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## **THE WIREFRAME MODELING IN FOR THE GEOMETRIC REPRESENTATION OF A PART IN A CAD SYSTEM**



**S.S. Beknazarova**

*Professor of Tashkent university of information technologies named after Muhammad al-Khwarizmi, Doctor of technical science, associate of professor*

*Department of Audiovisual technologies, Tashkent University of information technologies named after Muhammad al-Khwarizmi, Tashkent, Uzbekistan  
E-mail: saida.beknazarova@gmail.com*



**G.A. Kayumova**

*Teacher of Tashkent university of information technologies named after Muhammad al-Khwarizmi*

### **S.S. Beknazarova**

*Doctor of technical Sciences, associate Professor. Author of 189 research papers on audio, video, multimedia resources, and media education technologies.*

### **G.A. Kayumova**

*Author of 27 research papers on audio, video, multimedia resources, and media education technologies.*

**Abstract.** In the article describes several options for the geometric representation of a part in a CAD system. The choice of one or another option depends on the capabilities of the system and on the need for its application to create a control program. Not so long ago, the kulman was the main tool of the design engineer. With the advent of the first personal computers, a real revolution began in the field of design automation. Design engineers immediately appreciated the benefits of "flat scribe." Even the simplest CAD system for two-dimensional design allows you to quickly create various geometric elements, copy fragments, automatically apply hatching and affix dimensions.

The main tools in flat design are lines, arcs, and curves. Using the operations of extension, cropping and joining of geometric elements, the creation of an "electronic drawing" takes place. For full-fledged work with flat graphics in the CAM system, additional information on the depth of geometry is needed. The wireframe model represents the geometry of the part in three-dimensional space, describing the position of its contours and faces. The wireframe model, in contrast to a flat electronic drawing, provides the CAM system with partial information about the depth of the geometry. With the development of the automotive and aviation industries and the need for an analytical description of parts of complex shape on a PC, the basic prerequisites for the transition from flat to volumetric modeling have been formed.

**Keywords:** modeling types, wireframe model, 3D model, surface model.

**Introduction.** There are several options for the geometric representation of a part in a CAD system. The choice of one or another option depends on the capabilities of the system and on the need for its application to create a control program. Not so long ago, the kulman was the main tool of the design engineer. With the advent of the first personal computers, a real revolution began in the field of design automation. Design engineers immediately appreciated the benefits of "flat scribe." Even the simplest CAD system for two-dimensional design allows you to quickly create various geometric elements, copy fragments, automatically apply hatching and affix dimensions.

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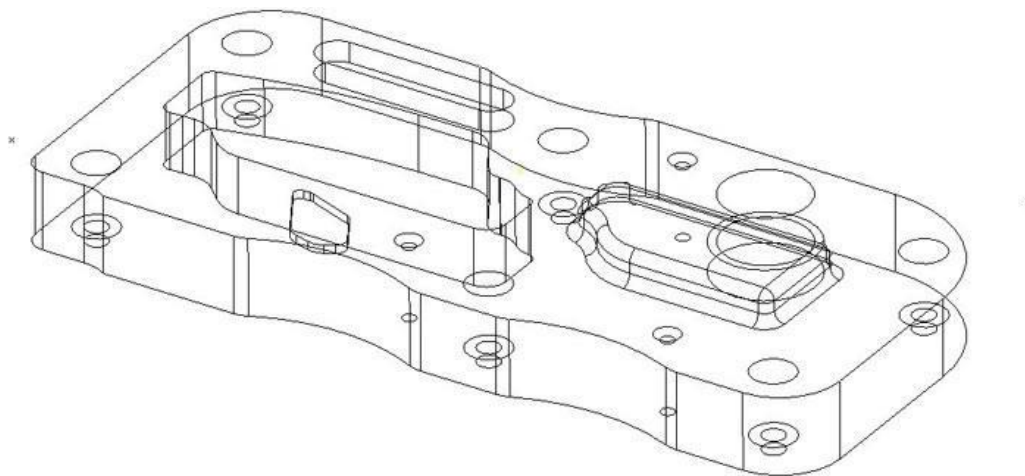


Figure 1. – Wireframe model

A three-dimensional or 3D model is designed to uniquely define the geometry of the entire part. Volumetric modeling systems are based on methods for constructing surfaces and solid-state models based on flat and non-planar sketches. The sketch, in turn, consists of simple geometric elements—lines, arcs, and curves. Engineer-constructor takes as sketches of the cross section and the centerline of the details.

The surface model is very similar to the frame model. Imagine that a thin fabric is stretched between the edges of the frame model. This will be the surface model. Thus, any product can be represented as a set of bounding surfaces.



Figure 2. – Surface model

Currently, surface models are widely used for working with SELF-systems, especially when it comes to tool production. For solid-state modeling, the main tools are bodies created from sketches. To build a solid body, you can use operations such as squeezing, cutting, and rotating the sketch.

Boolean operations allow you to add, subtract, and combine different solids to create a 3D model of a part. Unlike surface models, the solid model is not empty inside. It has some mathematical density and mass. Today, solid-state models are the most popular basis for calculating trajectories in the SAM system.

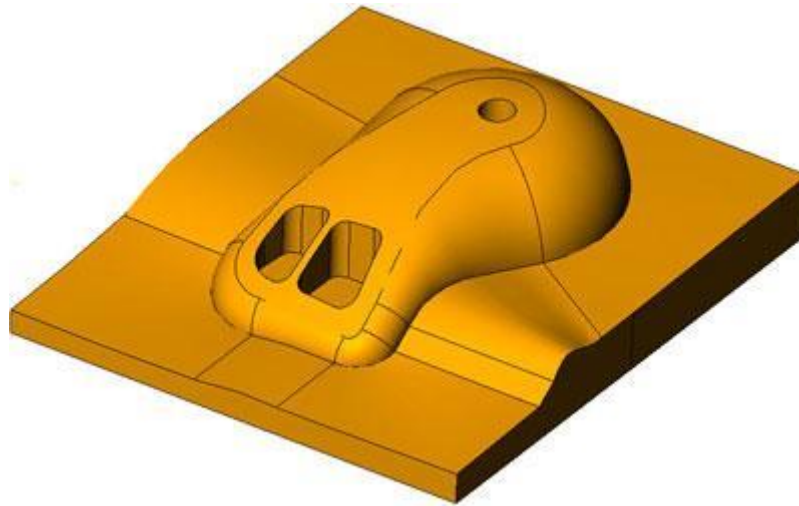


Figure 3. – Solid model

One of the main advantages of this method is the so-called parameterization. Parameterization means that you can change the dimensions and characteristics of a solid at any time by simply changing the numerical values of the corresponding parameters.

A modern CAD / SAM system must have the tools to create both surface and solid-state models.

#### **Frame modeling.**

The wireframe model is fully described in terms of points and lines. Wireframe models store the coordinates of vertices and their connecting edges. Wireframe modeling is the lowest-level modeling and has a number of serious limitations, most of which are due to the lack of information about the faces enclosed between the edges, and the inability to distinguish the outer and inner regions of the solid-state volume image.

The main factor in limiting the use of frame surfaces is the ambiguity of recognizing the orientation and visibility of the faces of the frame image. For example, a three-dimensional image can be represented in two ways: top and bottom (Fig.4.).

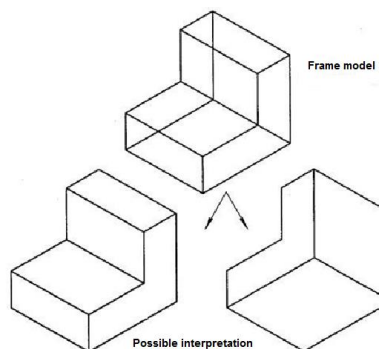


Figure 4. – Possible interpretations of the model in wireframe modeling

This effect, due to the nature of the wireframe model, can lead to unpredictable results. In contrast to the solid-state model, in a wireframe model, you can't distinguish visible geometric faces from invisible (hidden) ones.

The operation to remove hidden lines can only be performed manually by applying editing commands to each individual line. However, the result of this work will be equivalent to the "destruction" of the entire created frame structure, because the lines that are invisible on some projections are visible on others. And removing the "invisible" line on one projection will inevitably entail removing it on all other projections (Fig.5.)

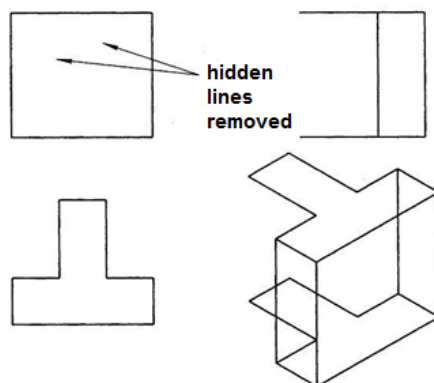


Figure 5. – Example of "destruction" of a wireframe model

Even more difficult is the case with curved surfaces. As you know, a cylindrical surface is defined by moving the generator along a certain guide, so in orthogonal projections, such a surface is depicted by means of outline generators. Naturally, these formers are not identical, for example, in the main view and the view on the left, so they are not recognized as elements of the frame model, and therefore are not depicted on it.

#### **Surface modeling.**

The surface model is defined using points, lines, and surfaces. Surface models are defined by rotation surfaces, planes, shear surfaces, and so on. thus, it can be considered as a higher-level model than the wireframe model, and therefore more flexible and multifunctional. The surface modeling method is most effective when designing complex curved surfaces made of sheet material, such as car body elements.

Surfaces are formed in various ways and can be divided for computer graphics purposes according to the way they are obtained into elementary geometric surfaces, rotation surfaces, analytical surfaces, and surfaces of arbitrary shapes (also known as "sculptural" surfaces or "free-form" surfaces).

Elementary geometric surfaces include surfaces that are formed by parallel transfer of a line along an axis perpendicular to it (Figure 6.).

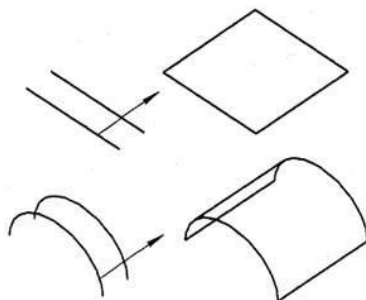


Figure 6. –Formation of geometric surfaces

In turn, surfaces can be transformed by parallel transfer operations into three-dimensional objects (Figure 7.). It should be noted that surface modeling systems do not recognize shapes such as

solid bodies. They represent them simply as surfaces (in Fig.7. - seven flat faces), connected in space with each other in some way and limiting the "empty" volume.

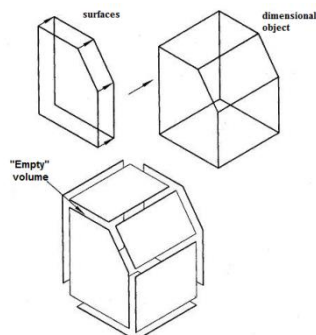


Figure 7. – Formation of a three-dimensional object by surfaces

Rotation surfaces can be easily obtained by rotating the envelope of a flat shape around a certain axis (Figure 8.).

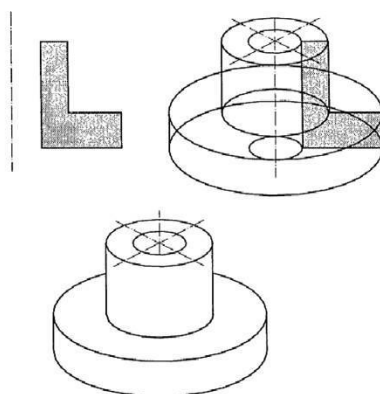


Figure 8. –Rotation surfaces can be easily obtained by rotating the envelope of a flat shape around a certain axis

### Information about wireframe models

When using a wireframe model, the design and intent is set at the beginning of the design or build process. The frame model placed on the Assembly and distributed with it can be opened independently of the installation and switched on at any time without abrupt transitions. The wireframe model can be used in multiple assemblies.

You can create a wireframe model at any time during the design process. The system always lists and regenerates the newly created wireframe model before all other components and design elements in the Assembly.

### Frame models and models with kinematic frame

There are two types of wireframe models: standard wireframe models and motion wireframe models. Standard wireframe models are created in an open Assembly as parts. Motion wireframes are subassemblies that contain structural frames (standard wireframes or internal sketches) and body frames. Standard wireframes are created using curves, surfaces, and reference design elements. They can also include solid geometry.

Although wireframe models can only be created in an Assembly, they can be extracted, manipulated, and saved as regular parts (standard wireframe models) or assemblies (kinematic wireframe models). Body frames are automatically saved as parts when they are created.

Features of working with frame models

Before creating a wireframe model, consider the following points.

- 1 You can create or insert only one motion frame in an Assembly.
- 2 You can create multiple standard wireframes in the same Assembly if the `multiple_skeletons_allowed` configuration option is set to yes.
- 3 The wireframe model is similar to any other component in the Assembly. It has design elements, layers, equations, views, bodies, and so on.
- 4 You can use external anchor management settings to restrict geometry placement and Assembly bindings to wireframe models only. (File > Prepare > model Properties and click change in the reference Control line to open the External Reference Control dialog box). These options control the bindings for all frames in the Assembly.
- 5 You can save family tables in wireframe models. This means that the Assembly can support many different instances of the frames within the table of the family.
- 6 All simplified view functionality present in part and build modes is also available in wireframe models (starting with Pro/ENGINEER 2001).
- 7 When managing simplified representations of the skeleton models can be selected using parameter According to the rule.

#### **Wireframe models in material sheets and model trees**

Wireframe models will not be visible in the bill of materials unless they are specifically included. Wireframe models do not affect the mass or surface properties. They can be shown in drawing views and enabled when creating and performing operations with simplified views and external lightweight design elements.

Wireframes and motion frames are placed in the model tree in front of components with solid geometry. Since wireframes differ in functional characteristics from other components, they are indicated in the model tree and in the Mechanism Design model tree using the following icons.

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## **КАРКАСНОЕ МОДЕЛИРОВАНИЕ ДЛЯ ГЕОМЕТРИЧЕСКОГО ПРЕДСТАВЛЕНИЯ ДЕТАЛЕЙ В САПР-СИСТЕМАХ**

***С. С. Бекназарова***

*профессора Ташкентского университета информационных технологий имени Мухаммеда Аль-Хорезми, доктор технических наук, доцент*

***Г.А. Каюмова***

*Преподаватель Ташкентского университета информационных технологий имени Мухаммеда Аль-Хорезми*

*Кафедра аудиовизуальных технологий, Ташкентский университет информационных технологий имени Мухаммеда Аль-Хорезми, Ташкент, Узбекистан*

*Кафедра аудиовизуальных технологий, Ташкентский университет информационных технологий имени Мухаммеда Аль-Хорезми, Ташкент, Узбекистан*

*E-mail: saida.beknazarova@gmail.com*

**Аннотация.** В статье описаны несколько вариантов геометрического представления детали в САПР-системе. Выбор того или иного варианта зависит от возможностей системы и от необходимости ее применения для создания управляющей программы. Не так давно Кульман был главным инструментом инженера-конструктора. С появлением первых персональных компьютеров началась настоящая революция в области автоматизации проектирования. Инженеры-конструкторы сразу оценили преимущества "плоского чертильщика". "Даже простейшая САД-система для двумерного проектирования позволяет быстро создавать различные геометрические элементы, копировать фрагменты, автоматически наносить штриховку и проставлять размеры.

Основными инструментами в плоском дизайне являются линии, дуги и кривые. Используя операции растяжения, обрезки и соединения геометрических элементов, происходит создание "электронного чертежа". Для полноценной работы с плоской графикой в системе САМ необходима дополнительная информация о глубине геометрии. Каркасная модель представляет геометрию детали в трехмерном пространстве, описывая положение ее контуров и граней. Каркасная модель, в отличие от плоского электронного чертежа, предоставляет кулачковой системе частичную информацию о глубине геометрии. С развитием автомобильной и авиационной промышленности и необходимостью аналитического описания деталей сложной формы на ПК сформировались основные предпосылки для перехода от плоского к объемному моделированию.

**Ключевые слова:** типы моделирования, каркасная модель, 3D-модель, модель поверхности.