CYLINDRICAL GEARS MODELING USING CATIA SOFTWARE

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Summary: *Cylindrical gears are common used machine elements and main parts of transmitters and many kinds of gear transmissions. Modeling of real cylindrical gears is not so simple to realize, specially involute gear profiles, but using CAD methods and new software it is possible to make easier than before. The aim of this paper is to present some posibilities of cylindrical gears types modeling using powerfull CATIA software. The first problem is making pure involute gear profiles of gear tooth. After gears profiles making it is to model different types of the cylindrical gear bodies. This models are made using part and assembly design module in CATIA V5R11 software. This paper gives descriptions of some main operations and ways to make external, but also for internal gears that are using in planetary gear trains and all of them are covered by examples of gear models. On the end of paper are also described a few applications of made gears models in finite elements analysis and optimization, also in CATIA software.*
Keywords: *cylindrical gears, modeling, computer-added design, CATIA*

1. INTRODUCTION

Gears are very important machine elements today and they are common used in different kinds of gearboxes and transmissions. Especially cylindrical gears are most applicable because of their very high efficiency and not complicated production. Modeling of cylindrical gears is very important process in machine design, as for making real model of gearbox, such for gear and transmission structure analysis and optimization. Last years this process can be done very fast and qualitative using new software tools such as **CATIA**. This software is very complex, but some main modules such **Part and Assembly design** are to use in cylindrical gear modeling. The main problem in any gears modeling is to define a real gear tooth and after that to import it into gear body making. So, cylindrical gears modeling consists of several phases, depends from gear body and kind of its production:

➢ The first phase of gear modeling is definition and making real involute gear teeth profile.
➢ In case of cutting or pressed gear body it is to use Part design CATIA module to make gear body.
➢ In case of welding way made gear body it is to use Assembly design module to connect all its parts.

All this phases consists of several operations and it is to be described separately in followed chapters. Every chapter gives principal facts of general modeling, some special operations with advantages of using CATIA software in gears modeling and examples of different cylindrical gears that are modeled.

2. THE INVOLUTE PROFILES MAKING

In analysis of internal and external gear profiles there are four different lines in one pitch, which defines complete profile of gear. So there are the involute profile arc, profile foot circle arc, addendum circle arc and trohoide arc as a connection [1]. In analytic-kinematics way for profile definition it is to define a lot of restrictions and constrains for setting parameter equations each of this profile arcs and angles. For this purpose are defined one fixed coordinate system Cxy located in instantaneous contact point and two relative coordinate systems related to internal (Cx_1y_1) and external (Cx_2y_2) gear profile on Figure1. After some matrix transformations can be determinated matrix parameter equation for contact line of engaged gear tooth profiles and based on this analytic-kinematics model is developed computer program to define points of gear profiles [2].
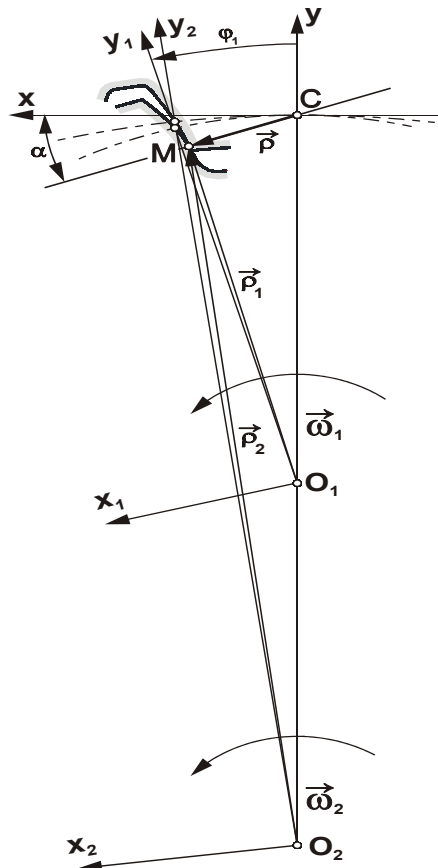
Figure 1: Gear pair profiles engagement

This program calculates coordinates of involute gear profile and they could be given in form of tables, because it is suitable for applying. When we have gear profile coordinates that is simple to import calculated point coordinates into software for graphics presentation and modeling of cylindrical gears.

3. MODELING OF CYLINDRICAL GEARS

Gears modeling is very useful and important, as to make real gear transmission simulation, so for lot of other analysis. Different software tools are in use today for machine design and machine elements modeling, as ACAD, Mechanical Desktop, Pro Engineer and last years Solid Works, CATIA etc. But it is to see that gear modeling (especially internal gears) with real profiles is more complicated compared with modeling of all other machine elements. Here will be presented the possibilities of cylindrical gears modeling using CATIA V5R11 software. Depends of production way and form of gear body it is possible to use **Part design** module or **Assembly design** module of CATIA software.

3.1. Cylindrical gears modeling in Part design

Part and Shape design are the basic modules of design in CATIA software. They are based on several tools for easy and qualitative modeling of any kind of machine elements. First step of design any part is to define position (plane) of Skatch and to draw profile in chosen Skatch. After that there is several groups of options that gives designers oportunity to make a 3D model:

➢ Sketch-Based Features

Features are entities you combine to make up your part. The features are obtained by applying commands on initial profiles created in the Sketcher workbench, or in the Generative Shape Design workbench as well as surfaces. Some operations consist in adding material, others in removing material. In this section, you will learn how to create the following features: Create a Pad, Create a Pocket, Create a Shaft, Create a Groove, Create a Hole, Create a Slot, Create a Loft etc.

➢ Dress-Up Features

Applying commands to one or more supports does dressing up features. CATIA provides a large number of possibilities to achieve the features meeting your needs. The application lets you create the following dress-up features: Create an Edge Fillet, Create a Chamfer, Create a Shell, Create a Basic Draft etc.

➢ Transformation Features

These features are very useful for different transformations such as: Create a Translation, Create a Rotation, Create Symmetry, Create a Circular Pattern, Exploding Patterns, Create a Scaling etc.

➢ Displaying and Editing Properties

You must use bodies as entities you will eventually associate to the Part Body using the capabilities described below to finish the design of your part. Here are Displaying and Editing Parts Properties, Bodies and Features Properties.

➢ Special tools.

This commands are use for some analysis such as Perform a Surfacic Curvature Analysis, Analyze Thread/Tap, Apply a Material, Display Parents and Children, Define an Axis System, Publish Elements etc.

For designing simplest cylindrical gear (flat) it is first right skatch to define, where should be imported involute profile tooth coordinates. After that designer can apply Skatch based features (Create pad), to get cuted gear model as is shown at Figure 2.
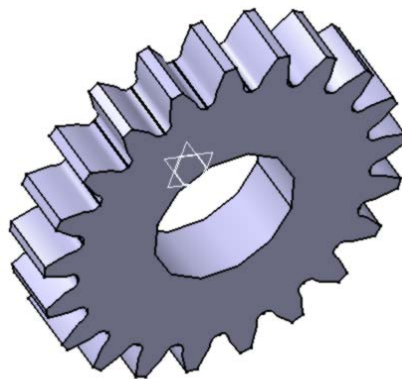

Figure 2: Simplest model of cylindrical gear

One step forward is designing a press made gear body, that could be modeled by rotating skatch made figure, or like simulation of production process. On Figure 3 is given a gear model made also by using skatch and few Sketch-Based, Dress-Up and Transformation Features.
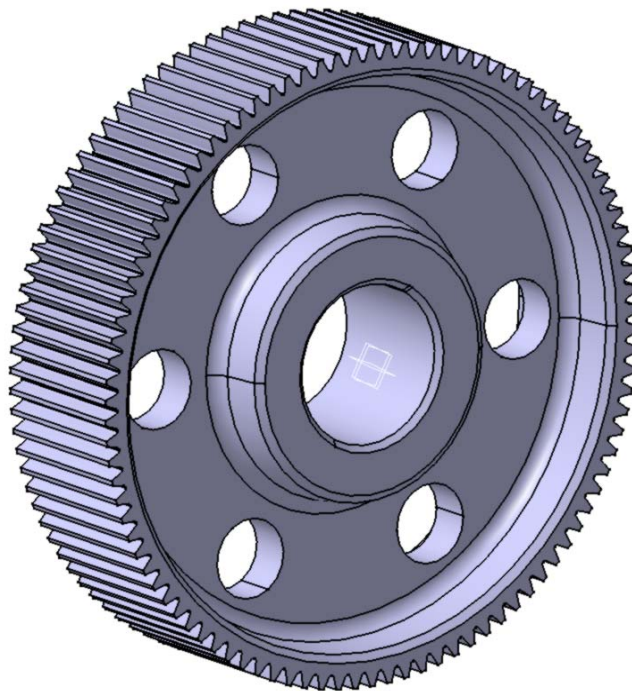

Figure 3: Press made model of cylindrical gear

Presented gears are common in use and they have an external involute profile. But in some cases for example in planetary gear train designing it is to make a model of internal profiled gear. For this purpose designer has to calculate a new table with involute profile coordinates, by using external gear as a tool for making internal profile. After that it is to use properly skatch and other features as for other cylindrical gears modeling. Figure 4 shows an internal gear involute profile.
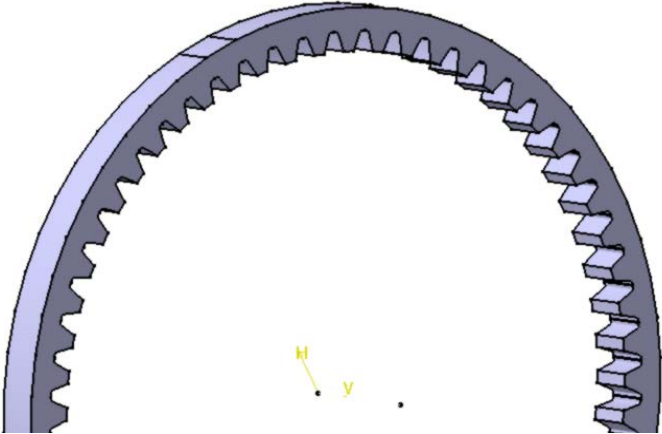

Figure 4: Part of internal ivolute profiled cylindrical gear

For designing gears that are made by welding parts or for completing a gearbox and transmission it is to use Assembly design module in CATIA.

3.2. Cylindrical gears modeling in Assembly design

Assembly design is another module in CATIA which is in use in aim to complete all parts and standard elements that are already modeled in Part or Shape design. Besides it is possible to insert new bodies in existing assembly and also to do Boolean Operations between bodies if it is necessary. These Boolean operations between bodies are Assemble Bodies, Intersect Bodies, Add Bodies, Remove Bodies, Trim Bodies, Remove Lumps etc.
The best sample of using Assembly design is exactly cylindrical gear made by welding number of separated elements. It means that this type of gear consists of many elements that are modeled in Part design. The main part is outer plate with involute profiles that are welded with central cylinder with two circle plates and six stiffeners at both sides (Figure 5.).
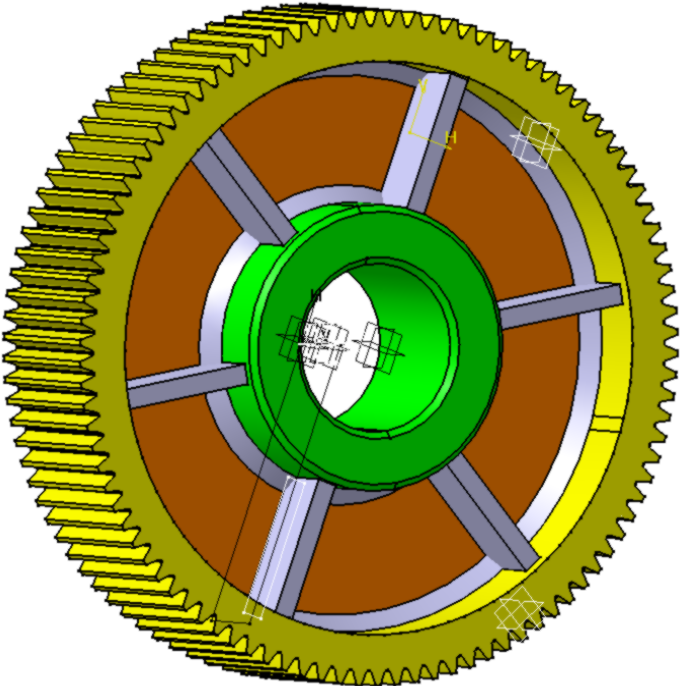

Figure 5: Cylindrical gear made by welding

Assembly design is also very usefull to complete several gears or whole gearbox, for example planetary gear train as shows Figure 6.
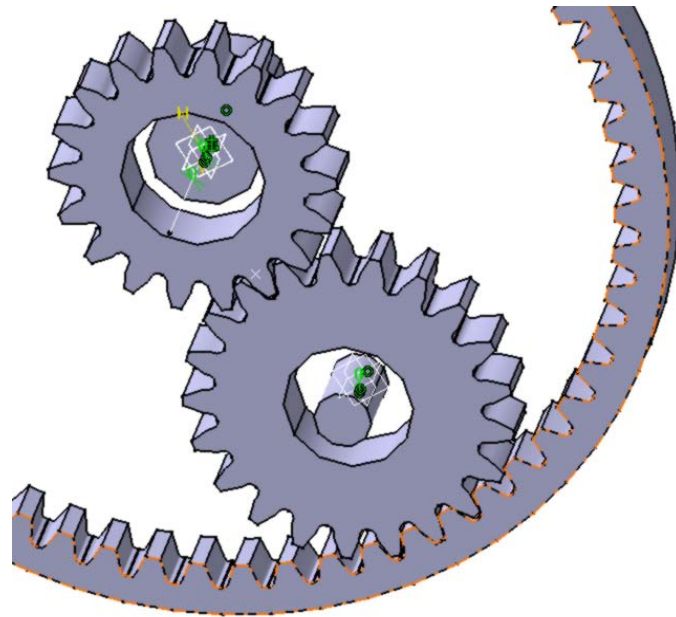

Figure 6: Planetary gear train assembly

5. CONCLUSION

To resume the point of this paper here could be said that it presents only a brief of cylindrical gears modeling possibilities in CATIA software. Besides presentation of modeling in Part and Assembly design modules, at the end of this paper it is to add that CATIA is powerfull and today may by completest design software in engineering with wide range of applications.

For whole procedure of gears modeling it is very specific and important to:

➢ Define involute gear profile based on analytic-kinematics way that gives proper coordinates of points in every gear profile section.
➢ To make properly gear body in Part design or to complete it using Assembly design module of CATIA.

A gear modeling is very significant because of many applications that could be done:

➢ After completing assembly it could be make kinematics simulations, also possible in another CATIA module DMU.
➢ Internal and external gears models can be used for solving a lot of problems in mechanical engineering, such as structural analysis, contact pressure between corresponding gears and also thermal and many other analyses.

Because of printing form of this paper, simulation can be shown completely only in multimedia presentation.

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