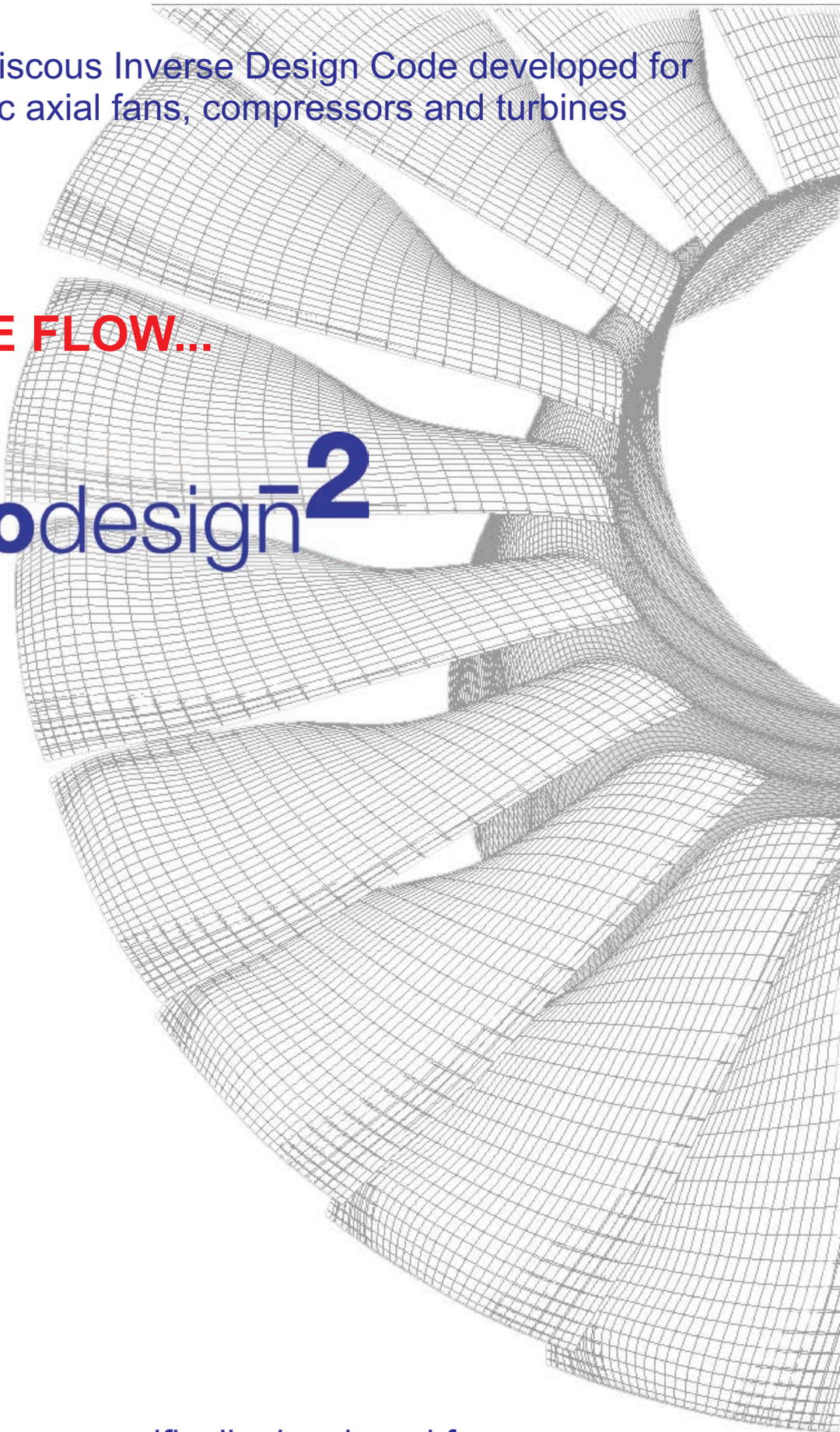
A fully 3D Transonic Viscous Inverse Design Code developed for application to transonic axial fans, compressors and turbines



MASTER THE FLOW...

TURBOdesign-2

TURBOdesign-2 has been specifically developed for the design of highly transonic Turbomachines where shock and boundary layer interaction has a very significant effect. Its application to the design of these of types of Turbomachines can offer many advantages

Advanced Design Technology

What are the advantages and benefits of TURBOdesign-2?

TURBOdesign-2 enables direct control of the 3D pressure field through the loading distribution, allowing the user to address flow features such as shock/boundary layer, shock/tip clearance interactions.

As a result of the Inverse nature of TURBOdesign-2, design know how obtained in any specific case will automatically become more universal, since it is based on flow physics. Simple and effective design guidelines can be generated and followed by all users.

This mechanism renders the design process systematic, which in turn substantially increases the likelihood of breakthrough designs, the benefits are as follows:

- Full shock capturing capability and viscous model.
- Blade geometry and 3D viscous flow fields are the direct outputs.
- Easy to export the resulting geometry to major CAD, FEA and CFD.
- Rapid design cycle.
- Easy to generate database of design know-how.

Main Features of TURBOdesign-2

- Mainly applicable to transonic axial fans and turbines.
- Rotating and stationary components.
- Two types of design specification:

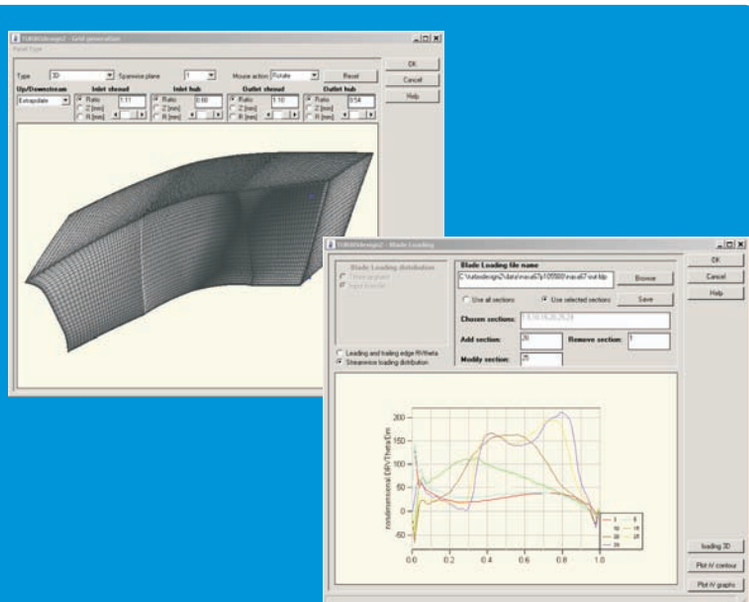
  Method 1 - The loading distribution or derivative of circumferentially averaged swirl velocity, as in TURBOdesign-1, is specified together with blade normal thickness.

  Method 2 - The surface static pressure Loading, $\Delta P (=P+ - P-)$ is specified together with the normal thickness.

- Possible to use both Analysis and Design Modes.
- Existing blade geometry can be read in and only certain parts of the blade is modified by changes to the loading distribution.

Pre-Processor

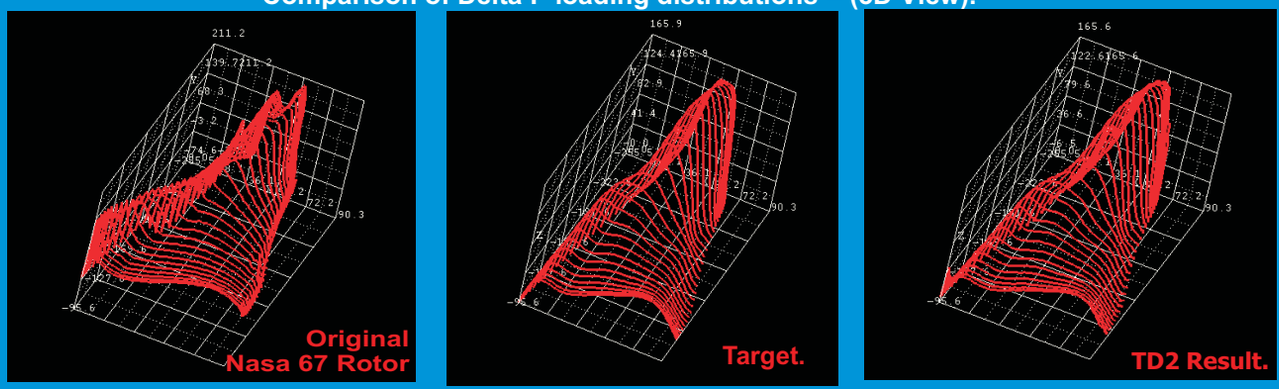
The TURBOdesign^{-2} pre-processor has a number of unique features as follows:



- An existing blade geometry can be brought into the program and the loading on the blade computed by using the code in analysis mode.
- The program automatically reads the normal or tangential thickness of the existing blade. The thickness distribution can be modified on any number of sections by using B-splines.
- The Mesh generation, based on a H Mesh, is fully automatic. But if required the code also allows the full control of clustering at the endwalls. The generated mesh can be observed in 3D, meridional and blade-blade views.
- The spanwise RVT distribution and loading distribution of an existing blade can be read in and modified interactively by using B-spline control points.
- The inlet boundary conditions can be specified in terms of flow angles and total pressure and temperature while at far downstream radial equilibrium can be satisfied or radial distribution of static pressure specified.
- The stacking conditions can be based on the existing blade geometry data.

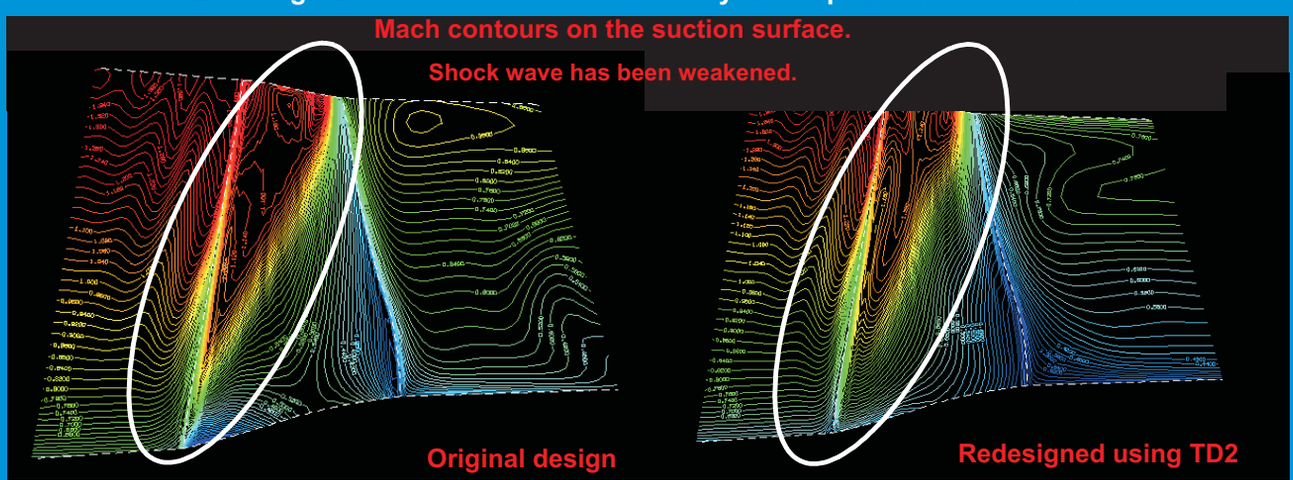
Case Study - NASA 67 Rotor

Comparison of Delta P loading distributions – (3D View).

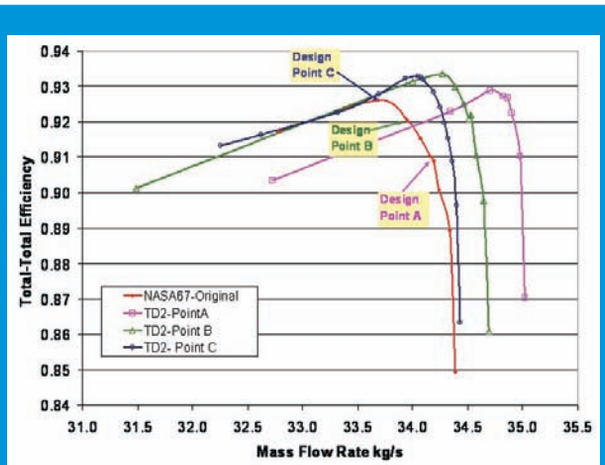


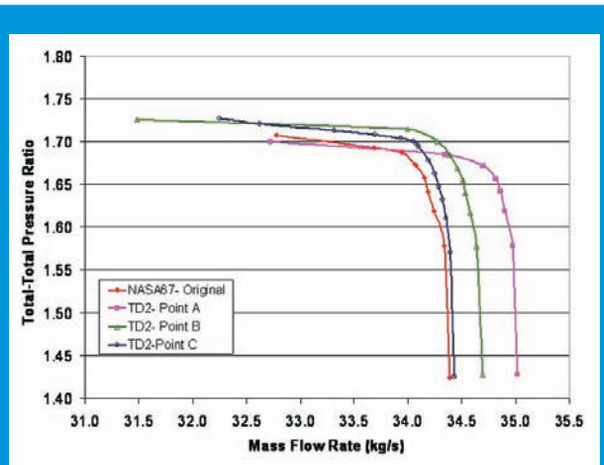
TURBOdesign-2 inverse design method with the multigrid technique is robust and fast. Typical CPU time needed on a Pentium 4 2.0 Ghz is about 1.3 hours, which will depend on the difference between target Δ P distribution and the original one. The blade loading can be easily and interactively modified by using B-spline control on as many or as few sections required. Smooth blade geometry usually can be obtained from the redesign, as long as the loading distribution is smooth.

TURBOdesign-2 models the effect of viscosity and captures shock waves.



Comparison of Mach number distribution near the suction surface of the original NASA 67 rotor with the rotor designed by TURBOdesign-2 indicates considerable reduction in the preshock Mach number in the designed Rotor.





The computed characteristics of original NASA 67 rotor are compared with the rotors designed by TURBOdesign-2 in the above Figure. In fact three different designs were performed based on different points on the characteristics of the original design. Point A which is close to choke point results in a rotor design with higher choke margin and slightly higher efficiency. While by choosing point C it is possible to obtain a design which has the same choke point as original NASA 67 rotor but has higher efficiency. The characteristics results also indicate that generally speaking the specific work is well preserved in TURBOdesign-2.

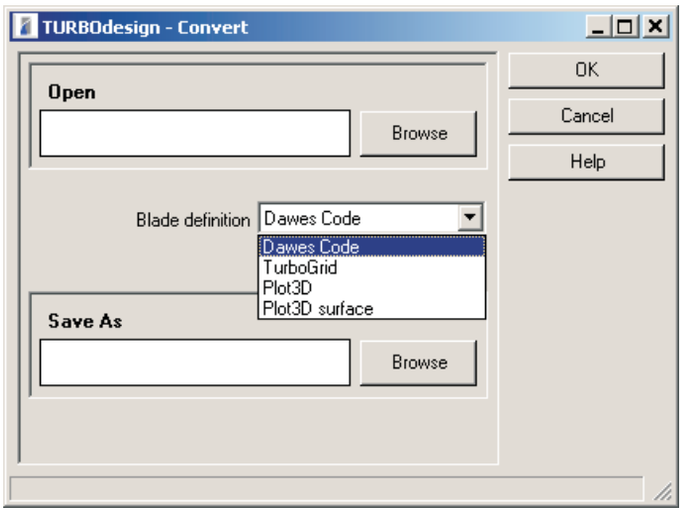
CAD and CAM Intergration

The geometry computed by TURBOdesign-2 can be immediately ported to most CAD, CFD and FEA codes. Examples of available general export data formats include;

- IGES
- STL
- VRML

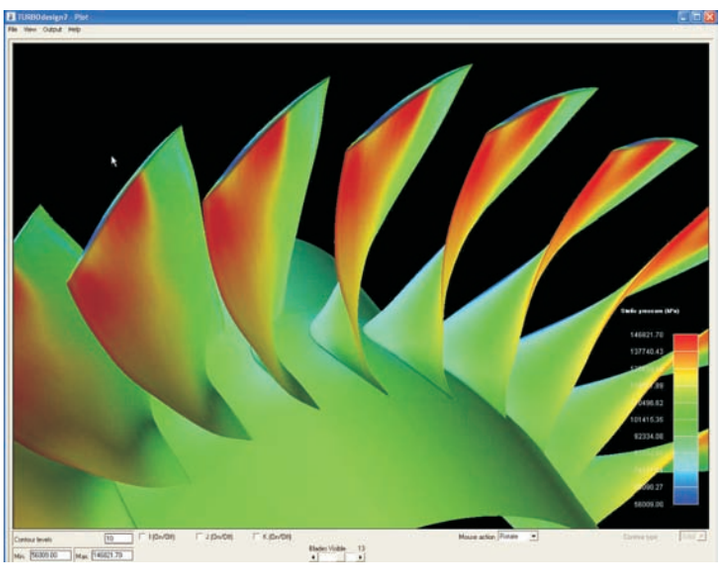
In addition program specific data export is available for all main CFD codes such as;

- Fluent (G/Turbo),
- CFX-TURBOgrid,
- CFX-Bladegen (.rtzt)
- STARCD (es-turbo)

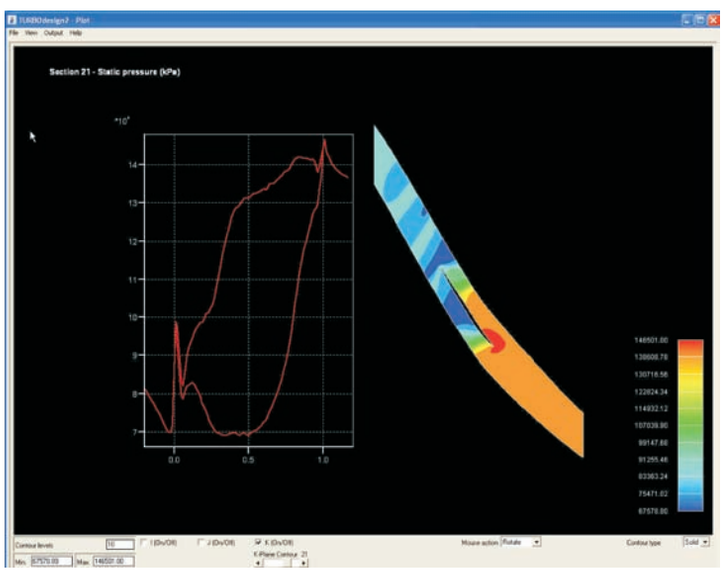


Post-Processor

TURBOdesign-2 provides a comprehensive post-processor which allows the plotting of the geometry as well as all flow variables in 3D, 2D and 1D.



3D Contours of Pressure Distribution on a transonic fan.



2D view of the blade pressure distribution and blade to blade contours.

System requirements

Operating System: Windows - XP, 2000, NT.

RAM: 500Mb minimum

Processor: 2.8GHz P4 and above

Disk Space required: 300Mb

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