VIRTUAL ASSEMBLING OF AN ENGINE BLOCK USING CATIA ENVIRONMENT

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ABSTRACT: This paper presents the fundamental concepts for obtaining and using of digital prototype of the internal combustion engine in four-stroke single cylinder air cooled assembly, used in the propulsion of light vehicles, motorcycles and vehicles designed to travel on all terrain. The modeling is structured around the part family of casing category. The assembling is governed by a complete set of geometric constraints imposed by the functional role and assembly of engine components. The digital prototype and its components are obtained in CATIA V5 environment. After modeling and virtual assembly, the prototype is used in the design stage, functional study and digital manufacturing technology.

KEY WORDS: Engine assembly, CATIA, Digital Mock-Up, Wireframe and surface design.

1 INTRODUCTION

The concept of digital prototype has appeared in the middle of '80s, when the solid modeling became faster and competitive, that allows to the companies to choose the transition from traditional 2D design wholly or mainly in 3D design. (Marcu, 2007). The advantages of this transition are (Marcu, 2007):

- removing the need for physical prototype;
- reducing the manufacturing costs;
- increasing the product quality;
- reducing the time required to market the product launch;
- the design teams accessing the information much faster.

In the automotive, aerospace and naval industry the Digital Mock-Up (DMU) technologies are studied in aim the view of the size models using planar facets transformation strategies in models of curved triangular elements. It allows to reduce the memory used in the rendering processes (Sun, 2007).

The DMU facilities are also related to the XML technologies designed for the integration of individual components in different CAD environments, thus there is the possibility to visualize models assembled without a CAD system installed on the computer used to view (Son, 2009).

The IBM and Dassault Systems company widely use the DMU technology in their product named CATIA.

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In the automotive engine domain, the Digital Prototype has a lot of applications for the study and the development of manufacturing technology design for Diesel engines (Zheng, 2009).

Using the Virtual Prototype Technology is made a dynamic simulation for crank-conrod-piston assembly for internal combustion engines (Zhang&Wang&Fang, 2012).

In order to develop the educational visual technologies are made virtual experiments conducted in virtual laboratories, based on the virtual assembly of digital models in digital media as Cult3D and Jawa (Yun&Zhang&Pan, 2009).

In the modern industry, Digital MockUp is an important tool in digital design processes, it is used successfully in combination with Modal Analysis and Simulation Analysis (Jiaxin&Xiang, 2009).

2 MODELING OF ENGINE PARTS

The digital prototype engine is based on assembling all components individual modelled in CATIA Mechanical Design - Assembly Design module. In the Part Design module are modelled the following components of the internal combustion engine in four-stroke single cylinder air cooled:

- engine block;
- cylinder casing;
- camshaft cover (figure 1).

All these elements with complex shapes can be generated using the basic tools of volume category (Ghionea, 2009):

- pad (the extrusion on a plan sketch);
- pocket (the cut on a plan contour);
- hole;
- shaft (the bodies of revolution);
- rib (the cooling fins and ribs).

Due to the complex cylinder head geometry, it was modelled using a combined modeling technology:
- modeling of the internal profile, the internal channels for intake and exhaust, in Wireframe and Surface mode an (figure 2);
- modeling of the profile of combustion chamber in Generative Shape Design mode;
- design in Part Design mode, the solid model and material assignment (figure 3);

In order to achieve accurate overlapping contact areas of all the components to the process used to generate 3D body adjacent projections shapes, in the sketch plane, under auxiliary boundaries, the Project 3D elements commands is used. In this way is made the positioning holes center for fixing screws, the semi-bearings camshafts axis coincidence, the possibility for synchron UpDate for all geometrical common elements of engine parts.

The Engine Block modeling was performed using CATIA environment facility to easily parameterize complex models, following the steps:
- modeling a part of the family of parts (the part with maximum complex geometry);
- creating of a parametric data file attached to the model (DesignTable.txt file);
- changing the parameter Design Table according to the engine block construction features used to achieve functional assembly (figure 4).

Intake and exhaust manifold are parts with geometric features of the class assembled by welding pipes. To get the solid model it was used the award function of the thickness of a surface
In order to obtain external surface of the manifolds was used to generate the process tube from extruding a profile along the axis of symmetry generator pipes assembly components.

Figure 5. Intake manifold surface modelled in CATIA Wireframe and Surface

Figure 5 shows how the external surface of the intake manifold of the engine fuel mixture is generated, using the path profile extrusion, profile extrusion section and the direction of extrusion.

In order to achieve the complex external surface of the manifolds were used the following commands of CATIA Wireframe and Surface:
- sweep (extrusion profile section by path, used tool to generate external pipe)
- split (the realization of the intersection pipes);
- join (union of adjacent surfaces);
- boundary (common contour extraction);
- blend (generation of pipe joints).

In the figure 6 is shown the complex 3D geometry of the burnt gases exhaust manifold of an internal combustion engine.

3 ENGINE ASSEMBLY GENERATING

The creation of the assembly is made in the Mechanical Design/Assembly Design CATIA V5 environment. At the core of the digital prototype assembly is the engine block, is used as the positioning of other components previously modelled. The insertion of the parts is made using the menu command Insert Existing Component in the following order:
- engine block (the positioning base);
- cylinder casing;
- cylinder head and the cylinder head gasket;
- camshaft cover;
- fixing screws (4 entities) and the upper nuts (4 entities);
- intake manifold;
- fixing screws for intake manifold (M10);
- exhaust manifold;
- fixing screws for exhaust manifold(M10).

The standard fasteners (nuts M10 and M10 screws) were inserted from the internal database Catalog Browser – ISO Screw and Nut database.

When performing the positioning of the elements were used the following categories of constraints:
- coincidence (the coaxial position);
- surface contact ;
- offset (setting the position block engine bolts).

In figure 7 is shown the isometric view of the engine complete assembly.

4 CASE STUDY

Using the default parameter files DesignTable.txt for the cylinder casing and the engine block, was made the digital prototype for an engine having the following technical characteristics:
- cylinder capacity 80 cm³;
- engine type: single cylinder, 4-stroke;
- ignition spark and air cooling;
-DOHC distribution, timing belt training camshafts positioned in an external case.
Figure 7. Engine assembly - CATIA DMU Fitting

Figure 8. Engine assembly in exploded mode - CATIA DMU Fitting
This digital prototype uses only items from the carcass, the tubes and the fasteners category.

For using the engine model in manufacturing technology development and assembly testing, the engine assembly is obtained in the Assembly Design mode. It is imported in DMU mode. In figure 8 is shown the engine assembly, after dismantling all levels, according to the constraints of positioning of the parts, with a disassembly rate of 5%.

Using the CheckClash tool, the interference detection between two components desired (engine block and cylinder casing) is checked and negative assembling allowance and the contact length (75.153 mm).

Figure 9. Engine block and cylinder casing interference CATIA DMU Fitting

Figure 10. Engine Sectioning in isometric view - CATIA DMU Space Analysis
The result can be visualized by the user (in graphic mode) in figure 9.

In order to establish the necessary of handling device, the positioning device and the storage space, it was set the weight of the engine assembly:
- engine block (Aluminium alloy)=1.212 kg;
- cylinder casing (Iron alloy)=0.687 kg;
- cylinder head gasket (Composite)=0.058 kg;
- cylinder head (Aluminium alloy)=1.235 kg;
- camshaft cover (Steel)=0.331 kg;
- fixing screws (Steel)=0.424 kg;
- upper nuts (Steel)=0.044 kg;
- intake manifold (Iron)=0.108 kg;
- exhaust manifold (Iron)=0.103 kg.
The total assembly mass is 4.202 kg.

In the DMU Space Analysis module, with the Sectioning tool, is made the view of the internal section of the engine assembly. It is shown in the figures 10 and 11.

![Figure 11. Section surface area 0.008 m² - CATIA DMU Space Analysis](image)

5 CONCLUSIONS AND REMARKS

The DMU technology is perfectly adapted to the requirements of the automotive industry, thereby is substantially shorten the time required to obtain functional prototypes and to minimize resource consumption and the raw materials.

In order to develop functional prototype using rapid prototyping/manufacturing technologies, based on knowledge package attached to the digital prototype, the scale of physical prototype is obtained at the desired size.

Later, the virtual engine assembly can be useful in design process of the manufacture technology using digital tools.

6 REFERENCES