

VIRTUAL MANUFACTURING OF CLASSIC EXTERNAL GENEVA MECHANISM

Iulian STANASEL¹, Florin BLAGA²

¹University of Oradea, stanasel@uoradea.ro

² University of Oradea, fblaga@uoradea.o

Abstract—Starting from the known relations, the paper presents the design and implementation of digital manufacturing using an integrated virtual prototype CAD_CAE_CAM. After determining the numerical values for the dimensions of the elements which compose the Geneva mechanism, the data are used in the CAD application in order to make 3D models. So, the obtained model is transferred to the CAM module that performs the tool paths. After post-processing the data, it is obtained the CNC program for the implementation on a machine tool with iTNC 530 Heidenhain equipment.

Keywords—Geneva mechanism, virtual model, postprocess.

I. INTRODUCTION

GENEVA mechanism is used as a mechanism for transforming rotary motion into intermittent motion running with acceleration jumps at the beginning and the end of the active phases [1]. The mechanism provides a precise positioning movement and its blockage, which makes it usable in many areas [2].

Synthesis of mechanism aims to determine the size and number of channels constructive established by different coefficients and in function of acting time [3].

This paper proposes a design method for classical Geneva mechanism by using CAD CAE CAM integrated applications.

For the known input data have been determined dimensional values of the elements, which compound up the mechanism. Then they were used in order to achieve the 3D models. Knowing the loads and speed coach, CAE modules were used also to determine stresses and deflections and kinematic parameters. Following validation of the virtual prototype it has passed to the next stage, the virtual manufacturing. It has been exemplified the wheel processing mechanism by CAM module and then the post-processing and CNC program implementation on iTNC 530 Heidenhain equipment.

II. THEORETICAL ASPECTS

Geneva mechanism (Fig. 1) consists of, the crank (1) and the wheel (2), which has several slots. Movement is

transmitted from the crank to the wheel through the bolt (3), which keeps moving the wheel (2) until the exit from the slot.

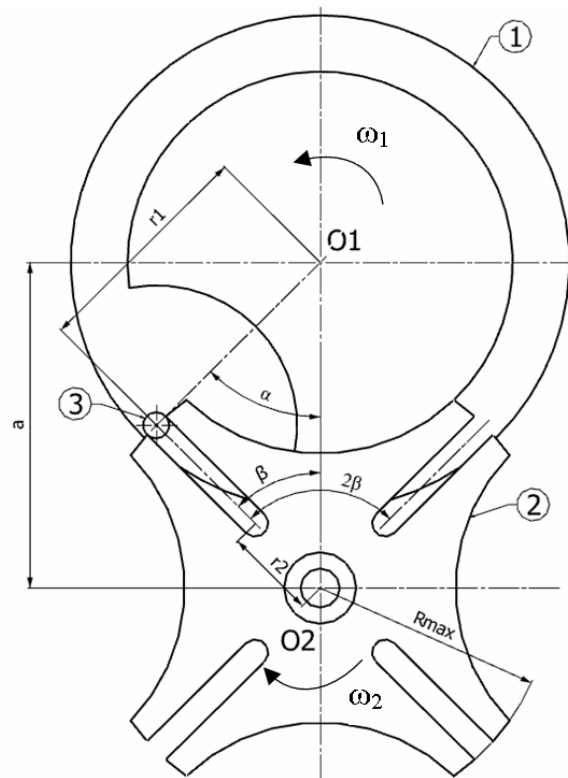


Fig. 1. xternal Geneva mechanism.

By turning the crank (1) with an active angle 2α the Geneva wheel (2) rotates with an angular step determined by the relation:

$$2\beta = \frac{2\pi}{z} \quad (1)$$

where z is the number of channels from the wheel.

The active rotation angle of the crank expressed depending on the number of slots is:

$$2\alpha = \pi \left(1 - \frac{2}{z} \right) \quad (2)$$

For constructive dimensioning of the crank and driven element is considered as known the distance between axes "a". Radius "r₁" described by roller centre (3) is given by:

$$r_1 = a \sin\left(\frac{\pi}{z}\right) \quad (3)$$

It is determined the radius r₂ of bottom of slots.

$$r_2 = a \left(1 - \sin\frac{\pi}{z}\right) \quad (4)$$

Also from Fig. 1 can be determined the maximum radius of Geneva wheel (R_{max}):

$$R_{\max} = a \sin\left(\frac{\pi}{2} - \frac{\pi}{z}\right) \quad (5)$$

III. COMPUTER AIDED DESIGN OF GENEVA MECHANISM

The term „virtual manufacturing” began to be used in the early 1990s. Over time it has consolidated the utilization and it has developed its field of application scope as a result of continue increase of hardware and software performances. The continuous growth of manufacturers of virtual manufacturing systems has led to continuous decrease of acquisition costs, allowing companies to purchase advanced systems for manufacturing.

Virtual manufacturing involves getting virtual 3D model of a product and its behavior simulation and later then the manufacturing processes [4]. Simulations enable companies to optimize various factors to reduce production costs while increasing the life cycle of the product.

For the studied Geneva mechanism has been considered known the data presented in table I. By using the previous relationships were obtained the results from table II.

TABLE I
INITIAL DATA FOR GENEVA MECHANISM

Initial data		
Center distance [mm]	a	100
Number of roller of the crank	n	1
Number of slots	z	4
Speed of crank (rot/min)	n ₁	100

The data from table II were used for the 3D modeling of the mechanism elements, respectively the wheel and the crank.

Assembly modeling assumes making each component separately and then their positioning within the assembly.

Making a 3D model of a component starts with making a basic sketch in one of the reference planes. In the Fig. 2 is illustrated the basic sketch for the construction of the wheel.

TABLE II
CALCULATED DATA FOR GENEVA MECHANISM

Calculated data		
<i>Wheel</i>		
Angle between slots (radians)	β	0.785398
External radius of wheel [mm]	R _{max}	92.38795
Minimum radius of the slot [mm]	r ₂	60
<i>Crank</i>		
Active angle of crank (radians)	α	1.178097
Active angle of crank (degree)	α	67.5
Radius described by roller centre [mm]	r ₁	38.26834
Angular velocity of the crank (rad/sec)	ω ₁	1.047198

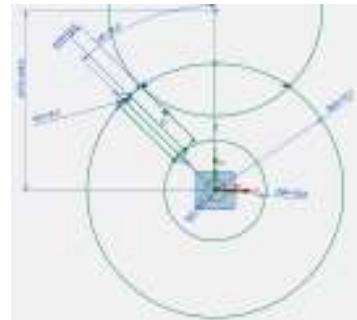


Fig. 2. The sketch of the Geneva wheel.

By using "Extrude" command is obtained the model from Fig. 3.

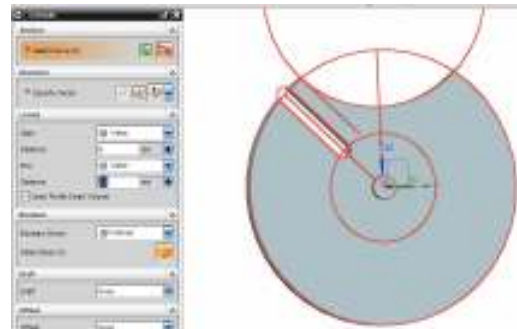


Fig. 3. The result of the "Extrude" command.

Multiplication of wheel channels is realized by "Pattern feature" command Fig. 4.

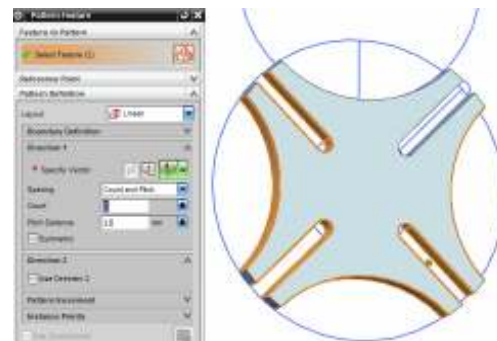


Fig. 4. The 3D model of the Geneva wheel.

You can proceed in a similar way to realize the 3D model of the crank. When performing basic sketch, the familiar elements are taken from the crank.

Following extrusion operation is obtained the 3D model of the crank (Fig. 5).



Fig. 5. The 3D model of the crank.

By using commands of specific positioning is achieved 3D model of the assembled Geneva mechanism (Fig. 6).



Fig. 6. The 3d model of the Geneva mechanism.

Using the facilities of the "Motion simulation" they can be graphically plot the changes of velocity (Fig. 7) and the angular displacement of the driven element regarding on time (Fig. 8).

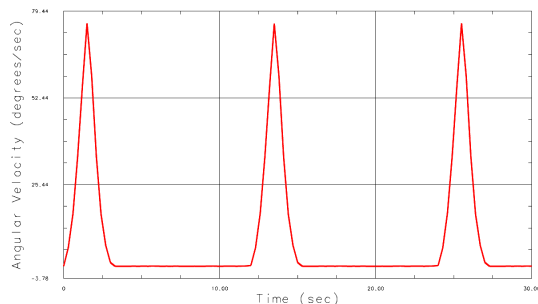


Fig. 7. Angular velocity vs. time of Geneva wheel.

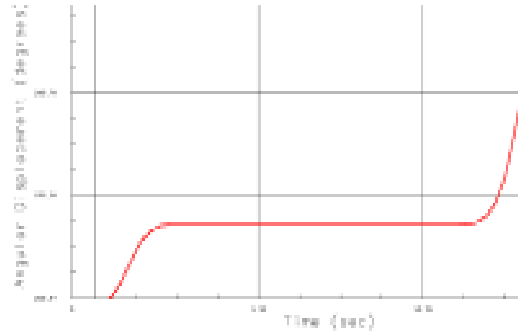


Fig. 8. Angular displacement vs. time of Geneva wheel.

IV. COMPUTER AIDED MANUFACTURING OF GENEVA MECHANISM

Computer Aided Manufacturing represents the next step in virtual manufacturing. The 3D model of the part designed in CAD system is taken over and processed in order to obtain the CNC software necessary to implement on the real processing machine. The CAM system is a system for planning, controlling the CNC machining operations, in order to increase the flexibility of production, to increase productivity and provide the products at a minimum cost and high quality [5].

In this paper it is exemplified the processing of Geneva wheel.

In the first step is established the work-piece origin, then is set the final geometry of the part and the blank (Fig. 9).

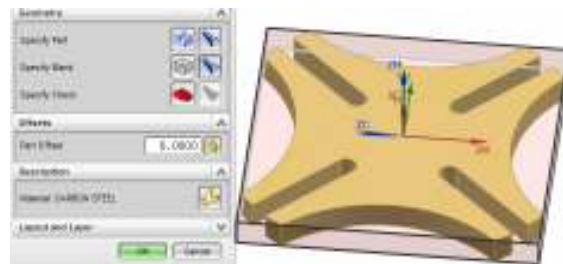


Fig. 9. The WCS the work-piece and blank geometry.

It creates virtual cutting tools, which will be used for processing and then is chosen the appropriate machining operation (Fig. 10).

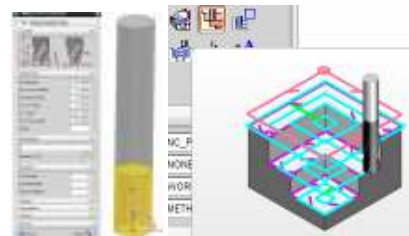


Fig. 10. The tool and the operation for contouring the wheel.

The contour machining operation is carried out with an end mill with 30 mm diameter, the tool path being presented in Fig. 11.

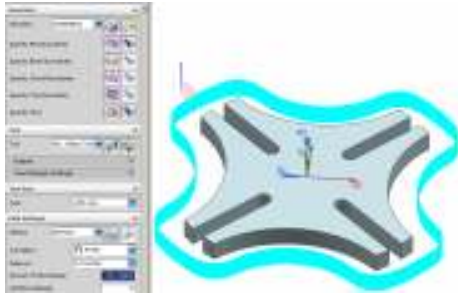


Fig. 11. The tool path for contouring.

For milling radial channels operation it is used an end mill with 6 mm diameter, the tool path being shown in Fig. 12.

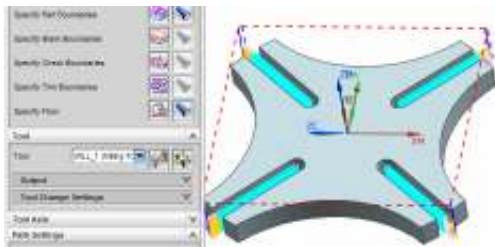


Fig. 12. The tool path for channels milling.

Post-processing was done for Heidenhain iTNC 530 equipment.

In Fig. 13 is presented contouring operation [6].

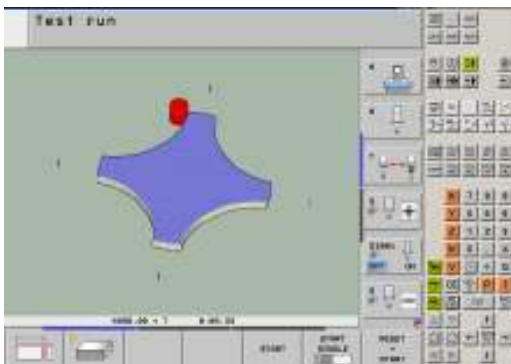


Fig. 13. The contouring operation on iTNC 530.

In Fig. 14 is presented the milling operation for radial channels of the Geneva wheel on equipment Heidenhain iTNC 530.

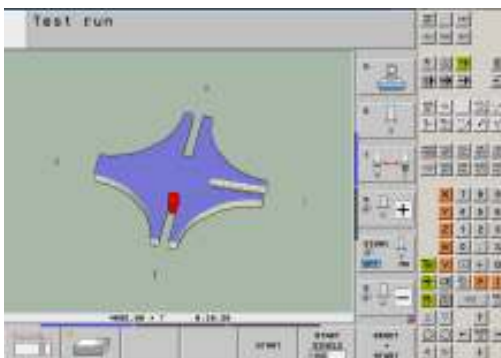


Fig. 14. The radial channels milling on iTNC 530.

A small fragment of CNC program is shown in Fig. 15.

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0 BEGIN PGM Wheel_7_1 MM
1 BLK FORM 0.1 Z X-73 Y-73 Z-8
2 BLK FORM 0.2 X+73 Y+73 Z+0
3 TOOL CALL 15 Z S2000 F500
4 L Z+100 R0 FMAX M3
5 L X+72.5 Y+0 RL F500
6 L Z-8
7 CC X+0 Y+0
8 C X+72.5 Y+0 DR-
9 L X+90
10 L Z+100 R0
11 L X+0 Y+0 R0 FMAX
12 TOOL CALL 7 Z S1000 F500
13 L Z+100 R0 FMAX M3
14 L X+80.03 Y+31.74 RL
15 L Z-8
16 CC X+100 Y+0
17 C X+80.03 Y+31.74 DR+
18 L X+80.03 Y+44.43 RL F500
19 L Z-8
20 CC X+100 Y+0
21 C X+80.03 Y-44.43 DR+
22 L Z+50 F500
23 L X+31.95 Y-80.36 RL
24 L Z-8
25 CC X+0 Y-100
26 C X-31.95 Y-80.36
27 L X+44.58 Y-80.36 RL
28 L Z-8
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Fig. 15. A CNC fragment from iTNC 530 Heidenhain.

V. CONCLUSION

- taking into account the presented relationships it was created a computer program to determine the geometric parameters of Geneva mechanism elements.
- the determined data were used for computer-aided design of the crank and wheel of Geneva mechanism using NX CAD module.
- by using adequate relationships was made Geneva mechanism.
- it was performed Computer aided manufacturing of virtual prototype of the Geneva wheel with NX CAM module
- It was verified the CNC program obtained by postprocessing on Heidenhain iTNC 530 equipment .

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