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Sifting Through the Optimal Strategies of Time-Based Tools Path Machining in Software CAD-CAM

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Abstract: One of the most significant issues that has drawn the attention of toolmakers is the strategies which lead to speedy production of tools and a faster way to meet the demands of market. Hence, toolmakers have made utmost effort to investigate the potential ways as to reduce machining time. One vital initial step in the process of production is roughening objects. CATIA and MASTER CAM are two of the softwares used in designing and producing NC CODE of tools. The two softwares are flexible in all the stages of production and are highly capable of producing product codes as well as displaying machining time. Numerous tools path strategies are incorporated in the aforementioned softwares. This article seeks to simulate tool-path planning strategies in accordance with the machining time displayed by the software. The accuracy of the operations verified the most suitable tools path strategy will be introduced in the present article. Research results indicate that the back and forth tools path strategy used in CATIA and End Mill tools enjoy a minimum machining time. As well as that, when Bull Nose tools employed, the inward helical strategy consumes less machining time in comparison with the Master CAM.

Key words: Roughening · Machining Time · CAD/CAM Process · CATIA · Master CAM · CNC Milling

INTRODUCTION

Obviously, when deciding on the best tools path strategy, one should pay special attention to the machining time. By using computer softwares, the tools path and the way the tool maneuvers on the raw block can be simulated. Afterwards, having verified the accuracy as well as the efficiency of the operations, we will be fully able to produce the parts without confronting any problem of any kind. This, indeed, is one another privilege of using computer in the production process i.e. saving time as well as reducing the production costs. The less the machining time, the less the production costs. In 1997, several researches were conducted in optimizing the machining time parameters for roughening operations. In these researches, the roughening operations were carried out by Rad-Toloei and I.M.Bidhendi. Interestingly, the results of the research have been showered with attention [1]. In 2000, other researches were done in determining the parallel tools path in milling By S.C. Park and B.K. Choi, who, interestingly, arrived at significant conclusions as for some surfaces [2]. In 2003, the impacts of tools path strategies on high-speed milling were examined by Monreal M and CiroA.Rodriguez [3]. As well as that, in 2003 and 2008, several researches were conducted so as to determine and optimize machining strategies such as cutting tools and cutting depth allowance [4, 5, 6, 7]. In the present article, a pre-designed sample part is simulated via Master CAM V9 and CATIA V5R18; effort is made to determine the most suitable strategy based on the machining time.

Introducing the Softwares and the Models Used: The models, which are examined in this article, are as follows:

- Gearbox as displayed in Figure 1
- Disc screens as displayed in Figure 2

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Fig. 1: Pocket Model NO 1

Fig. 2: Pocket Model NO 2

Examining the results of the two aforementioned softwares gives the toolmakers the opportunity to determine the best tools path strategies as for similar objects.

The writer of the present article has employed CAD, an advance designing computer software as well as CAM, an advance production software. CATIA V5R18 has been used to design the models. Needless to say, CATIA is one of the fewest types of software with numerous useful applications. Moreover, accurate designs can be made via CATIA, designs which can be saved in various formats. The designed models are saved as STEP so that making the same object can be machined via Master CAM. Furthermore, to determine the tool path, Master CAM V9 and CATIA V5R18 are used. In fact, Master CAM, with an interesting environment, is software with many useful applications and probably one of the strongest of the CAM softwares. And, adjusting the options on Master CAM requires a more in-depth knowledge of its codes and commands as well as its various types of tools path when compared with CATIA.

Adjusting Parameters: Numerous adjustable parameters are found on CAM. As far as the two softwares employed in the present article are concerned, there are parameters with identical, similar, or even different options. Such parameters are discussed along with other important parameters. In the actual fact, identical adjustments have been made to the parameters for all the models.

Similar and Identical Parameters: All the achieved similar and/ or identical options are demonstrated in Table 1. All the options, as shown in the table, are adjusted with identical number. Also, similar parameters have been implemented in order to assure that the adjustments are accurate.

Table 1: Applicable options used in CAM

Master CAM	CATIA
Tolerance	Tolerance
Step over	Step over ratio
Step down	Depth of cut
Stoke to leave	Offset on part
End Mill	End Mill
Bull Nosed	Ball Mill
Feed rate	Feed rate
Spindle Speed	Spindle Speed

Table 2: The degree of steady input in CAM

Master CAM	CATIA	Input Type
0.1 MM	0.1 MM	Tolerance
70 Rpm	70 Rpm	Spindle Speed
1000 Unit/min	1000 Unit/min	Feed Rate
3 mm	3 mm	Depth of Cut
1 mm	1 mm	Offset on Part

Type and its Advancing Degree While Machining: As for roughening the parts, End Mill and Ball Nosed tools have the most frequent applications. Thus, in this article, as for the all strategies, the two tools stated above have been used with a fixed diameter of 10 mm. The types of tools used are shown in the table. The degree to which the tools have advanced while machining is calculated based on the diameter of the tools. The diameter considered for End Mill is approximately 70% and that of used for Ball Nosed is roughly 15%.

Examining the Implementation of Strategies on Various Tools: Now, the tool path strategies are simulated according to the models previously stated. The resulted data is listed in the tables related to each of the models on the basis of their geometry. In the tables, utmost effort is made to implement the most important options.

CATIA V5R18: In this software, the operations of Pocketing and Prismatic roughing are considered in machining. As for Pocketing, five types of

Table 3: The results achieved from the roughening strategies on pocket NO 1 in CATIA V5R18

Machining time	Total time	Mill(D)	Strategy
39min23s	40min14s	End Mill 10	Outward helical
38min20s	39min11s	End Mill 10	Inward helical
29min28s	37min18s	End Mill 10	Back and forth
42min59s	45min40s	End Mill 10	Offset on part one – way
42min59s	45min40s	End Mill 10	Offset on part zig – zag
2h15min47s	2h16min43s	Ball Nosed 10	Outward helical
1h53min43s	1h54min37s	Ball Nosed 10	Inward helical
2h10min2s	2h17min31s	Ball Nosed 10	Back and forth
2h12min8s	2h15min18s	Ball Nosed 10	Offset on part one – way
2h12min8s	2h15min18s	Ball Nosed 10	Offset on part zig – zag
1h2min21s	1h11min40s	End Mill 10	helical
1h0min51s	1h19min30s	End Mill 10	Back and forth
3h6min1s	3h14min29s	Ball Nosed 10	helical
2h56min59s	3h14min50s	Ball Nosed 10	Back and forth

Table 4 the results achieved from roughening strategies on pocket NO 3 in CATIA V5R18

Machining time	Total time	Mill(D)	Strategy
26min45s	27min15s	End Mill 10	Outward helical
26min51s	27min21s	End Mill 10	Inward helical
22min10s	26min52s	End Mill 10	Back and forth
26min25s	28min29s	End Mill 10	Offset on part one – way
26min25s	28min29s	End Mill 10	Offset on part zig – zag
1h36min25s	1h36min59s	Ball Nosed 10	Outward helical
1h27min21s	1h27min52s	Ball Nosed 10	Inward helical
1h33min45s	1h38min23s	Ball Nosed 10	Back and forth
1h36min17s	1h38min10s	Ball Nosed 10	Offset on part one – way
1h36min17s	1h38min10s	Ball Nosed 10	Offset on part zig – zag
39min47s	43min38s	End Mill 10	helical
39min14s	47min59s	End Mill 10	Back and forth
2h20min36s	2h24min9s	Ball Nosed 10	helical
2h16min18s	2h24min45s	Ball Nosed 10	Back and forth

Table 5: The results achieved from roughening strategies on various geometric models in Master CAM

Total time	Mill (D)	Strategy
2h13min4.67s	End Mill 10	Zig – zag
2h20min20.07s	End Mill 10	Constant overlap spiral
2h16min46s	End Mill 10	Parallel spiral
2h26min4.97s	End Mill 10	Parallel spiral clean corners
3h42min32.06s	End Mill 10	Morph spiral
lengthy	End Mill 10	High speed
2h38min30.53s	End Mill 10	One way
3h29min59.23s	End Mill 10	True spiral
9h26min6.42s	Bull Nose 10	Zig – zag
8h55min12.64s	Bull Nose 10	Constant overlap spiral
9h24min57.45s	Bull Nose 10	Parallel spiral
10h7min37.26s	Bull Nose 10	Parallel spiral clean corners
15h40min14.24s	Bull Nose 10	Morph spiral
lengthy	Bull Nose 10	High speed
11h44min29.7s	Bull Nose 10	One way
14h37min3s	Bull Nose 10	True spiral

Table 6 the results achieved from roughening strategies on various geometric models in Master CAM

Total time	Mill (D)	Strategy
1h49min26.3s	End Mill 10	Zig – zag
1h49min27.68s	End Mill 10	Constant overlap spiral
1h46min27.23s	End Mill 10	Parallel spiral
1h51min17.98s	End Mill 10	Parallel spiral clean corners
2h42min2.8s	End Mill 10	Morph spiral
Lengthy	End Mill 10	High speed
2h7min39.61s	End Mill 10	One way
2h50min15.34s	End Mill 10	True spiral
7h35min23.09s	Bull Nose 10	Zig – zag
7h8.94s	Bull Nose 10	Constant overlap spiral
7h34min13.76s	Bull Nose 10	Parallel spiral
7h56min47.28s	Bull Nose 10	Parallel spiral clean corners
11h36min26.35s	Bull Nose 10	Morph spiral
lengthy	Bull Nose 10	High speed
9h5min23.01s	Bull Nose 10	One way
12h34min1.53s	Bull Nose 10	True spiral

strategies are used. And, as for Prismatic roughing, two strategies can be used for simulating the tools path strategies. The main difference between the strategies used in Pocketing and Prismaticroughing is the tools path direction.

Tables (3) and (4) clearly illustrate the results of roughening strategies on various geometric models by CATIA. As shown in the table, using various roughening strategies account for the discrepancies in the roughening time. Also, using End Mill and Ball Nosed tools, for each of the strategies, has had a considerable impact on reducing the roughening time for each of the geometric models.

Master CAM V9: Using Master CAM V9, machining is simulated with the aid of the Pocketing operations carried out by the software. As for Pocketing operations, this software enjoys eight tools path strategies. The results of the roughening Strategies via Master CAM V9, having been implemented on the aforementioned models, are illustrated in Tables (5) and (6).

SIMULATION

To shed more light on simulating the Pocketing operations, in Tables (3, 4, 5, 6), it is clearly shown that CATIA employs five tools path strategies and

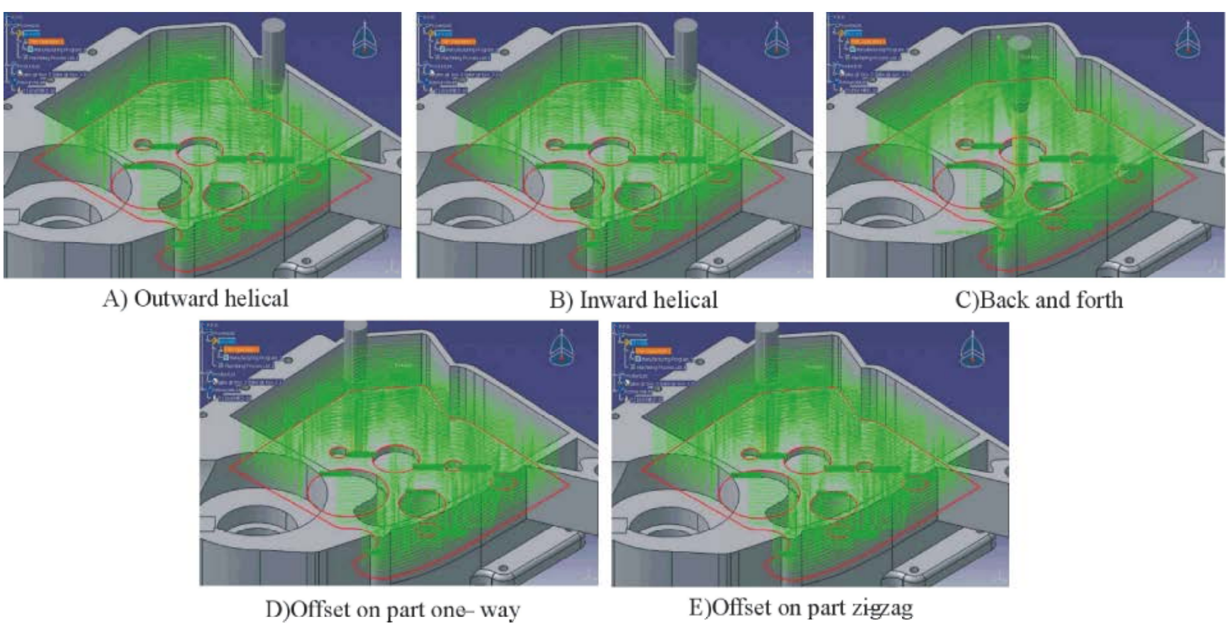

Fig. 3: Comparing tools path strategies in CATIA V5R18

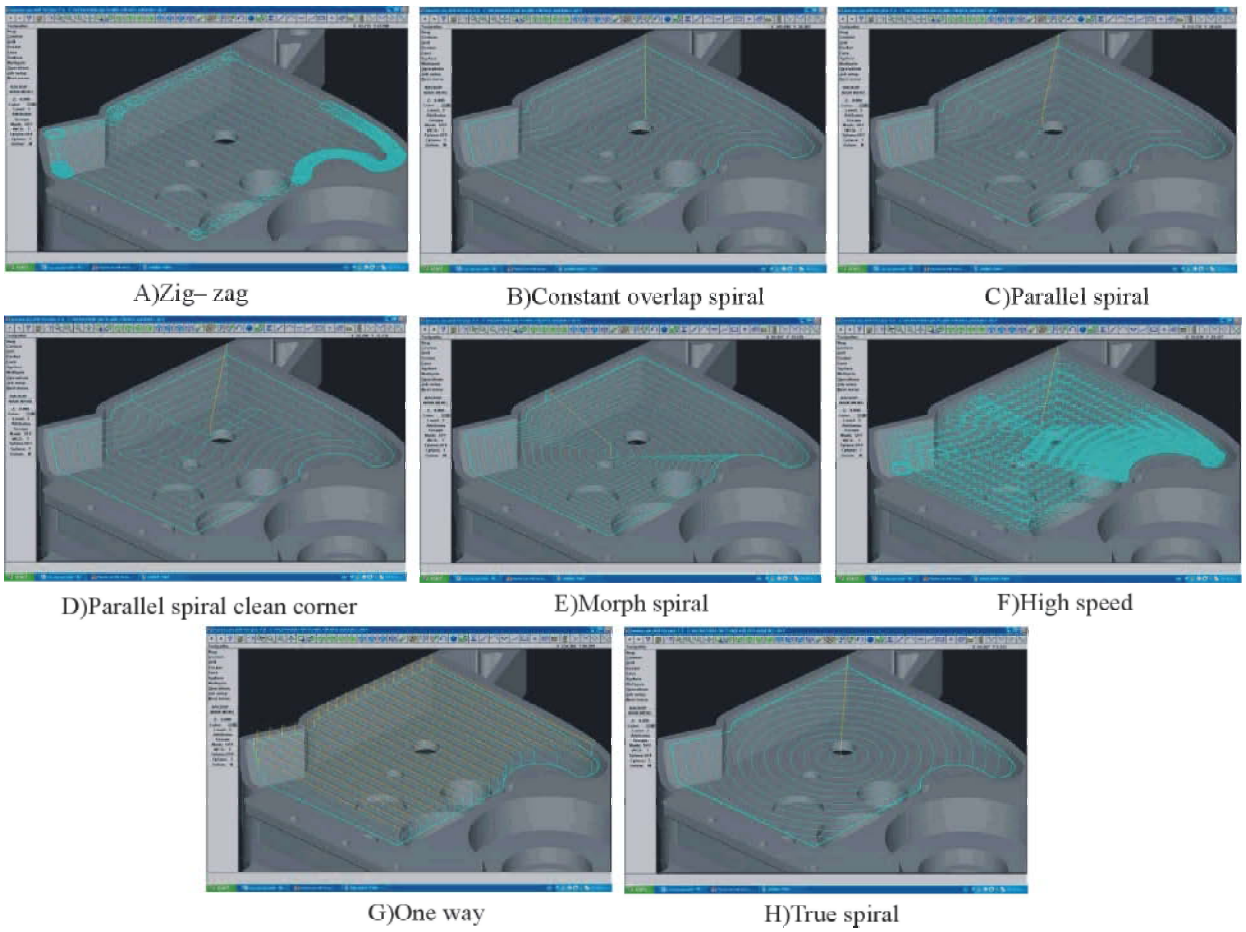

Fig. 4: Comparing tools path strategies in Master CAM V9

Master CAM, on the other hand utilizes eight tools path strategies. The selected paths consume various machining time. All tools path strategies have been simulated via the softwares. In Figure 3, the five types of tools path strategies, having been taken by CATIA, are listed and compared. And, Figure 4 elaborates on the eight types of strategies by Master CAM. As demonstrated in the figures, the differences in the strategies render significant discrepancies in the resulted tools paths.

CONCLUSION

To measure the discrepancy in the machining time of End Mill and Ball Nosed tools, one may refer to the Tables (3, 4, 5, 6). Studying Tables (3, 4), one can conclude that, as for CATIA, when back and forth strategy set, the minimum amount of time consumed was when End Mill was used. Also, when Bull Nose used, the inward helical strategy consumes the least amount of time. Studying Table 4, one can draw the conclusion that changing the geometry of the pocket does not leave any effect on the output of the software. As well as that, the least amount of time, as far as CATIA is concerned, is linked to the strategies of Back and forth and Inward Helical which are done by End Mill and Bull Nose tools.

Scrutinizing Tables (5, 6), in regard with Master CAM, one can draw the conclusion that the least amount of machining time is reached when zigzag strategy is used via End Mill. And, when Bull Nose used, Spiral Constant overlap tools path strategy has the least machining time. The significant point to heed here in connection with the Master CAM is that the machining time changes when the geometry of the object is altered. Table 5 demonstrates the importance of the matter. In table 5, the data regarding the machining time in relation with the geometry of the object is illustrated. The least machining for End Mill tools is linked to Parallel Spiral tools path strategy. And, as for Bull Nose, Constant overlap spiral consumed the least machining time.

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