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STUDY REGARDING THE INDUSTRIAL MANUFACTURING OF THE CAMS USED IN THE DISTRIBUTION SYSTEM OF THE INTERNAL COMBUSTION ENGINES

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ABSTRACT : The paper presents a study regarding the 3D model rendering and the creation of a CNC program for processing a cam whose profile is defined in Cartesian coordinates by a law based on trigonometric and fourth degree ratios, which ensures the good functioning of the mechanism without detachments, shocks, noise or vibrations.

1 OVERVIEW ON THE MANUFACTURING OF CAMS USED FOR THE CAMSHAFTS OF THE INTERNAL COMBUSTION ENGINES

The component parts of the camshaft function in very harsh weather conditions varying from –25 °C to +700 °C, at high variable speeds, accelerations and stress depending on the engine speed. For an accurate functioning of the camshaft through the valves, research has been initiated regarding the shape and calculus of the kinematic couples, the materials and thermal treatments, the manufacturing technology, the size accuracy and surface quality in case of wear or lubrication, all these to increase its working life and reliability.

The camshaft manufacturing uses the special grey cast iron in alloy with Cr, Mo, V, Ni, Cu, nodular cast iron, high-quality carbon steel slightly alloyed with Cr, Mn, Si and sometimes Ni, the cementing carbon steel OLC 10, OLC 15, or the improvement carbon OLC 45 X, OLC 55 [2].

The cast iron semi-finished parts are obtained using the mould casting or backelit shell casting [2], and those made of iron can be processed by confined multiple-cavity die forging or pressing.

The mechanical tooling involves the following main operations: choice and processing of the base, the cam cylindrical, frontal or profiled surface lathing, adjustment and control operations.

Due to the high ratio between camshaft length and diameter, its rigidity is low, thus needing additional support with open bezels and the driving of the central or bilateral shaft.

The cams are processed using lathing, adjusting or super-finishing operations. These can be achieved by mould duplication or reference camshaft duplication on specialized machines, or duplicating semi-automated lathing machines with two slides and several blades. The lathing process involves two stages: rough cutting and finishing, using the duplication technique where the cutting tool angular position remains constant, or the oscillating blade holder duplication, if the cam height exceeds 6 mm.

The angular positioning of the camshaft as compared to the reference cam is achieved depending on the notch of the spindle on which the driving wheel is mounted, or on a hole that was made with this purpose on the cam front side.

2 3D MODELING OF THE CAM USING THE POINT PROFILE IN CARTESIAN COORDINATES

The cam solid 3D model was designed in SOLID EDGE using the Cartesian coordinates of the points defining its profile, obtained as a result of optimizing the functional performances of the D118 engine distribution system.

These coordinates are saved in a MATLAB file named G1.m, containing a three-column matrix corresponding to the x,y,z coordinates and a number of lines equal to those of the points resulted from the cam profile rendering.

In order to use these matrix elements in the SOLID EDGE program, it was required its copying from Matlab to EXCEL using the “Excel Link 2.0 for use with MATLAB” key. By the above-mentioned languages, matrices can be automatically updated with new values. The newly acquired matrix is presented in Figure 1.

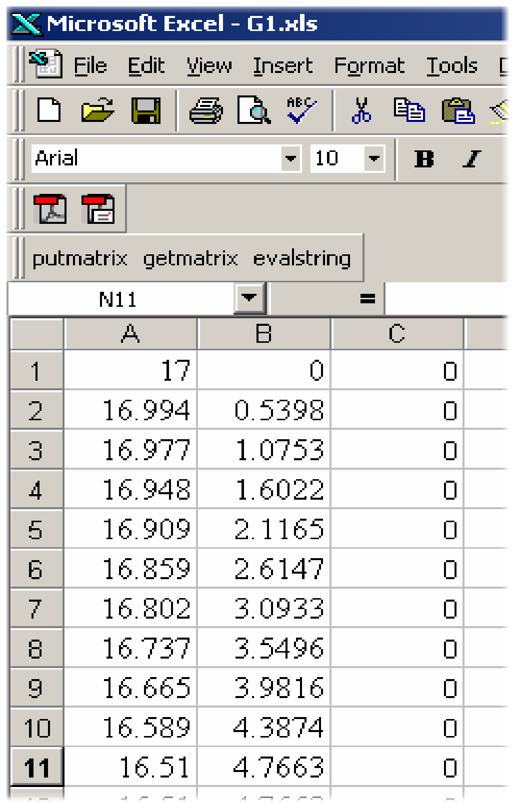


Figure 1. Matrix G1 imported in Excel program

Next, in order to obtain the cam solid model, the “curve by table” key is used from the “Part” menu of SOLID EDGE program. This key enables the curves spatial representation using their coordinates from the columns A, B, and C on the EXCEL page.

The draft in Figure 2 represents the curve that defines the cam profile in Cartesian coordinates and in SOLID EDGE program.

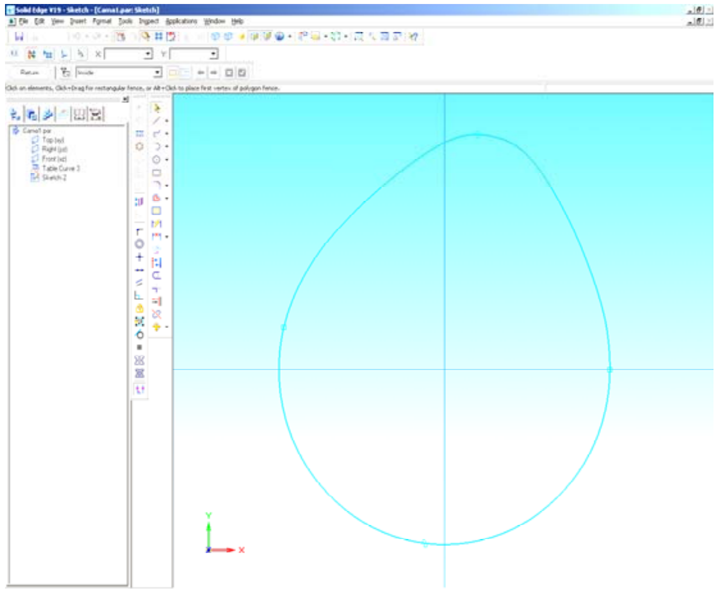


Figure 2. Cam flat profile in Cartesian coordinates, rendered in SOLID EDGE

The cam solid model is rendered pressing the "Protrusion" key. Using the "Cutout" key, it was achieved the bore preparing the assembly on the shaft, the cam fixing hole drilled between them and the notch; the side edge chamfering and the joining of the collar to the cam body was obtained pressing the "Round" key, whose values are ranging between 0,5 to 1,0 mm, as presented in Figure 3.

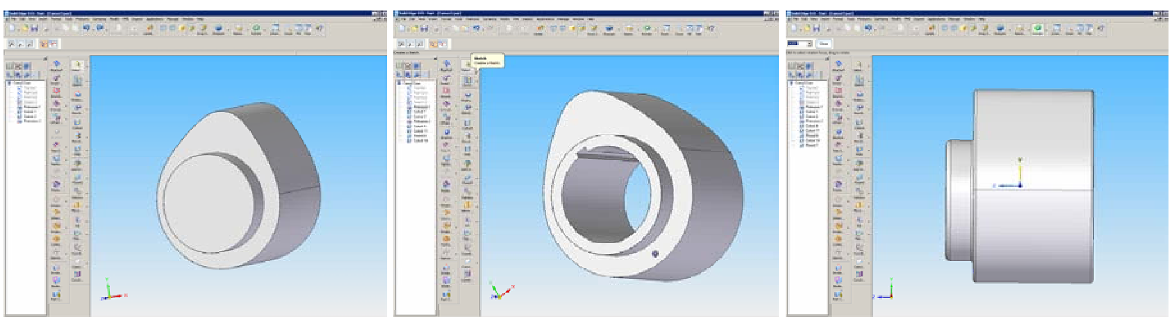


Figure 3. Solid 3D model rendering with cavities and chamfered edges of the joining radius

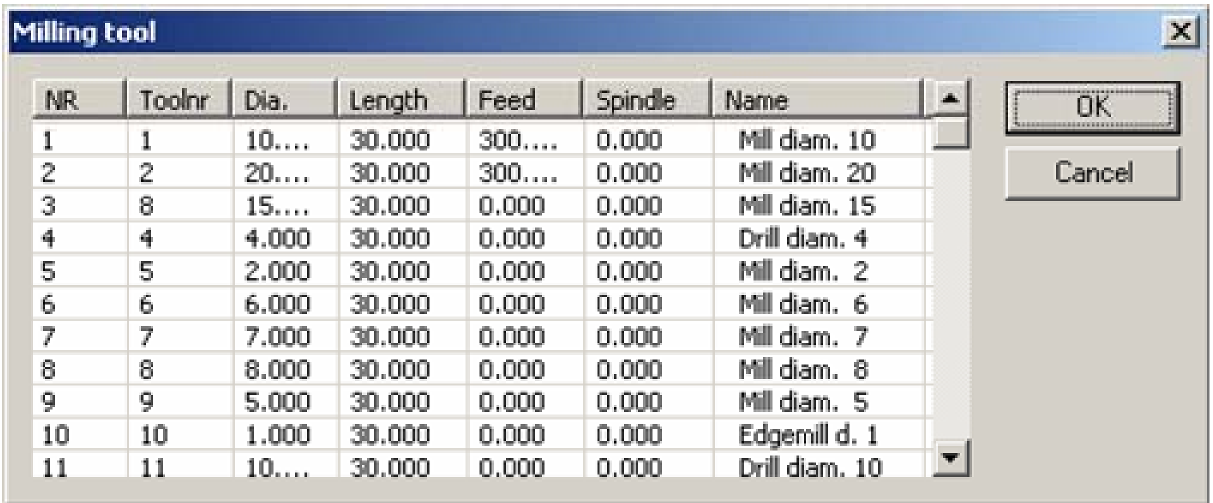
The SOLID EDGE – rendered 3D model can be used in creating the cam drawing prior to its industrial manufacturing.

3 CNC PROGRAM FOR THE CAM TOOLING ON AN AUTOMATIC NUMERICALLY CONTROLLED MACHINE

The cam mechanical processing program on an automatic numerically controlled machine involves an automatic milling machine.

The first step is the choice of the semi-finished part shape and size in order to mount it on the machine table. This is in fact a parallelepiped sized with L = 40 mm, l = 45 mm, h = 25 mm, located with its front left corner in the origin of the machine coordinate system. The origin of the part coordinate system (point 0), has the following coordinates X = 20 and Y = 19 mm, and the scale factor was chosen as equal to 1.

The tools used in the process are arranged in the tool division of the machine, in the same order as presented in Figure 4, their position being also mentioned in the CNC program


Milling tool

NR	Toolnr	Dia.	Length	Feed	Spindle	Name
1	1	10....	30.000	300....	0.000	Mill diam. 10
2	2	20....	30.000	300....	0.000	Mill diam. 20
3	8	15....	30.000	0.000	0.000	Mill diam. 15
4	4	4.000	30.000	0.000	0.000	Drill diam. 4
5	5	2.000	30.000	0.000	0.000	Mill diam. 2
6	6	6.000	30.000	0.000	0.000	Mill diam. 6
7	7	7.000	30.000	0.000	0.000	Mill diam. 7
8	8	8.000	30.000	0.000	0.000	Mill diam. 8
9	9	5.000	30.000	0.000	0.000	Mill diam. 5
10	10	1.000	30.000	0.000	0.000	Edgemill d. 1
11	11	10....	30.000	0.000	0.000	Drill diam. 10

OK
Cancel

Figure 4. Tool division of the automatic machine used for the cam processing

For the cam manufacturing, the following technological processes are executed on this machine tool:

- The two-step boring process ensuring the shaft-assembly using drills of different sizes; in this stage, the fixing is made on the exterior side of the semi-manufactured part.
- The internal milling of the cam bore; beyond this stage, the part mounting on the machine is made on the interior cylindrical surface of this bore.
- The exterior milling to roughen the cam profile.
- The front surface milling and cam collar manufacturing.
- The reference hole drilling to mount the cams on the shaft.
- The cam profile finishing.

The notch and adjustment procedures are realized using other types of machine tools but these are not the subject of this CNC program.

The CNC program is created using specific ISO CNC command codes. These are designed to choose and change the tools, the tool feed, the movement direction, and the interpolation procedure meant to determine the tool trajectory between the marked points, the switching on and off of the tool holder ax rotation and the coolant control, etc.

The points creating the cam surface profile are defined by Cartesian coordinates (x, y), and the z coordinate represents the axial feed of the material deep processing.

The CNC program validation was made by the cam processing simulation using the Free CNC Simulator Version 4.44f software of the MicroTech Systemutveckling AB company from Sweden.

The images acquired from the monitor in different moments of the simulation stages are presented in Figure 5.

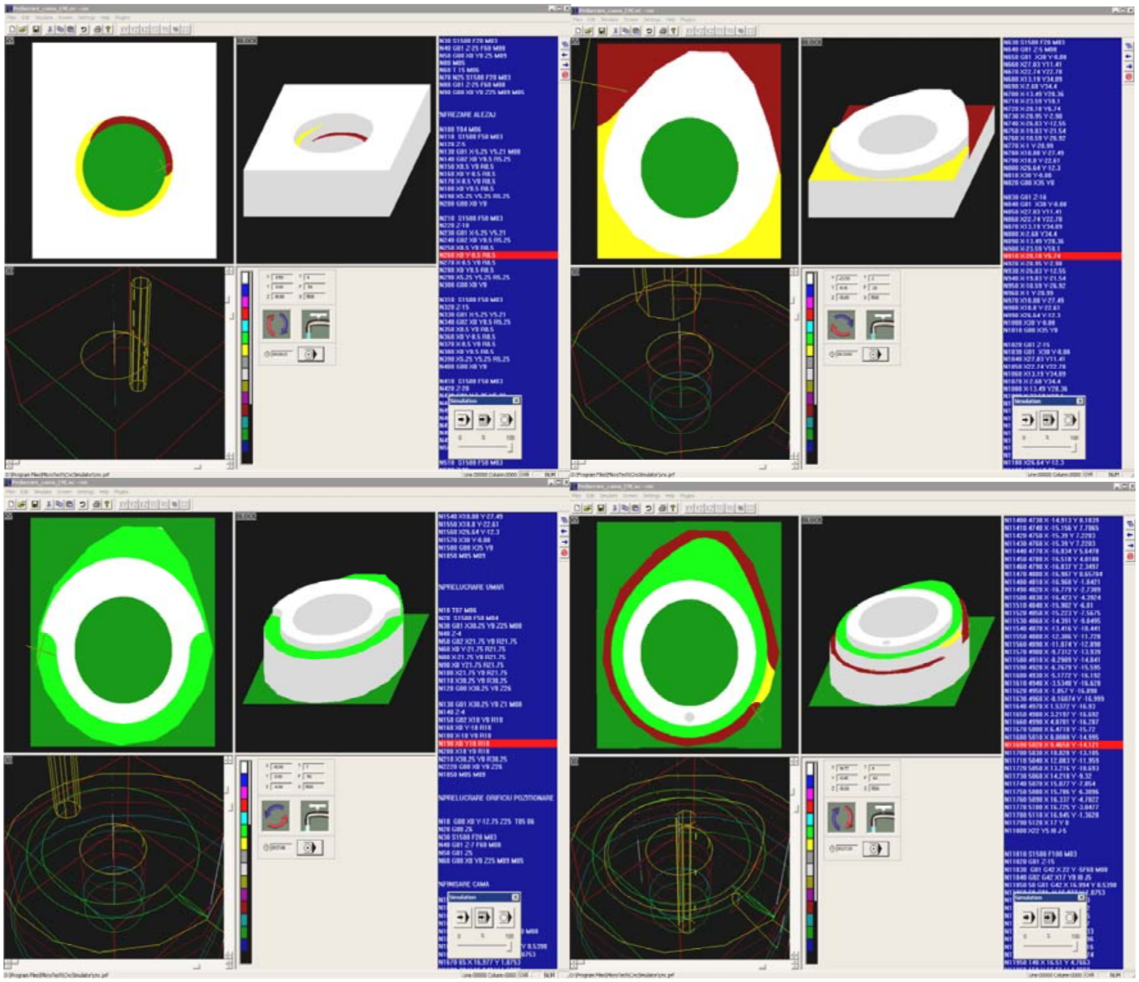


Figure 5. Cam processing simulation: a) bore milling; b) roughing milling of the cam profile; c) cam collar milling; d) finishing milling of the cam profile

4. REFERENCES

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