Parametric Design
SOFTWARE CAD PLM @ CONSULTING @ TRAINING

Reverse engineering with Mathcad
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Job description

• Client for whom the project is to be developed

  Leader group in the production and maintenance of gas turbine engines for the generation of electric power (gas turbine from 8 to 240 MW)

• Product characteristics

  Gas turbine engine compressor blades

• Objective to be reached for the client

  Reconstruction of 3D parametric models of the blades, necessary for the testing of the airfoils on a CMM machine
Work objective

Generating a parametric 3D model of the blades

**Input**
Numerical data representing the coordinates of points forming the concave and convex profiles of the blades at different heights

**Output**
3D model derived from curves calculated by polynomial regression of the numerical data
Why Mathcad?

- It provides advanced calculation features, easily modified in a user-friendly interface.

- It includes text-writing commands (string manipulation). Which allow the generation of text files that can be used by Pro/Engineer as input for parametric modelling.
Input data

Numerical values representing coordinates of the points forming the concave and convex profiles of the blade at different heights

Elaboration in Mathcad

Best-fit procedure to obtain optimal curves approximating the data points, through polynomial regression at the desired order (with control of the curvature)

Generation of the 3D model

Importing the text files to Pro/Engineer, with automatic updating of the equation-driven curves and of the concave and convex surfaces built on the curves

Exporting the results from Mathcad

Writing of a text file containing the definition and values of parameters necessary for the construction of the blade profiles curves in Pro/Engineer
Reverse Engineering: flow chart

Input data

Elaboration in Mathcad

```
Definizione dell'ordine del polinomio di regressione ed estrazione del polinomio

n := 4
coeff_conv := regress(X_conv, Y_conv, n)
regressione_profilo_convesso(x) := interp(coeff_conv, X_conv, Y_conv, x)
coeff_conc := regress(X_conc, Y_conc, n)
regressione_profilo_concavo(x) := interp(coeff_conc, X_conc, Y_conc, x)
```
Reverse Engineering: flow chart

Generation of the 3D model
The degree of polynomial regression is chosen in Mathcad on the basis of a two-way cross analysis:

- Maximum error obtained with respect to the data points
- Course of the curvature of the blade profiles
This preliminary analysis allows Pro/Engineer to produce 3D surfaces with the desired curvature.
Creating the fillets between convex and concave profiles

The centre coordinates and the radius of the circumference tangent to the profiles are calculated in Mathcad and exported as parameters in text files.

In Pro/Engineer the fillets are created as curves controlled by parametric equations.
Defining analysis features in Pro/Engineer

Some parameters have to be checked in a post-modelling step, particularly the value of the maximum cord for each blade section.
The implemented methodology has the advantage of allowing rapid and easy modification of the project through the following phases:

- Updating the Mathcad worksheet:
  - changing the input data (coordinates of the profiles points or the number of sections taken on the blade)
  - changing the degree of polynomial regression

- Updating the model in Pro/Engineer:
  - importing/reading the text files generated by Mathcad
  - Regenerating the model
Conclusions

• The described procedure can be used to automate the creation of 3D models of components characterized by complex curves and surfaces that require suitable control of the curvature

• Employment of Mathcad allows the choice of the most suitable mathematical function for the reconstruction of curves (polynomial regression in this example)

• It is possible to obtain in Pro/Engineer a 3D model and relative 2D drawings, automatically updatable after modifications carried out in Mathcad spreadsheet