Applications – Power train – Miscellaneous engine components

Table of content

8 Miscellaneous engine components

8.1 Introduction

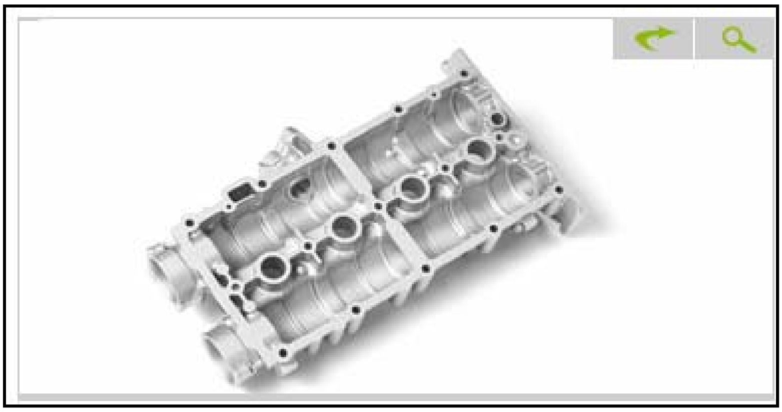
Many engine (under-the-bonnet) components are today made from aluminium (generally in the form of aluminium casting alloys). The dominating applications are housings for different aggregates, but there are also aluminium applications in individual parts of the various aggregates. In the past, cast iron parts (and sometimes zinc die castings) were used for the housings, whereas the functional components of the aggregates were made from different materials. Today, cast iron and zinc housings have been largely replaced by aluminium.

But the application of aluminium in some of these components, in particular housings, is nowadays threatened by new lightweight solutions. Further lightweighting requirements have led in some cases to the substitution of aluminium high pressure die castings by magnesium high pressure die castings. Furthermore, temperature resistant high performance plastics and composites are increasingly considered to reduce the cost and weight of these components. The cost competitiveness of high performance plastic components is mainly achieved through the possibility to produce increasingly complex shapes allowing sophisticated integrated designs.

Nevertheless, parts integration and the integration of additional functions into a single component is also a strength of the aluminium high pressure die casting technology. Therefore appropriate aluminium solutions will remain also in future, in particular for components where exposure to higher temperatures is a determining factor (improved strength and dimensional stability in the temperature range 150 °C and above).

8.2 Cylinder head covers

The cylinder head covers seal the oil-pressurized camshaft space externally. Other main functions include the protection of the valve train and to cover peripheral parts from the increasingly higher engine temperatures. The reduction of structure-borne noise is a further requirement. Oil filler nozzles, sensors, and cable harness fixations may be integrated too. Newer developments also integrate other functions such as valve train bearings, crankcase ventilation and effective oil mist separation for the blow-by gas into the cylinder head covers, resulting in space savings and hence an increase of the overall rigidity.

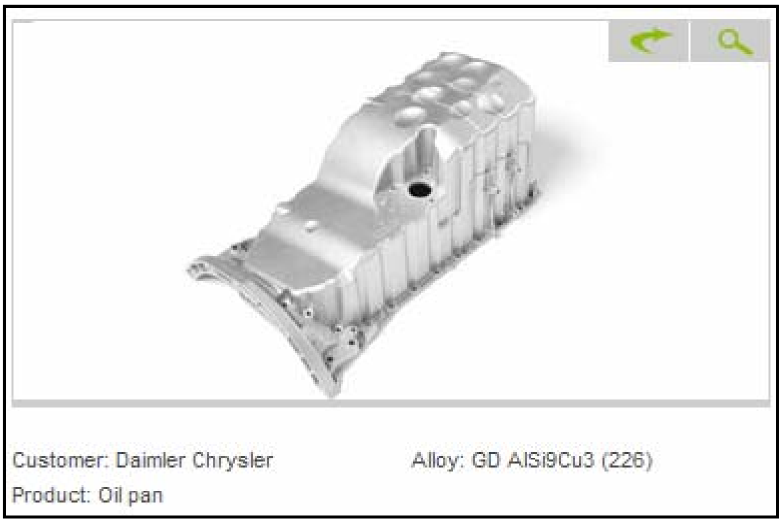


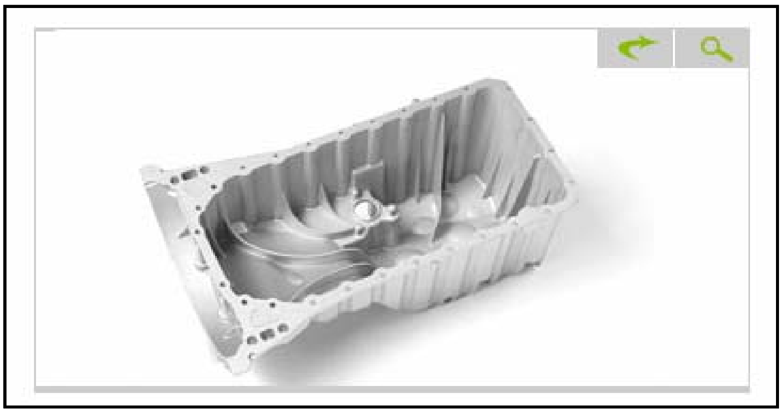
Aluminium cylinder head cover produced by high pressure die casting

Source: BDW

8.3 Oil pans

From a technical point of view, there are many parallels between oil pans and cylinder head covers. The main requirements of both components are tightness, strength, improved acoustic properties, weight reduction and the possible integration of additional functions. As a result of its being fitted in a partially exposed position, the oil pan may be subject to stone strikes. Thus, oil pans must also be able to resist stone strikes and grounding. Furthermore, the oil pan in a passenger vehicle is frequently also used to reinforce the engine-gearbox unit.





Aluminium oil pan produced by high pressure die casting

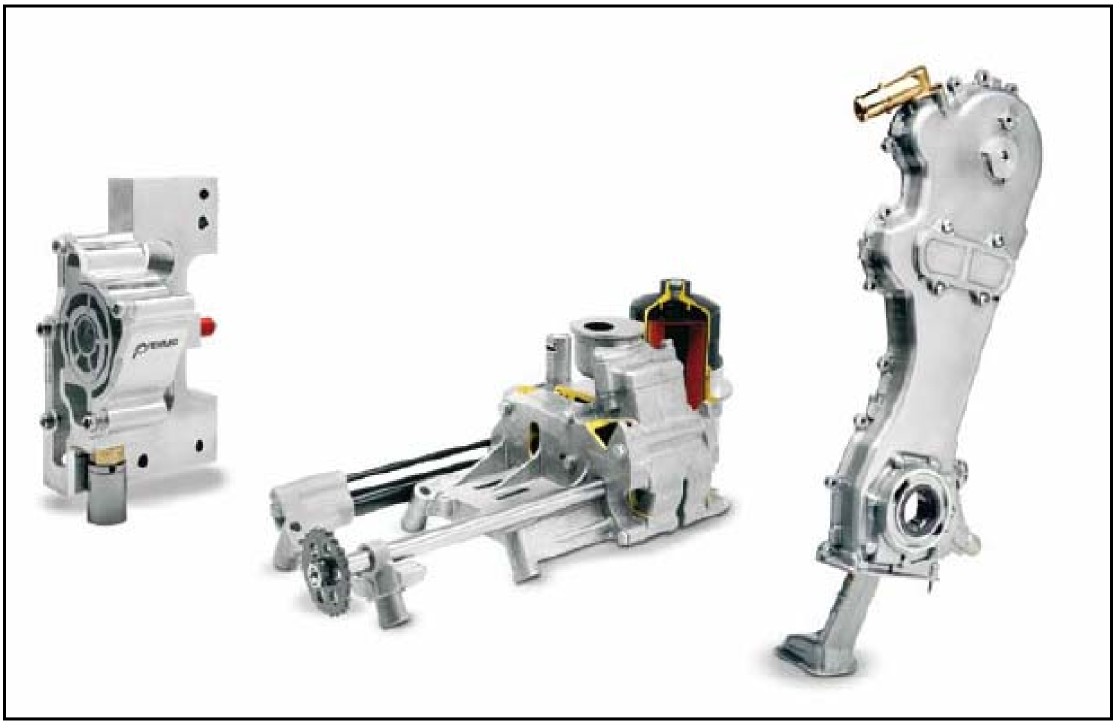
Source: BDW

8.4 Pumps

Pump housings and various other components for the different types of pumps used in the automobile are a preferred application for aluminium. Aluminium pump housings are generally produced by high pressure die casting, functional pump components can be made either from wrought or cast aluminium alloys.

8.4.1 Oil pumps

Today's engines require disproportionally large oil flows. Since conventional unregulated oil pumps do not fulfil these requirements under all engine operating conditions, new developments were necessary. The aim is to supply pumps that fulfil all functional requirements while maintaining maximum efficiency and achieving the slightest possible losses. For this purpose, fully variable-flow vane pumps for constant oil pressure and automatic adjustment of oil flow across the engine's entire speed and load range have been developed.



Oil pumps with different aluminium housings

Source: Pierburg Pump Technology AG

The controlled pendulum-slider oil pump, for example, enables the demand-based supply of oil pressure and volume which translates to a potential CO_2 reduction in the New European Driving Cycle (NEDC) of up to two percent compared with a conventional oil pump.

Pendulum-slider oil pump with a die cast aluminium housing

Source: Mahle AG

8.4.2 Water circulation and coolant pump

In contrast to oil pumps, coolant pumps operate on the turbo machine principle. The conventional water pump consists of a body and an impeller mounted on a spinning shaft with a pulley attached to the shaft on the outside of the pump body. In future, however, electrically operated controlled pumps will be more and more used to convey coolant. Because of the controlled operation and minimal mechanical wear of this type of coolant pump, the optimized coolant circuit another contributing factor to reduced CO_2 emissions in the driving cycle.

Mechanical coolant pumps

Source: Pierburg Pump Technology GmbH

Electrically operated pumps deliver coolant independently of the engine and only when really needed. Additionally, these type of pumps do an indispensable cooling job on turbochargers, power electronic and exhaust gas recirculation systems.

Electrically operated controlled coolant pump

Source: Mahle AG

Additional aluminium housings may be used in the oil filter module/system which contains multi-functional components such as integrated oil-water-heat exchangers, crankcase ventilation, oil pressure switches, sensors or compact valves that fulfil further essential functions in addition to filtration.

8.4.3 Vacuum pumps

Nowadays, more and more vehicles depend on pumps that generate the vacuum necessary for boosting brake performance to increase brake reliability and ease of handling. For diesel engines and increasingly also for or gasoline engines, specifically those with direct injection, vacuum pumps are used for supplying servo valves with vacuum for controlling exhaust gas recirculation systems and turbo chargers, for example.

Single-vane vacuum pump for Audi TSI

Source: Pierburg Pump Technology AG

8.5 Air intake management

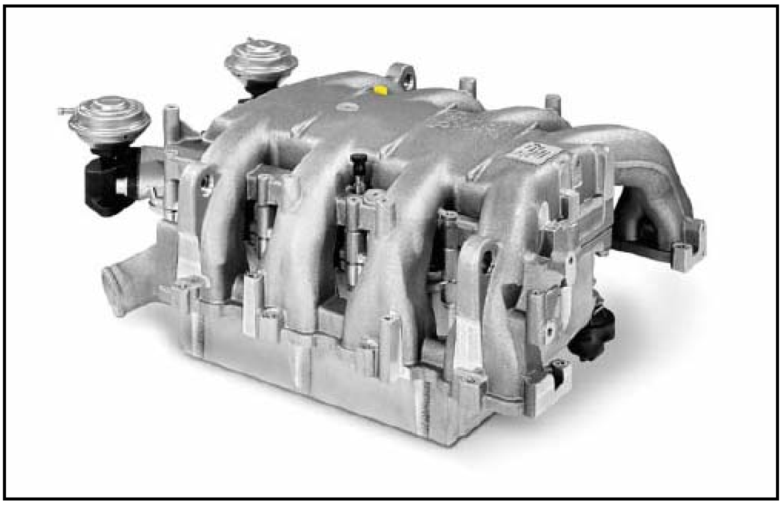
Apart from the actual engine block, the intake manifold assembly ranks among the biggest individual parts of the engine. The complete air intake system comprises the air filters and intake manifolds, but also dirty air, clean air and turbo ducts, silencers, intake air preheating boxes, heating pipes, control valves, design covers, fuel supply rail, oil mist separators and rocker covers. Therefore, lightweight design and lightweight materials are absolutely essential and a prime reason to opt for magnesium and aluminium as intake manifold materials, in particular on large engines. Today's intake manifolds cover a multitude of functions reaching beyond the mere routing air flow; they include dynamic supercharging, swirl and tumble control and positive crankcase ventilation. Integrated components of such systems nowadays are exhaust gas recirculation (EGR) subsystems comprising EGR valves, EGR coolers, bypass systems and the related electric or electro-pneumatic actuators. The advantages of aluminium are thin walls yet high strength; mechanical, thermal and chemical resistance to exhaust gases; plus the possibility of complex packaging solutions together with a host of integrated solutions.

8.5.1 Manifolds

In an internal combustion engine, the intake manifold is the part of the engine that supplies the fuel/air mixture to the cylinders. Its main purpose is to evenly distribute the combustion mixture - or just air in a direct injection engine - to each intake port in the cylinder head. An even distribution is important to optimize the efficiency and performance of the engine. It may also serve as a mount for the carburetor, throttle body, fuel injectors and other components of the engine.

The performance and torque of combustion engines have been significantly improved through the development of variable air intake manifolds which can switch between different runner lengths. A short runner optimizes performance at higher speeds, whilst a long runner provides favourable torque in the lower and medium speed ranges. As well as the throttle body, further components such as an air mass meter, sensors, EGR ducts, fuel rail and injection valves are integrated into the unit.

Historically, the intake manifold has been manufactured from cast iron and aluminium, but the use of composite plastic materials is gaining popularity too. Aluminium manifolds are usually designed as high pressure die castings, a technology which allows the production of thin-walled components in a highly complex shape as well as the integration of additional functions (e.g. attachment points). But there are also designs based on wrought aluminium products (aluminium sheet stampings, extruded tubes which are subsequently bent or hydroformed into the desired shape).



Audi 8-cylinder TDI intake manifold with integrated air cooler/EGR cooler, throttle body and two EGR valves (hybrid design consisting of an aluminium pressure die casting and an aluminium gravity die cast part)

Source: Pierburg GmbH

VW 6-cylinder intake manifold (aluminium die casting)

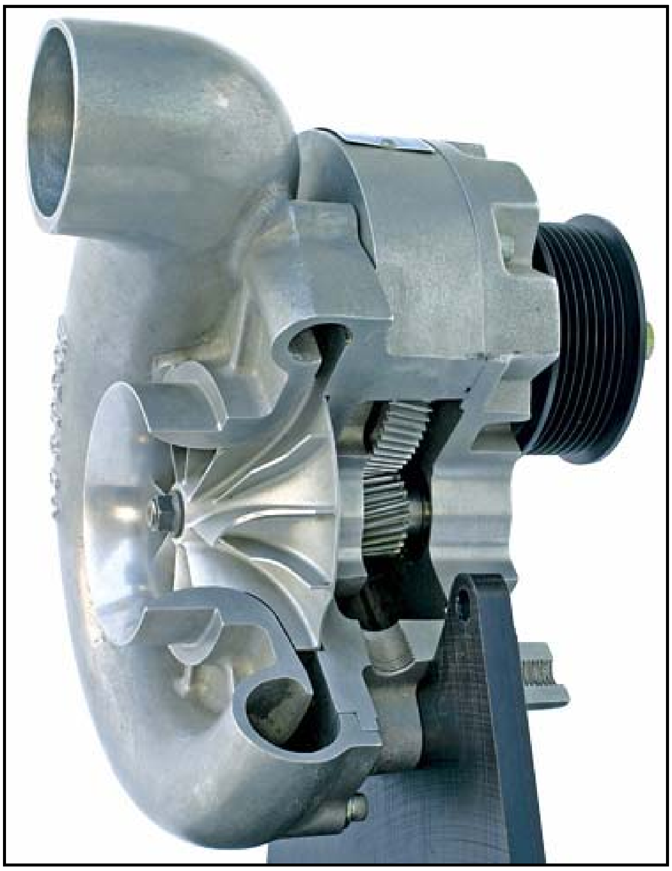
Source: Pierburg GmbH

8.5.2 Turbochargers

In a naturally aspirated engine, the combustion air is drawn directly into the cylinder during the intake stroke. In turbocharged engines, the combustion air is already pre-compressed before being supplied to the engine. Consequently, more fuel can be burnt, so that the engine's power output increases. Any device that pressurizes the intake air to above atmospheric pressure is called a supercharger. In fact, the term "turbocharger" is a shortened version of "turbo-supercharger".

The difference between a supercharger and a turbocharger is their source of energy. Turbochargers are powered by the mass-flow of exhaust gases driving a turbine. Superchargers are powered mechanically by belt- or chain-drive from the engine's crankshaft. Therefore, fuel consumption is higher when compared with a naturally aspirated engine with the same power output. In exhaust gas turbocharging, some of the exhaust gas energy, which would normally be wasted, is used to drive a turbine. The compressor is mounted on the same shaft as the turbine, there is no mechanical coupling to the engine.

As the air is compressed, it gets hotter, which means that it loses its density and cannot expand as much during the explosion. For a supercharger to work at peak efficiency, the compressed air exiting the discharge unit must be cooled before it enters the intake manifold. The intercooler is responsible for this cooling process. Intercoolers come in two basic designs: air-to-air intercoolers and air-to-water intercoolers (→ Heat exchangers). The reduction in air temperature increases the density of the air, which makes for a denser charge entering the combustion chamber.



Supercharger

Source: Vortech

Honeywell GT22 VNT Turbocharger

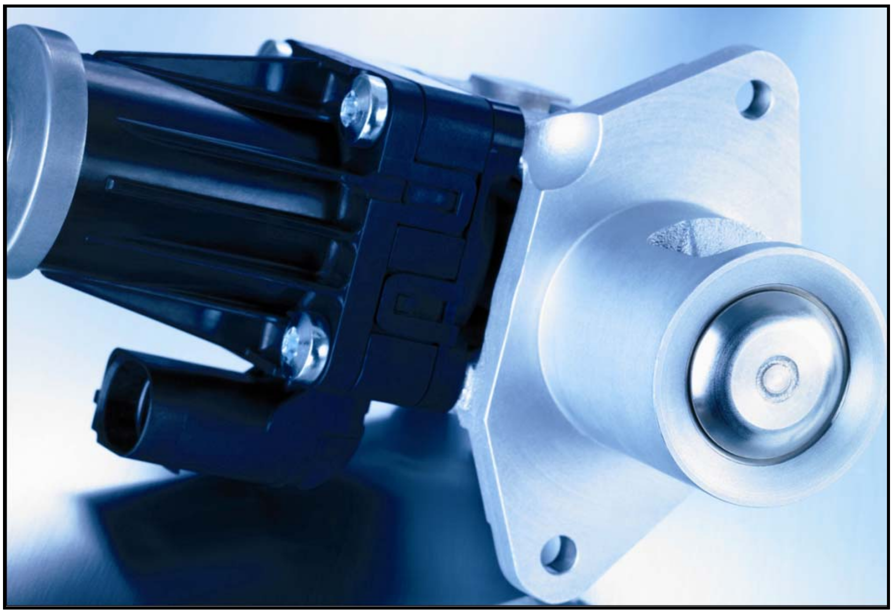
Source: Honeywell

A key element of both devices is the impeller which is generally made from aluminium. The high technical requirements of this part ask for a top quality products, i.e. aluminium impellers are generally produced using sophisticated casting methods such as investment casting, semi-solid casting, etc.

8.5.3 Exhaust gas recirculation

The tighter future emission limits call for a closed-circuit exhaust gas recirculation (EGR) system. The effect of exhaust gas recirculation is based on a reduction of the combustion temperature for both diesel and gasoline engines. The lower combustion temperature leads to a reduced nitrogen oxide content. In gasoline engines, this also leads to a throttling of the engine under part-load conditions and hence to fuel consumption reduction.

In combination with aluminium coolers and exhaust gas flaps, EGR valves control the pressure difference for a further significant abatement in nitrogen oxides. Because of the stricter emission standards, both diesel and turbocharged (lean-mixture) gasoline engines will be inconceivable without EGR cooling. The newly developed die-cast aluminium cooler that, versus the stainless steel variety used hitherto, represents a low-cost and weight-saving alternative while exploiting the superior thermal conductivity of aluminium.



EGR unit

Source: Pierburg GmbH

8.6 Engine bearings

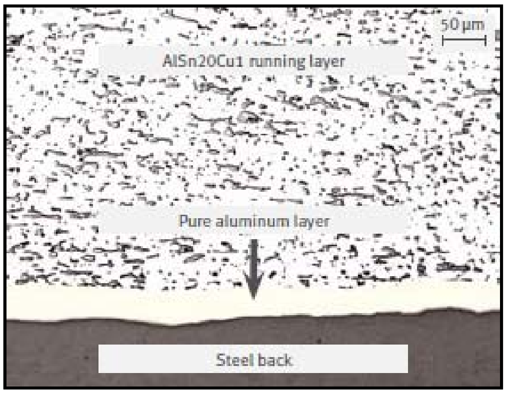
The essential tasks of a bearing consist of supporting the moving parts as well as absorbing and transmitting the resulting forces. However, in today's engine designs, increasing attention must be paid to other objectives, such as improving the load resistance, wear reduction, NVH optimization, as well as increased conformability of the bearing material to the shaft or the shaft deformation respectively.

Three different families of sliding materials are available. The first group consists of the classical aluminum-tin sliding material and the innovative aluminum-zinc-bismuth alloy in which bismuth replaces lead. From the strands continuously cast on site, strip is generated in defined and coordinated rolling and annealing operations for subsequent cladding. The various steel-aluminum composites are finally produced by roll bonding. These are used as so-called bimetal bearings for connecting rods and crankshafts in internal combustion engines.

In the second sliding material family, the new sintered bronze, lead is again replaced by bismuth. This group contains outstanding connecting rod and bushing materials.
Bronze and brass continuously cast onto steel strip make up the third material family. These materials are distinguished by their extreme dynamic load-bearing capacity coupled with sufficient tenacity, making them ideal for use in connecting rod bearing shells and connecting rod bushings for high-performance diesel engines.

However, it is not only the sliding material and the geometry-generating processes that affect plain bearing function, innovative coatings also ensure optimal running-in behaviour and low-wear continuous running. The spectrum of possible surface coatings at KS Gleitlager extends from galvanic films deposited electrochemically, thermal spray layers and sputter layers applied in a high vacuum, to synthetic antifriction coatings.

Bearings and bushings

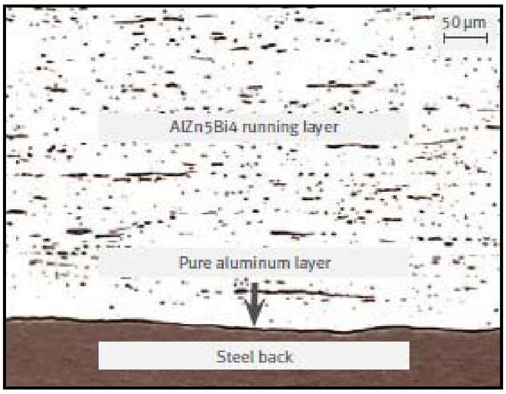


Chemical composition of the running layer

mass-%	Sn	16.5 to 22.5 %
	Cu	0.7 to 1.3 %
	Si	max. 0.7 %
	Ti	max. 0.2 %
	Ni	max. 0.1 %
	Fe	max. 0.7 %
	Mn	max. 0.7 %
	others combined	max. 0.5 %
	Al	rest

Lead-free steel-aluminium composite material for main bearings KS R20

Source: KS Gleitlager GmbH



Chemical composition of the running layer

mass-%	Zn	4.40 to 5.50 %
	Bi	2.0 to 4.5 %
	Si	1.00 to 2.00 %
	Cu	0.80 to 1.20 %
	Mg	max. 0.60 %
	Ti	max. 0.20 %
	Ni	max. 0.20 %
	Fe	max. 0.60 %
	Mn	max. 0.30 %
	Sn	max. 0.20 %
	others combined	max. 0.5 %
	Al	rest

High load, lead-free steel-aluminium composite material for main bearings and connecting rod bearings KS R45

Source: KS Gleitlager GmbH