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The **rotary-piston supercharger** incorporates a rotary piston moving about an internal axis. The driven inner rotor (rotary piston) turns through an eccentric pattern in the cylindrical outer rotor. The rotor ratios for rotary-piston superchargers are either 2:3 or 3:4. The rotors turn around fixed axes without contacting each other or the housing. The eccentric motion makes it possible for the unit to ingest the maximum possible volume (chamber I) for compression and discharge (chamber III). The internal compression is determined by the position of the outlet edge A.

A ring and pinion gear with sealed grease lubrication synchronizes the motion of the inner and outer rotors. Permanent lubrication is also employed for the roller bearings. Inner and outer rotors employ gap seals, and usually have some form of coating. Piston rings provide the seal between working chamber and gear case.

Superchargers on IC engines are usually belt-driven (toothed or V-belt). The coupling is either direct (continuous engagement) or via clutch (e.g., solenoid-operated dutch, demand actuation). The step-up ratio may be constant, or it may vary according to engine speed.

Mechanical positive-displacement superchargers (MVL) must be substantially larger than their centrifugal counterparts (MKL) in order to produce a given mass flow. The mechanical positive-displacement supercharger is generally applied to small and medium-displacement engines, where the ratio between charge volume and space requirements is acceptable.

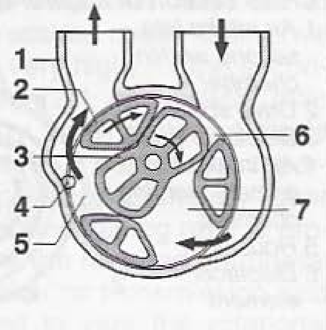
Exhaust-gas turbochargers

The exhaust-gas turbocharger consists of two turbo elements, a turbine and a compressor, which are installed on a single shaft. The turbine uses the energy of the exhaust-gas to drive the compressor. The compressor, in turn, draws in fresh air which it supplies to the cylinders in compressed form. The air and the mass flow of the exhaust gases represent the only coupling between the engine and the compressor. Turbocharger speed does not depend upon engine speed, but is rather a function of the balance of drive energy between the turbine and the compressor.

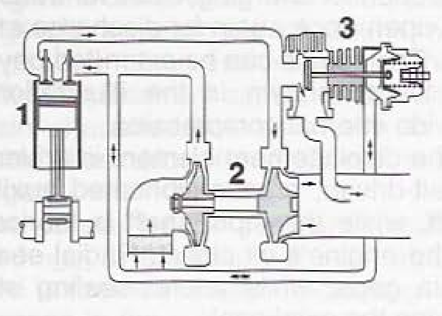
Exhaust-gas turbochargers are used on engines in passenger cars, trucks and heavy-duty engines (marine and locomotive power plants, stationary generators).

The typical engine-performance curves for this type of application are illustrated in a compression graph (p. 427), valid for all displacements, in which the surge line separates the stable operating range on its right from the instable range. It is obvious that the instable range presents no difficulties provided that the correct turbocharger is selected, as all of the points representing potential operating conditions lie either on the engine operating curves (full load) or below them (part-load operation).

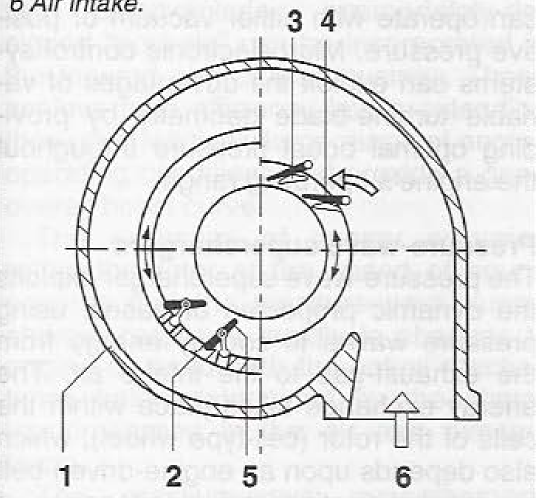
Cross section of a rotary-piston supercharger
1 Housing
2 Outer rotor
3 Inner rotor
4 Outlet edge A
5 Chamber III
6 Chamber II
7 Chamber I



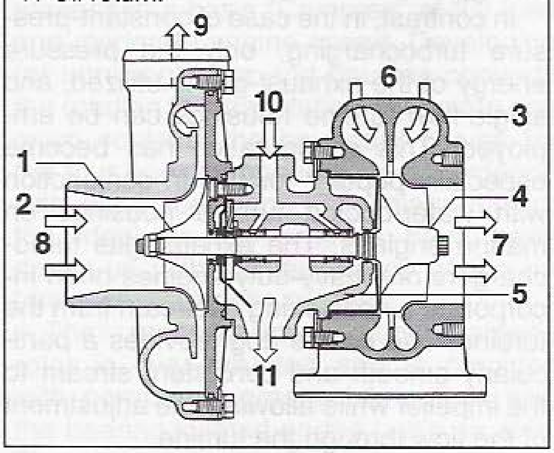
Boost-pressure regulation via exhaust-side boost-pressure control valve (wastegate)
1 Engine, 2 Exhaust-gas turbocharger, 3 Wastegate.



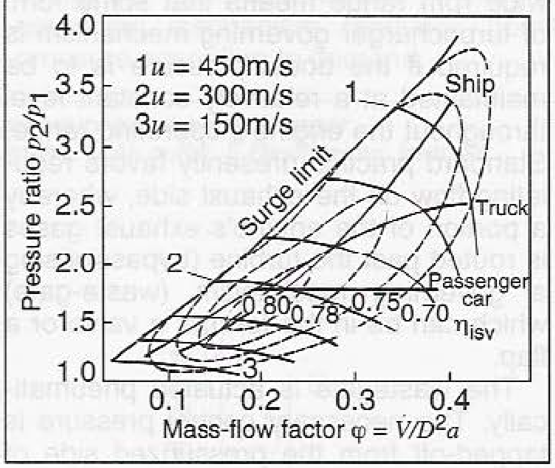
Variable turbine geometry (schematic diagram)
1 Turbine housing, 2 Adjusting ring, 3 Control cams, 4 Adjustable guide blades, 5 Guide blades with adjusting lever, 6 Air intake.



Truck exhaust-gas turbocharger with twin-flow turbine housing
1 Compressor housing, 2 Compressor wheel, 3 Turbine housing, 4 Rotor, 5 Bearing housing, 6 Incoming exhaust-gas, 7 Exhaust-gas discharge, 8 Atmospheric air, 9 Compressed fresh air, 10 Oil supply, 11 Oil return.



Compression graph with typical engine operation curves valid for all displacements



Different applications require various configurations. However, all exhaust-gas turbochargers have practically the same major components: the turbocharger rotor and shaft assembly, which combine with the bearing housing to form the so-called core assembly, and the compressor housing. Other components such as turbine housing and control elements vary according to the specific application.

Piston rings are installed on both the exhaust and intake sides to seal off the bearing housing's oil chamber. In some special applications sealing is enhanced by trapped air or a compressor-side carbon axial face seal. Friction bearings are generally used, installed radially as either floating double plain bushings or stationary plain-bearing bushings, while multiple-wedge surface bushings provide axial support. The turbocharger is connected to the engine's lube-oil circuit for lubrication, with oil supply and return lines located between the compressor and turbine housings. No additional cooling arrangements are provided for the bearing housing on standard units. The temperatures can be maintained below critical levels using devices such as a heat shield, and by thermally isolating the bearing housing from the hot turbine housing, supplemented by incorporating suitable design

Water-cooled bearing housings are employed for exhaust-gas temperatures in excess of 850°C. The rear wall of the compressor seals the compressor side of the bearing housing.

The housing of the radial compresor is generally made of cast aluminum. An air bypass valve can be integrated in the housing for special applications.

Turbine housings differ substantially according to intended use. Casting materials for turbine housings range from GGG 40 to NiResist D5 (depending upon exhaust-gas temperature). Exhaust-gas twin-flow turbine housing in which the two streams join just before reaching the impeller. This housing configuration is employed to achieve pulse turbocharging, in which the pressure of the exhaust-gas is supplemented by its kinetic energy.

In contrast, in the case of constant-pressure turbocharging, only the pressure energy of the exhaust-gas is utilized, and single-flow turbine housings can be employed. This configuration has become especially popular for use in conjunction with water-cooled turbine housings on marine engines. The exhaust-gas turbochargers on heavy-duty engines often incorporate a nozzle ring upstream from the turbine. The nozzle ring provides a particularly smooth and consistent stream to the impeller while allowing fine adjustment of the flow through the turbine.

Exhaust-gas turbochargers for passenger cars generally use single-flow turbine housings. However, the car engine's wide rpm range means that some form of turbocharger governing mechanism is required if the boost pressure is to be maintained at a relatively constant level throughout the engine's operating range. Standard practice presently favors regulating flow on the exhaust side, whereby a portion of the engine's exhaust gases is routed past the turbine (bypass) using a governing mechanism (waste-gate) which can be in the form of a valve or a flap.

The wastegate is actuated pneumatically. The necessary control pressure is tapped-off from the pressurized side of the turbocharger, making it possible to combine turbocharger and wastegate in a single unit.

The available energy is exploited more efficiently by governing systems incorporating turbines with variable blade geometry. With this system, the turbine's flow resistance is modified continuously to achieve maximum utilization of the exhaust energy under all operating conditions.
Of all the potential designs, adjustable guide blades have achieved general acceptance, as they combine a wide control range with high efficiency levels.

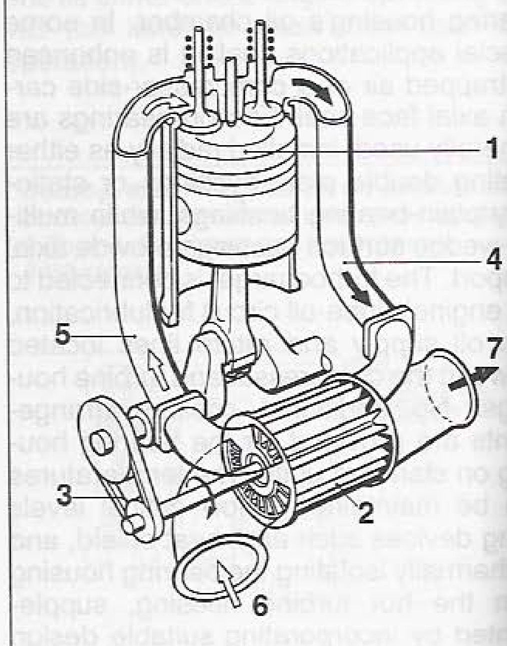
simple adjustment of the blade angle. The blades, in turn, are swiveled to the desired angles using adjusting cams, or directly via adjusting levers attached to the individual blades. The pneumatic actuator can operate with either vacuum or positive pressure. Microelectronic control systems can exploit the advantages of variable turbine-blade geometry by providing optimal boost pressure throughout the engine's operating range.

Pressure-wave superchargers

The pressure-wave supercharger exploits the dynamic properties of gases, using pressure waves to convey energy from the exhaust-gas to the intake air. The energy exchange takes place within the cells of the rotor (cell-type wheel), which also depends upon an engine-driven belt for synchronization and maintenance of the pressure-wave exchange process.

Inside the rotor, the actual energy-exchange process proceeds at the speed of sound. This depends upon exhaust-gas temperature, meaning that it is essentially a function of engine torque, and

Pressure-wave supercharger
1 Engine, 2 Cell-type compressor wheel, 3 Belt drive, 4 High-pressure exhaust-gas, 5 Pressurized air, 6 Low-pressure air intake, 7 Low-pressure exhaust outlet.



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