Hybrid modeling in CAD

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Abstract

Computer aided 3D modeling is rapidly growing field of techniques. Various modeling techniques are continuously developed and improved – but hybrid modeling as combination of the best features seems to be worthy of interest. This article describe main principle of full hybrid modeling with examples of practical applications.

KEYWORDS: **hybrid modelling**, **CAD**, **solid-surface modeling**

Introduction

Computer aided greatly reduced time of design process providing incomparably greater possibilities. Nowadays more and more often calculation performance and hardware are not limitation - capabilities and imagination become the design barrier. New opportunities provide hybrid modeling techniques – it is not new method of design, but development of information technology give them a new meaning.

1. Basics of geometrical modelling

Solid modeling and surface modeling are two main methods of geometrical modeling in three dimensions (3D). In case of solids (fig. 1), from theoretical point of view, 3D models have defined material, weight and wall thickness. From practical point of view designers are mainly focused on physical fidelity, solid representation of the object attributes and mechanical functionality [1].

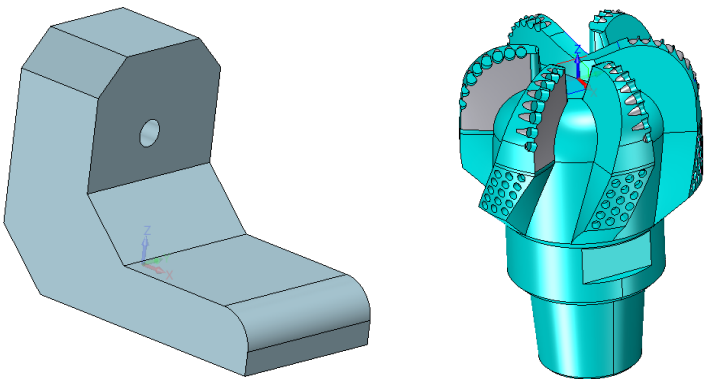

Fig. 1. Solid modeling (models made in ZW3D CAD/CAM)

Surface modeling (fig. 2) is a mathematical modeling technique, used to define the external characteristics of objects with infinitesimal thickness.

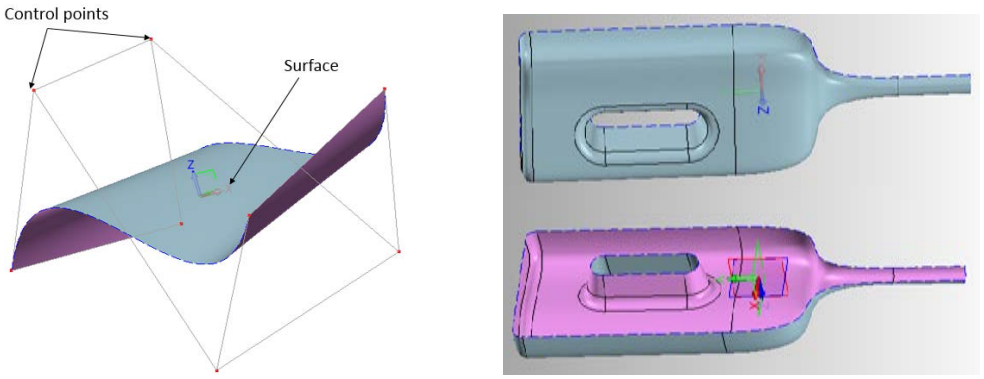

Fig. 2. Surface modeling (models made in ZW3D CAD/CAM)

Solid modeling clearly represents an object, describing its boundary surfaces and topological orientation, so we can determine for each surface point, which side lies inside the solid. Surface modeling, by comparison, only gives a geometric description of the object border without topological information. Surfacing greater than, however, solid modeling in the range of possibilities when it comes to creating objects with complex and varied shapes.

Less popular is wireframe modeling (called also 3D sketch) – this method (considered separately) is rather for creating different kind of paths or edges, e.g. for: loft, profile extrude, rude, weldments (fig. 3) or CAM. 3D shape is created using spatial lines and curves, without surfaces or solids.

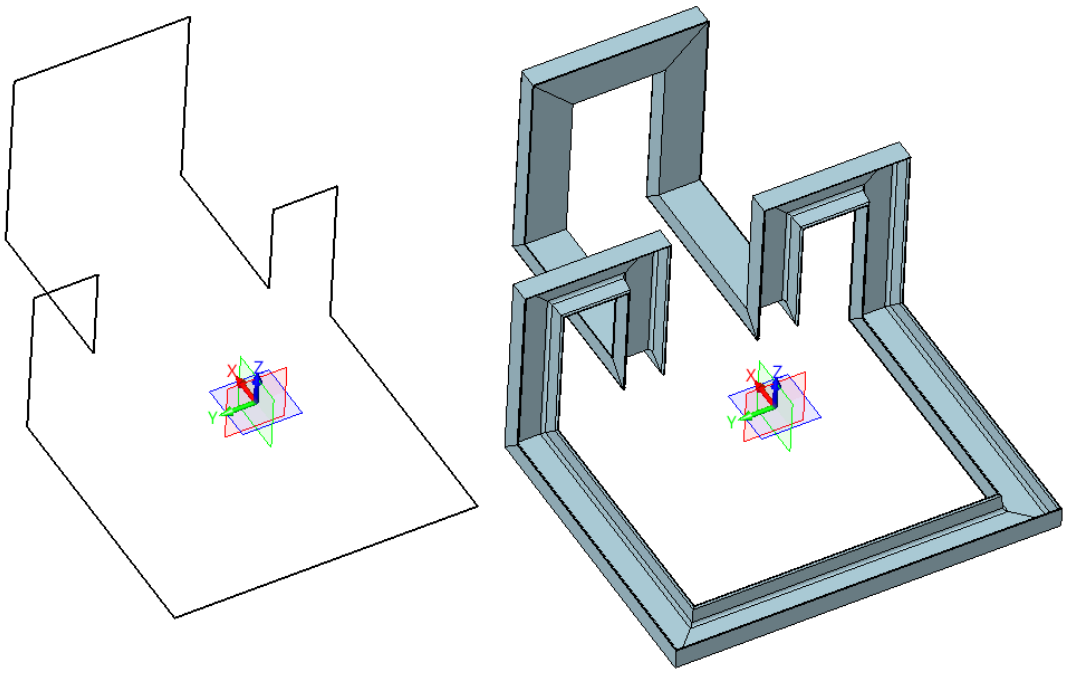

Fig. 3. Wireframe modeling as a base for weldments (models made in ZW3D CAD/CAM)

The last type of 3D shape representation in CAD software is cloud point (and mesh based on it). It is basically a set of points in 3D space (in STL file points are connected via triangle/polygons mesh), as result of 3D scanning (fig. 4) or 3D measurement on CMM. Theoretically shapes can be created point by point manually or using some calculation algorithm to determinate XYZ position consecutive points. Usually STL geometry is used directly for milling or creating surface/solid model in reverse engineering process.

In case of many CAD systems, users must be specially trained to observe and understand the difference between commands to different modeling technics – it causing many limitations and makes 3D modeling is not effective and useful only for professionals.

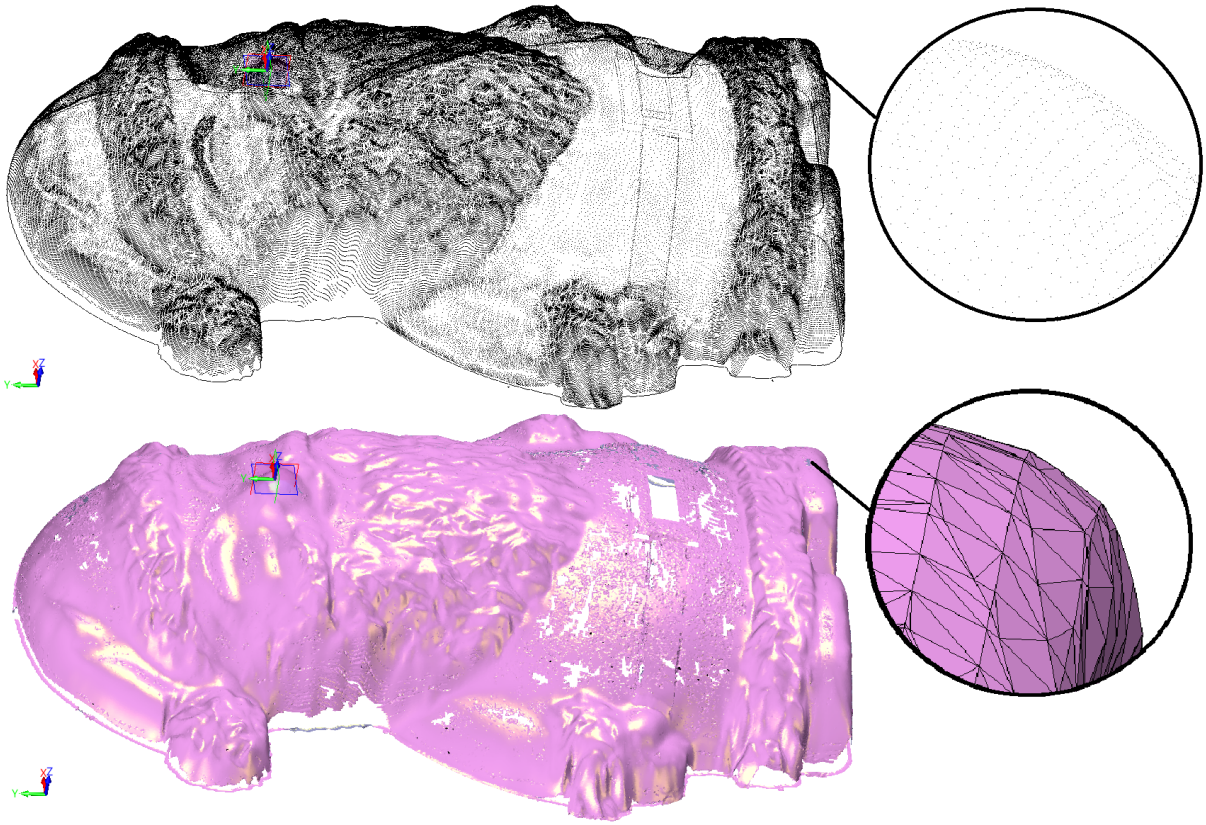

Fig. 4. Cloud points (top) and STL mesh based on it (bottom)

2. Genesis of hybrid modelling

Each operation have its own advantages and limitations, so smart solution seems to select the best features from them and use all methods in the same time. It is main assumption of hybrid modelling [2]. The main barrier can be a clear boundary at the transition between different types of modeling and the use totally different command/modules each time. It is not a problem if we want to perform a single operation to trim solid using the surface (fig. 5) – it is not nuisance. Thus, in many cases, hybrid modeling just looks like described.

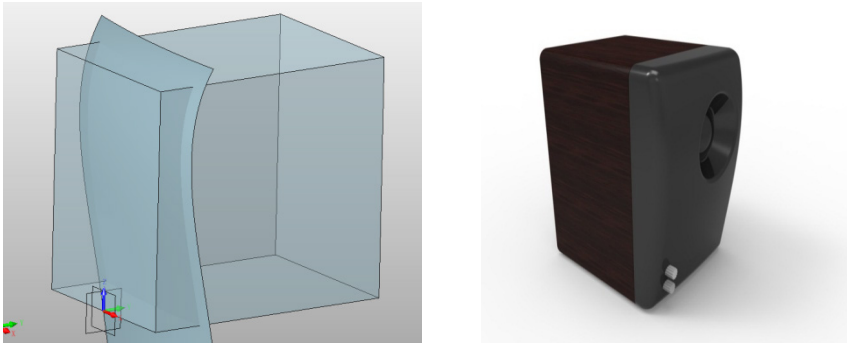

Fig. 5. Trimming the solid shape by the surface

For many CAD programs more complicated is opposite situation: trim surface using solid (fig. 6). Walls of solid are considered as surfaces with conventional surface operations. This small step brings us closer to a full, true hybrid modeling.

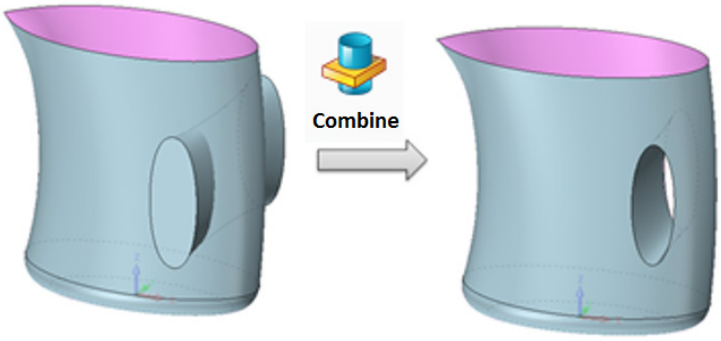

Fig. 6. Combine surface model with solid by trim operation

Next level is smooth mixing and combining different modeling technics with "the same icons" in CAD program, the same commands (fig. 7). The most popular is solid-surface hybrid modelling, supporting by wireframe.

True hybrid modeling significantly changes the idea of modeling and the same approach to the design and increases work efficiency.

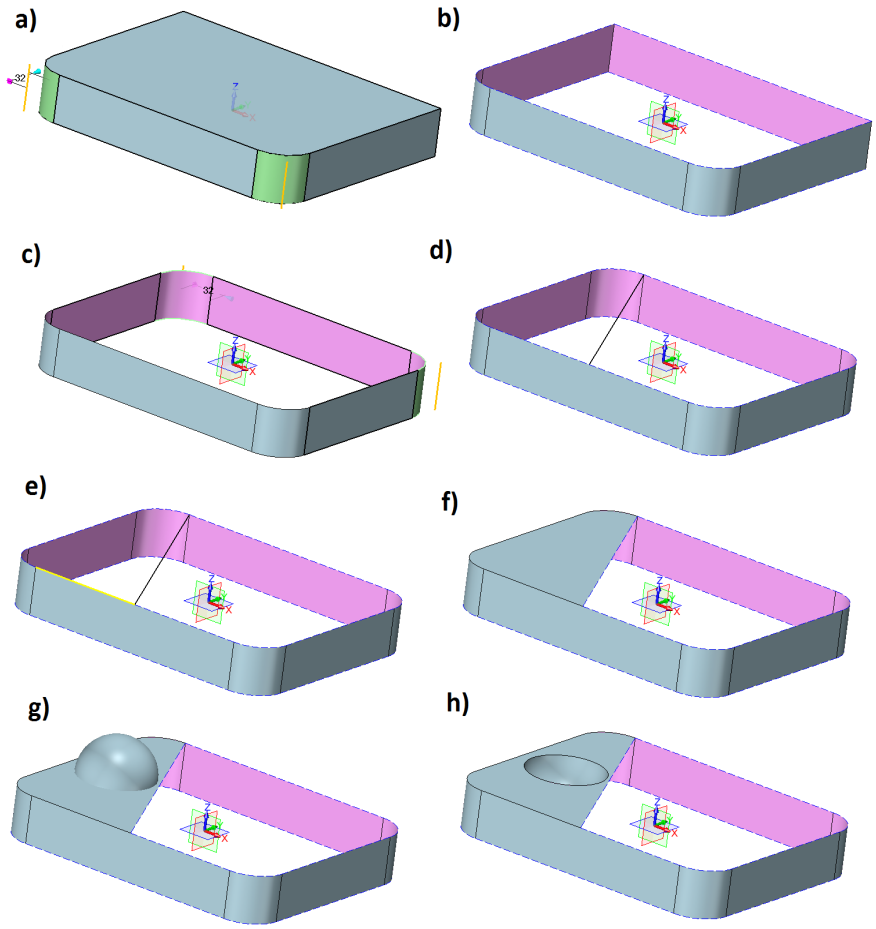

Fig. 7. Example of hybrid modeling steps: a) round command on solid, b) delete walls to get surface model, c) round (the same) command on surface, d) new edge using wireframe, e) split command on edge, f) new n-side surface, g) solid-surface-wireframe model, h) cutting surface with solid

3. Application of hybrid modeling

With hybrid modeling, Boolean operations work on both types of geometry, which opens new possibilities and imagination during the design process. For the complex process, as shown in fig. 8, it is not easy to change shape only by surface modification, also simply hybrid modeling in most systems works only with one Boolean logic operation or design environments are clearly separated into dedicated to solids and surfaces. In full hybrid modeling software most operations works both: for solid and surface – there is no difference, so it is just the same command.

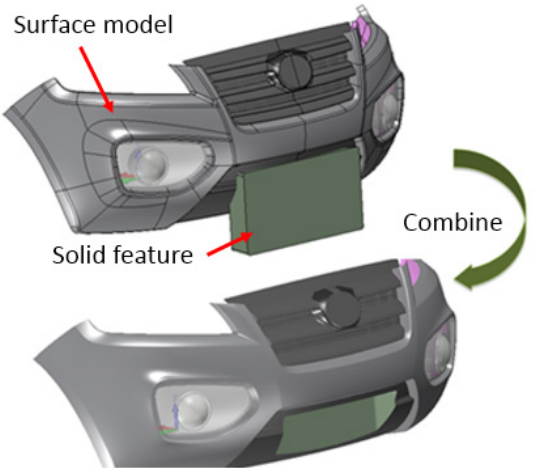

Fig. 8. Hybrid modeling with combination of solids and surfaces in ZW3D

Morphic transformations provide much greater opportunities if, for example, shape change and wrap shape/pattern are diversified on the type of geometry (solid or surface), then the new feature can be somehow "stuck" to the model (fig. 9). The hybrid modeling technology eliminates barriers between modelling techniques, which limited many advanced features only for professional design.

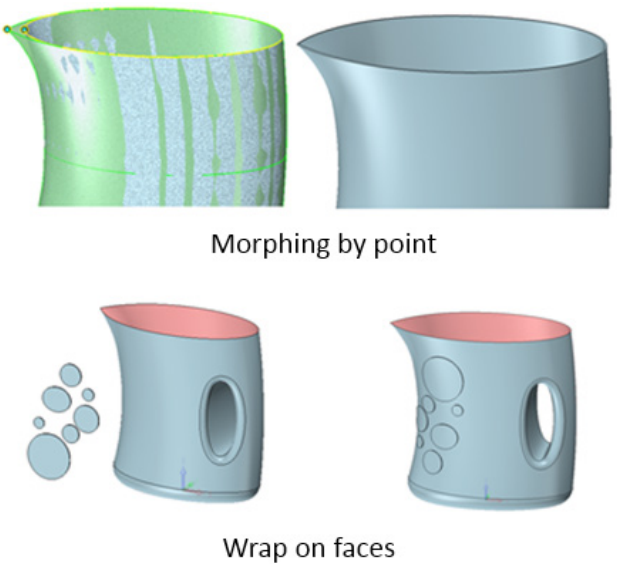

Fig. 9. Examples of advanced design operations simplified to one command by hybrid modeling in ZW3D [1]

Hybrid modeling simplify mold design process. This well-known and widespread phenomenon that we get imperfect models while importing other file formats. Typically, designers must spend a lot of time to repair models and use mold design tools (e.g. creating parting lines and surfaces, divide surface model to the core and cavity solid parts – see fig. 10) or getting mass properties. Hybrid modeling allows designers to save laborious repair jobs and concentrate on more creative tasks.

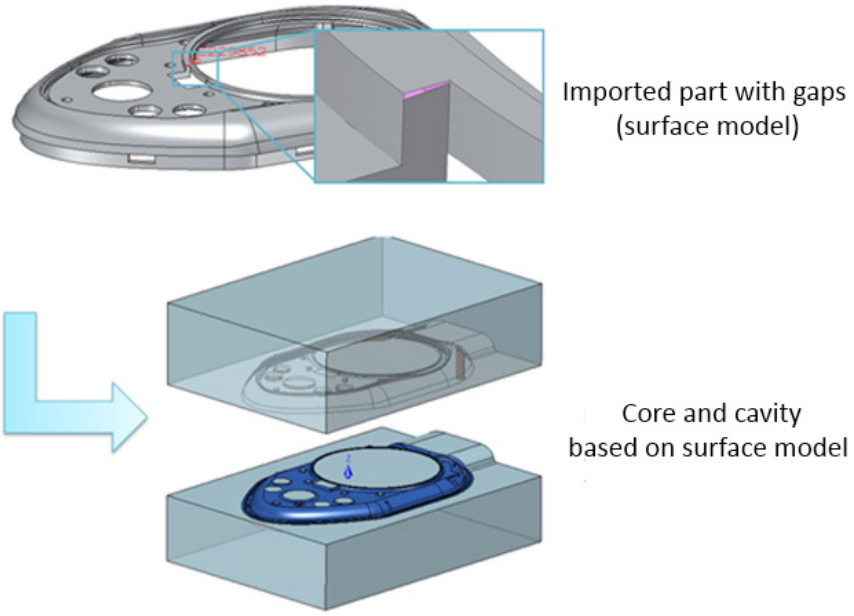

Fig. 10. Mold design tools on surface model [1]

Hybrid modeling is not just a feature of the software. This is the core programming technology, which is visible in all CAx activities. With this technology, designers do not need to consider whether they work with solids and non-solids, thereby simplifying the whole process of production.

A lot of CAM software work only with solid models – so there is the same problem with repairing parts before design manufacturing process like with molds. Hybrid modeling cornel in CAM shortens the process of model preparing and there is no difference if machining is made on solid or surface. If there is some gaps in 3D model, software approximate surfaces and recognize them like a continues perfect model. Tool movements are protected against sudden plunge into the gap (fig. 11).

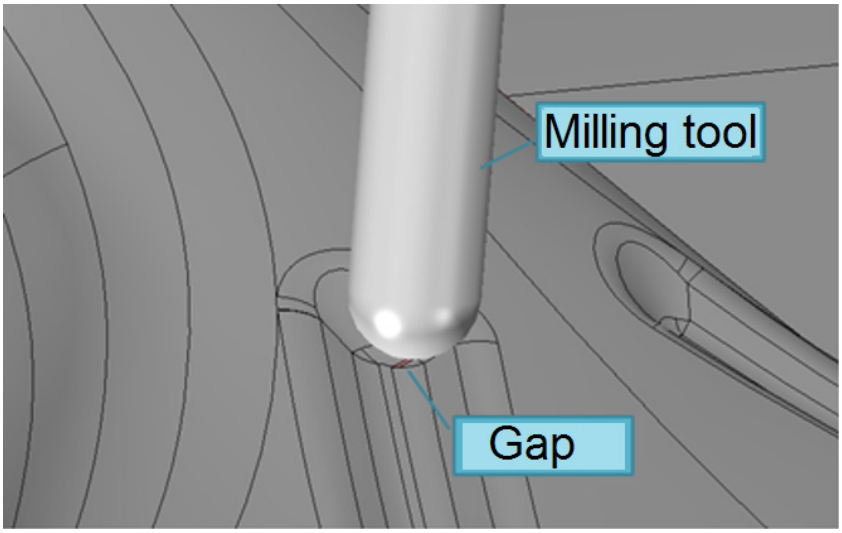

Fig. 11. Tool movements are protected against sudden plunge into the gap

Summary

Obviously in the future will be more and more technologies invented to overcome design problems that will help CAD users to focus on the project creation, but 3D modeling technology is the core. Hybrid modeling technology provides the perfect combination of advantages and functionality different design methods and will have a significant impact on future design trends.

References

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