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## **Contributions on Computer Aided Manufacturing of Drill-Jig Bushings**

*The paper presents the steps for computer aided manufacturing (CAM) of the bushings technological class parts: design of the part in CAD software; generation of the parametrical link with MSEXcel files; extract of the useful information for the technological design (mass, volume, surfaces); setting of the CNC lathe and necessary tools; programming of the CNC code for manufacturing. Given the large variety of the bushings shapes and dimensions, the application focused on the jig bushings used in drilling processes.*

**Keywords:** CAM, CAD, jig bushings

### **1. Introduction**

The manufacturing on CNC tool-machines requires a new technological design for each new part. This process may be shorted in time if a CNC technology is designed for a class of parts. A technological class of parts has the next proprieties:

- similar shapes;
- similar dimensions;
- similar manufacturing technology;

The paper presents the steps for computer aided manufacturing of the drill-jig bushings technological class parts.

### **2. The part model**

The geometrical model of the jig bushing was created in Autodesk Inventor. The sketch with the part external profile has been revolved, a part without bore being obtaining. The bore was generated by *Hole* command and the internal chamfers with *Chamfer* command. For each dimension the soft generated a parametrical variable [3].

In order to obtain rapid generation of new parts with other dimensions/shapes the parameterized models was linked to *MSEXcel* software (figure 1) [1]. The data may be imported in Excel from the data bases, standards or electronically catalogs. The structure of the *MSEXcel* file must be the same with the structure of the table from Parameters box of *Autodesk Inventor*. This note must be taken in consideration in the import of data from the data bases.

The CAD model may be used to kinematical analyze of assemblies, to finite element analyze, to CNC code generation and also to obtain necessary information in technological design of the part. The information regarding mass and volume are shown in *iProperties* box of *Autodesk Inventor* (figure 2). For the parts with complex shape this information generates time economy and increase of calculus precision.

	A	B	C	D	E	F	G	H	I	J	K
1	Dext1	27 mm	Diametru exterior 1								
2	Dext2	20 mm	Diametru exterior 2								
3	Dext3	18 mm	Diametru exterior 3								
4	Dint	12 mm	Diametru interior								
5	L1	10 mm	Lungimea 1								
6	L2	25 mm	Lungimea 2								
7	R	0.5 mm	Raza de subtaiere								
8	Lt	1 mm	Lungimea testurii								
9											
10											
11											
12											
13											
14											
15											
16											
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**Figure 1.** The configuration of parameters table in MS Excel

The screenshot shows the *iProperties* dialog box for a part. The material is set to "Steel, Mild". The density is  $7,860E-006 \text{ (kg/(mm}^3))$  with an accuracy of "Very High". The general properties section includes: Mass: 0,073 kg; Area:  $4,595E+003 \text{ mm}^2$ ; Volume:  $9,271E+003 \text{ mm}^3$ . The center of gravity coordinates are X: -47,136 mm, Y: 21,442 mm, and Z: -51,477 mm. The inertial properties section shows Principal Moments: I1:  $10,439 \text{ kg m}^2$ , I2:  $6,373 \text{ kg m}^2$ , and I3:  $10,435 \text{ kg m}^2$ .

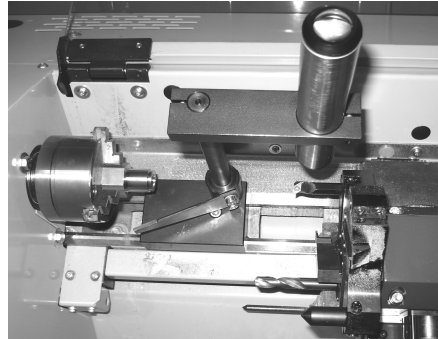
**Figure 2.** The inertial proprieties of the part

### 3. Lathe and cutting tools setting

The tool-machine (figure 3) used for manufacturing was the educational CNC lathe EC Turn 55 [4]. The numerical command of this lathe is changeable between GE Fanuc and NC Sinumerik. It was used the second alternative.



**Figure 3.** The CNC educational lathe



**Figure 4.** The optical device for tools preset

The lathe has two axis numerical controlled (Z and X). The rates of spindle and feed are programmed also. The automatically change of the tools is assured by the turret head which has eight workholders (four internal / four external).

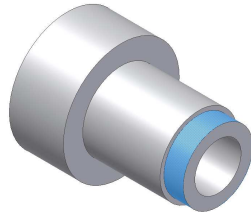
The clamping of parts and cutting tools is made manually. For parts correct positioning is necessary to have a clean surface which will be coplanar with the right surface of the headstock flange.

An optical device (figure 4) allows the tools positioning. Each tool tip is brought in the center of ZX axis from the optical device. The offset distance between the coordinates of a reference tool and the coordinates of the cutting tools are measured and imported into CNC soft. Those offset distances are so called "tools corrections". The setting order of the tools must take into consideration the workspaces of the machine, tools, and parts.

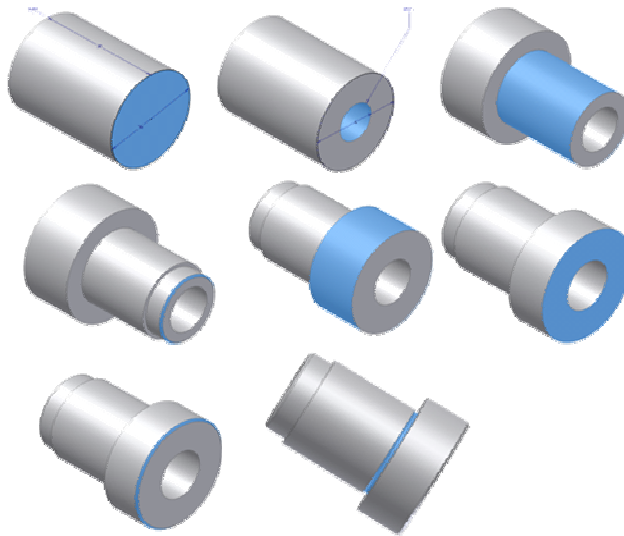
#### **4. CNC programming**

The CNC code was created line by line following the manufacturing phases (figure 6). Due to parts clamping positions was necessary to create two subprograms. Each subprogram has one or more manufacturing cycle. After the generation of the code the cycles have been validated by a simulation on CNC soft. In order to reduce de manufacturing time, two types of programs have been studied: work in relative coordinates and in absolute coordinates. Figure 5 show the program sequence for external turning from  $\varnothing 20$  to  $\varnothing 18$ .

**N0780 S1500 M03 F0.05**  
**N0790 G00 Z200**  
**N0800 T02 D01 M06**  
**N0810 G01 X19.5 -**  
**N0820 Z77.5**  
**N0830 G00 X22 Z83**  
**N0840 G01 X19**  
**N0850 Z77.5**  
**N0860 G00 X22 Z83**  
**N0870 G01 X18.5**  
**N0880 Z77.5**  
**N0890 G00 X22 Z83**  
**N0900 G01 X18**  
**N0910 Z77.5**  
**N0920 G00 X22 Z80**



**Figure 5.** Program cycle



**Figure 6.** Manufacturing steps

The selected technology is not valid for long bushings (length/diameter>10) where a deep-hole drilling is necessary.

## 5. Conclusion

After the experimental validation of the steps presented in this paper the following conclusions emerged:

- The optical device used for setting the cutting tools may induce important errors. In order to reduce errors is recommended to have the same human operator for tools preset;
- If in the manufacturing process is necessary only a clamping position of the part the work in relative coordinates is optimum;

The research will be continued with generation of the CNC code in specialized software and validation on the machine.

## References

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