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Comparative Study of Tool Path Strategies in NX for Pocket Machining

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ABSTRACT

Pocketing is a frequent operation used in aeronautic and automotive industries. The path that must be followed by the tool during the milling process can be generated using different strategies.The aim of this study is to compare different tool path methods in NX software for pocket machining. Tool path generation is proposed to be integrated objective of minimizing machining time under selection of an appropriate roughing method for a pocket of given shape. In this work, we have compared four distinct tool path strategies i.e. follow part, zig, zig-zag and zig with contour. NC code generated by NX software were fed to CNC milling machine. The machining time was recorded from simulation as well as from CNC machine. Then after analysis of excess thickness was carried out to compare all these tool path strategies. Considering all these factors, results shows that follow part method is suitable for all condition among other methods, due to its moderate cycle time and good surface finish.

Keywords

Pocket machining, CNC milling, tool path, machining time, follow part, zig, zigzag, zig with contour

INTRODUCTION

A pocket machining can be defined as any machining which removes all the material located inside the pre-set boundary between two horizontal planes. A pocket is an area with defined borders where material should be milled away. In NX pocket machining, if the tool path and the outer boundary of a machined region on a cutting plane are given, in process shape of the part geometry can be easily produced. Pocketing is often used in the machining of aeronautical parts and in the roughing of moulds and dies. The goal of these milling operations is to remove all the material inside a profile between two horizontal planes in a minimum of machining time and to respect the required accuracy at the boundary of the pocket.

METHODS OF POCKET CLEARANCE

The removal of additional material in the case of inside pocket can be done in a number of ways. Most of the CAM systems would provide for different area clearance options which the user can choose considering the type of geometry. NC pocket milling can be carried out mainly by two tool paths: linear and non-linear.

1. **Linear tool path:** In this approach, the tool movement is unidirectional. Two types of linear toolpath are zig-zag and zig.

a. **Zig-zag tool path:** In zig-zag milling, material is removed both in forward and backward paths.

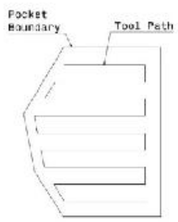

Fig 1:Zig-Zag tool path

b. **Zig tool path**: In zig milling, the tool moves only in one direction. The tool has to be lifted and retracted after each cut, due to which machining time increases.

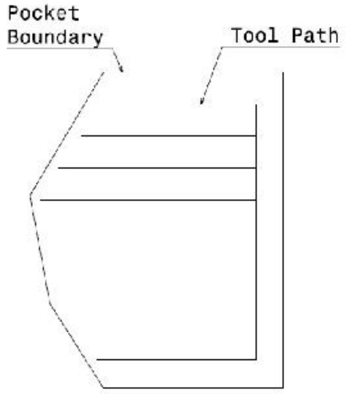

Fig 2:Zig tool path

2. Non-linear tool path: In this approach, tool movement is multi-directional. Examples of non-linear tool path is contour-parallel & curvilinear tool path.

a. **Contour-parallel tool path:** In this approach, the required pocket boundary is used to derive the tool path.

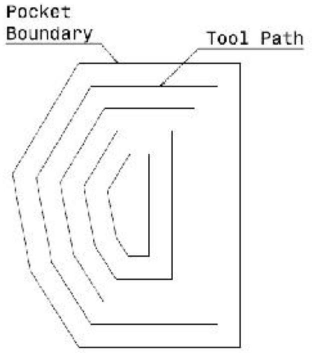

Fig 3: Contour parallel tool path

b. **Curvilinear tool path:** In this approach, the tool travels along a gradually evolving spiral path. The spiral starts at the center of the pocket to be machined and the tool gradually moves towards the pocket boundary.

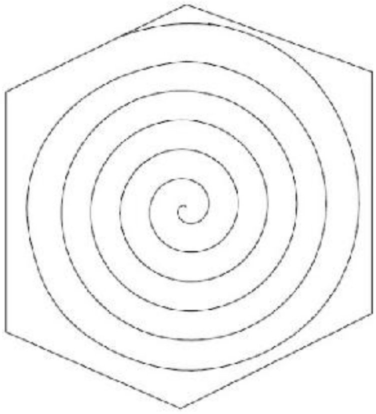

Fig 4: Curvilinear tool path

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STEPS TO GENERATE TOOL PATH

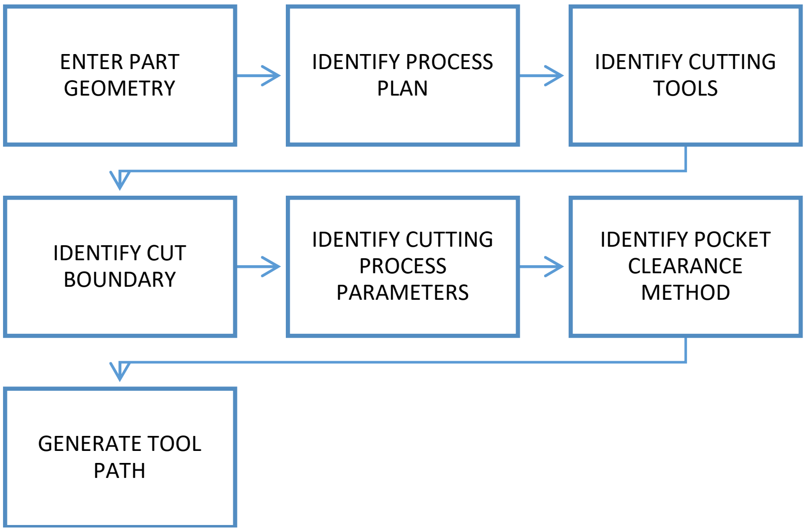

Fig 5: Steps to generate tool path

SIMULATION IN SOFTWARE

The experiments can be done accordingly to the machining cutting path strategies. There are seven cutting path strategies being used for pocketing function in NX and each cutting method has advantages and disadvantages. In this study we have compared these four methods:

1. **Follow Part:** This is the most optimal strategy where the tool path is manipulated depending on the part geometry.
2. **Zig:** This takes a linear path in only one direction of flow.
3. **ZigZag:** This tool takes a zigzag path at every level of depth.
4. **Zig with Contour:** This takes the path in one direction either climb or conventional. The unique thing is that it moves along the contour shape nonlinearly.

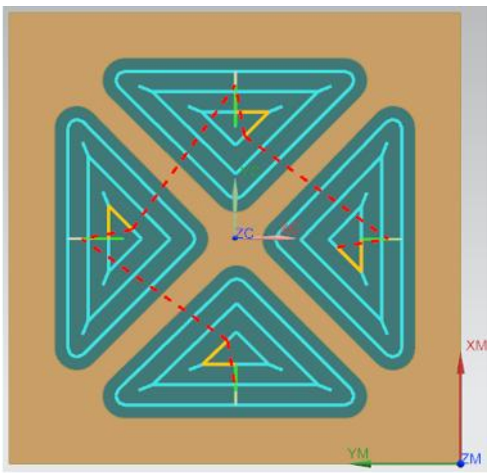

Fig 6: Follow Part Method

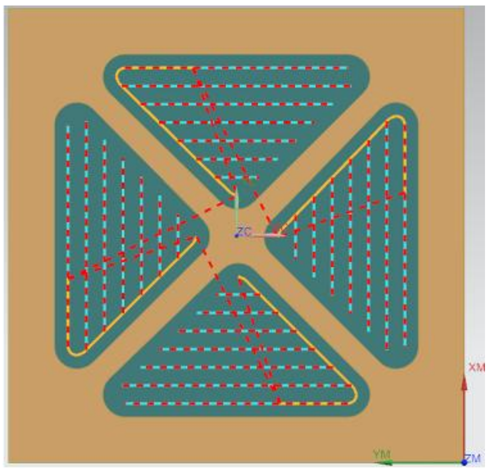

Fig 7: Zig Method

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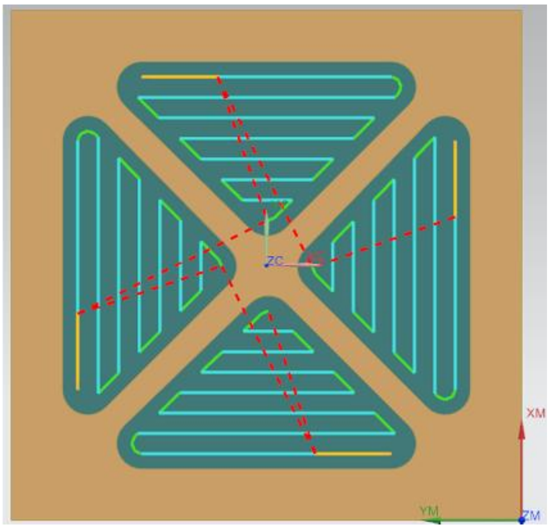

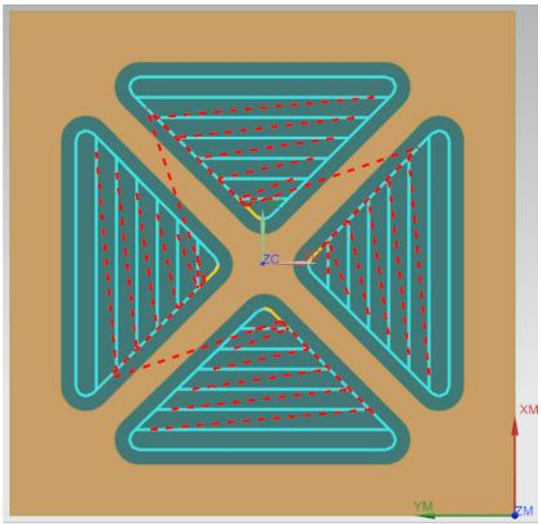

Fig 8: ZigZag Method **Fig 9: Zig with Contour Method**

EXPERIMENTAL SET-UP

In vertical CNC milling process, HSS end mill rotated at a constant speed and feed at a constant cutting forces for removing the material, to be milled. The work part to be milled has to be fixed in a manner that prevents loose work from being forced apart during milling.

Experimental set-up consist of:

a. Mazak (Vertical Center Smart 430A) CNC machine
b. Holding fixture for workpiece
c. HSS end mill tool
d. Aluminium Workpiece

a. **Mazak (Vertical Center Smart 430A) CNC machine:**In our experiment Mazak (Vertical Center Smart 430A) CNC milling machine is used. The smart series Mazak milling machine are designed for high productivity, compact design and experimental consideration. It is widely used by multinational companies like SIEMENS, McLAREN MERCEDES, MIRANDA TOOLS, etc.

Fig 10: Mazak (Vertical Center Smart 430A) CNC machine

b. **Holding fixture:** During pocket milling process number of forces will act like, downward force, traverse force which are necessary to maintain the position of the tool at the or below material surface: the traversal force acts parallel to tool motion and is positive in the traversal direction; the lateral force acts perpendicular to the tool traverse direction and it is positive towards the advancing side of the milled surface. Under the effect of these forces fixture must capable of hold the plates to be milled rigidly to get desired quality of part surface.

Fig 11: Holding Fixtures applied to Aluminium Plate

c. **HSS End Mill:**Miranda multi flute End mills are made from M2 grades of HSS. In our experiment 6mm diameter End mill with 4 number of flutes is used.

Fig 12: HSS End mill

d. **Aluminium Plate:** In our work commercial aluminium was used for the experiment. Aluminium plates with dimensions of length 100mm, width 100mm and thickness of 10mm is used.

Fig 13: HSS End mill

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EXPERIMENT OF POCKET MACHINING

NC program generated by the NX software were fed to CNC machine for process. In our experiment we have manufactured pocketing with all these four tool path methods.

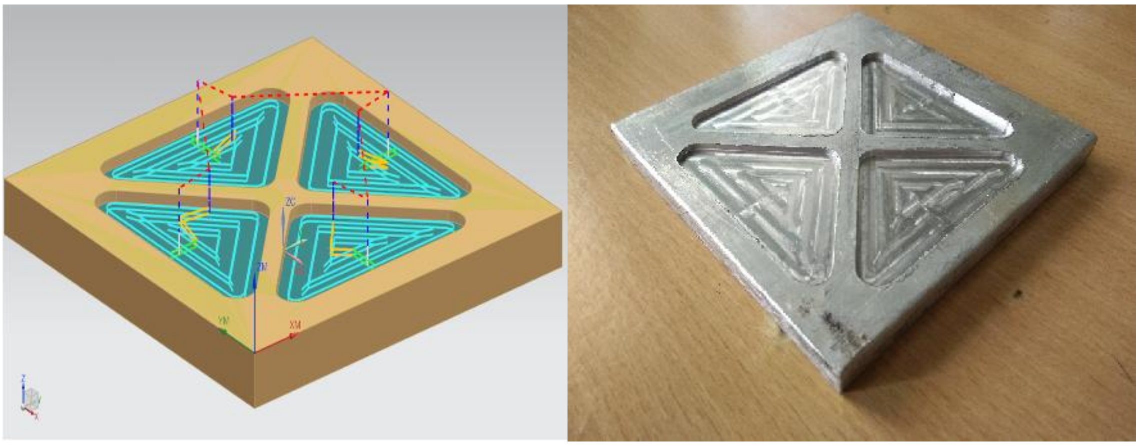

Fig 14: Model and Actual Pocketing by Follow Part method

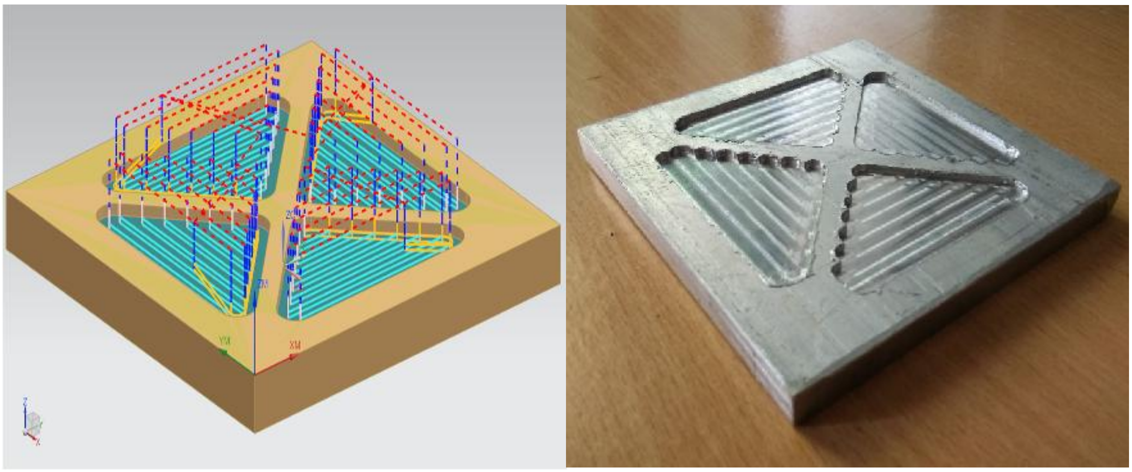

Fig 15: Model and Actual Pocketing by Zig method

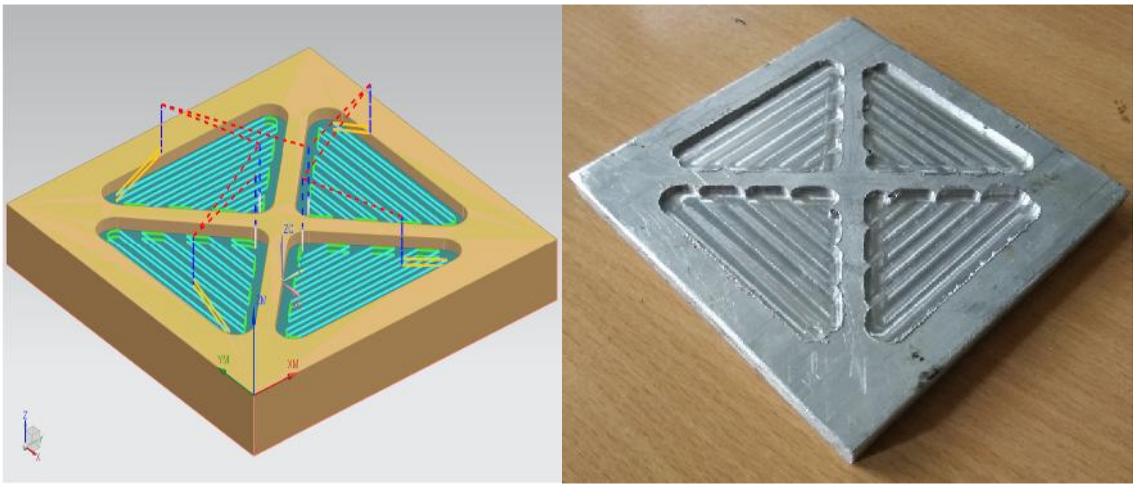

Fig 15: Model and Actual Pocketing by ZigZag method

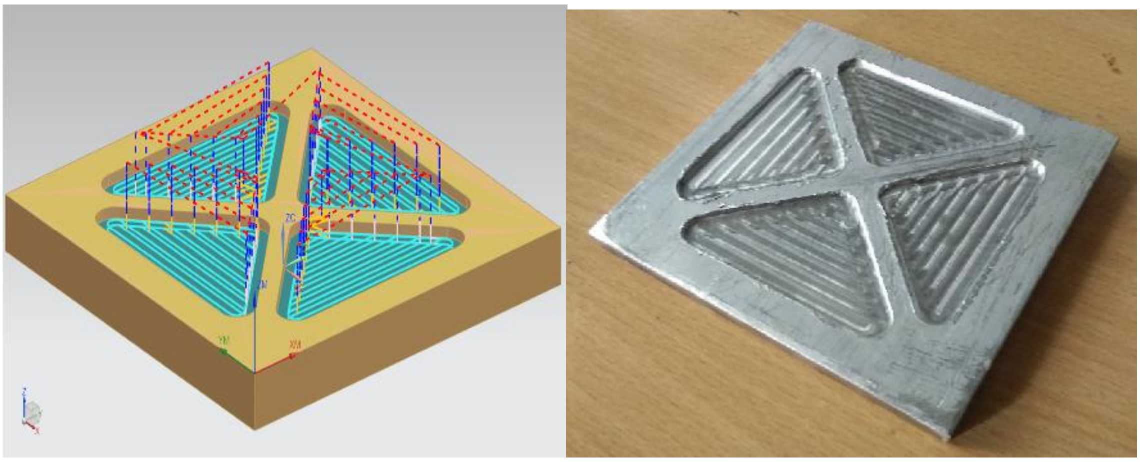

Fig 16: Model and Actual Pocketing by Zig with Contour method

COMPARISON OF DIFFERENT TOOLPATH METHODS

Table 1.Comparisonof pocketing methods

Parameters		**Follow Part**	**Zig**	**Zig-Zag**	**Zig with Contour**	**Maximum value**	**Minimum value**
Cycle time	Software	31.39 m	33.36 m	28.88 m	38.82 m	38.82 m	28.88 m
	CNC Machine	31m 45s	35m 40s	29m 29s	40m 35s	40m 35s	29m 29s
NC CODE Length	Lines	285	461	181	585	585	181

ANALYSIS OF EXCESS THICKNESS

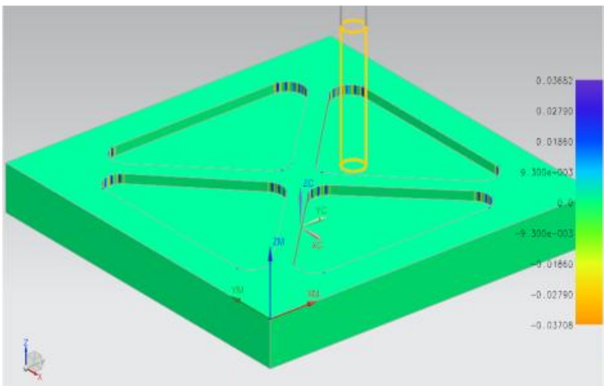

Fig 17: Follow Part Method

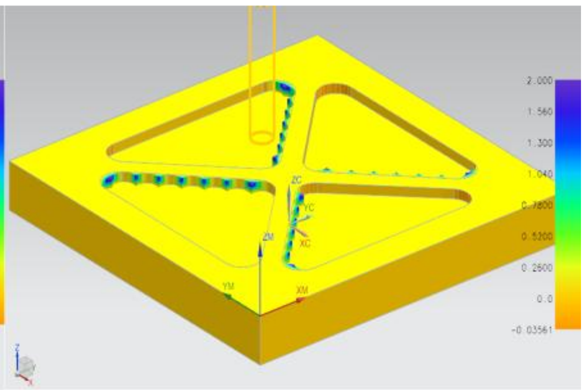

Fig 18: Zig Method

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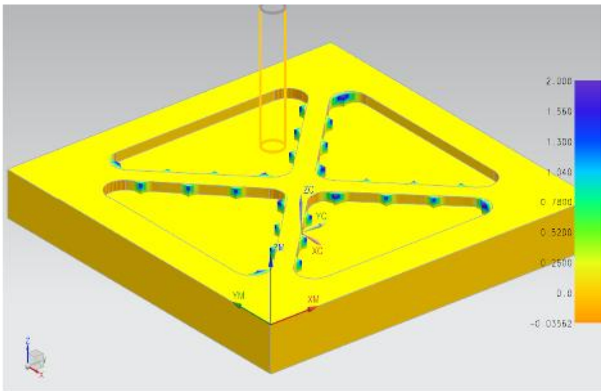

Fig 19: ZigZag Method

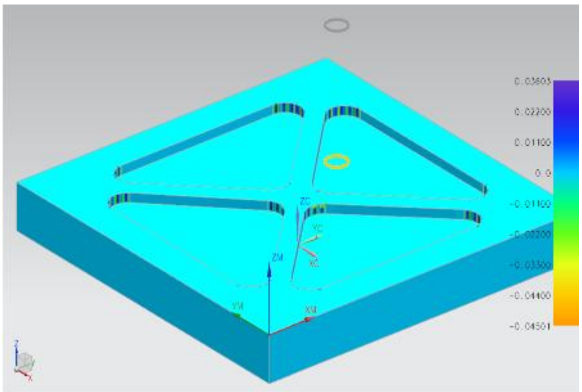

Fig 20: Zig with Contour Method

CONCLUSIONS

From the comparison table, it shows that the zig-zag method is very much impressive in results due to small cycle time and programme length. Follow Part &Zig method have moderate cycle time and tool path length. On the other hand Zig with Contour method has very lengthy NC programme code and cycle time is also high. Pocket machining is very essential for large scale mass production system for economical benefits. Zig with Contour method of pocketing is very lengthy at all in this distinct comparison of four methods, having maximum cycle time and tool path length. From the analysis excess thickness, we can see that by using follow part and zig with contour method excess thickness is very less and almost negligible. While in zig and zig-zag method excess material thickness is high compared to other two methods. Amongst various cutting strategies available in NX follow part toolpath method is found to be more favourable than any other strategies for rough machining the part considered here.

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