Concepts NREC
EXPERTS IN TURBOMACHINERY

Dyson
CASE STUDY

Dyson Technology Reduces Power Requirements with Optimization Tools from Concepts NREC and Cadence

Dyson Technology manufactures and sells a wide range of best-in-class home appliances, including vacuum cleaners, fans, heaters, hair dryers, and lighting. The company has expanded its product range over the years, including bladeless fans, air purifiers and humidifiers. Of course, there are actually blades in the bladeless products, but they are hidden within the casing on a rotating compressor impeller.

Figure 1: Dyson air purifier products

Dyson is a leader in research and development, constantly pushing the boundaries of technology to create new products and services. It is this philosophy that has grown Dyson into a 7 billion dollar company. The company is a long-time user of Concepts NREC turbomachinery design tools for fans and impellers, going back to 2005.

Dyson's products are well known for quality, which encompasses not only ease of use and comfort, low noise, and long life, but also reduced energy consumption. As such, the Dyson research and development team was recently tasked with making improvements to the compressors such that a single compressor design could be used for a family of applications, over multiple points of operation and speeds. When given this challenge, Dyson R&D chose to take its design process to the next level, using design optimization technology from the Concepts NREC/Cadence partnership to automate the workflow.

Design Optimization

Tools used:

AxCent, FINE/Design3D

Result:

4.6% power reduction at high flow

2.5% power reduction at low flow

Engineers at Dyson hypothesized that they could get higher pressure rise and flows at the same impeller speed by optimizing for impeller efficiency at both low and high speed. In Figure 2, the red and green curves represent hypothetical compressor performance curves at two different speeds. The dashed black curve represents the system restriction effects, essentially how much pressure rise is required to overcome the losses from the inlet to the outlet of the entire device. The intersection of the system restriction curve and the performance curve is the operating point. The belief was that not only could point A be improved to A', but also point B (on a higher speed line) could be improved to B'.

Using Concepts NREC's AxCent turbomachinery CAD geometry engine connected to Cadence's FINE/Design3D optimization and Computational Fluid Dynamics (CFD) tool, various design parameters could be allowed to vary while optimizing performance at both speeds of operation. In this case, to minimize the design and manufacturing impacts and implications, Dyson chose to vary only the number of blades and the blade angle distribution relative to the current design as input parameters. In the optimization process (Figure 3), FINE/Design3D provides an automated communication link between AxCent and CFD, performing a Design of Experiments (DOE) analysis and determining the individual and interactive effects of the geometric input parameters on the impeller performance. Once these effects are established, a surrogate model, which runs much faster than CFD, is automatically generated and used for further analysis and optimization.

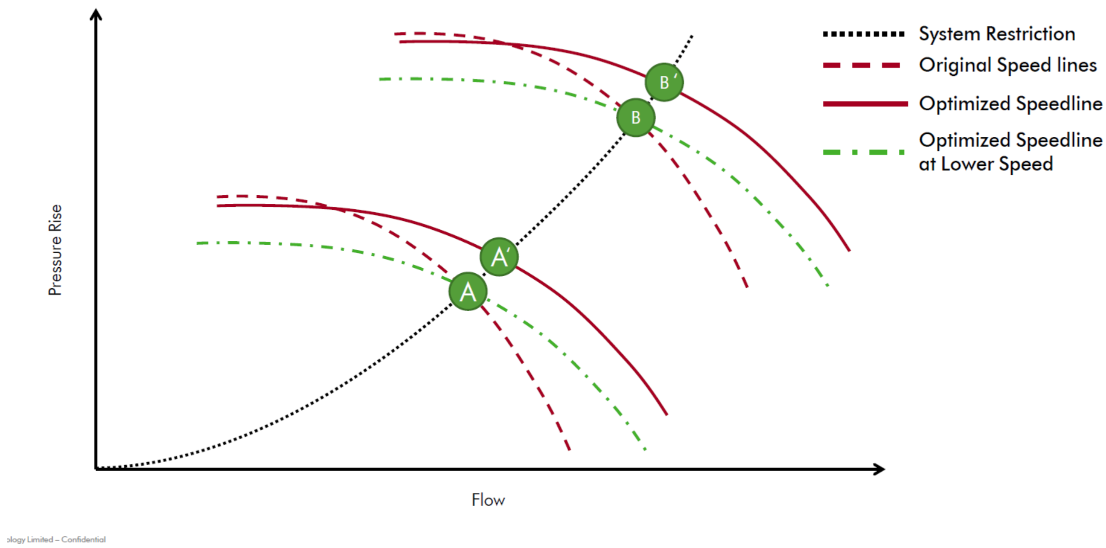

Figure 2: Hypothesized compressor performance improvements

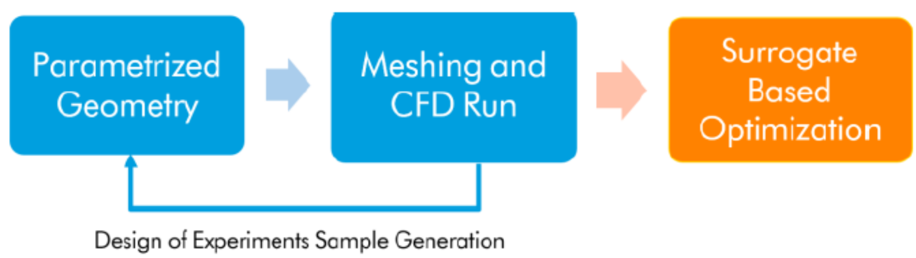

Figure 3: Optimization workflow with AxCent and FINE/Design3D

Rapid prototyping was deployed for laboratory testing, using Siemens NX CAD to link AxCent to 3D printing algorithms (Figure 4). Dyson engineers chose the optimal geometry found for both high-flow and low-flow conditions and then confirmed these results in the laboratory. Indeed, the best of these two designs, which fit the same original packaging requirements, showed significantly higher flow and pressure at both speeds. The Dyson engineers then tested these same impellers at *reduced* speeds that would provide the same flow and pressure rise as the original requirements, and confirmed that using the improved impeller at reduced speeds led to a significant reduction in power, requiring 2.5% less power for low-flow conditions and 4.6% lower for high-flow conditions.

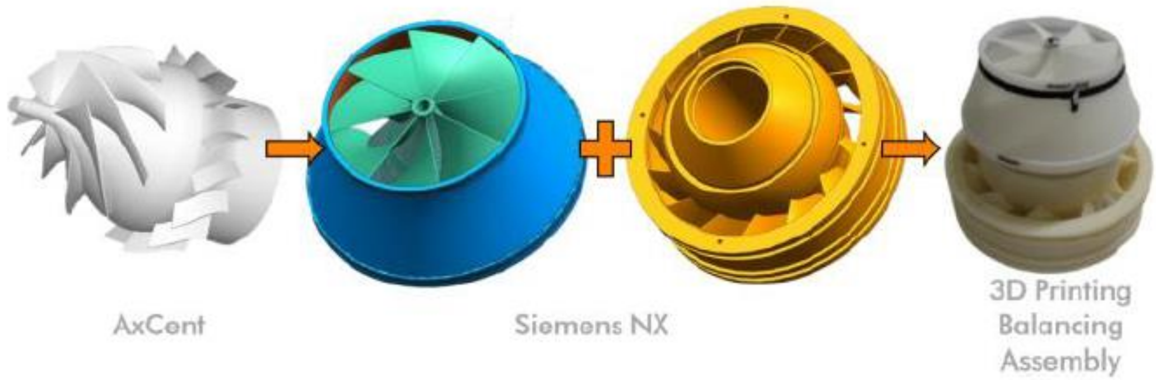

Figure 4: CAD and 3D Printing workflow

Dyson engineers were thrilled with these results because the required change involves only one part, the impeller. Before implementing this change, they will need to confirm the impacts on acoustics and noise. In addition, evaluating other modifications in the flow path with further optimization studies for further improvements can be explored.