SOLVING SPECIFIC GEOMETRICAL TASKS WITH AutoCAD SYSTEM

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Abstract: The paper deals with creation of graphics database for automated design and modeling of developments of nonlinear revolved surfaces with AutoCAD system. The methodic of creation of database is described. This database is adapted to AutoCAD2000 release.

Key words: automated design, database, development, drawings AutoLISP, DXF.

1. Introduction

Computer aided drafting and design systems (CAD) are tremendously powerful tools. The speed and ease with which a drawing can be prepared and modified using a computer offer a phenomenal advantage over hand preparation.

There are a lot of CAD systems supplied with graphical databases adapted to create technical drawings. Using these systems designer can solve different technical tasks. Apart from all the advantages of CAD systems sometimes these systems are not able to solve special problems. It is a common case that the popularity of CAD system in the region is related to the database assigned to the system, existing possibilities to adjust it to the special users' requirements, to availability of technical literature and to the activity of the dealers and extensiveness of the advertisements.

In our region, in the West Europe and all over the world the AutoCAD system is very popular. A lot of design, business firms and universities are working with that system. This system is used as a basic one for the first year students also at Lithuanian universities.

AutoCAD system is the software with an open architecture. Knowing programming languages, design principles of that system we can adjust it to specific users' requirements. In such case special geometrical tasks which can not be done directly with a base system can be solved.

The paper deals with creation of AutoCAD subsystem. This subsystem is used to create developments of nonlinear revolved surfaces which are presented in detailed drawings (in 2D space). Such surfaces as a sphere or a torus belong to undevelopable surfaces. Existing methods for constructing their developments give only approximate results. In common, the development of nonlinear surface can be created by segmentation of the feature into small elements. These elements can be converted into the linear ones. This job is labour-intensive. While using graphical methods the deviations from natural forms and size appear. With CAD technique the deviation of errors was minimized by adding theoretically and practically unlimited number of segments. Algorithm of solution is presented in the paper. With the use of AutoLISP and DCL programming languages specific programs were created. DXF code analysis assigned to the drawn entities was done in order to calculate random points on developed surface.

The results of investigations showed to be suitable to create developments of revolved surfaces, to set up the areas of these surfaces and to calculate material expenditure required for surface covering. Comparison of used method with a graphical one is presented in this paper.

2. The Technique of Nonlinear Developments Creation for Undevelopable Rotational Surfaces

Theoretically all nonlinear surfaces due to its great deformations (wrinkles and splits) over developing process are undevelopable on a plane. Due to their physical properties the surfaces are frequently used in chemical, oil and other industries (spherical tanks etc.). Frequently the volume of tanks exceeds hundreds of m^3. These tanks are produced from separate metal sheets using welding processes. In order to prepare the metal sheet for welding process, the surface development must be done at first. In particular, the developments of nonlinear surfaces are important if one wants to calculate the area of so complicated surface, which is directly related to high costs of the material used for covering.

The development of a surface is a surface, which is laid out on a plane. Practical applications of developments occur in sheet-metal works, stone cuttings, pattern making and package design. Single-curved surfaces and surfaces of polyhedra can be developed. Warped surfaces and double-curved surfaces can be developed approximately.

In order to introduce the technique for creation the developments of undevelopable rotational surfaces the analysis of rotational surfaces will be done.

The intersection of a plane and a sphere is a circle. The diameter of the circle depends on the plane position relative to the sphere's centre. Choosing meridian and perpendiculars to its plane, the sphere can be dismembered into quadrangles or triangles, which sides create arcs. Theoretically, arcs can be changed to cords if the cutting planes are located close to each other.

Similarly it is possible to create developments for all rotational surfaces. Using computer technique it is possible to create unlimited number of sectional planes to omit random errors. In order to create such developments, the AutoCAD computer aided design system was used.
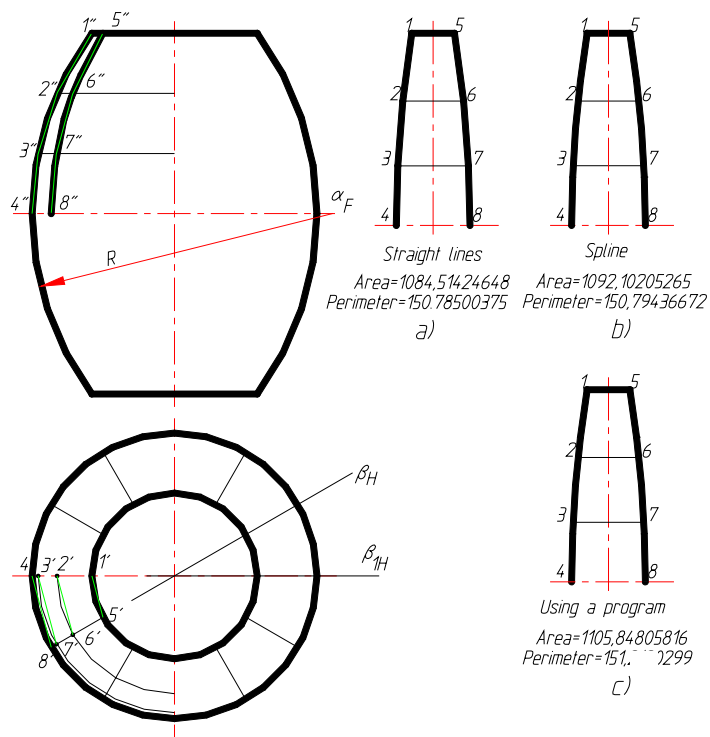

Fig.1 The Development of Torus

In order to understand modelling of undevelopable rotational surfaces drawn using 2D technique, let us analyze the development of torus presented in Fig.1. Since the presented surface is respectively symmetrical to the sectional plane α_F, we will analyse only development of the upper side of torus. Using meridian planes the surface is divided into 12 equal pieces. Using more planes the overweight of the drawing with auxiliary lines and assigned description to it will be made.

The arc, which radius R, is divided into 3 parts (see Fig.1). The arcs between points 1-2, 2-3, 3-4 on the main meridian can be changed into chord, which real length is put on axis of coming development. The arcs between points 1-5, 2-6, 3-7 and 4-8 are changed to chord. These changes allow to draw development of torus segment located between β_H and β_{1H} planes. Automated design systems allow changing chord to spline. That action improves accuracy of calculations, too. The arrays of described developments allow to create full development of torus surface, to calculate areas required for coverage and expenditure of materials.

The comparison of different methods used for areas calculation shows:
1. total area of one segment defined using graphical method (all drawings were done using AutoCAD drafting system) is equal A1=1084,514mm^2, perimeter P1=150,785mm (Fig.1. a);
2. total area of one segment defined using graphical method and having points 1-2-3-4 and 5-6-7-8 jointed with a cubic B-spline, is equal A2=1092,102 mm^2, perimeter P2=150,794 mm (SPLINESEGS system variable value – 8,);
3. total area of one segment defined using computer technique is equal A3=1105,8486 mm^2, perimeter P2=151,212 mm. In this case the number of segments is 6x12;
4. total area of one segment defined using computer technique is equal A4=1110,0857 mm^2, perimeter P2=151,5478 mm. The number of segments is 1000x12.

Having compared the calculations provided above we found out that in all cases the area and perimeter has a tendency to be increased. Those results make sense as the linear segments were changed with arcs and its real lengths. The deviation of results between the first and the fourth cases is 2,358%. That is not a big value, but the efficiency of computer technique in time for the development drawing and calculation of area size is obvious.

Using computer technique, we can get array of segments developments and calculate full area of development for any undevelopable rotational surfaces.

In order to create developments for undevelopable surfaces an appropriate subsystem was made inside of AutoCAD 2000 system. For that purpose an appropriate programs in AutoLISP and DCL program language were written. The graphical menu attached to that subsystem presented on the Fig.2.

Using AutoLISP programming language the lists of the data required for development creation were made (the size of the list deals with a number of used segments in calculation process). For that purpose the `internal AutoCAD database was used and DXF code analysis assigned for entities in the drawing was done [1, 2].

In order to use calculated data for development drawing, the drafting command was formed at the end of the program.

Some important steps for solving the tasks are presented below.

```
(defun C:TORUS ( )
…(setq sar (ssget))     ; Prompts the user to select object and returns a selection set,
…(setq en1 (ssname sar 0)); Returns the object name of indexed element of a selection set,
…(setq e1 (entget en1))     ; Retrieves an object's definition data,
```

…(setq ent1 (assoc 0 e1)) ; Returns associated list entry,
…(setq tip1 (cdr ent1))   ; Set's object name…and so on.

Using objects' name we can recognize object and DXF codes' structure assigned to it. As well we can find necessary points located on the object, in order to set up geometrical characteristics used for development creation. As an example list with DXF code 10 assigned to line will be start point of line, 11 – end point of line; for arc: 10 – center point, 40 – radius of arc, 50 and 51 start and end point angles of arc and so on.
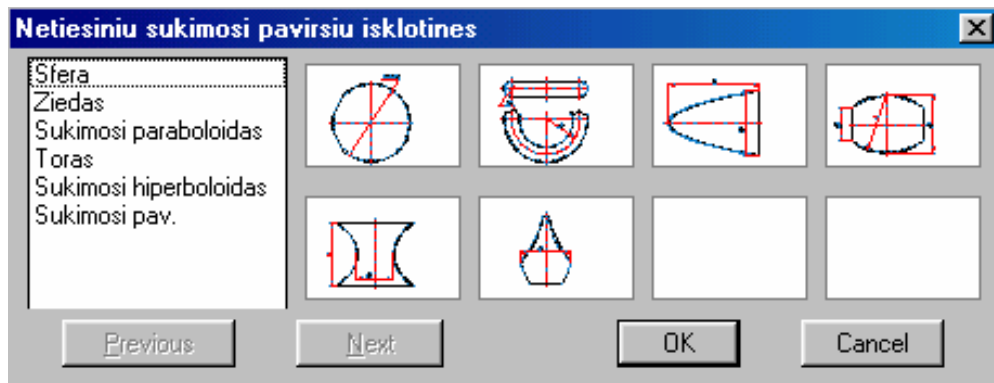
Fig.2 Graphical Menu for Development Creation

For the data list formation and development drawing, the AutoLISP geometric, conditional and list manipulation functions were used.

The AutoLISP command function was created at the finally step of program and presented as follows:

  (apply 'command px1); where px1 is all the arguments associated with command function structure, assigned to development drawing.

Practically the number of arguments assigned to variable px1 is not limited. This number deals with the number of equators and meridians used for development calculation.

3. Conclusion

The AutoCAD subsystem for automated design and modelling of developments of non-linear revolved surfaces (drawn in detail drawings in 2D space) was created. It allows increasing the accuracy and the speed of developments creation, calculation of its areas and expenditure of materials required for its covering.

The results of investigations could be adapted to CAM systems, for planchet preparation and learning process.

Biblography

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Recenzent: dr inż. Renata A. GÓRSKA