

AUTODESK INVENTOR APPLICATION – MODELING OF A TYPE T1 DIFFERENTIAL TORSEN

Abstract: This paper aims to make the presentation of steps in order to achieve a 3D model of Torsen differential T1 and the presentation of the necessary stages for the functioning gears with the help of the Autodesk Inventor 2015 application to better understand the functioning of this type of differential.

Key words: Autodesk Inventor, simulation, Torsen differential, gears

INTRODUCTION

The role of the differential is to enable the motor driving the wheels arranged on the same axle, with different angular speeds, if the vehicle is traveling in curves, the wheels inside and those outside of the turn having passed through different paths. Structurally, it comprises a planetary gear system, enabling different speed motors driving the wheels [1].

2. PRESENTATION OF THE DIFFERENTIAL TORSEN

Torsen is a term that derives from the phrase "torque sensitive" (which "feels" torque, torque-sensitive) expression that describes the operation of the system itself. This is part of limited slip differentials category - L.S.D. (Limited Slip Differential).

The quality and the performance of the differential is to react immediately to any torque imbalance emerged between the two wheels, directing the torque to the wheel with high adherence.

These types of LSD sites have so called "multiplier report" of the torque, generally with values of 1:4 or 1:5. This means, if a torque of 30 N·m is directed to the wheel with least grip, the LSD will instantly direct a torque of approximately 120 N·m or 150 N·m at the wheel with better grip, i.e. 4 or 5 times higher than the minimum torque on the low adhesion wheel [2].

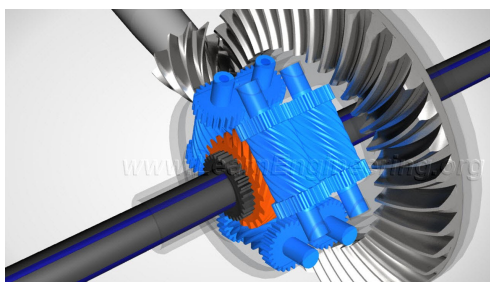


Fig. 1 Torsen differential used as a model [3]

For sports cars, limited slip differential is spectacular on roads with corners successions, because it allows accelerating much earlier and more intense. Enthusiast drivers claim that after the fitting of LSD they felt like they were sitting at the steering wheel of a four-wheel drive vehicle [4].

The Torsen differential is a real mechanical gem, being constituted of three groups of gears formed from helical pinions and pinions with straight teeth. At the Torsen differential, the two driven wheels are connected by helical transmission. They limit high differential speeds, ensuring the necessary equilibrium at completing the corners [5].

3. THE TORSEN DIFFERENTIAL MODELING

The differential shaping started off with the Figure 1, there was chosen the representation of a Torsen differential mounted on the rear axle of a car.

Differential modeling was performed using Autodesk Inventor in Assembly Mode and in the beginning the pinion's planetary gear generation was performed using the Spur Gear command, the necessary data for the gear's carrying and for the generated model from the order are shown in the Figure 2.

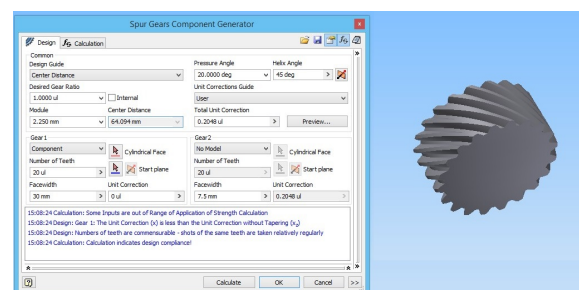


Fig. 2 The planetary pinion

The generation of the helical pinion

To generate the pinion, there was used the same command as in the case of the planetary gear, and the modeling data are presented in Figure 3.

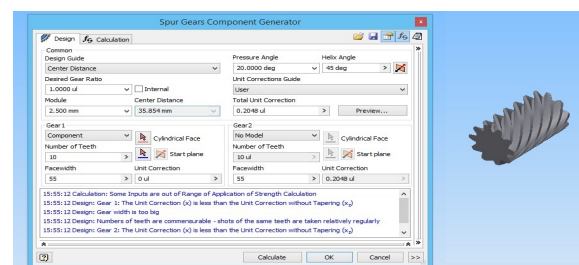


Fig. 3 The helical gear

After generating the helical gear, the planetary gear was edited, based on a circle with a diameter of 15 mm, extruded with the Cut command. Similarly, it has been done with the helical gear, Figure 4.

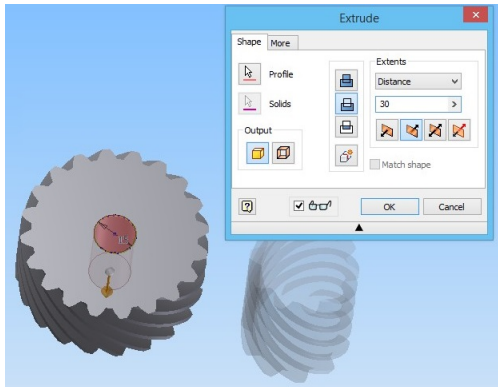


Fig. 4 The execution of the sprocket bore

3.1 Making constraints for fixing the piece

- A projection plane of origin was chosen and it was made visible with right click (the plane of origin is always fixed);
- Using the Constrain command one side of the planetary gear was selected and then the chosen plane was selected.

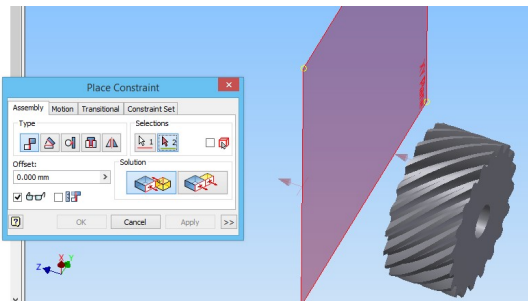


Fig. 5 The pinion's constraint on a principal plan

- The axis from the piece's center was designed with the help of the Axis command;
- The axis from the toolbar was right clicked and the Grounded command was checked.

The piece was fixed, allowing it the freedom to rotate around the central axis.

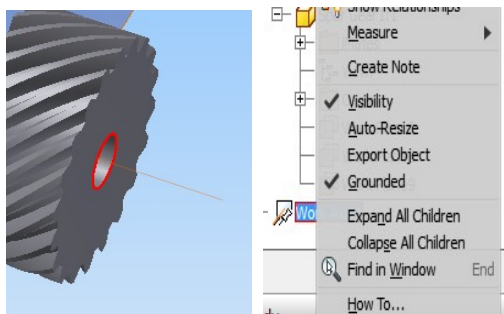


Fig. 6 The design of the central axis and its fixing

3.2 The helical pinion's settlement and coercion

In the planetary pinion's center was created a plane with the help of the Plane command.

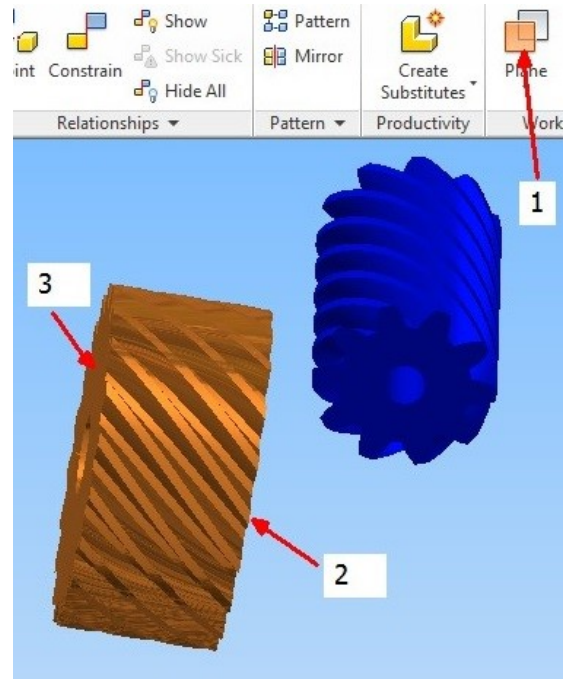


Fig. 7 Creating the central plane of the planetary pinion

The central axis of the helical pinion was constrained on the plane thus created.

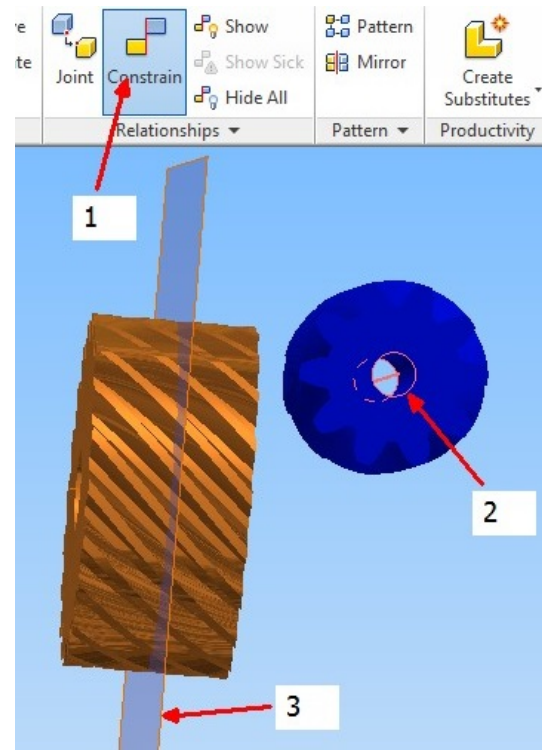


Fig. 8 The constraint of the central axis of the helical pinion on the central plane of the planetary pinion

Using the Plane command there was created a parallel plane at the offset of 40 mm from the planetary pinion's horizontal plane.

With the help of the Constrain command, the helical gear's axis was constrained on this plane as well.

After positioning the component, with the help of the Plane command, the side planes were created. These two planes were constrained with the help of the Grounded command. The created planes have been made invisible, see Figure 9.

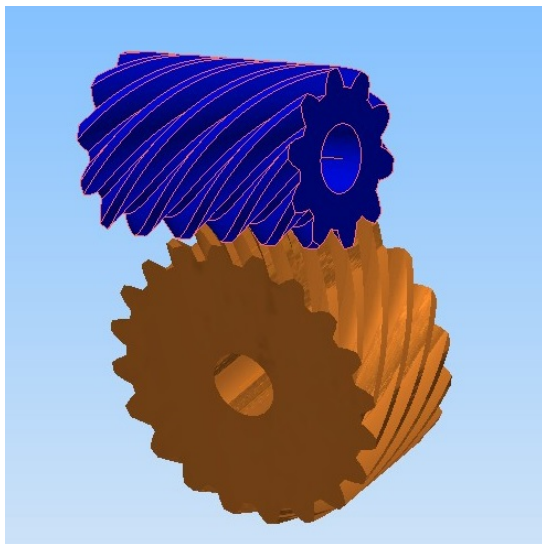


Fig. 9 The mutual positioning of the sprockets

3.3 The multiplying of the helical gears

Using the Pattern command, the other two helical gears were generated, following the next steps:

1. Select the Pattern command;
2. Select the Circular mode;
3. Select the Component button;
4. Select the helical gear;
5. Change the number of pieces;
6. Change the piece's angle to 120° ;
7. Select the Circular reference button;
8. Select the planetary pinion's centre, Figure 10.

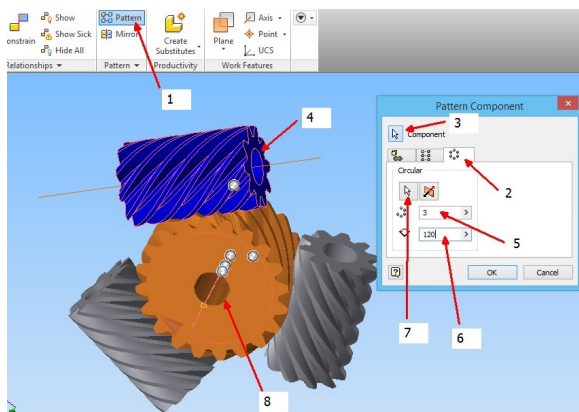


Fig. 10 The generation of the helical gears

3.4 The generation of the symmetrical components

A plane has been created at a distance of 10 mm from one side of the planetary pinion, Figure 11.

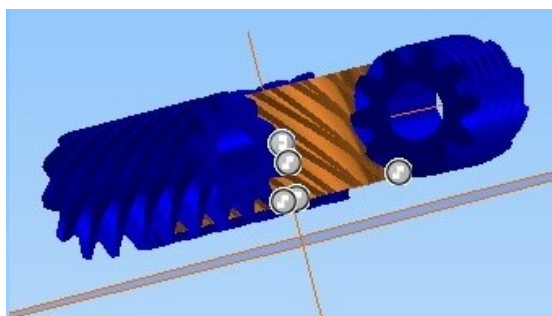


Fig. 11 The creation of the symmetry plane

For the symmetrical parts generation, the Mirror command has been used, following the sequence of commands:

1. Select the Mirror command;
2. From the commands window, select the Components button;
3. Select the 4 pieces;
4. Select the Mirror Plane button;
5. Select the created plane.

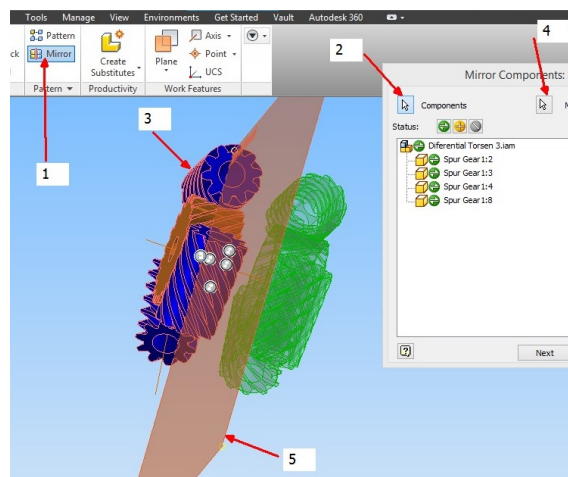


Fig. 12 The generation of the symmetrical parts

Following this command, the pieces from the mirror were automatically forced to reference parts, needing only the positioning and the generation of the symmetrical parts. All the constraints created automatically were subsequently removed.

3.5 The fixing of all the components in order to operate the gear

After generating the symmetrical components, all the part's axes have been designed, see Figure 13. The pieces were already positioned correctly and with the help of the Plane command, the sided planes of the helical sprockets were created (these planes were modelled on the faces of the gears, so they were actually glued to the pieces), figure 14.

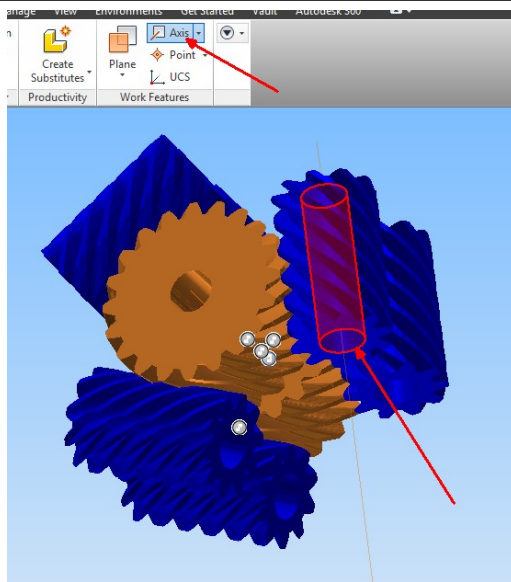


Fig. 13 The designing of the axes with the help of the Axis command

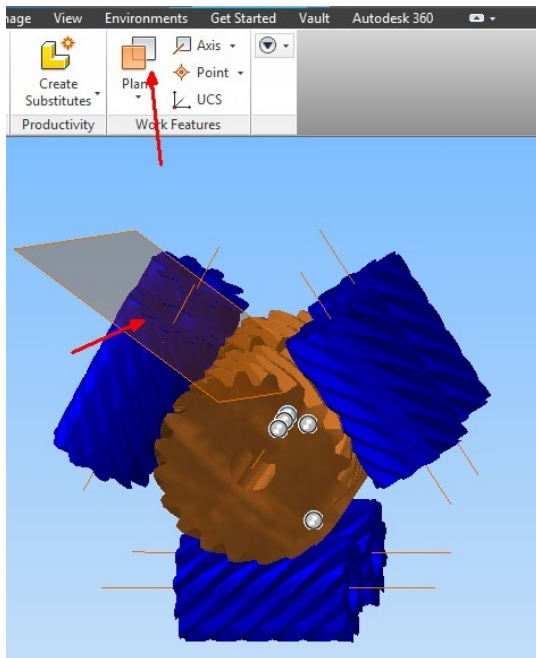


Fig. 14 The sided planes of the helical sprockets

With the help of the Constrain command, the sprockets faces were forced on the created planes, Figure 15. Following the constraints, if the pieces were to be moved, you could see that the pieces were moving along with the planes, that's why the Grounded command was applied to each plane.

Similarly, it has been proceed with the part's axes.

The final result was the total compulsion, all the pieces having a single degree of freedom, the rotation around their own axes.

The pieces are rotating individually and with the help of the Constrain command their engagement phases are defined, Figure 16:

1. Select the Constrain command;
2. Select the constraint mode Motion;
3. Select the direction of rotation;
4. Select the profile of a helical pinion's tooth;
5. Select the profile of a planetary pinion's tooth.

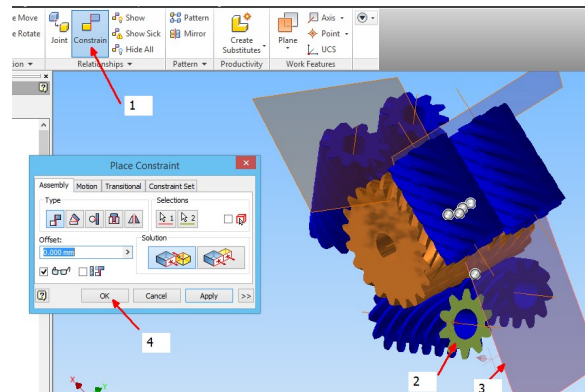


Fig. 15 The sprockets faces constrained on the waxed planes

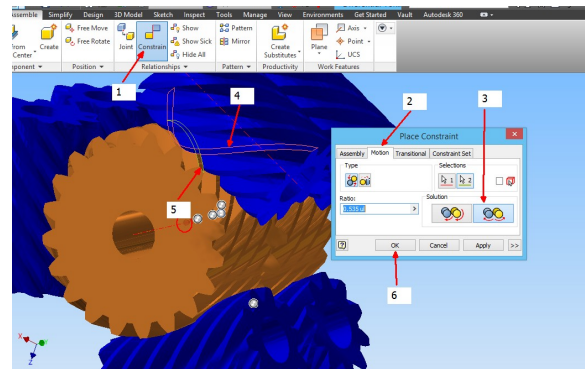


Fig. 16 The defining of the gearing mode of the planetary gear with the helical pinion

The same way is proceed with the other gears, the ratio between the two gears being calculated automatically, in some cases the placement of the sign being necessary before the calculated report.

3.6 Straight denture gears shaping which links the helical gears

To model the gears with straight teeth, the Spur Gear command was used, Figure 17.

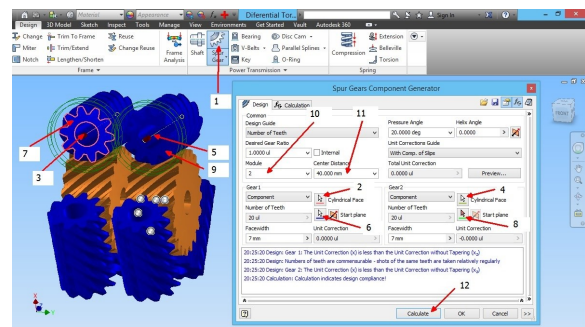


Fig. 17 Straight toothed gears modelling

1. Access the Spur Gear command;
2. Select the Cylindrical Face Gear 1 button;
3. Select the central axis of the first pinion;
4. Select the cylindrical Face Gear 2 button;
5. Select the central axis of the pinion 2;
6. Select the Start Plane Gear 1 button;
7. Select the face of the first pinion;
8. Select the Start plane Gear 2 button;
9. Select the pinion's face 2;
10. Modify the module;
11. The automatic calculation of the distance between axles.

This command was only used to perform the computation and the shape of a toothed gear, the command's results automatic constraints which were troubling, the rotation's direction being unwanted and the toothed gears engaging couldn't be created at the same time with the helical gears so everything that had been worked was saved until then (to stay saved for the straight toothed gear and being able to further use the toothed gear). After saving, the straight-toothed gear has been deleted. With the help of the Place command, from the document in which all the components of the entire assembly were saved, there was placed only one of the gear's wheels.

With the Copy command the toothed gear was multiplied 12 times. The 12 wheels were positioned with the help of the Constrain Command and were then forced to rotate at the same time with the helical gears, Fig. 18.

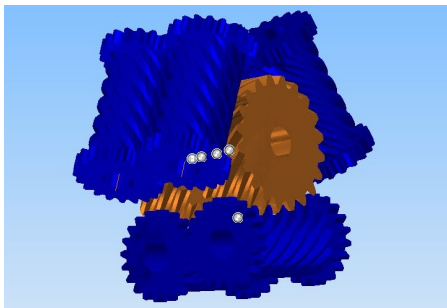


Fig. 18 The positioning of the straight-toothed gears in relation to the helical wheel

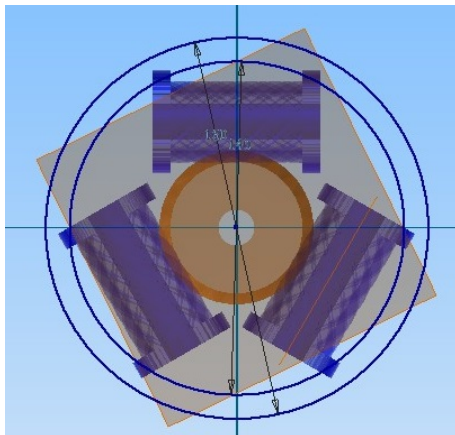


Fig. 19 Creating the differential's housing sketch

In these circumstances, the gear is functional and through enabling by clicking any wheel or pinion the engagement of all toothed wheels is visible and, therefore, the entire clutch system functionality.

For the design of the differential housing the symmetry plane of the planetary gears was made visible, creating a sketch on this plane, figure 19.

The sketch was extruded on both sides, then using the commands Plane, Extrude, Fillet resulted the differential's housing, Figure 20.

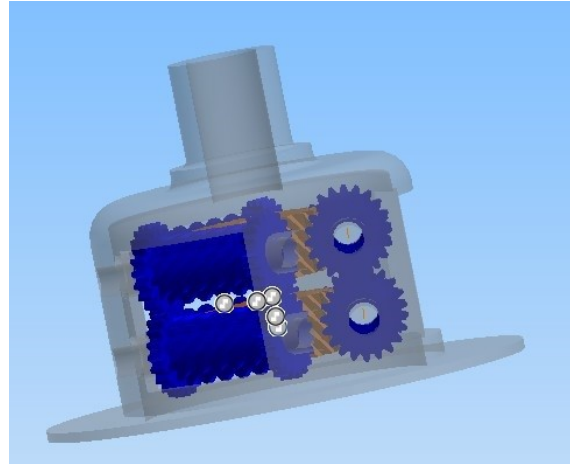


Fig. 20 Differential's housing

After shaping the shell with the Shaft command, the helical gears axes were created and placed with the Constrain command, Figure 21.

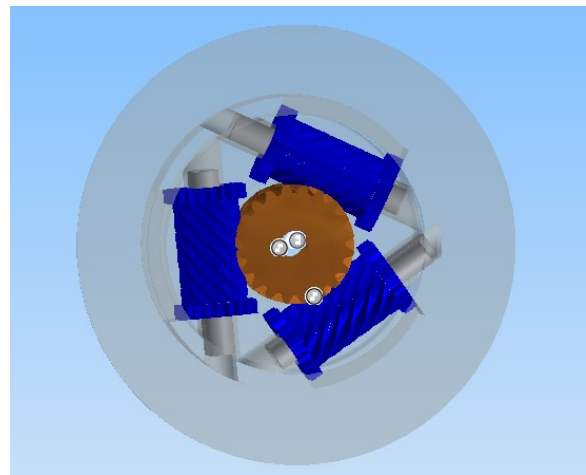


Fig. 21 The helical gears axis

With the help of the Bevel Gear command, the toothed crown and the pinion situated on the differential's housing have been created, Figure 21.

The shaft pinion was constrained, leaving it one degree of freedom, the rotation around its own axis.

It was observed that the wheels are engaging correctly, and to print a movement of solidarity to the housing as well, the successive operations have been achieved:

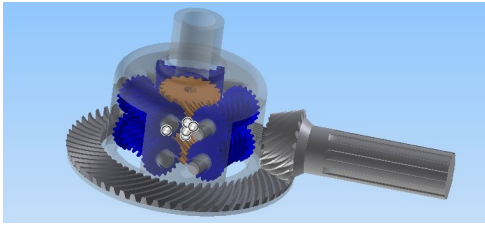


Fig. 22 Toothed crown and pinion on differential's housing

- Constraining the housing, leaving it a single degree of freedom, the rotation around its own axis;
- Constraining the housing to rotate in solidarity with the toothed crown;
- Constraining the axes on the housing and rotating them in solidarity with it;
- Constraining of the helical gears and the straight-toothed wheels on the axle;
- Coercion of the internal gears rotation, similar to those from the exterior.

After making proper engagement, planetary shafts have been created using the Shaft command, and then the grooves between the planetary wheels and the planetary shafts have been created using the Parallel Splines command, Figure 23.

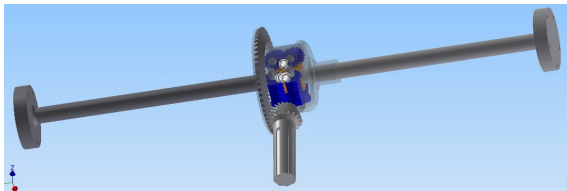


Fig. 23 Planetary shafts

In the Part module, the wheels were created and placed, constrained, on the planetary shafts, figures 24-26.

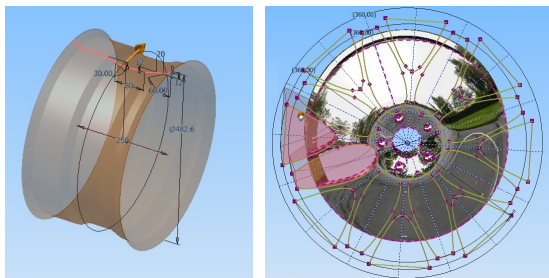


Fig. 24 Wheel – sketches from the Part module

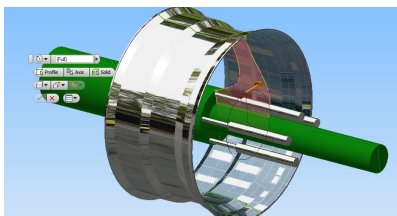


Fig. 25 Wheel constrained on the planetary shaft

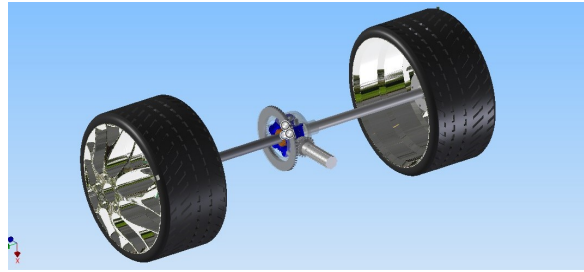


Fig. 26 Wheels placed on the planetary shaft

4. CONCLUSIONS

Torsen differentials are used on many SUV, particularly on those that have transversely mounted engines, being functionally superior to those with electronic control system, that not only reduces engine power but indirectly the vehicle's performance as well.

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