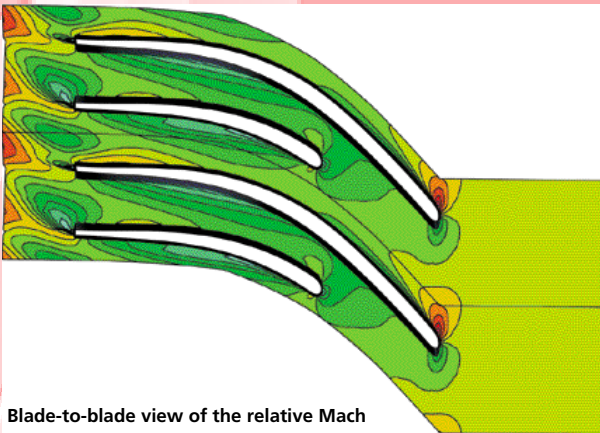


Optimised compressor delivers high efficiency

by **Olaf Niestroj** and **Chris Robinson**, PCA Engineers, Lincoln, UK

Turbomachinery consultants, PCA Engineers, use CFX-TASCflow as an integral part of their design system for the development of industry-leading turbomachinery components. PCA's approach is to seamlessly combine traditional 1-D and 2-D methods with the best available CFD. This ensures that preliminary designs incorporate the proven empiricism distilled from past experience, and soundly based designs can then be thoroughly investigated and optimised using CFX.

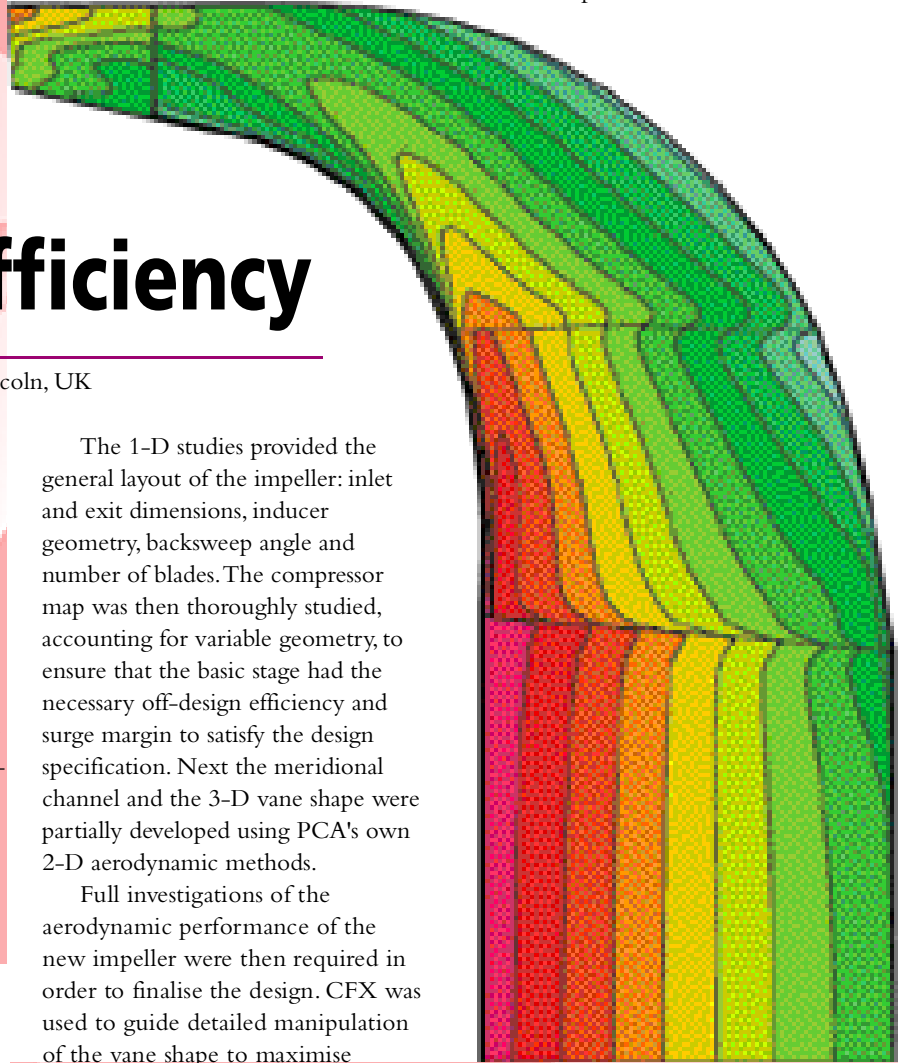
In a recent project, PCA optimised a centrifugal impeller to deliver high efficiency over a wide flow range when close-coupled to a variable-vaned diffuser in a single-stage air compressor. This configuration is a low-cost alternative to stages with higher backsweep, which need an additional variable inlet guide vane to achieve the required 60% turndown in flow from the nominal operating condition.



Blade-to-blade view of the relative Mach number near mid-span

The 1-D studies provided the general layout of the impeller: inlet and exit dimensions, inducer geometry, backsweep angle and number of blades. The compressor map was then thoroughly studied, accounting for variable geometry, to ensure that the basic stage had the necessary off-design efficiency and surge margin to satisfy the design specification. Next the meridional channel and the 3-D vane shape were partially developed using PCA's own 2-D aerodynamic methods.

Full investigations of the aerodynamic performance of the new impeller were then required in order to finalise the design. CFX was used to guide detailed manipulation of the vane shape to maximise efficiency and to investigate off-design behaviour, well in advance of high-cost test-bed validation. Key parameters, such as efficiency and work input, can be deduced from these simulations and post-processing of the results reveals details of the blade element behaviour, such as the shock structure and sources of loss, giving valuable feedback to the designer. PCA's integrated approach to design has resulted in high levels of performance, achieved 'right first time', ensuring that the manufactured blade meets predicted performance.



Pitchwise-averaged relative Mach number distribution in the meridional plane at the nominal operating point. The impeller being unshrouded, tip clearance has been included as it is an important source of loss for this class of machine

Computational model of an 11+11 centrifugal compressor

