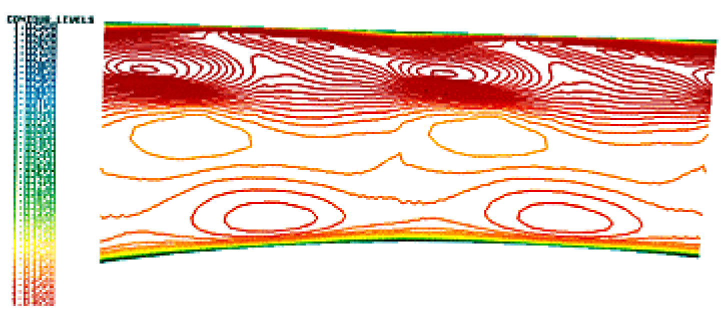
Vacuum Cleaner Fan Being Improved

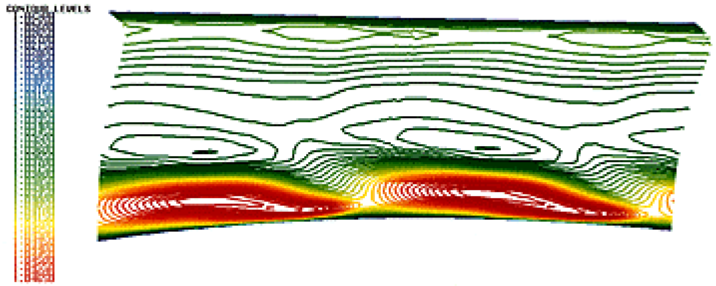
As part of the technology utilization program at the NASA Lewis Research Center, efforts are underway to transfer aerospace technologies to new areas of practical application. One such effort involves using advanced computational fluid dynamics (CFD) codes for turbomachinery to analyze the internal fluid dynamics of low-speed fans and blowers. This year, the Kirby Company in Cleveland, Ohio, approached NASA with a request for technologies that could help them improve their vacuum cleaners. Of particular interest to Kirby is the high-frequency blade-passing noise generation of their vacuum cleaner fan at low airflow rates.

To assess the current capability, Lewis researchers studied two Kirby centrifugal fan impellers, a standard (baseline) impeller and a modified (tapered) impeller, analyzing them aerodynamically with a three-dimensional viscous turbomachinery CFD code (RVC3D) that was developed by R.V. Chima at Lewis. Both impellers were simulated at the same airflow (102 ft^3/min) and at slightly different rotational speeds corresponding to the measured differences in Kirby tests performed on the two impellers.

The Kirby test data indicated that the tapered impeller generated significantly less noise at all flow rates, but especially at very low flow rates. The main goals of the CFD simulations were to investigate whether substantial differences could be seen in the computed results for a relatively high airflow rate and to determine if those differences suggested the observed trend in noise reduction.

Contour plots of the computed (absolute) total-pressure fields just downstream of the impeller exit for the baseline and tapered impellers are shown in the figures. A complete inversion of a high total-pressure region is apparent from the results. In particular, the baseline impeller produces higher total-pressures near the shroud (the top of the passage in the top figure), whereas the tapered impeller produces higher total-pressures near the hub (bottom of the passage in the bottom figure). These differences are much larger than expected since there is only a modest change in the impeller geometry between the baseline and tapered configurations. In view of the spanwise extent and general character of the circumferential (left-to-right) variations in total-pressure, we concluded that the CFD results do allow a reasonable inference about relative noise generation. That is, compared with the baseline impeller, the tapered impeller should generate less noise.





Fan exit absolute total-pressure fields for Kirby impellers at an airflow of 102 ft^3/min. Top: Kirby baseline propeller at a rotational velocity of 13,500 rpm. Bottom: Kirby tapered impeller at a rotational velocity of 14,000 rpm.

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