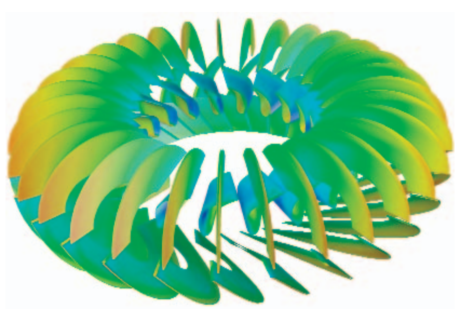
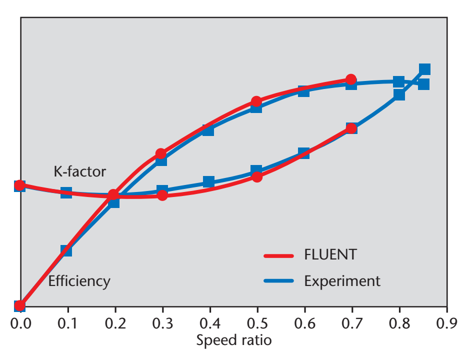
An exploded view of the torque converter showing the pump (top), stator (middle), and turbine (bottom)

Torque Converters Get In Gear

By Vamshi Korivi, DaimlerChrysler, Auburn Hills, Michigan, USA
Sandeep Sovani and Pepi Maksimovic, Fluent Inc.



Contours of total pressure on the blade surfaces of the three elements; large pressure losses can be seen across the stator blades (in the middle)



Predictions of efficiency and k-factor as a function of speed ratio show good agreement with measured values

TORQUE CONVERTERS ARE FLUID-COUPLING DEVICES that transmit power from vehicle engines to the wheels. They are used in automobiles with automatic transmissions to smoothly control the torque supplied to the wheels at all speeds.

Torque converters are essentially chambers filled with transmission fluid, with the primary active parts being the pump (or impeller), stator, and turbine. The impeller blades rotate at the engine speed and impart angular momentum to the fluid as they force it radially outward. The turbine blades receive the fluid from the pump and turn it radially inward. The angular momentum thus absorbed by the turbine is passed to the transmission as torque. The flow exits from the turbine blade passages with little remaining angular momentum and encounters the stator blades, which accelerate the fluid back to the pump rotational speed. This action creates a torque on the stator, which is arrested by a non-rotating shaft built into the transmission housing. Torque multiplication results from the fact that the turbine torque is larger than that of the pump.

Numerical simulations of torque converters are important because the complex topology and rotation of these devices make detailed experimental investigation virtually impossible. Simulations help identify optimal designs that yield improved performance and fuel economy. Using the multiple reference frames (MRF) model in FLUENT, a DaimlerChrysler torque converter has been studied. The MRF model allows the different parts of the torque converter (the pump, stator, and turbine) to be simulated using one relative orientation, but separate rotating frames. The model is well suited for torque converters, since the number of blades is chosen to prevent the amplification of harmonics and possible structural damage to the parts. This means that any single relative position of the blades is a good representation of the averaged behavior of the system as a whole. For the torque converter considered here, the number of blades for the pump, turbine, and the stator is 31, 29, and 20 respectively.

A hexahedral mesh of about 2.9 million cells was used for the initial calculation. A pressure gradient-based mesh adaption was subsequently performed to enhance the solution accuracy. Using transmission fluid and a pump speed of 2000 rpm, the turbulent flow was captured using the realizable k-ε turbulence model. Custom postprocessing tools were created for the automatic extraction of torque converter quantities of interest, such as the mass-averaged flow angles at the inlet and outlet of each element, the efficiency, and the torque imbalance, for example.

The results illustrated several flow features. Total pressure contours were used to illustrate the pressure loss across the stator blades. Velocity vectors were used to check for separation regions. The k-factor, the ratio of pump torque to the square root of pump speed and an indicator of the torque converter capacity, was found to be within 2% of measured values at all speed ratios (the ratio of turbine speed to pump speed) studied.

Predictions of efficiency, defined as the product of torque ratio and speed ratio, were found to be within 1.6% of the data at a speed ratio of 0.7. The torque ratio, defined as the ratio of turbine torque to pump torque, was found to be within 5% for speed ratios above 0.2. The ability to predict efficiency and torque ratios at high speed ratios is important for improving fuel economy. ■