ANSYS®

CASE STUDY

Defense Contractor Designs Safer Environmental Control System for Marine Corps' New Amphibious Vehicle Using CFX Software

FAIRCHILD CONTROLS

EXECUTIVE SUMMARY

Challenge:

To redesign the ventilation system of the U.S. Marine Corps' Expeditionary Fighting Vehicle (EFV) to perform at peak efficiency while minimizing noise.

Solution:

Implement CFX® computational fluid dynamics software, from ANSYS, Inc., to design a solution that efficiently meets multiple operational parameters.

Benefits:

Built fan for environmental control system in-house at lower cost than purchasing components from an outside vendor.

Modeled and analyzed multiple fan designs in just two weeks, streamlining design cycle by several months.

First prototype built performed as required and predicted, thus reducing development time and expense.

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Introduction

Since 1775, the United States Marine Corps has symbolized the courage and valor of America's fighting forces. First to arrive and often last to leave the battlefield, the Marines traditionally take on the military's most difficult and daring assignments. To safeguard its troops in these brutal environments, the Corps increasingly relies on advanced technology. As such, by the end of the decade, the Marines will roll into combat in General Dynamics Amphibious Systems' new Expeditionary Fighting Vehicle (EFV) — a hybrid tank/boat designed to carry 17 combat-equipped marines and a three-person crew over both land and sea at speeds of up to 30 miles an hour. More heavily armed and armored, yet faster and more maneuverable than its predecessor, the EFV will be the Marines' primary combat vehicle.

To protect both its passengers and the electronic systems in its crew compartment from overheating, the EFV contains an environmental control system (ECS) that circulates and cools the cabin air. The ECS unit must keep air at a comfortable temperature even when temperatures outside are as high as 125º Fahrenheit, while still operating quietly enough to pose no risk to the crew's hearing during extended exposure without heavy ear protection. After its initial prototype failed to fully meet those high standards, General Dynamics put the ECS back out to bid.

Air Handling Unit Fan (Shown with shroud removed)

The winner of the re-bid process was Fairchild Controls Corporation of Frederick, MD, a 40-year supplier to the aerospace industry of sophisticated pneumatic, hydraulic, and cooling systems. The firm was tasked with improving the ECS unit's airflow and minimizing operational noise while remaining within a strict budget. Furthermore, to meet the Marine Corps' deadline to deliver combat-ready EFVs in 2008, Fairchild Controls needed to design, test, and qualify the improved ECS in just 14 months.

Challenge

The ECS is essentially a high performance air conditioner that uses a hydraulically driven fan to pull air through a refrigerant cooled evaporator and circulate it throughout the EFV cabin. Each EFV contains two air handling units and two compressor units, one on each side of the crew compartment.

Because the design of the EFV itself was already set, Fairchild Controls could not alter the basic size or shape of the ECS; the redesigned components had to fit within the space and location already allocated to them. Additionally, for the system to provide the cooling capacity required and use low cost commercial off the shelf (COTS) components, the new fan was required to produce an airflow rate of 1,000 cubic feet per minute with a pressure rise of 6.5 inches of water at a speed of less than 4,500 revolutions per minute (RPM). These parameters were based on

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Jeff Hutchison
Principle Engineer
Fairchild Controls

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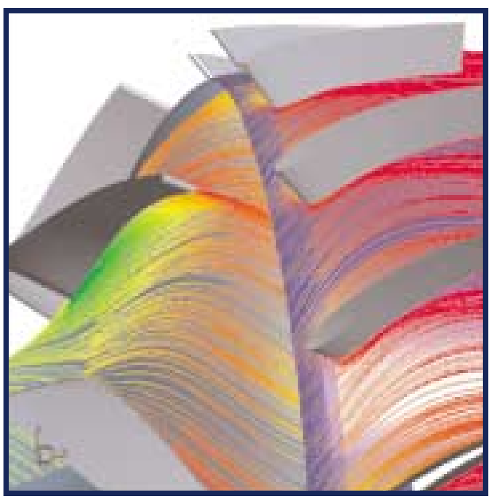
the size of the crew compartment, the heat load from the electronics and crew, and the infiltrated heat load from outside the vehicle on a 125º Fahrenheit day. Furthermore, while meeting these parameters, the system also needed to operate at a noise level the human ear could tolerate for a full day without protection.

"Typically, we purchase components from vendors, which essentially forces us to design our systems around available parts, build and test prototypes for performance, and then repeat the cycle until we reach a satisfactory solution," says Jeff Hutchison, principle engineer for Fairchild Controls. "By comparison, CFX software from ANSYS enabled us to create, analyze, and compare dozens of virtual designs for the ECS in just weeks, then manufacture the components ourselves. By letting us perform that work in-house, CFX tools helped streamline the design and procurement process and deliver a prototype that performed perfectly after a single round of testing."



Multi Frame of Reference CFD Analysis Using CFX-TASCflow, Hub Streaklines colored with static pressure

Solution

Fairchild Controls realized it could best improve the ECS unit's performance by replacing the original model's fast but loud vane axial fan with a slower, mixed flow fan with both rotating and stationery elements. To design the fan, the company turned to CFX software from ANSYS, Inc. The industry's most powerful solution for modeling fluid dynamics, CFX features specialized modules that allow users to rapidly design and predict the performance of complex turbomachinery. Using CFX-BladeGen, CFX-TurboGrid, and CFX-TASCflow, Fairchild Controls swiftly derived the optimal combination of design features within the necessary parameters.

The manufacturer's engineers used the suite of CFX solutions to create and analyze 3-D models of candidate fan designs in order to compare various combinations of blade shape, blade number and blade height and select a design that met all of the performance objectives. Next, CFX-TASCflow's rotating machinery case builder set the fan designs in motion, allowing the engineering team to simulate performance and explore what-if scenarios under a wide range of simulated operating conditions.

Over the next three months, the firm then constructed a working prototype. It imported the selected design's geometry from CFX-BladeGen directly into its CAD system as an IGES file in order to create a solid digital model. Next, it coded its computer-automated machining tool directly from the solid, saving hours of drafting time and ensuring the dimensions of the computer design were duplicated in a physical prototype as precisely as possible. Finally, it assembled the working prototype and compared its performance to the data generated in its simulations.

"Our physical prototype performed precisely as the CFX tools predicted it would, and we were absolutely confident the final product would also perform as it was supposed to, even under the demanding conditions the Marine Corps would subject it to," Hutchison says. "With no need to start the development cycle again for another prototype, we were able to move swiftly into manufacturing and testing deliverable hardware."

Benefits

CFX enabled Fairchild Controls to produce a fan that created just 85 decibels of sound — well within the limits of soldiers' comfort and safety — without compromising the environmental control system's ability to keep the EFV's crew compartment adequately cool. Moreover, CFX streamlined the design and test cycle significantly by allowing the design to be kept in house, allowing Fairchild Controls to deliver an affordable final product in just 14 months.

The redesigned ECS unit has completed shipping all units required for the system design and development phase of the program and is currently preparing to enter low rate initial production, facilitating the Marine Corps' plans to complete and deploy the EFV in 2008.

"Whether we're creating new products or measuring the performance of legacy products with an eye toward improvement, there's simply nothing better for measuring and analyzing air and fluid flow in turbomachinery than CFX software from ANSYS," says Hutchison. "By allowing us to move smoothly from virtual designs to perfectly operating prototypes, CFX helps us reduce the development risks associated with new designs."

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