

# CFX SHORTENS FAN DESIGN TIME FROM THREE MONTHS TO ONE



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The Flakt Woods Group, a well-known manufacturer of large industrial fans, had to deliver to a major defense organization fans to be used in many different applications with very stringent and widely varying technical specifications and requirements. In order to meet the delivery schedule, they outsourced the design of one of the more challenging fans to PCA Engineers, engineering consultants specializing in turbomachinery design.

The critical requirement was that the fan should have nearly flat operating characteristics, so that delivery pressure does not rise significantly as the volume flow falls. Normally, we would have begun by looking for a similar design that we had done in the past, but we had never produced anything similar to this one. So we selected C4 airfoils as a starting point based on our client's preference and our previous experience. We used our in-house program, Vista-AC Blade, to generate the initial profile curves, which we imported into CFX-BladeGen to refine the edges of the rotor and stator, set up clearances and evaluate the interaction with the annulus. Once we had completed an initial design that looked good, we used CFX-TurboGrid to generate a mesh of the blade passages and CFX-TASCflow to analyze the performance of the initial design. We used the build case option in CFX-TASCflow to automatically generate a two-stage geometry and organize the meshes for each stage.

We ran the analysis at five different flow rates to construct a pressure-volume curve. The results were what would be expected from a typical fan design: as the volume flow fell, the delivery pressure rose substantially. The results didn't just tell us that it didn't meet the requirements; they also provided detailed information that helped us to understand why the initial design didn't work.

Looking at the flow velocity plots provided insight into the physics behind the shape of the characteristic curve. Normally, in a standard fan the rotor and stator are configured so that their minimum loss points coincide with the normal operating point of the fan. But this approach inherently creates a pressure-volume curve with a relatively steep slope. We addressed this issue by changing the design to deliberately stall the stator over the entire flow range of interest, in order to mitigate the rotor's tendency to deliver increasing

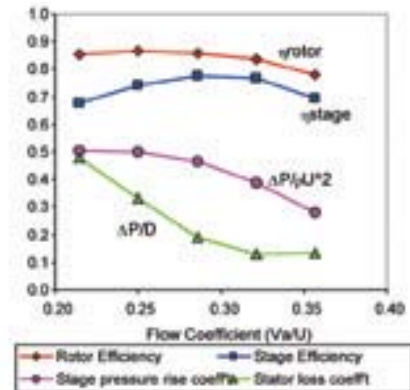
pressure as the flow is reduced. While this technique does reduce the efficiency of the fan, the losses were still completely acceptable to the client. After creating three more iterations to fine tune the performance of the design, we had achieved the goal of a nearly flat pressure-volume curve. The final design had 12 blades in the rotor and 17 in the stator.

When Flakt Woods built and tested the fan, performance was nearly exactly as predicted, and they were very pleased both with the performance of the final design and with the speed with which we delivered it. The key to achieving these results was the use of CFX for turbomachinery design and analysis. It provided insight into the performance of

our early design, allowing us to quickly proceed to one that met the client's specifications.



We were able to design the fan in only one month, where it would have taken at least three months using the traditional build and test approach.



Fan characteristic showing rotor-stator mismatching – the rotor is just below its peak efficiency flow and is beginning to show signs of increased leading edge loading. The stator, on the other hand, is showing fully separated flow along its entire suction edge.

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Top to bottom: CFX prediction of fan flow at high, medium and low volume flow.