Oil Pumps for Internal Combustion Engines and Transmissions
Conventional, Variable and Electrical
Oil pumps for internal combustion engines – conventional, variable and electrical

Virtually all the engine makers use Pierburg Pump Technology oil pumps, customers including the global car and commercial vehicle industries. On an I.C. engine, the oil pump is one of the those components selected at the drawing board stage since the quality of its design and execution is a major ingredient in sustaining the upgradeability of the basic engineering throughout many years of series production.

Highly efficient R&D centers in Italy, France, and Germany, operate large numbers of engine test rigs and dynamometer test stands plus product-specific continuous and functional testing rigs. The engineering design and computations are carried out using customer-specific CAD software and the latest programs for computing pumps and pump components.

Pierburg Pump Technology pumps have external gearing, internal gearing for direct crankshaft or auxiliary drives as well as gearing engineered to customer specifications.

Oil flow is normally regulated by integrated, piston-type pressure-limiting valves.

Fig. 1: Crank-shaft driven VOP with solenoid valve

Fig. 2: Chain driven VOP with hydraulic control system

Fig. 3: VOP with hydraulic control system
Innovative oil pumps

With in some cases additional oil/hydraulic functions to perform such as hydraulic valve lifting/timing, piston cooling, and the use of aluminum engine blocks, today’s engines require disproportionately large oil flows, especially at low engine RPM. On conventional, unregulated pumps this leads to substantial losses (Fig. 4) at higher engine speeds since the output of these pumps is locked to engine RPM.

Pierburg Pump Technology has mapped out a variety of approaches with a view to ensuring dependable lubrication and reliable regulation of the oil supply system under all operating conditions. The aim is to be able to supply pumps that address all the functional requirements while maintaining maximum efficiency and achieving the slightest possible losses.

As a result of the demand for improved efficiencies to reduce emissions, conventional gear pumps controlled with dissipative systems are being increasingly superseded by new pumps that control the flow rate and pressure without energy losses. The advantage of vane pumps is that they can be simply and continuously controlled over a large adjustment range with constant efficiency. What’s more, they can be positioned both on the crankshaft and in the oil pan. The solution chosen by Pierburg Pump Technology permits the use of various passive and active forms of control. With the control system employed, a precise and constant pressure setting can be achieved even at a high speed and with a large quantity of water air dissolved in the oil. The eccentricity of the rotor and hence its displacement are modified by means of the pressure difference between the two limiting chambers. This modification is effected by means of a hydraulic valve and can be corrected for adaptation to the temperature or numerous other operating parameters by means of a thermostat or electric valve. To achieve an optimal result, variable pressure control is necessary, as the NEDC shows. The pressure is limited here at low speeds and at temperatures differing from the usual operating temperatures. Depend-

![Fig 4: The advantages of pump regulation](image-url)
ing on the strategy, good results can be achieved with an electronic control over two different pressure stages. Going beyond this, continuous pressure control permits a further improvement in the results even outside the test cycle. By referring to the NEDC, the oil pump’s power consumption can be reduced by up to 70% by using this technology. The effect on fuel consumption is a reduction up to 3%.

Variable oil pumps can be integrated in modules including vacuum pumps, water pumps, balancer shafts.

Pierburg Pump Technology’s design department has highly advanced design and simulation tools as well as extensive expertise in the structural analysis of finite elements (static, modal, spectral and fatigue), computer fluid flow dynamics (CFD) and multi-body simulation. Multi-body analyses were introduced to obtain precise information on the factors affecting moving components. With simulations it is possible to analyse the effect of the drive in terms of the engine’s dynamic conditions, such as the torsional vibration of the crank- and camshaft. To assess the hydraulic interaction between the pump and lubrication system, Pierburg Pump Technology has developed a simulation model based on a systems analysis platform that replicates the specific properties of the pumps with the aid of a one-dimensional model. The use of CFD simulations is of fundamental importance for optimizing the flow dynamics in the pump and diminishing the pressure fluctuations, particularly when large quantities of air are present in the oil being pumped. The physics of multi-phase flow (oil, air and oil vapor) is integrated in the computational model. Key results of these simulations are the magnitude, intensity and location of the arising pressure peaks as well as the percentage share of air and oil vapor in the various regions of the pump. Pierburg Pump Technology’s outstanding expertise in this field is the outcome of close cooperation with highly reputed research institutions and universities.
Electric oil pumps

For hybrid drives and engines with automatic start-stop, the use of electric gear oil pumps is indispensable if hydraulic pressure has to be maintained in the subsystems after the internal combustion engine has been switched off. Electrical oil pump can be used also in combination with mechanical oil pump of the engine as a booster pump, or in any case is needed oil pressure to actuate devices independently from the thermal engines.

For the development of new oil pumps, Pierburg Pump Technology exploits synergies with the electrical water pumps and thus cuts costs and development time while at the same time boosting reliability. By integrating the electric motor and hydraulics, installation size, weight and complexity have been reduced. This way, Pierburg Pump Technology is able to realize integrated electric oil pumps based on 50 W to over 400 W motors. By way of example, Figure 7. shows the X20 oil pump based on a 200 W motor and already in mass production. Depending on the requirements, the electronics, which primarily ensures the sensorless commutation of the brushless DC motor, can be implemented in a separate control unit or integrated in the pump housing. Like sensorless rotor position detection, the generation of the motor control signals is performed by the software in the ASIC (user-specific IC) developed in-house. Since actual rated motor currents can be as high as 40 A, the design of the semiconductor output stages requires special attention as regards electromagnetic compatibility and cooling. This is where an early forecast of the pump’s thermal behavior is required, as well as the interdisciplinary expert knowledge that Pierburg Pump Technology has accumulated over many years.

Fig. 7: X20 electric oil pump  
Fig. 8: Example of the new generation electrical oil pump