

CFD Design Tool Improves HVAC Design and Cuts Product Development Cycle Time

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ABSTRACT

In an effort to shorten and improve the efficiency of the product design process (PDP), Delphi has developed an application specific CFD design tool that helps design engineers optimize designs prior to prototyping. This new tool enables design engineers to set up an HVAC module, powertrain cooling system, or heat exchanger model for CFD analysis in relatively short time. The ability to evaluate and improve the design of the product at the very early stages of the development cycle greatly reduces the need for design changes late in the process, which are expensive and time-consuming. Besides reducing the design cycle, the new CFD tool has also reduced the model shop and testing expenses for each development project with fewer prototypes. In this paper, a case study for using this tool during the HVAC module development process in early stage is demonstrated.

INTRODUCTION

In the last fifteen years, Delphi has employed CFD to determine the flow and thermal characteristics of their thermal products and systems. Traditionally, CFD analyses have to be performed by CFD experts during the late stages of the product development process. Unfortunately, this practice provided little benefit and opportunity for design engineers to develop and optimize their thermal product and system design concepts in early PDP(Production Development Process). In an effort to shorten and improve our PDP, We have developed a product-specific CFD design tool aimed for design engineers to analyze their design concepts during the early phase of the product and system development process.

This product-specific CFD design tool is very easy to use with minimal CFD knowledge and training. In the last five years, this product-specific CFD design tool has been gaining its popularity from the design engineers. We are able to deploy the tool to most of design engineers at Delphi Thermal Systems to support their

product design and development. According to the recent record, this CFD tool is the integral part of PDP and has been used for all the production programs at Delphi Thermal System.

One of the biggest advantages for this CFD design tool is able to provide design engineers a tool to evaluate their designs in the early phase of the product development cycle. It significantly reduces the need for design changes in the late stage of the process and lead to shorten the product development cycle and make substantial cost savings. Besides reducing the design cycle, the CFD design tool has also reduced the prototype "build and test" expenses for each development project.

CFD DESIGN TOOL

Delphi CFD design tool was built on Flowizard from Fluent, Inc. A customized interface was created using the GUI customization functionality available in Flowizard, as shown in Figure 1. The customization incorporated "best practices" for CFD modeling from CFD experts and standard product design processes from design engineers for each product. The design tool guides the design engineer step-by-step through the process of analyzing a product or part through an examination of airflow and thermal performance.

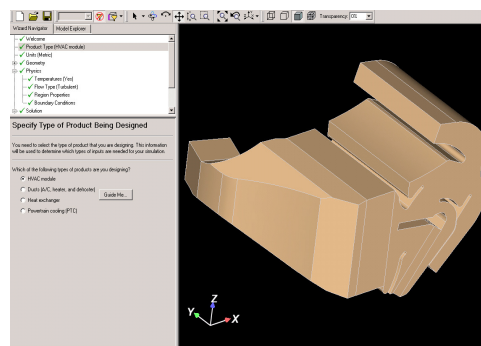


Figure 1 Delphi CFD Design Tool

Product-Specific Customization

Since each product has its own “best practices” for CFD modeling and standard design procedure, the customization was created for each product or part, as shown in Figure 2. This made it possible for design engineers to input the geometry from their latest concept design directly, enter information specific to the design, and do flow and thermal simulations in a very short period of time. The interface limits the entry of design parameters to the range for which the model has been validated, for ensuring its accuracy. To date, interfaces have been created for design engineers to set up an HVAC system, Power-Train-Cooling system, or heat exchanger for analysis in a short time.

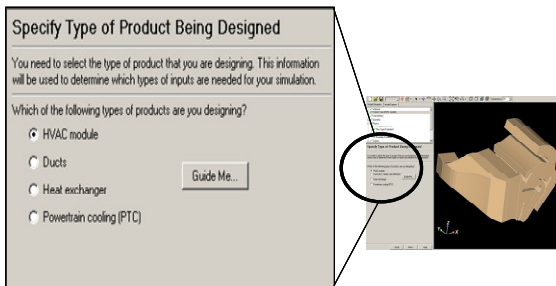


Figure 2 Menu for product selection

The customized interface walks the design engineers through the entire product-specific CFD process. After the CAD geometry is imported, the CFD design tool automatically performs the clean-up operation to the geometry required for efficient CFD analysis. The design engineer is then asked to graphically identify key components of the geometry along with the corresponding boundary conditions, as shown in Figure 3. Depending on the specific type of product to be analyzed, the mesh building routine includes guidelines for the type and size of the mesh in different areas of the problem. Throughout the process, a model is created that takes advantage of the best practices developed by CFD experts and design guidelines developed by Delphi product experts.

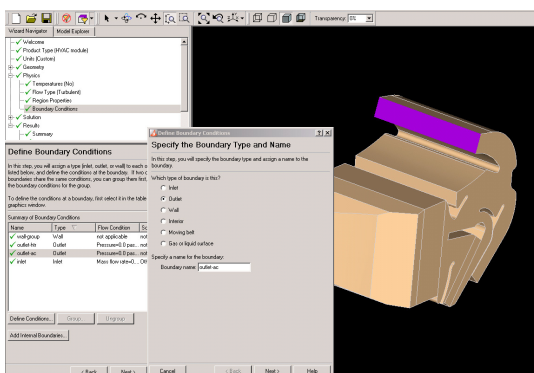


Figure 3 “Best Practice” for each product

Accuracy and Speed

Mesh type has a strong effect on mesh count, which can directly affect computational run-time. Two types of meshes, tetrahedral and hexahedra, are available in the CFD design tool. Tetrahedral mesh enables design engineers to mesh complex geometry automatically, but with relatively larger mesh count. Hexahedra mesh with same mesh size can significantly reduce the mesh count, but may fail to mesh most of complex geometries. In our product-specific CFD processes, hexahedra mesh is used wherever are allowed. For instance, the mesh count for a typical HVAC module is about 1.5 millions for tetrahedral only meshes but 1 million with using our HVAC CFD meshing process.

In general, smaller mesh size will take longer run-time with higher accuracy. In the design concept phase (early stage) of HVAC module development process, in order to find out main design stream, the requirement for analysis speed has higher priority than prediction accuracy and is critical to the process. In the development phase (later stage of the process), prediction accuracy is getting more important for define design. To meet those needs, design engineers can select a different meshing level from the CFD design tool. For instance, with the priority on speed (larger mesh size), ½ million meshes are typical for HVAC module and the entire solution process would only be hours. With priority on accuracy (smaller mesh size), the mesh count for above case would rise to about 1 million with run-time of about a day on typical window desktop. To ensure the accuracy of the CFD analysis, higher order of scheme is implemented in the tool.

Component model and data base

One of the difficulties for the design engineer to perform CFD analysis is the selection of component models and the corresponding performance data base. For instance, let's look at heat exchanger modeling. How to model evaporator airside pressure drop and thermal performance? What type of CFD model should be employed? What are the specific performance maps for that evaporator?

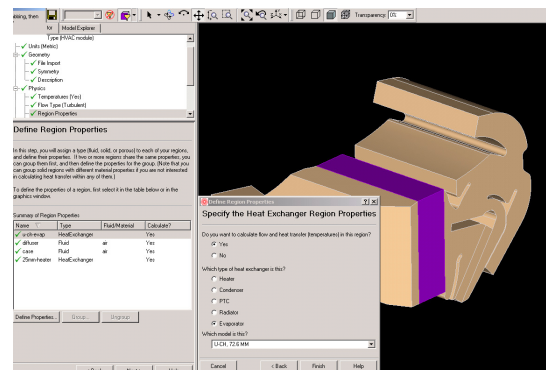


Figure 4 Menus for component data base