OPTIMIZATION OF AN AUTOMOBILE COOLING FAN

Emmett Dempsey, USA
Supervisors: R.A. Van den Braembussche, Z. Alsalihi, J. Prinsier, T. Verstraete

The goal of this investigation is to design a fan for automotive cooling applications. Modern automobiles have several heat exchangers within the engine compartment that are stacked together to form the radiator. To evacuate the heat produced by the engine coolant, lubricating oil, turbocharger, and air conditioner a cooling fan is required to produce a sufficient uniform cooling flow of air through the stack. In addition, the fan was desirable to have high efficiency, low weight and cost, and optimum mechanical properties in a high temperature (393 K) environment.

Knowing the inlet conditions, an initial 1-D design was performed. This 1-D design yielded flow angles and the amount of flow turning each blade has to do at 3 radial positions: hub, middle, and tip. The 2-D blade contour designs are achieved using the inverse design method in which a specified contour velocity distribution is used to calculate each radial section's geometry. The design for each section must meet several criteria, including optimum blade thickness, controlled-diffusion on the pressure and suction sides, and the necessary flow turning. This design method calculates the geometry for inviscid flow, so a Navier-Stokes solution is required to verify the performance of the design. 2-D Grids are created for each blade section, and the Navier-Stokes analysis is performed with TRAF2D. The resulting velocity profiles compare well with the inviscid design for the hub and middle section, but the tip section is observed at incorrect incidence.

To get a 3-D solution, the grids are stacked to form a 3-D mesh and predicted using TRAF3D. The TRAF3D results are verified using CFX, which required generation of a separate mesh. The efficiency of the blade is higher for the CFX case (77%) than for the TRAF3D case (49%). The higher efficiency in the CFX solution resulted from a higher pressure rise with lower flow turning than the TRAF3D solution. A performance map for the fan was created using TRAF3D and compared with the experimental results from a similar fan provided by the Valeo Company. Both computational solutions gave lower static pressure rise than the experimental fan data.

To improve efficiency, a 3-Dimensional optimization was performed with TRAF3D calculations. The optimization is performed by adding circumferential lean to the blade. The results showed that efficiency increases with increasing lean. The results are dependent on the rotating shroud upstream of the blades and the flow property averaging method.