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PARAMETERIZED MODEL OF A CYLINDER JACKET FOR A SLIDE-VALVE DISTRIBUTION

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Abstract: The rotating jacket is the main component of a four-stroke engine with distribution system through slide-valves. This has a crown gear on the bottom which transfers the movement from the crankshaft a through gear system. At the top, two rectangular windows, for distribution, diametrically opposed, are applied. In order to reduce weight, in the crown gear, holes are made, serving at the same time, for the passage of lubrication oil. Since the engine on which will be implemented such a distribution system is still in prototype stage, building the distribution jacket requires a special attention. Thus, for choosing the optimal size, a study in virtual environment is required.
Keywords: Rotating jacket; distribution; parameter; modeling.

1. INTRODUCTION

The parameterized model of distribution jacket is necessary, to study its behavior during operation, when wall thickness and type of material are changing. With such a 3D model, simulations can be done in several versions, with different cylinder assembly plays, such as: for different materials (iron and steel) to investigate their influence on the play and wear and with different thicknesses to see the resistance to thermo-mechanical loads. During operation, the distribution jacket expands in the window area, thereby the sealing is achieved. Simulations in virtual environment can determine the optimal size of construction and eliminate loss of material by obtaining a single physical model.

The article presents methods for modeling parameterized the rotating distribution jacket, using specialized software such as CATIA. To obtain the 3D model data taken from measurements on four-stroke engine with distribution through windows were used, engine which is still in prototype stage.

2. CONTENT

Rotating shirt distribution will consist of two parts that will be assembled by threading. First, the crown gear is necessary to rotate the jacket through the distribution system consisting of gears. The second piece is actually the jacket which has in the upper part, two windows of distribution.

For the crown gear the profile and flanks line equations are parameterized defined parameter**.** In our case the profile is involute and the line is a segment of a straight line. The crown gear is corresponding to a spur gear, a component of a parallel cylindrical involute spur gears (STAS 12222-84 and STAS 12224-84).

For representation the body and the sidewall of the wheel, were used equations that contain the following basic parameters: 1) *alpha* - reference pressure angle (degrees); 2) m - module (mm); 3) $p = m\cdot\pi$ - reference pitch; 4) $h_a = m$- tooth head height (mm); 5) $h_f = 1.25\cdot m$ height of the tooth foot (mm); 6) $r_p = m\cdot z/2$ - radius of division circle (mm); 7) $r_a = r_p + m$ - head circle radius (mm); 8) $r_f = r_p - h_f$ - foot circle radius (mm); 9) $r_b = r_p\cdot\cos(alfa)$ - base circle radius; 10) $r_c = 0.38\cdot m$ - foot circle radius of connection to the tooth; 11) t - running parameter ($0 \le t \le 1$).

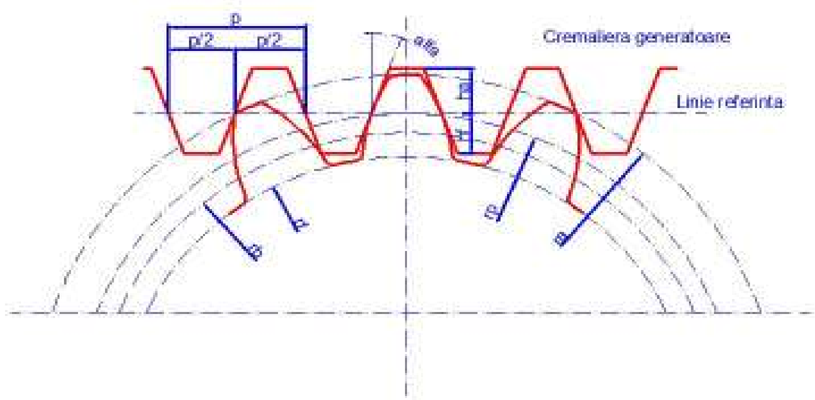


Figure 1: Parameters of cylindrical gears with involute profile

The parametric equations of tooth-profile are:

1) $y_d = r_b \cdot (\sin(t \cdot \pi) - \cos(t \cdot \pi) \cdot t \cdot \pi)$;

2) $z_d = r_b \cdot (\sin(t \cdot \pi) + \cos(t \cdot \pi) \cdot t \cdot \pi)$.

To define the parameters „*alpha*”, „*m*”, and „*z*”, with the „*New Parameter of type*” command, for each the type and the value is established: for „*alpha*” the type is angle, for „*m*” is „*Length*” and for „*z*” we use „*Integer*”.

Tracing the parametric laws for the involute profile is given by the formulas defined by the Cartesian positions of pairs of points (y_d, z_d) located on the sidewall profile.

It is noted that all other parameters (p, h_a, r_p, r_a, r_f, r_b, r_c,) depend on at least one of the three parameters from the specification tree. Are defined by formulas and automatically calculated the parameters: r_p, r_a, r_b, r_f and r_c.

$r_p = m \cdot z / 2$

$r_a = r_p + m$

$r_b = r_p \cdot \cos\alpha$

$r_f = r_p - 1{,}25 \cdot m$

$r_c = 0{,}38 \cdot m$

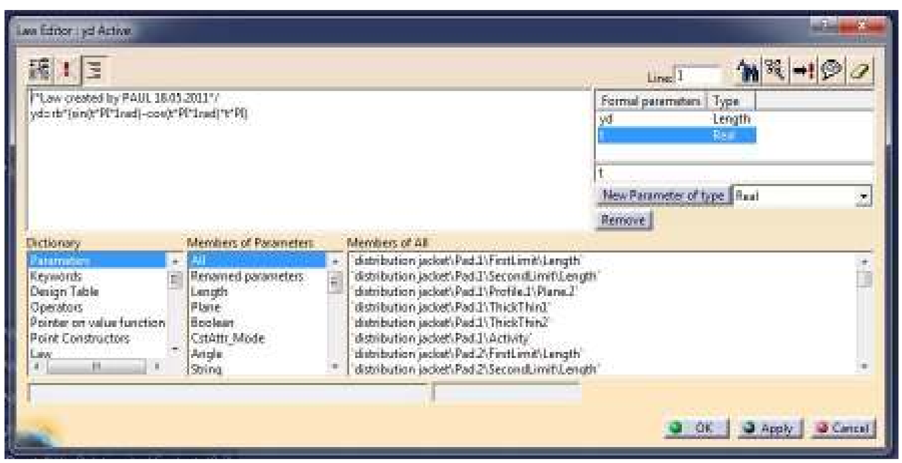


Figure 2: Coordinate y_d equation

Cartesian formulas that define positions of pairs of points (y_d, z_d) of the sidewall profile are introduced. In the two parametric equations the item „*1rad*” is seen because the trigonometric functions *sin* and *cos* arguments require angular values, not numbers, and *PI* = π. For geometric construction a geometric body will be used, created in the module „*Catia Generative Shape Design*” , which will be called „ *wheel body*”. In the YZ plane are positioned six points using the tool, „*Point*”. The first point is the origin and will have the coordinates X, Y, Z equal to 0. Beside the origin another five points are added, the position of each one is defined by the parametric laws $y_d(t)$ and $z_d(t)$, where t takes successive values 0, 0.1, 0.2, 0.3, 0.4 and the X coordinate is equal to 0.

Origin – (0; 0; 0)

Point 1 – $(0; y_d(0); z_d(0))$

Point 2 – $(0; y_d(0.1); z_d(0.1))$

Point 3 – $(0; y_d(0.2); z_d(0.2))$

Point 4 – $(0; y_d(0.3); z_d(0.3))$

Point 5 – (0; y_d(0.4); z_d(0.4))

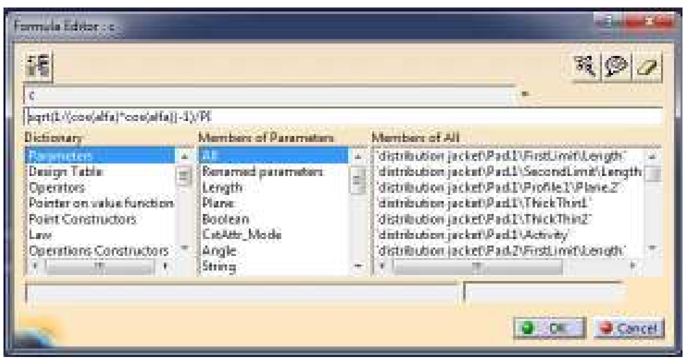
To determine the coordinates Y, Z, formulas,„*Relations\\$y_d$.Evaluate(t)*”, respectively „*Relations\\$z_d$.Evaluate(t)*” are inserted into the menu „*Formula Editor*”, where „*t*” take successively the values presented above. The five points will have similar formulas, but different, to establish horizontal, respectively, vertical coordinates in the YZ plane.

wheel body\Point.1\Y=Relations\\$y_d$.Evaluate(0) si *wheel body\Point.1\Y=Relations\\$z_d$.Evaluate(0)*
wheel body\Point.1\Y=Relations\\$y_d$.Evaluate(0.1) si *wheel body\Point.1\Y=Relations\\$z_d$.Evaluate(0.1)*
wheel body\Point.1\Y=Relations\\$y_d$.Evaluate(0.2) si *wheel body\Point.1\Y=Relations\\$z_d$.Evaluate(0.2)*
wheel body\Point.1\Y=Relations\\$y_d$.Evaluate(0.3) si *wheel body\Point.1\Y=Relations\\$z_d$.Evaluate(0.3)*
wheel body\Point.1\Y=Relations\\$y_d$.Evaluate(0.4) si *wheel body\Point.1\Y=Relations\\$z_d$.Evaluate(0.4)*

Next, through the points defined above, a curve, „*spline*” will be drawn. As the tooth is considered to be represented symmetrical to the plane ZX, in the next stage a rotation of the tooth flank profile relative to the plan is done. To calculate the angle of rotation, first must be determined the position of a point on the involute on the circle of division, considered parameter, with the formula *c = sqrt(1/cos(alfa)^2-1)/PI*. The „*phi*” rotation angle, is calculated, using a formula depended on the parametric laws $y_d(c)$ si $z_d(c)$:

phi = atan(y_d(c)/z_d(c))+90deg/z
phi = atan(Relations\\$y_d$.Evaluate(c) / Relations\\$z_d$.Evaluate(c)) + 90deg / z

The rotation is performed around the X axis and the angle of rotation is determined by a formula in which is considered equal to „phi”:
wheel body\Rotate.1\Angle = phi



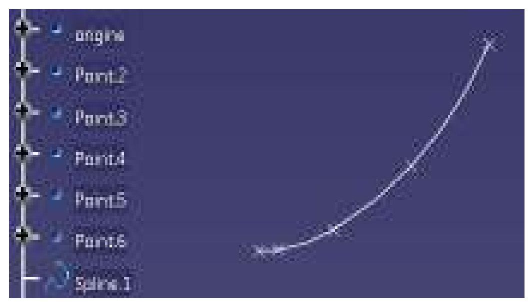


Figure 3: „*c*” parameter calculation

Figure 4: The „*spline*” and the points

Next, the circle of the head and foot are drawn, with r_a and r_f, previously defined by formulas, as radius.
wheel body\Circle.1\Radius = r_f – foot circle
wheel body \Circle.2\Radius = r_a – head circle

The next tooth profile will also have an identical connection. Thus, the first connection will be copied by symmetry to a plan created at an angle to the plane ZX. This angle is determined by the number of teeth „*z*” of the wheel:

Plane.1:
Plane Type – Angle/Normal to plane;
Rotation Axis – X;
Reference – ZX
Angle – wheel body\Plane.1\Angle = 180deg / z.

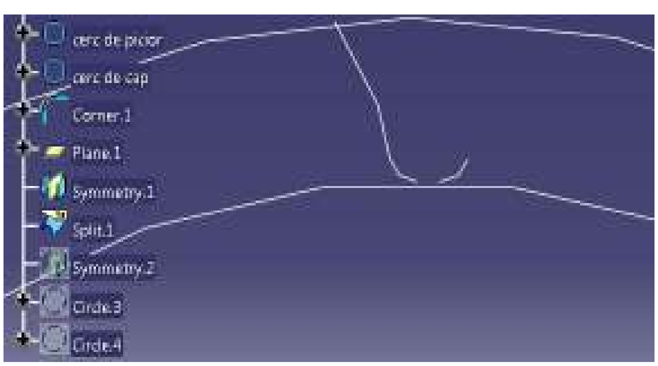


Figure 5: Head and foot circles with connections

Angle value is calculated automatically in real time, when the number of teeth of the wheel is changed. Sidewall profile exceeds the two circles, head and foot, requiring editing with the „*Split*” tool, on the „*Operations*” bar.

The second sidewall profile is symmetrical with the ZX plane and can be obtained by using the „*Symmetry*” instrument. Once the copy operation by symmetry is done, the two circles (head and foot) are hidden using „*Hide/Show*” option from the context menu „*Circle.1*” si „*Circle.2*”. Next the radius r_f is traced.

The next operation is to join all created elements using the instrument „*Join*”. Getting the crown wheel is achieved by inserting the item „*Join.1*” in a circular array. Of course, the number of clones (copies) on the circumference of the wheel depends on the number of teeth „*z*” of it:

wheel body\CircPattern.1\AngularNumber = z

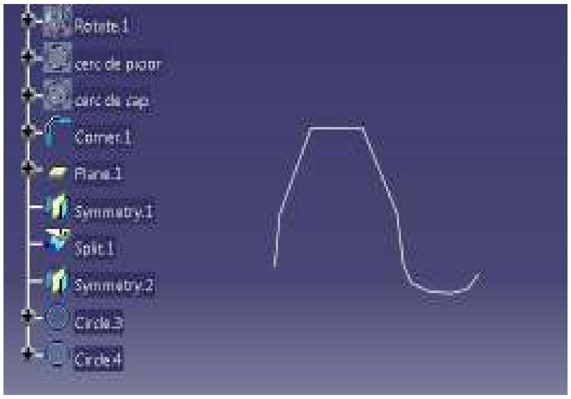


Figure 6: Joining the teeth elements

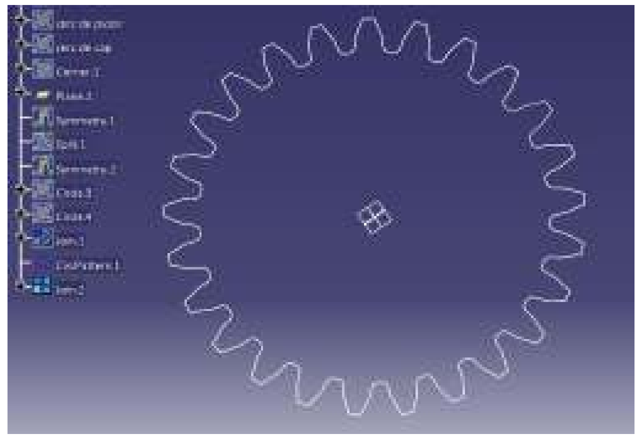


Figure 7: 2D profile of the crown wheel

The „*Complete Crown*” option was chosen and the X axis as a reference for circular replication. Again using the tool „*Join*” elements „*CircPattern.1*” and „*Join.1*” are united to create the final 2D profile of cylindrical gears. Using the tool„*Pad*” from the „*Catia Part Design*” module, Catia Part Design", the 3D model of the wheel is obtained.

Obtaining relief holes, which at the same time have the role of lubrication is achieved by arranging „*Hole.2*” item in a circular array. Of course, the holes are dependent on the „*r*” and „*n*”, parameters, added in the specification tree:

distribution jacket\Hole.2\Diameter = $2 \cdot r$

distribution jacket\CircPattern.2\AngularNumber = n

The length of the distribution jacket can be dependent on the „*L*” parameter, but in our case is not necessary, because the thickness and material are those covered in the simulations in virtual environment. To obtain an efficient control of thickness parameters „R_e” and „R_i”, were introduced, which actually define the outer and inner diameters of the distribution jacket.

distribution jacket\Sketch.1\Radius.7\Radius = R_e

distribution jacket\Sketch.1\Radius.3\Radius = R_i

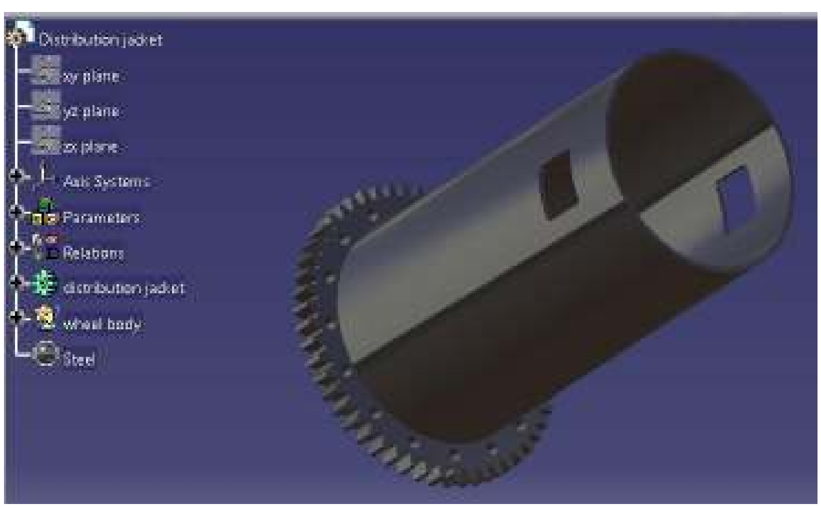


Figure 8:The 3D model of the distribution jacket

Distribution windows, which are placed on top, do not require parametric modeling because their size was achieved as a result of previous calculations accurate, and the change in thickness of the rotating jacket does not affect their position.

3. CONCLUSION

The rotating jacket is a component of the gas distribution system for a four-stroke engine, which is still in prototype stage. Its construction requires a precise calculation, given the conditions imposed during operation. This has an important role for cylinder sealing and gas exchange. During the operation, due to increased temperature of burned gases, the jacket will expand on top and the play between it and the cylinder becomes minimal. Parameterized 3D Model is needed to facilitate simulations in virtual environment, from which one can obtain important data on rotating jacket behavior during operation.

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