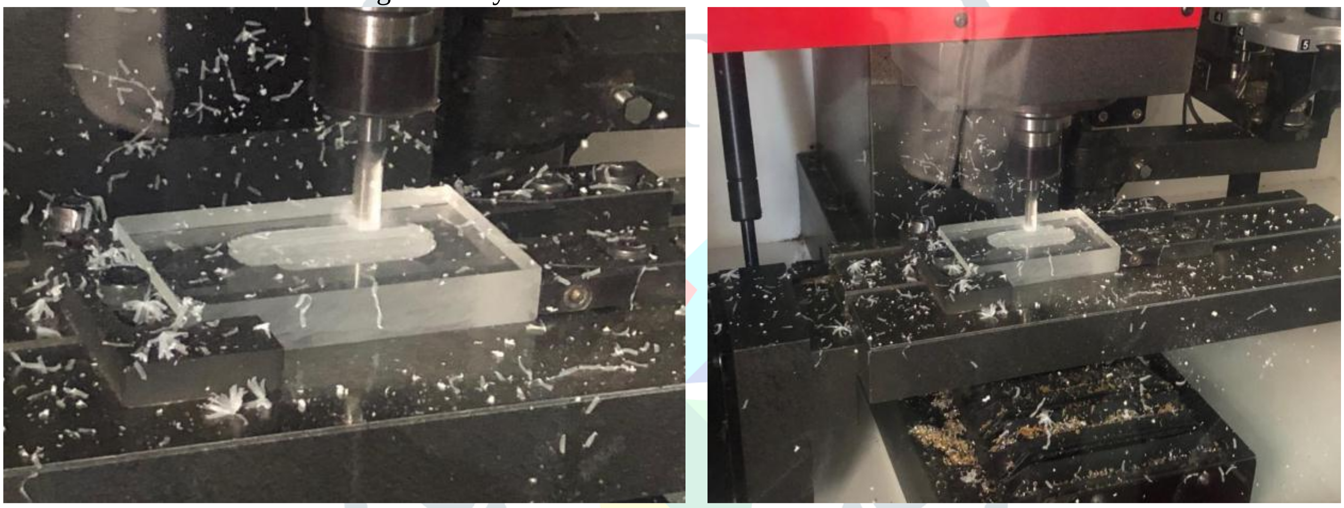


Fig. 4.2 pocketing operation on CNC Machine

Fig 4.3 High Speed Toolpath

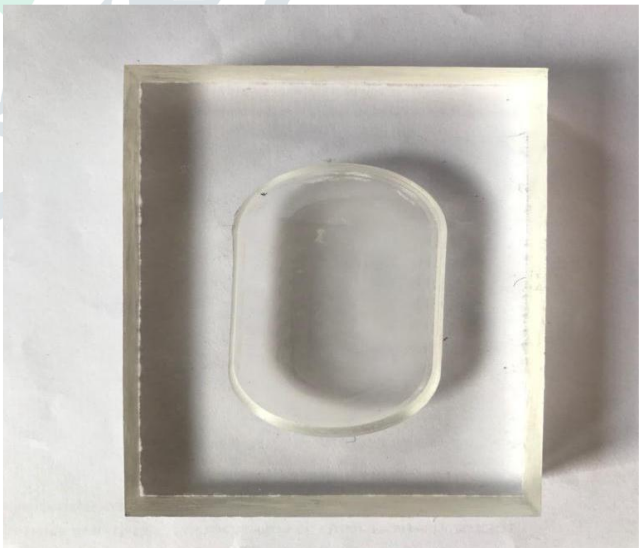


Fig 4.4 Contour Spiral Toolpath

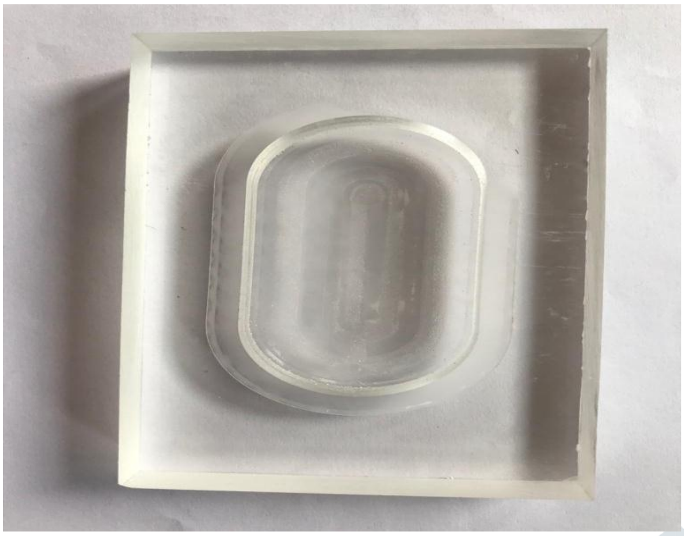


Fig 4.6 Parallel Spiral Toolpath

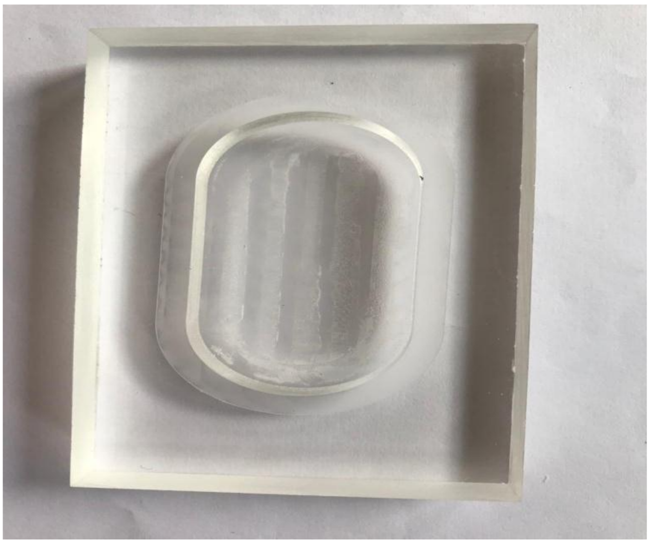


Fig. 4.7 One Way Toolpath

The figures shown indicating pocketing operation is manufactured completely in 3-axis vertical machining centre (VMC) machine. Pocketing operation are produced for each as shown in table Zigzag toolpath require minimum actual machining time of 12m 49sec compared to other toolpaths. The True spiral toolpath gives maximum machining time of 19min 39sec.

Table 4.3: Cutting Parameters

Sr. No.	Toolpath	Experimental Machining Time
1	Constant spiral	13min 40sec
2	Zig Zag	12min 49sec
3	Parallel Spiral	14min 45sec
4	High Speed	15min 0.2sec
5	One Way	15min 1sec
6	True spiral	19min 39sec
7	Parallel spiral, clean corner	14min 50sec
8	Morph Spiral	19min 8sec

V. RESULT AND DISCUSSION

Software simulation time, experimental machining time and difference of them are elaborate in the table

Table 5.1: Compression of Experimental and Software simulation time

Sr. No	Toolpath	MasterCAM Software simulation time(min)	Experimental Machining Time(min)	Time difference software and machining
1	Constant spiral	14m 11.54sec	13min 40sec	31sec
2	Zig Zag	13min 2.98sec	12min 49sec	13sec
3	Parallel Spiral	14min 26.17sec	14min 45sec	19sec
4	High Speed	14min 32.85sec	15min 0.2sec	28sec
5	One Way	13min 28.19sec	15min 1sec	85sec
6	True spiral	19min 17.21sec	19min 39sec	22sec

7	Parallel spiral, clean corner	14min 32.85sec	14min 50sec	18sec
8	Morph Spiral	20min 0.26sec	19min 8sec	52sec

VI. CONCLUSION

The comparison of machining and simulation results shows that the best tool path depends on the geometry and the cutting conditions. The cutting tool takes non-productive time or "airtime" and need to be reduced. Amongst various cutting strategies available in MasterCAM zigzag toolpath is found to be more favorable than any other strategies for pocketing operation. Whereas morph spiral take maximum machining time as compare to other tool paths.

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