

Turbine blade profiles generation using NURBS

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Abstract: In modern integrated environment, it is possible to use computer aided design (CAD) to explore design options and subsequently employ computational methods with the CAD model for design and development. For the geometric definition, most of the existing CAD systems rely upon the 'Non Uniform Rational Basis Spline (NURBS) representation for geometric definition. Once the geometric definition is ready with a CAD model, it needs to be analyzed. It is known that the NURBS gives more control over the geometric definition of the body. In the paper a simple method for generating various profiles is proposed. Firstly, new profiles are generated and control points holding the profile is calculated. Later, these points are used to design the model using C-language. Some examples are provided to show effectiveness of proposed paper.

Keywords: CAD, Parametric Modeling, NURBS

1. INTRODUCTION

Lot of real world objects is inherently smooth and computer graphics involves modeling the real world. The need to represent curves and surfaces arises either in modeling existing objects (a figure, an airplane, a car etc.) or in modeling from scratch, where no pre-existing physical object or data is available as source of information. In the proposed paper second methodology is used for design purpose.

To create the object, user sculpts the object interactively or describes it mathematically or gives an approximate description to be filled in by program. Synthetic curves are used (curve is represented by a collection of measured data points) as they are flexible (to bend, twist or change the curve shape by changing one or more data points. Design process is based on description of object where the initial body of object is defined by parametric curves in

front or a side view. The parametric curves contain geometric features and dimensions. The paper deals with the designing of turbine blade using NURBS, without using pre-existing data.

2. LITERATURE SURVEY

Parametric technology was widely used since the 60s of last century. Parametric technology is based on the kernel of constraints being a superior approach [2].

Geometric constraints are either structural or dimensional in nature. These elements of parametric model should fulfill the constraint requirements desired by customers. The main feature of parametric modeling is to carry out the update of variable (dimensional) parameters while keeping the invariable (structural) constraints unchanged. [2]

For parametric designing of parts with free form surfaces firstly input point data are used to generate new profiles. Then, the information is extracted from existing model. Lastly, old profiles are replaced with new profiles, preserving old associative information of existing model and generating various drawings [4].

For designing large blade profiles, 2D shells for aerodynamic surfaces and internal shear web composites are defined and 3D bricks for volumes of glue are used to connect the sub-components. The aerodynamic shape is defined by an interpolation process to create a smooth curve through successive curves. [5]. The topicality of dealing with curves is constantly stimulated by the practical human needs in the various areas of his activities, but they are also significant for the "joy at observing the forms" that is human aesthetic and artistic need.

The analytic and synthetic method of obtaining and researching of the curve lines, using different means and procedures, are mutually intertwined, complemented and overlapping while striving towards the common goal. [6]

In this paper, parametric modeling of various profiles is done using Non Uniform Rational B-Spline curves. The method uses geometric parameters as initial data allowing the designer with additional feature to refine the section curve by moving its control points. Thus, the profiles can be edited keeping geometric parameters same, helping the design the construct the desired profiles effectively and efficiently.

3. A METHOD FOR DESIGN OF PARAMETRIC CURVES

Non-uniform rational basis spline (NURBS) being a mathematical model is used in computer graphics for generating and representing curves and surfaces. It can handle both analytic (surfaces defined by common mathematical formulae) and modeled shapes.

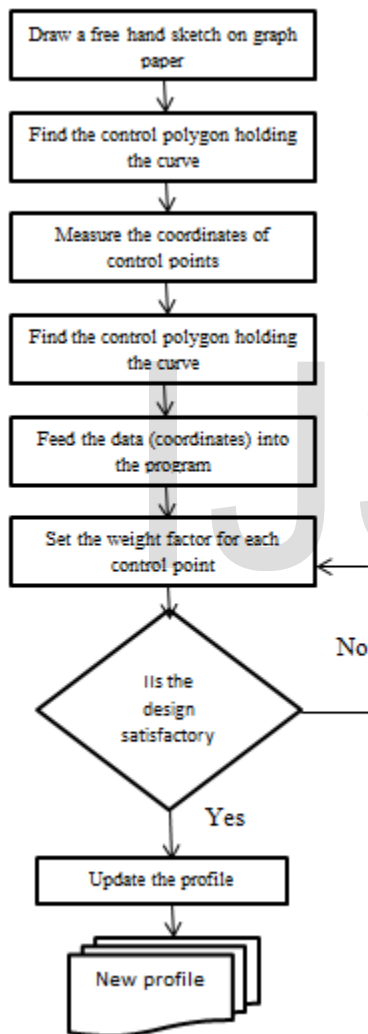
The shape of the surface is determined by control points which may be either connected directly to the curve/surface or act as if they are connected by a rubber band.

A NURBS curve can be defined as vector valued piecewise rational polynomial function which helps in constructing any profile by breaking it into sections and joining them, to form a smooth curve. 'C' programming is used to design variety of 2D objects such as cup model, plate model, turbine blade, car body, aircraft winglets etc. which can be modified to meet the customer's demand. Finite element analysis is applied to reduce the equations to efficient numerical algorithms computable at interactive rates on common graphics workstation.

In this paper a turbine blade profile is designed without using any pre-defined standard parameters. A free hand sketch made on the graph paper, without use of any geometrical parameter such as length, angle etc. provides the input for the design process. The coordinates measured from graph are used as input (control points) in the program. The splines for each set of control points are defined independently on the basis of weight functions. The values of

weights are adjusted for each control point such that they form the desired shape of any profile. The mathematical value of weight for each coordinate can be changed at any point to generate various set of profiles using the same control polygon.

Flowchart showing the procedure of design process:



APPLICATIONS OF DESIGN PROCESS

The control polygon made manually gives the input for program. Any free hand sketch of an object can be drawn without using mathematical functions or data. The

feature of NURBS helps in generating the required profile by finding a large number of coordinates between two given control points. The shape or structure of curve can be controlled by varying the knot vectors or weight functions which help in producing the continuous shapes. Example: a Cup model (Fig. 3.1).

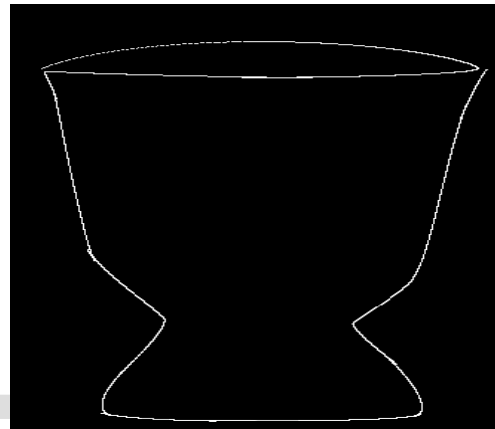


Figure 3.1 showing a cup model

TURBINE BLADE MODEL

The same process is followed where a template model is used as input for the parametric design process (Fig. 3.2). An airfoil is defined by profile curves composed of arcs and line segments. The figure 3.3 shows the profile as smooth curve.

If any discrepancy is found, the curvature can be edited by simply modifying the weight functions accordingly. There is no need to start the process from the beginning.

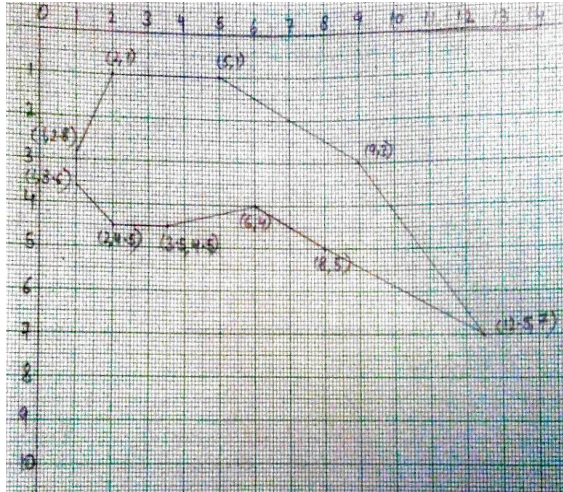


Figure 3.2 showing initial free hand sketch of turbine blade on graph paper

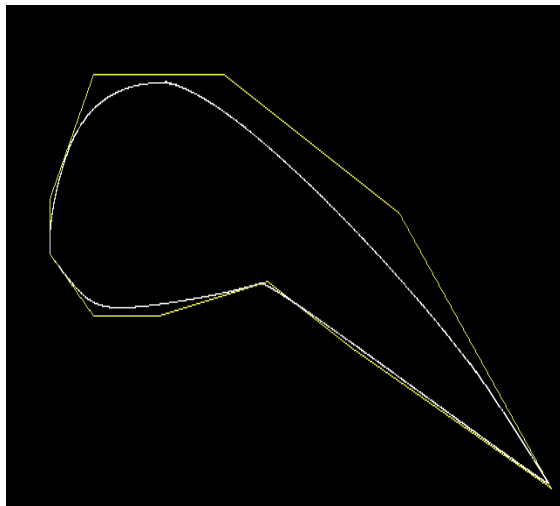


Figure 3.3 showing turbine blade(2D) using the coordinate points of graph paper

4. RESULTS AND DISCUSSIONS

The proposed program and methodology produces successful and desirable results. The process can be extended to design various other components. The turbine blade design is just based on designer's inputs, irrespective of standard profile parameters. This method provides enough scope to design and modify new components with less efforts and time

investment. The same input coordinates can be used to produce various profiles just by changing the weights related to each coordinate point. Few coordinate points can also be altered to produce different profile. (Fig. 4.1).



Figure 4.1 showing a different blade profile

5. CONCLUSION AND FUTURE SCOPE

After the modeling, the 2D cross-section can be extruded. Turbine blade formed in 3D can be tested for stress, strain distribution. Various other parameters can be calculated on simulation software to check whether the design is feasible from manufacturing point of view.

The proposed method of design and analysis can be extended to various components taking into consideration multiple factors. The exposure of parts to extreme temperatures, pressure and other conditions makes it important for designer to study the effect of the time varying factors.

5. REFERENCES

- [1] T KORAKIANITIS AND G I PANTAZAPOULOS (1993), Improved turbine – blade design techniques using 4th order parametric spline segments.
- [2] SONG YUWANG, XI PING 2004. Parametric design of turbine blades on feature modeling. *Journal of Beijing University of Aeronautics and Astronautics*. 30(4): 321-324
- [4] KIM YEOUNG-IL, KIM LI-RA, JUN CHA-SOO 2006. Parametric design of a part with free- form surfaces. *Journal of Zhejiang University SCIENCE A*. 1530-1534
- [5] PAUL A. BONNET and GEOFF DUTTON 2007. Parametric Modeling of Large Wind Turbine Blades. *Energy Research Unit*.
- [6] BISERKA MARKOVIÆ 2001. Comparison of the analytic and synthetic Methods for transformation of the nth order curves into the 2nd order curves, *Architecture and Civil Engineering Vol. 2, No 3, 2001, pp. 219 – 230*.
- [7] PIEGL, Modifying the shape of Rational B spline Part 1; Curves; CAD, Vol 2, No. 8, October 1989 pp.509-518.
- [8] THOMAS W. SEDERBERG, G. THOMAS FINNIGANZ, XIN LIY. HONGWEI LINX, HEATHER IPSON, Watertight Trimmed NURBS
- [9] DAVID F. ROGERS AND J. ALAN ADAMS, Mathematical Elements for

Computer Graphics. 2nd edition.
McGraw-Hill Book Company, (2012).