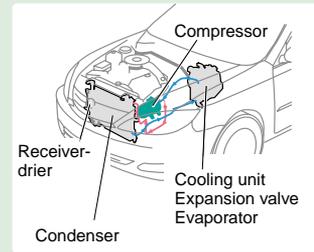


Toyota Industries continues to lead the industry through its efforts to reduce the environmental impact of car air-conditioning compressors.

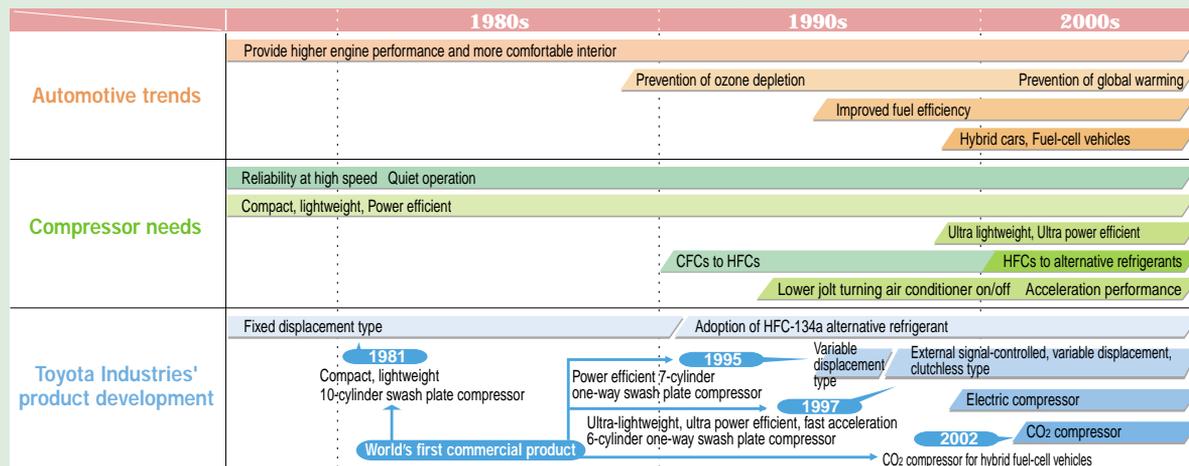
The company has made its compressors lighter to improve fuel efficiency and is exploring the use of natural refrigerants for its compressors.

In December 2002, the Japanese government took delivery of four revolutionary hydrogen-powered fuel-cell hybrid vehicles developed by Toyota Motor Corporation. These cars were equipped with an electrically driven CO₂ compressor that Toyota Industries jointly developed with DENSO Corporation. CO₂ is a natural refrigerant.

In addition to offering outstanding cooling performance and durability, the new compressor is ideally positioned for use in the next generation of vehicles, since it contributes to protect ozone layer depletion and to slow down global warming. Major technological leaps in compressor technology have always been triggered by society's increasing concern for the environment.



Automotive Trends and Toyota Industries' Compressor Product Development



Improving Fuel Efficiency

Since the 1990s, Toyota Industries has continually sought to improve the fuel efficiency of its compressor products in an attempt to minimize air pollution and prevent global warming. The company's efforts have been focused on reducing weight and improving the efficiency of its compressors.

Weight Savings Made Possible by Advanced Technologies
Toyota Industries has led the compressor industry through its aggressive efforts to incorporate aluminum in its compressor products. Aluminum is lighter than other materials but also lacks

World's First Variable Displacement Compressor with One-Way Swash Plate
Toyota Industries developed the world's first variable displacement compressor with a one-way swash plate. This compressor delivers a variable output displacement in response to external variables such as the outside temperature, sunlight and driving speed. Toyota Industries developed this compressor based on the need for improved cabin comfort, faster acceleration and improved fuel efficiency.

In response to the increasing interest in environmental conservation and fuel efficiency, Toyota Industries developed an external signal-controlled, variable displacement, clutchless compressor. This compressor offers dramatically improved fuel efficiency for air conditioners by incorporating sensors that detect changes in engine acceleration and other external variables.

Switching Refrigerants

In 1991, in response to concerns over ozone depletion, Toyota Industries began switching from CFC-12 chlorofluorocarbon-based refrigerants to HFC-134a hydrofluorocarbon-based refrigerants for use in its car air-conditioning compressors. Since then, research has indicated that the global warming potential (GWP) of HFC-134a is still 1,300 times greater than CO₂, which has led the company to explore new refrigerants that are friendlier to the environment. Toyota Industries is actively working to develop compressors that use alternative refrigerants.

Lubricants and Sealing Materials
As a byproduct of its successful development of hydrofluorocarbon-based compressors, Toyota Industries has succeeded in developing lubricants and sealing materials that are free of chlorofluorocarbons.

strength. Toyota Industries has succeeded in reducing the weight of its compressors by carefully selecting appropriate materials that are shaped for optimum performance. This same expertise was also used in the development of the company's CO₂ compressor.

Future Activities

Toyota Industries will continue its efforts to improve the fuel efficiency of its compressor products by focusing on its proprietary weight reduction technology and external signal-controlled, variable displacement compressor technology. The company will also expand its line of variable displacement compressors in order to offer environmentally conscious compressors for all applications. Furthermore, Toyota Industries will develop new compressors that offer outstanding fuel economy for use in hybrid and fuel-cell vehicles.

Future Activities

Experts are currently predicting that the natural refrigerant CO₂ will eventually become the refrigerant of choice for car air-conditioning compressors. However, CO₂ has several drawbacks, such as a low molecular weight allowing easy passage through rubber and other sealing materials, and a high operating pressure that requires greater component strength than was needed before.

Toyota Industries is confident that its successful attempts to develop an electrically driven CO₂ compressor for Toyota's fuel-cell hybrid vehicle will also lead to the development of a similar CO₂ compressor to be used in standard engine vehicles.



Electrically Driven CO₂ Compressor