PARAMETER MODELLING OF GEARS

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ABSTRACT
*In this paper, the results of the research of three-dimensional (3D) parameter modelling of different types of standard catalogue gears using CATIA V5 software system. Gears modelling by computers are based on geometric and perspective transformation which is not more detail examined in the paper because of their large scope. Parameter modelling application makes possible the control of created 3D gear model through previous defined parameter which is based on relations and geometric constraints (parallelism, perpendicular, etc.). The final shape of gear changes by changing of values of characteristic independent changeable parameters, and that makes possible model creation in short time. Obtained 3D gear model from CATIA V5 system is used as the base for technical documentation making, analysis of stress and deformation by **F**inite **E**lement **M**ethod (FEM), generating of NC/CNC programs for production of the parts on machine (CAM/NC), **R**apid **P**rototyping (RP), etc. Final taking into consideration shows that functionality of parameter associatively must obligatory apply in interaction with traditional geometric modelling approach that appears until now. Modelling methodology and functionality that is described by selected examples can be used in any category of industry and in any process.*
Keywords: parameter modelling, CAD/CAM/CAE system, CATIA V5

1. INTRODUCTION

CATIA V5 (*Computer-Aided Three-dimensional Interactive Application*) is the product of the highest technological level and represents standard in the scope of designing [1,2]. Instantaneously, it is the most modern integrated CAD/CAM/CAE software system that can be find on the market for commercial use and scientific-research work. The biggest and well-known world companies and their subcontractors use them. It is the most spread in the car industry (Daimler Chrysler, VW, BMW, Audi, Renault, Peugeot, Citroen, etc.), airplane industry (Airbus, Boeing, etc.), and production of machinery and industry of consumer goods. In the „heart" of the system is the integrated associational data structure for parameter modelling, which makes possible the fact that the changes on model reflects through all related phases of the product development. In that way, time needed for handmade models remodelling cancels. The system makes possible all geometric objects parametering, including solids, surfaces, wireframe models and constructive elements. [3,4,5] To obtain the maximum during the work with CATIA V5 system, optimized certified hardware configurations are recommended [6].

2. MODELLING OF GEARS

In addition is shown modelling of characteristic standard catalogue gears: spur gear, bevel gear and worm. It is possible to do a control of gear geometry by use of tools palette *Knowledge*. Gears modelling were done in *Sketcher*, *Part Design* and *Generative Shape Design* modules of CATIA V5 system. As prerequisite for this way of modelling, it is necessary to know modelling methodology in the following CATIA V5 modules, too: *Wireframe and Surface Design* and *Assembly Design*. [7,8] Parameter marks and conventional formulas (Table 1.) which were used in gear modelling can be

found in literal quotation [9] (pgs. 139, 154-155, 160-161). Clear explanations for particular gears can be found in literal quotation [10] (pgs. 54-106, 118-135, 135-151).

Table 1. Parameters and formulas

Spur gear	Bevel gear	Worm
z	$z1$, $z2$	$z1 = 1$
m		$m = 1,5$
$a = 20$ deg		
$p = m * PI$		
$r = (z * m) / 2$	$r = (z1 * m) / 2$	$d = 20$ mm
$rb = r * \cos(a)$	$rb = rc * \cos(a)$	
$rf = r - 1.2 * m$		
$ra = r + m$		$ra = d / 2 + ha$
$rr = 0.38 * m$		
$ha = m$		
$hf = 1.2 * m$		
$xd = rb * (\cos(t * PI) + \sin(t * PI) * t * PI)$		$N = 6,5$
$yd = rb * (\sin(t * PI) - \cos(t * PI) * t * PI)$		$L = (N + 1) * p$
$0 \leq t \leq 1$		$gama = a\tan(m * z1 / d)$
	$delta = a\tan(z1 / z2)$	$dZ = -L / 2$
	$rc = r / \cos(delta)$	
	$lc = rc / \sin(delta)$	
	$tc = -a\tan(\text{Re}\,lations \setminus yd.Evaluate(a / 180\deg) / \text{Re}\,lations \setminus xd.Evaluate(a / 180\deg))$	
	$b = 0.3 * rc$	
	ratio=1-b/lc/cos(delta)	
	$dZ = 0$ mm	

2.1. Spur gears parameter modelling

Spur gear geometry is in the function of few fixed parameters: cog number z, module m and line of contact angle a. We can, changing parameters z and m, generate every spur gear. In Figure 1., three different standard catalogue spur gears got from the same CATIA V5 file, changing parameters m and z, are show.

Table 2. Selected spur gears parameters

Part Number	m	z	d_g	d	b_z	b_g	b_k	t_k
G2-20	2	20	30	15	20	35	5	2,35
G3-40	3	40	60	25	30	50	8	3,34
G4-60	4	60	120	30	40	60	10	3,34
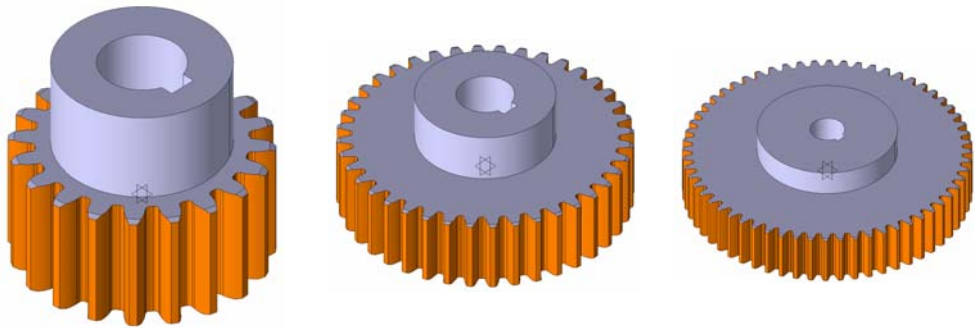
1° G2-20

($m = 2$ mm, $z = 20$)

2° G3-40

($m = 3$ mm, $z = 40$)

3° G4-60
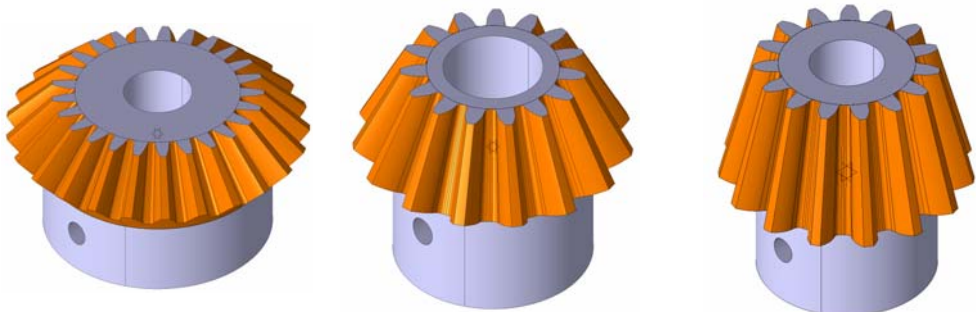
($m = 4$ mm, $z = 60$)

Figure 1. Different spur gears are the result of parameter modelling

2.2. Bevel gears parameter modelling

We can, changing parameters z and m, generate every bevel gear. In Figure 2., three different standard catalogue bevel gears got from the same CATIA V5 file, changing parameters m and z, are shown.

Table 3. Selected bevel gears parameters

Part Number	m	z_1	z_2	d_g	d	b_z	b_g	Connection between hub and shaft
B2-25	2	25	25	40	12	10,6	25,52	M5
DB3-15	3	15	30	36	18	17	36,26	M6
FB4-15	4	15	60	48	20	34	59,9	M8

1° B2-25

($m = 2$ mm, $z_1 = 25$, $z_2 = 25$)

2° DB3-15

($m = 3$ mm, $z_1 = 15$, $z_2 = 30$)

3° FB4-15

($m = 4$ mm, $z_1 = 15$, $z_2 = 60$)

Figure 2. Different bevel gears are the result of parameter modelling

2.3. Worms parameter modelling

We can, changing parameters m, z_1 and N, generate every worm. In the Figure 3., three different standard catalogue worms got from the same CATIA V5 file, changing parameters m, z_1 and N, are shown.

Table 4. Selected worms parameters

Part Number	m	z_1	d_g	d	L	L_g	Connection between hub and shaft
W1,5-1	1,5	1	23	10	35	45	M5
W2,5-2	2,5	2	35	15	45	60	M6
W3-3	3	3	41	20	55	70	M8

1° W1,5-1
($m = 1,5$ mm, $z_1 = 1$, $N = 6,5$)

2° W2,5-2
($m = 2,5$ mm, $z_1 = 2$, $N = 5$)

3° W3-3
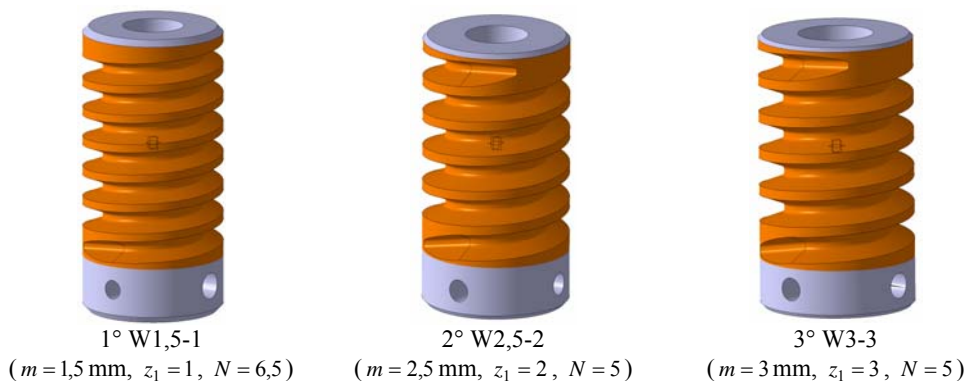($m = 3$ mm, $z_1 = 3$, $N = 5$)

Figure 3. Different worms are the result of parameter modelling

3. ANALYSIS OF THE RESEARCH RESULTS AND FINAL DISCUSSION

Parts which are not suitable for interactive modelling are modelled parameter. While geometric gear modelling in CATIA V5 system, we do not have to create shape directly, but, instead of that, we can put parameters integrated in geometric and/or dimensional constraints. We get resulted 3D solid gear model by characteristic parameters changing. In this way, designer can generate more alternative designing samples, concentrating his attention on design functional aspects, without consideration of details of elements of shape. Time used for designing is reduced for 50%, by parameter modelling application and focusing on preparation phase. Direct financial effects can be seen in reducing of production costs, and that is the result of increase production. In that way, better profit and price of products are lower. We can conclude that CATIA V5 system offers possibility of creating of geometric associatively defined by relations made between parameters. This type of functionality makes possible flexibility and, certainly, it could be used in combination with traditional geometric modeling approach.

4. REFERENCES

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