SECONDARY AIR SYSTEM –
Electrical Secondary Air Pump and Secondary Air Valve
Technical description

In 1990 vehicle emissions in Germany were reduced significantly by mandating all new cars to have a 3-way catalytic converter. Subsequently, as emissions regulations grew even stricter, the gap between what a 3-way catalytic converter could achieve and what government regulations required grew. It soon reached a level where additional exhaust gas after-treatments systems were needed, to meet regulations. In the early nineties, Pierburg GmbH was one of the first OEM suppliers to develop a secondary air pump. Since then Pierburg has evolved a secondary air system that includes the pump and the associated air valve.

In the past 15 years, expectations for secondary air components have increased substantially. Secondary air pumps are expected to be light, quiet and very compact in size. Secondary air valves are expected to be reliable, even under extreme conditions. In addition the ever-stronger emissions regulations need to be met.

Why secondary air? On gasoline engines with stoichiometric operation, today’s catalytic converters are able to reach conversion rates of over 90 percent but only once the converter reached its light-off temperature of 300 to 350°C. More than 80% of the emissions produced in the driving cycle are generated directly after the cold start of a gasoline engine because in that phase the cold catalytic converter does not yet deploy an exhaust gas cleaning effect. This is the point where the secondary air system comes in which initiates exothermal oxidation of unburnt hydrocarbons (HC) by injection of secondary air into the exhaust gas manifold. In this way, HC and CO emissions in the cold start phase are reduced and the light-off time is shortened by the heat thus generated. As an example, Fig. 1 illustrates schematically the layout of the secondary air system.

Fig. 1: Secondary air injection system: setup and operating principle
Secondary air pump

Pierburg secondary air pumps of two-stage radial flow design (Fig. 2) have been established in the market. A secondary air pump working on the principle of a side-channel blower (Fig. 3) is the latest member of the Pierburg pump family.

The service-proven radial flow blower lends itself to manifold applications and can resort to a comprehensive portfolio of components available worldwide which allows for their adaptation to virtually all and any customer requests.

The new side-channel blower excels by an extremely quick air flow build-up and its high delivery capacity at minimal space requirements. When having to overcome increased exhaust gas backpressure, a typical situation with gasoline turbo engines, the side-channel blower deploys the full range of its benefits.

As an experienced automotive system supplier, Pierburg GmbH has continuously advanced developments in the area of secondary air in the course of the past years and today it is able to offer a compact secondary air system. The pump and impeller geometry of the side-channel blower was improved consistently by means of comprehensive calculations as well as pressure and speed simulations.

The acoustic optimization of the side-channel blower has had top priority from the very beginning. It had to match with
the secondary air pump best in class in acoustics, i.e. the radial flow fan. Thanks to painstaking detail work, Pierburg GmbH achieved this goal. Acoustic measurements of series-produced systems make sure that the high quality standard of the secondary air pump (SAP) is reached. This level was optimized once again in 2003 by introducing sound power measuring technology.

Thanks to the modular design and availability of DC motors of different power outputs, now both large-volume gasoline engines and vehicles of restricted installation space can be supplied with sufficient secondary air. This enables a wide range of engine types to be covered.

The flow characteristics covered by Pierburg secondary air pumps are shown in Fig. 4.

All Pierburg secondary air pumps distinguish themselves by their reliability and ruggedness. Externally, they are protected from dirt and splash water. The DC-motor compartment is encapsulated against the pump unit in order to protect the DC motor from any in-leaking corrosive exhaust gas condensate.

Secondary air pumps can be either engine or chassis mounted. Depending on the mounting location, appropriate means of isolation are required. When mounted to the chassis, it is essential to select a location which should be as rigid as possible, e.g. the longitudinal beam, to avoid the transmission of structure-borne noise. For this purpose, Pierburg offers a modular connector concept composed of support bracket and vibration-absorbing elements so that the SAP is safely isolated from its mounting location.

Secondary air valve

The function of the secondary air valve is to prevent backflow of exhaust gases into the secondary air blower or the environment. At the same time, the valve has to ensure that when the secondary air system is in operation, fresh air can flow into the exhaust manifold and uncontrolled inflow of air into the exhaust gas system is avoided outside the operation of the secondary air system. For this purpose, three valve types are available at Pierburg:

**Fig. 4:** Flow characteristics, realized by Pierburg secondary air pumps
The vacuum controlled check valve (ARV) is a pneumatically operated on-off valve featuring low pressure loss. To activate this valve, vacuum from the intake manifold is supplied by a solenoid valve. The ARV operates on the check valve principle. This will reduce return flows when the valve is open.

With a view to reducing system costs, an alternative, self-opening valve was developed. This secondary air valve (SLV), shown in Fig. 5, will open as soon as the system pressure generated by the secondary air pump exceeds the valve opening pressure. The SLV enables system complexity to be distinctly reduced because the electrical switch valve, the electrical activation and the complete vacuum lines can be deleted. With this valve type, it is likewise possible to integrate a check or non-return function. The SLV can also be chosen with an enlarged membrane diameter to enhance the actuating force.

A new development is the electric secondary air valve (ESV), cf. Fig. 6, which has been available in series production since 2007 and which combines the benefits of the ARV and the SLV. The ESV is independent of the secondary air pump pressure and intake vacuum levels. It has a quicker response time than the pneumatic valves. The excessive force at the opening point which ensures the functional reliability of the valve, particularly at ambient temperatures below the freezing point, is achieved through a split armature and the ensuing plate magnet effect. With this electromagnetic drive, the ESV develops a maximal opening force of about 110 N for the decisive first 0.5 mm of the travel.

For future on-board system diagnostic requirements of the secondary air system (OBDII, EOBD), the ESV can be equipped with integrated pressure sensor. As an option, all valve types can be provided with a pressure sensor integrated in the intake flange.

Based on the system components existent at Pierburg which are submitted to ongoing enhancement, optimal secondary air support will be available for future applications as well.