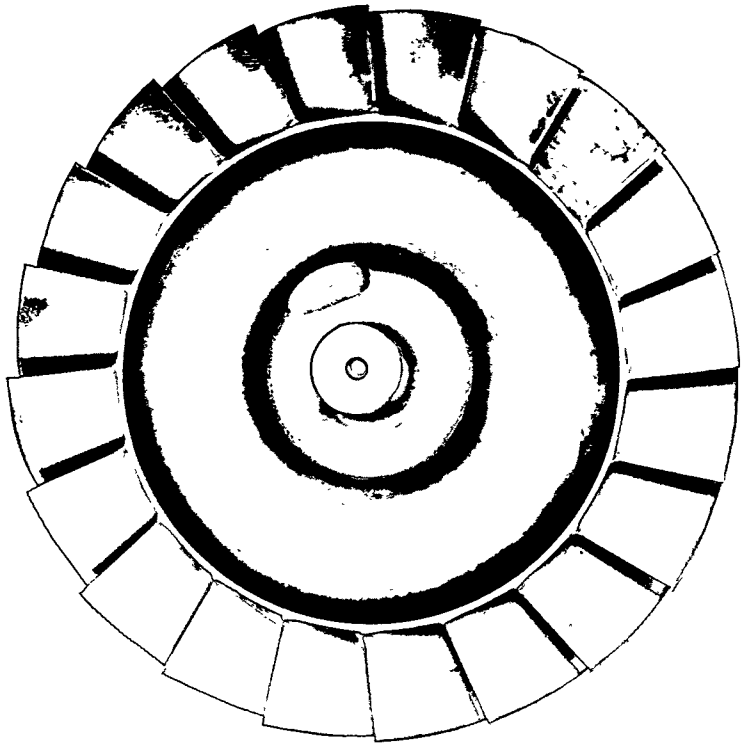
include improved performance, energy efficiency, power density, and, in the case of diesel engines, lower exhaust emissions. Almost all heavy-duty trucks already use turbocharging for these reasons. About 500,000 turbocharged light-duty vehicles are sold annually in the United States, primarily for high-performance applications.

A major barrier to turbochargers penetrating the automobile market, however, has been the lack of a reliable, low-mass, high-response rotor capable of withstanding the high temperatures and loads inherent in turbochargers. If such a lightweight, high-strength ceramic turbocharger rotor could be developed, it could reduce the response time of the turbocharger, thereby increasing engine responsiveness and drivability. In addition, it would replace superalloy material (currently used in turbocharger rotors) containing large amounts of strategically important elements such as cobalt, chromium, and nickel.

DOE has sponsored extensive research in developing advanced ceramic materials and designing and fabricating ceramic rotors for automotive gas turbines. Although gas turbine rotors are considerably larger than automotive turbochargers and operate at higher temperatures, substantial similarities exist between them. DOE's research has focused on ceramic material development, fabrication processes, ceramic-to-metal joining, and nondestructive evaluation techniques. Great progress has been made in constructing prototype ceramic gas turbine engines, with hundreds of hours of successful testing completed.

The success of DOE's research has already resulted in the commercialization of ceramic turbocharger rotors in Japan and substantial fleet testing in the United States. Nissan, working with the Garrett Corporation and Japanese ceramic suppliers, has sold several hundred thousand ceramic turbochargers on high-performance vehicles in Japan during the last three years. Not one in-service failure has been reported. Garrett engineers also claim that one ceramic turbocharger has better response than two smaller metal turbochargers. It is expected that Nissan will introduce ceramic turbocharged vehicles in the United States in the 1990s.

General Motors has also produced 500 ceramic-turbocharged, specially prepared Buick Grand National GNX vehicles and has tested hundreds of turbocharged Pontiac Sunbirds using Garrett ceramic turbochargers.



Ceramic rotors developed by Allison (a division of General Motors) improve performance and engine efficiency in automotive gas turbines.

Cost remains a concern with ceramic turbochargers, because the current low-volume production means that the ceramic rotor assembly still costs about five times more than conventional superalloys. However, estimates of worldwide market potential exceed six million units annually by 1992; if ceramic turbocharger production volumes can be increased so that prices can be lowered to about two times premium, as much as 75% of the total demand might then be met using ceramic material technology. In fact, in a worldwide survey of ceramic engine experts, ceramic turbochargers were projected to capture 20% of the U.S. light-duty and 27% of the heavy-duty turbocharger market by 2000 and 38% of the light-duty and 48% of the heavy-duty market by 2010.

Typically, turbocharging results in a 5% improvement in efficiency in spark-ignition engines and 10% in diesel engines. In addition, the extra power produced by turbocharging allows engine sizes to be reduced, improving the energy efficiency of this technology by an additional 10%. Based on the survey data, ceramic turbochargers could save 5.3 trillion Btus or 39 million gallons of fuel in 2010.