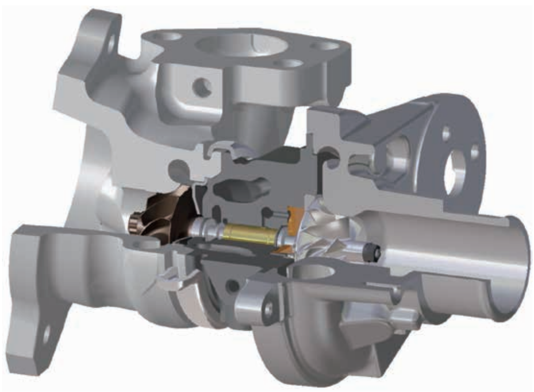
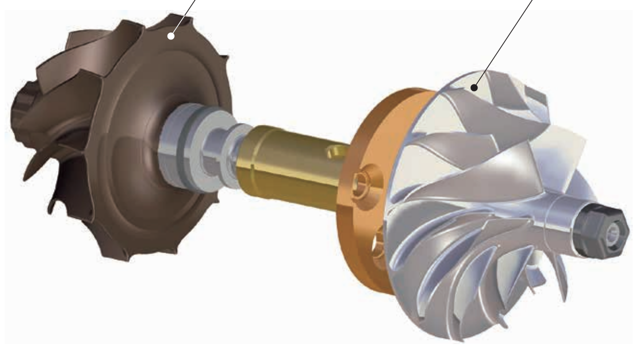
A Powerful Run with a Compact Engine

RHF3 turbocharger accelerates downsizing of domestic passenger cars

Downsized engines, whose concept is that an engine is downsized to improve fuel consumption and the resulting insufficient torque is covered by a turbocharger, are widely employed by gasoline cars in Europe.
In recent years, downsized engines have been employed in Japan as well, and IHI's automotive turbochargers have started to play an active role.



Cross-sectional model of RHF3 turbocharger



RHF3 turbocharger rotor

Downsizing started in Europe

The "downsizing concept" is a design philosophy proposed in Europe for the purpose of improving fuel consumption. Its fundamental design is to downsize an engine itself to reduce fuel consumption, and cover the resulting insufficient torque by a turbocharger (hereinafter referred to a "turbo"). A conventional turbo engine has an image of high power but poor fuel consumption. However, the new downsized engine is different from the conventional turbo engine in aiming to improve practical torque in a low rotation speed range.

In Europe, since around 2006, Volkswagen (Germany) has put downsized engines for gasoline cars into the market, and as a result, downsized engines have drawn increasing attention. In recent years, in particular, small-sized cars using naturally aspirated (non-turbocharged or conventional) engines have already been in the minority. On the other hand, in Japan, the actual situation is that hybrid cars are highly popular, and therefore cars for the domestic market can not sufficiently respond to downsized engines.

However, with the launch of downsized engines equipped with a supercharger as a start in 2012, in Japan as well, car models employing downsized engines have gradually increased in number. IHI had already developed and sold turbos for European downsized engine cars, and in such situations, we started a project for developing turbos for downsized engines once again together with domestic car manufacturers. Specifically, we aimed to equip 1.2-*l* engines with turbos to thereby obtain power comparable to that of a 1.8-*l* naturally aspirated engine.

Achievement of sufficient torque even at low rotation speed

A turbo is a mechanism adapted to obtain high power by increasing aspiration pressure using engine exhaust gas, and requires exhaust energy enough to rotate a turbine. For this reason, there has been a problem that when an engine rotates at low speed, the exhaust energy is small, thus being unable to obtain large torque. Also, there is a turbo lag that is a time lag from stepping on the accelerator to activating a turbo through an increase in the rotation speed of a turbine impeller, and consequently it has been considered that drivability (ease of driving) is spoiled.

Even when an engine rotates at low speed, as long as a turbo can sufficiently function to obtain large torque, the time lag can be eliminated. For this purpose, indispensable components are a turbine and a compressor that allow the required rotation of the turbo to be obtained even at the low rotation speed. This can be achieved by decreasing the impeller sizes (diameters) of the turbine and compressor. However, the problem of being unable to ensure the maximum flow rate of turbocharged aspiration newly occurs instead.

IHI solved the problem by decreasing the size of and increasing the rotation speed of a turbine simultaneously. We contrived the shape of a turbine impeller and air flow paths to review the shape as compared with a conventional comparable turbine having the same flow rate, and consequently successfully increased the maximum rotation number from 220 000 rpm (revolutions per minute) to 270 000 rpm.

Accumulation of knowhow during long time turbo development contributes to designing

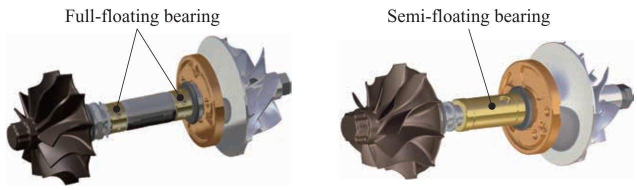
The development of downsized engines for gasoline cars was based on the diesel engine turbo technology, and therefore it was also necessary to cope with problems specific to a gasoline engine. For example, the temperature of exhaust gas from a diesel engine is approximately 800°C, whereas that of exhaust gas from a gasoline engine is as high as approximately 950°C. For this reason, designing further taking account of heat resistance was required. Also, the increase in rotation speed by approximately 20% caused the Noise and Vibration (NV) problem in a conventional model, and therefore new countermeasures were required.

As for the former, we applied a designing process using analysis technology raised by long time turbo development. At that time, in order to perform analysis with high accuracy, we focused on grasping the correlation between analysis and reality by utilizing a previous database and knowhow. In addition, performing unsteady analysis to evaluate the transient states of temperature and thermal stress distributions allowed improvement of reliability.

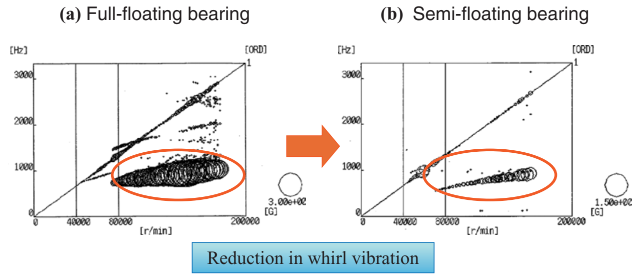
As for the latter, the high-speed rotation was made available by changing a full-floating bearing employed in the conventional model to a semi-floating bearing. Although the difference in wording is tiny, actual structural change is as big as completely difference model.

Such contrivance allowed the 1.2-*l* engine to output the power comparable to that of the 1.8-*l* naturally aspirated engine as intended as well as allowing smooth car dynamic characteristics.

In addition, while proceeding with the project, we learnt a research and development process unique to the car manufacturer and different from the IHI's conventional process. This also became an asset for us.



Full-floating bearing (left) and Semi-floating bearing (right)



Comparison of change in vibration between different bearing types

For fun-to-drive car

Cars equipped with the RHF3 turbo have been sold in Japan since April, 2015. For this series of cars, three-types of power trains are available, i.e., hybrid, 1.8/1.5-*l* natural aspiration, and 1.2-*l* turbo. As turbo development personnel, we are expecting that the 1.2-*l* turbo car will be a "fun-to-drive car."

Although the RHF3 turbo developed this time is a product for the domestic market, we are planning to produce it in China in the future as well. When developing the turbo, designing taking account of production at a Chinese supplier is performed, such as designing of a housing including connection to the engine parts. Although the employment of the Japanese downsized engines were started behind the European counterparts, the IHI's RHF3 turbo is expected to significantly contribute to an increase in market share in regions including Asia.

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