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Some Aspects on Technological Design of a Cam Type Workpiece Using CATIA Software

The paper presents the geometrical models of cam and of semi-finished piece, obtained with CATIA software. Two cam technological routes are shown and the optimal route is chosen. From the technological route, rough milling operation is simulated with CATIA software. By using different milling parameters, various machining time values are obtained.

Keywords: *technological design, rough milling, CATIA.*

1. Introduction

In order to machining a workpiece on a numerical control machine tool, a manufacturing program has to be established. This manufacturing program can be done manually by the NC machine tool operator or can be achieved as a result of computer aided technological design, using a specialized software.

In the latter case, the geometrical models of semi-finished piece and of final piece have to be created [1], [2], [4]. Then, a software module for simulating the different machining processes and for generating the NC manufacturing code is used [3].

The machining time could vary, depending on different factors (type of process, workpiece material, tool material).

2. Geometrical Models of Semi-Finished Piece and of Final Piece

In order to obtain the geometrical models and to assembling them, CATIA software is used [5].

The cam profile is obtained with *Spline* command; the profile curve contains 360 control points, defined on radius, covering 360° with a step of 1°.

The geometrical models of semi-finished piece and of final piece are accomplished using *Extrude* option from *Part Design* module. The assembly of these models (fig. 1) is obtained using *Assembly Design* module.

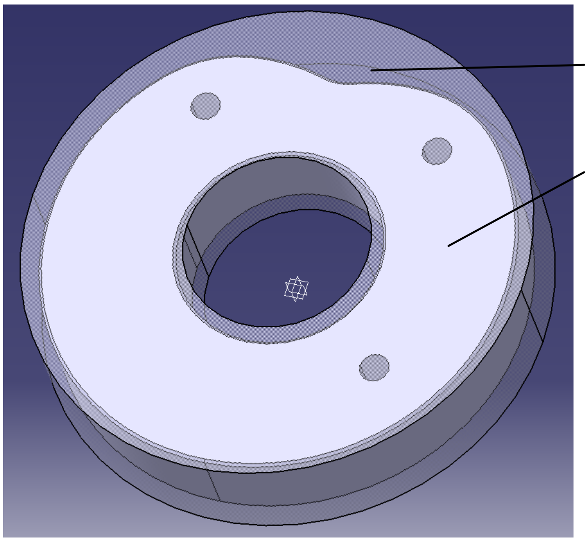

Figure 1. Assembly of semi-finished piece and of final piece.

3. Technological Route

Two variants of technological route are proposed, as shown in table 1.

Table 1. Two variants of technological route

Variant 1	Variant 2
010 – Face rough milling – clamp 1	010 – Face rough milling – clamp 1
020 – Face finish milling – clamp 1	020 – Face finish milling – clamp 1
030 – Face rough milling – clamp 2	030 – Face rough milling – clamp 2
040 – Face finish milling – clamp 2	040 – Face finish milling – clamp 2
050 – Curve following rough milling	050 – Drilling Ø77
060 – Curve following finish milling	060 – Drilling Ø11
070 – Drilling Ø77	070 – Curve following rough milling
080 – Drilling Ø11	080 – Curve following finish milling
090 – Chamfer milling – clamp 1	090 – Chamfer milling – clamp 1
100 – Chamfer milling – clamp 2	100 – Chamfer milling – clamp 2
110 – Final checking	110 – Final checking

By comparing the 2 variants of technological route, it can be observed that in the former variant, the profile milling with internal clamping is accomplished, then the drilling is done. By milling the profile first, is difficult to center the cam afterwards, in order to obtain the Ø77 reaming and the Ø11 holes.

In the latter variant, the Ø77 drilling with clamping on external cylindrical surface is accomplished, maintaining the centering of semi-finished piece. The profile milling with internal clamping in Ø77 reaming is accomplished afterwards.

Taking into account these centering aspects, the latter variant of technological route is chosen.

3. Simulation of Rough Milling Operation

From the technological route, curve following rough milling operation is analyzed (table 1, variant 2, operation 070).

Fig. 2. shows the dimensions of milling tool with 4 teeth.

Nominal diameter (D):	30mm
Corner radius (Rc):	2mm
Overall length (L):	100mm
Cutting length (Lc):	50mm
Length (l):	60mm
Body diameter (db):	30mm

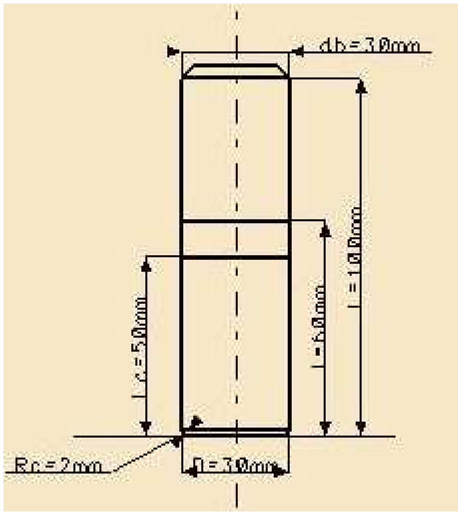

Figure 2. Dimensions of the end mill tool.

The curve followed by the end mill (fig. 3) is defined in the same way as the cam profile. On the same radius, the difference between the curve followed by the end mill and the cam is equal to the tool radius.

The milling time is difficult to be computed for complex profiles; it is provided automatically by CATIA *Machining* module as a result of simulation process.

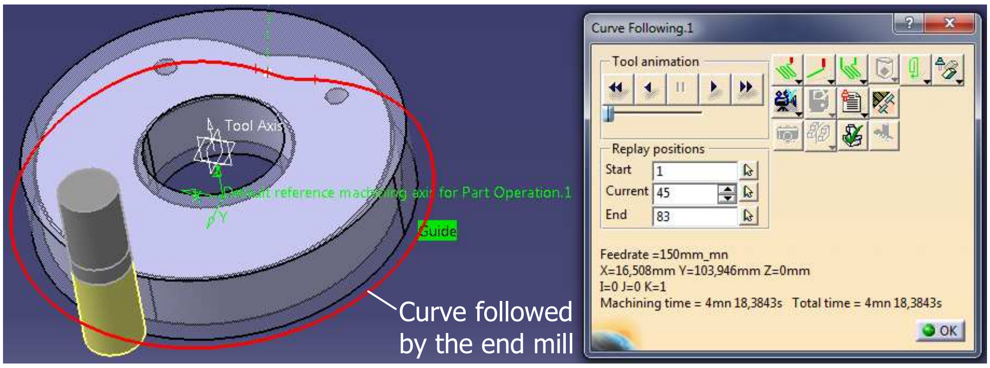

Figure 3. Simulation of rough milling operation.

The relations for milling parameters are as follows [6]:

$$f_n = z \cdot f_z, \tag{1}$$

$$v_f = n \cdot z \cdot f_z, \tag{2}$$

$$v_c = \frac{\pi \cdot D_c \cdot n}{1000}, \tag{3}$$

where: f_n - feed per revolution [mm/rev]; f_z - feed per tooth [mm]; z – number of tool teeth; v_f – cutter feed [mm/min]; v_c – cutting speed [m/min]; D_c – tool diameter [mm].

The milling parameters are shown in tables 2, 3 and 4, for spindle speed n = 140, 150 and 160 [rev/min] and for cutting speed v_c = 13,19; 14,13 and 15,07 [m/min] respectively.

Table 2. Milling parameters for spindle speed n = 140 [rev/min]

Crt. no.	Feed per tooth f_z [mm]	Feed per revolution f_n [mm/rev]	Cutter feed v_f [mm/min]	Milling time Δt [s]
1.	0,21	0,84	117,6	329,57
2.	0,23	0,92	128,8	300,91
3.	0,25	1	140	276,84
4.	0,27	1,08	151,2	256,33
5.	0,29	1,16	162,4	238,66

Table 3. Milling parameters for spindle speed n = 150 [rev/min]

Crt. no.	Feed per tooth f_z [mm]	Feed per revolution f_n [mm/rev]	Cutter feed v_f [mm/min]	Milling time Δt [s]
1.	0,21	0,84	126	307,60
2.	0,23	0,92	138	280,85
3.	0,25	1	150	258,38
4.	0,27	1,08	162	239,24
5.	0,29	1,16	174	222,75

Table 4. Milling parameters for spindle speed n = 160 [rev/min]

Crt. no.	Feed per tooth f_z [mm]	Feed per revolution f_n [mm/rev]	Cutter feed v_f [mm/min]	Milling time Δt [s]
1.	0,21	0,84	134,4	288,38
2.	0,23	0,92	147,2	263,30
3.	0,25	1	160	242,24
4.	0,27	1,08	172,8	224,29
5.	0,29	1,16	185,6	208,82

The graphical variations of cutter feed and of milling time, depending on feed per tooth, are presented in fig. 4 and 5.

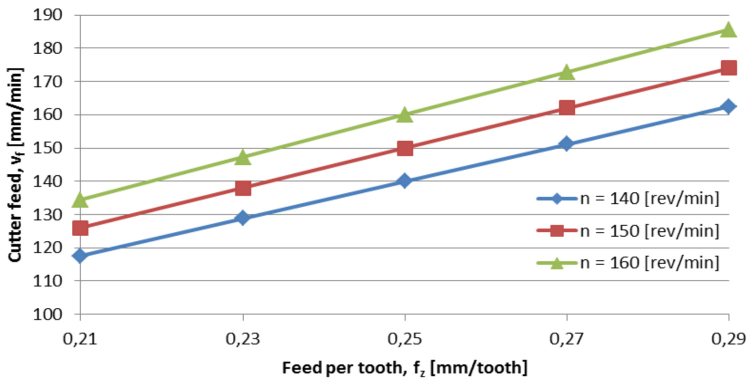

Figure 4. Cutter feed depending on feed per tooth.

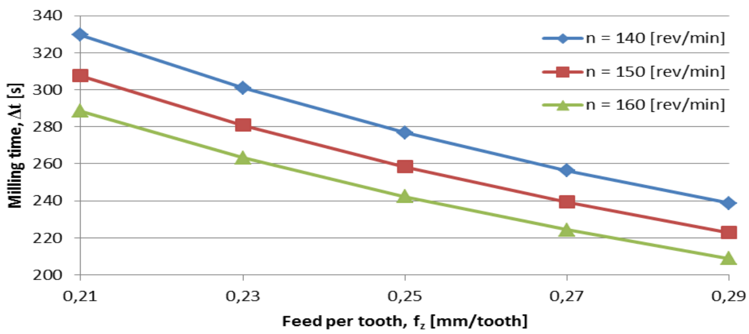

Figure 5. Milling time depending on feed per tooth.

4. Conclusions

The simulation of rough milling operation allows the determination of machining time of complex profile workpieces.

The increase of feed per tooth with 38,1% (from 0,21 to 0,29 mm/tooth, in relation to 0,21 mm/tooth) determines the decrease of milling time with 27,6% (in relation to the value of milling time corresponding to 0,21 mm/tooth) for all values of spindle speed.

By increasing the feed per tooth, i.e. cutter feed, the productivity increases but the tool wears significantly.

In order to reach a milling time with an acceptable tool wear, a feed per tooth of 0,25 [mm/tooth] and a spindle speed of 150 [rev/min] are proposed for this operation.

As further research, a statistical method (e.g. Taguchi method) could be applied for analyzing machining operations.

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