pdesk® **Version 2.2.0**

Better control for the blade geometry design process

pdesk® is an advanced software system for the geometry design of turbomachinery blades.

pdesk® gives the engineer 100% control on the variety of parameters and physical properties.

With **p**desk® you can find an optimum design with all the advanced features incorporated in next generation turbomachinery and aircraft.

pdesk® comprises a suite of parametric geometry repre-sentations and a customisable adapter interface to your company standard.
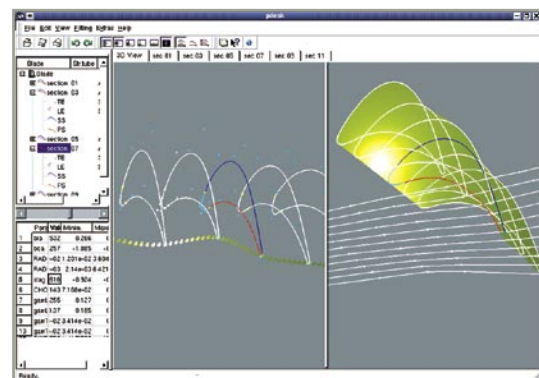
pdesk® includes methods for parametric stacking, fitting, smoothing of the blade shapes, airfoil modifications and radial parametrisation.

A rules based design option, a database connection, interfaces to major CAD systems and CFD packages and optimising functions form a complete system. With the command line interpreter, a script language and a programming interface (API) you are able to do systematic variations in a multistage en-vironment.
All this comes with a comfortable and convenient graphical user interface 3-D graphics.

Standard plots for surface curvature, thickness and camber angle distribution are included as well as many different types of stream section representations including (m, r*theta), (m',φ) and Cartesian (x,y) of cone unwinding. The resulting geometry and the calculated physical properties are displayed immediately. The user can design the blade on an arbitrary number of 2-D sections on arbitrary defined stream-surfaces. Sections can be interpolated, shifted, twisted, rotated etc.
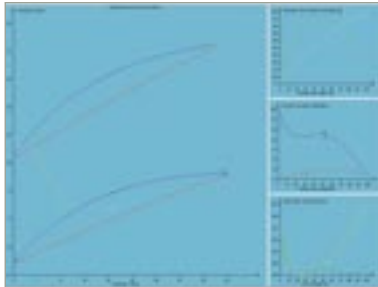

In different plot views all parameter data of sections and segments you can indicate.

The **p**desk® software is fully object-oriented and runs on all major hardware platforms.
All Section and stream surface data can be displayed, ordered and modified in tabular form. Modifications can be done either on the geometry or on the related spline control points. The flexibility in the design covers all turbomachinery applications such as HP and LP turbines, compressors, fans, inlet and outlet guide vanes. Different rules for rotors and stators and different operation ranges are included in the "knowledge based design" option.

Geometry interfaces

open STEP adapter, SPLINE-Interfaces to major CAD-Systems (CATIA, UG, CADDS, Pro/E) **p**desk® has an XML interface.

System requirements

UNIX platforms (SUN, SGI, HP), Linux
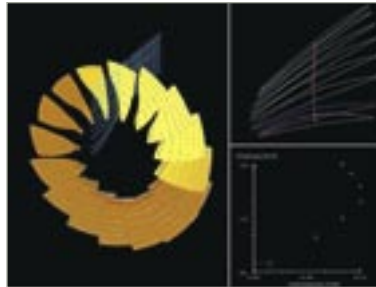Windows NT, 2000, XP (128 MB RAM minimum)

2D View

pdesk® supports a number of 2D-views for cuts (sections). The visualization offers (x, y) and (z, r*theta) standard views.

Command Line Interpreter

All design operations executable via the **p**desk® -GUI can also be accomplished with the integrated command line interpreter. In **p**desk® you can either input single commands in the command line box in the respective toolbar (see picture below) or you may load script-files for easy to repeat multiple operations with the "Open Command File"-button or the "include"-command in the command line box.
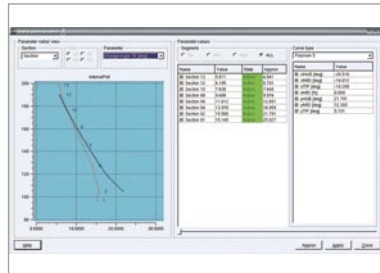
Data Explorer

In the data explorer on the left hand side you see the data for an individual cut chosen in the structure browser and for the entire blade. Therefore different parameter tables can be switched on and off.

3D View

In the 3D View you can interactively move, rotate and zoom the blade. Various properties of the 3D-windows can be set. You can switch the presentation of the blade surface, displaying the points, lines wire mesh) or filled polygons of the surface of the blade which is defined by the individual sections.
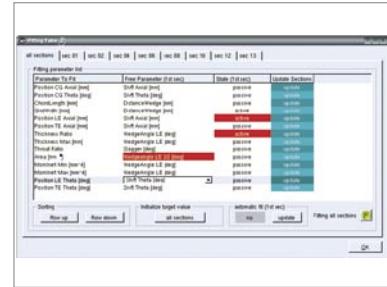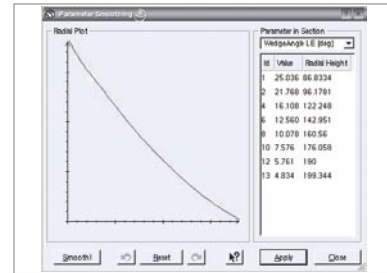
Tools > Value Fitting…

The concept of the value fitting is to achieve target values for derived parameters of a section by freeing and changing various master parameters in an adjustable interval.

Radial parameterization

This tool allows to adjust master parameters and fitting parameters according to certain constraints by a polynomial approximation.

Parameter Smoothing

This tool allows the smoothing of the parameter distribution by using an approximating B-spline. The parameters will be flattened by a stepwise application of a smoothing function.

Airfoil Modifications

This tool allows the modifications of structural mechanic parameters.

Import modules

There are several possible parameter types in **p**desk®. These are connected with special import modules. For the interfaces to important CAD -, to CFD and FEM systems there are already a number of importers available. For information about available import modules being in development please contact atech GmbH.

Data Export

The data of the modified blade can be exported and continued to process in different formats. These formats are XML *.xml and the STEP-format *.stp. Further exporters for special requirements can be requested.

Axial Curve Stacking

In the Axial curve stacking dialog the user can apply a parametric specified curve on the blade stacking line. For this purpose the Blade is divided in three segments: Hub, Mid and Tip. For each segment it is possible to adjust the angles of the curve, the shifts and the segment height with either a slider, a spin box or by directly entering values using the keyboard. The stacking line will be applied to the leading edge, the trailing edge or the centre of gravity of the blade.
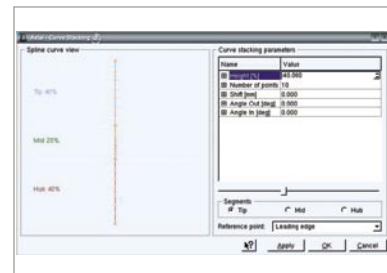
Use Cases

The following list presents a number of use cases for the pdesk® design system.

TURBOMACHINERY

Multistage transonic HP compressor
The design process for a high pressure compressor blade requires different operation steps. To simplify matters they are demonstrated at only one section of the blade.
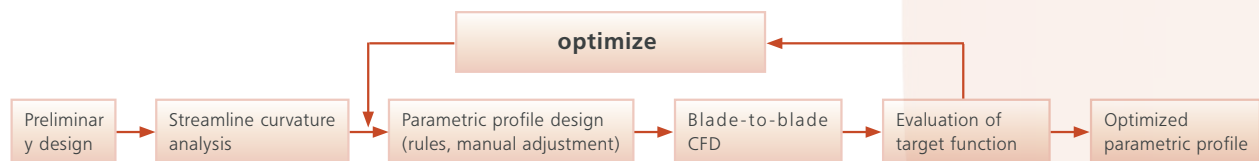The steps described in the following represent no defined processing order. Because a lot of adjustments of different parameters affect each other some steps have to be repeated to get the required final result.

AIRCRAFT / AEROSPACE

Multivariate airfoil geometry optimization
A given airfoil was optimized with **p**desk® using the optimization toolkit. A user-defined target function was specified, which consists of a number of different components such as loss loop, boundary layer optimization (controlled diffusion), radial thickness distribution, position of maximum thickness and leading edge aerodynamic patterns.

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                    │       optimize        │ ◄──────────┐
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│y design  │─►│  │curvature     │─►│design            │─►│CFD           │─►│target function│─►│parametric    │
│          │     │analysis      │  │(rules, manual    │  │              │  │              │  │profile       │
└──────────┘     └──────────────┘  │adjustment)       │  └──────────────┘  └──────────────┘  └──────────────┘
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The advantage of using **p**desk® is

- an excellent control on surface curvature distributions
- an multivariate optimization toolkit which is integrated into **p**desk®
- the use of well-conditioned engineering parameters for the geometry
- a fast and efficient optimization

AUTOMOTIVE

Formula 1 wing and diffuser aerodynamic performance optimization
The inlets, wing and diffuser of a Formula 1 car can be optimized with **p**desk® according to aerodynamic performance. This can be done with parametric systematic change of geometry parameters which are closely linked with aerodynamic performance characteristics such as drag, loss and aerodynamic lift. A complete cycle envelope with certain key points such as needle curves, top speed, acceleration and deceleration figures can be analyzed and optimized with multivariate optimization techniques.

Aesthetical modification of a car body with quantifiable measures
The aesthetical appearance of a car in general can not be quantified or measured. However, certain aspects can be subject to exact measurements very well. This can be surface smoothness, deviation of the mirror image, parallelism of edges etc.
With **p**desk® some of these specific surface properties can be analyzed and optimized. Rules can be generated for a "nice looking" surface shape. The result is a class A surface definition of the exterior or interior design part.

pdesk® Product Overview

Viewing

2D

2 different master section view plus extra 3 properties views

Standard properties views
- Thickness
- Surface curvatures
- Camberangle distribution
- Throat and throat area distribution

Interactive change of view

Zoom functionality

Different coordinate systems: (m,r,theta), (m',phi), (m,r*theta), cartesian (x,y) of cone winding, (z,r*theta)

Arbitrary streamsurfaces (pointwise or polynomial description), cones

3D

single blade, streamtube lines,

stage, segments

view properties: light, shading

control points

active/passive sections

highlight sections or segments of sections

Parametric Design

Interactive changing of geometry master parameters

Interactive changing of global properties (number of blades, axial and circumferential offset)

Fitting of existing data

Modification of thickness distribution

Modification of throat

Modification of curvature distribution / properties

Different geometry types

Radial interpolation of stream section to surfaces

Copy/Paste/Move/Interpolation of stream sections

Do/Undo functionality

Derived Values

Simultaneous display and calculation of various derived values

Aerodynamic Data

Relative Mach number inlet

Relative Mach number outlet

Air inlet/outlet angle

Incidence, Deviation

Choke margin

Effective Throat

Geometric Properties

Maximum thickness

Position maximum thickness

Thickness/chord ratio

Throat, Throat area

Back surface deflection

Meridional and axial chord

Inlet/Outlet spacing

Different continuity options in radial and streamsurface direction

Section size

Data Manager

Parameter list for sections and side segmens

Derived value list for sections and side segmens

Global properties list

B-Spline control point coordinates

I/O Interfaces

STEP, NetCDF, ASCII

Customer-specific formats

2-D CFD (MISES)

3-D CFD (Fluent) – planned

3-D FEM (ANSYS, etc.) – planned

XML interface

Adapters

Various adapters are available for different geometry representation types:
- B-Spline parametrisation (standard: 28 parameters)
- Hermite Spline representation of degree 5 (20 parameters)
- Segmented Hermite Spline representation of degree 5 (variable number of parameters; for 4 segments: leding/trailing edge, suction/pressure side, a total of 42 parameters, can be extended arbitrarily)

Optimization

Different optimization procedures for inverse design and optimization of geometric features according to geometric as well as functional requirements based on the evaluation of target functions for aerodynamic performance, mechanical properties etc.

Certain special features can be introduced, eg. linear curvature distribution for suction side of a compressor airfoil etc.

Parametric Stacking

Parametric stacking module for systematic introduction of 3D stacking features

A stacking by a user defined curve in radial or circumferential direction is possible.

Airfoil Modifications

modifications of structural mechanic parameters

Radial Parametrisation

adjust master parameters and fitting parameters according to certain constraints by a polynomial approximation

Radial Blade smoothing and interpolation

Smoothing of radial distributions of design (master) parameters

Different spline-options:
- B-Spline , approximation/ interpolation
- Linear , interpolation/extrapolation

Identification/Repair of scattered sections

Interpolation to new stream surfaces

Overview plots, detailed plots of individual radial distributions

Rules based design

Rules based design and analysis package for the systematic analysis, trend analysis and semi-automatic generation of high-performance high-quality blade surfaces for stages and complete components.

Module is not included in pdesk® standard package.

Command Line Interpreter

All interactive functionality can be handled via a command line

Scripting language

Batch mode facility for automated program runs

API (Application programming interface)

Plotview

View all parameter data of sections and segments of the sides

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