WATER PUMPS

technical manual

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AUTOMOTIVE PASSION

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The Metelli technical manual on water pumps for internal combustion engines

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3. To guarantee efficiency and the proper functioning, the product must necessarily be used for the purpose it was designed to.
4. Product set up must be carried out by qualified personnel with a specific and technical expertise in the spare parts industry, in compliance with the laws and safety regulations and according to the instructions included in this TECHNICAL MANUAL.
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Internal combustion engines and their cooling circuits

All fuels (diesel, petrol, methane, etc.) contain a large amount of energy, this energy is “chemical” and is released in terms of pressure and heat during combustion.

Within the cylinder volume, enclosed between the motor head and the piston’s upper surface, the mixture of air and fuel ignites, transforming chemical energy into heat and pressure (hence the term internal combustion engine).

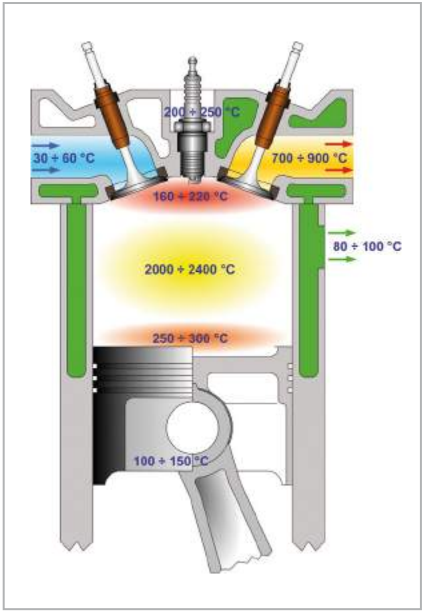
The particular mechanical structure of the motor is able to transform the energy released by the combustion into mechanical energy for the vehicle (or for other purposes if for example the engine is an engine for industrial applications).

The temperatures generated inside the combustion chamber are extremely high, and this heat must somehow be removed, if not the first result would be an overheating engine, and shortly thereafter its meltdown.

In order to remove the heat generated during combustion, all around the cylinder and inside the cylinder head there are a large number of channels in which the engine coolant flows *(image 1.1)*.

The liquid absorbs heat from the walls of the ducts warming up and as it flows it transfer this heat to the surrounding environment through the radiator.

There are two main reasons for engines to be liquid-cooled: increasingly elevated power density, increasingly higher operating temperatures.



1.1 Temperatures in the various areas of the engine

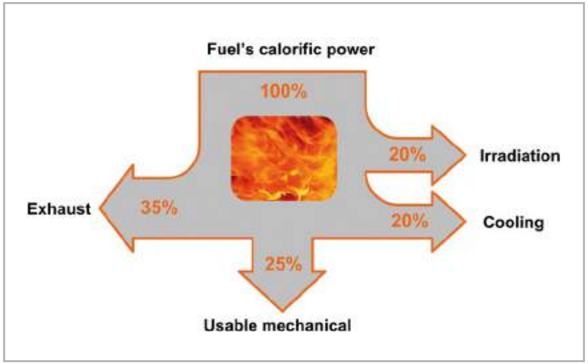
These two factors have, for some time, been the main reasons for engine manufacturers moving towards solutions with liquid cooling systems, even those manufacturers who historically had initially made different choices. Cooling engines by means of a liquid makes them more compact (without the bulky cooling fins that are typical of air-cooled engines) and capable of operating at higher temperatures, improving overall efficiency.

The heat generated by fuel combustion in the combustion chamber goes to the surrounding environment by following different routes: in the exhaust fumes, by radiation and conduction to the environment surrounding the motor itself, and finally through the engine's cooling circuit *(image 1.2)*.

Monitoring the temperature of the engine is important, the proper functioning thereof depends on maintaining the correct temperature; temperatures that are too high firstly compromise lubrication and then the engine materials themselves, while temperatures that are too low make the engine work with excessive friction and incorrect combustion.

The task of the engine cooling circuit is therefore to keep the temperature of the engine under control, handling the thermal transient and the disposal of heat produced inside the engine during operation.

The first cooling systems did not even have a water pump for forced circulation, but the wide section of the pipes, combined with a great vertical development of the radiator, was enough to generate a natural flow of water by exploiting the difference in density at different temperatures *(image 1.3)*.



1.2 Internal combustion engine efficiency

1.3 Old engine without water pump

This was possible because the engines of the past had a very low power density and the volume inside the engine hood was extremely wide.

Things changed rapidly with the passing of time, the design of the cars, the engines themselves, the space available, are drastically different from those of the past.

The cooling circuits of modern engines therefore have had to adapt becoming more compact, more efficient and above all they must operate with coolant circulation guaranteed by the presence of a water pump *(image 1.4)*.

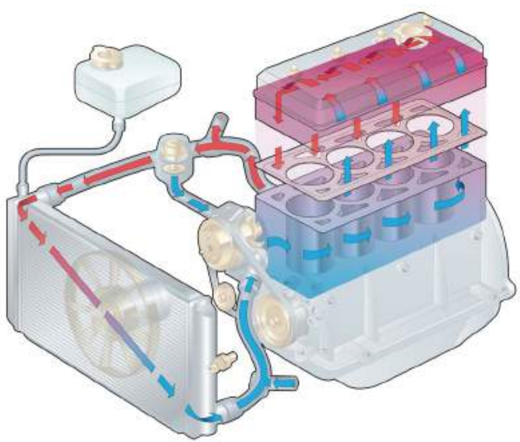
The cooling circuits of modern engines are now real subsystems (with a certain degree of complexity); main component of the circuit is the water pump that has to guarantee the circulation of coolant throughout the whole circuit.

Since the engines improve their overall performance especially when operating at higher and higher temperatures, many circuits are pressurized.

This means that they can work at higher temperatures without the cooling liquid coming to a boil.

Pressurized circuits mean smaller radiators, better performance of the engine, but also higher temperatures; the materials of the entire circuit must be carefully chosen to withstand the high temperatures of the pressurized circuit.

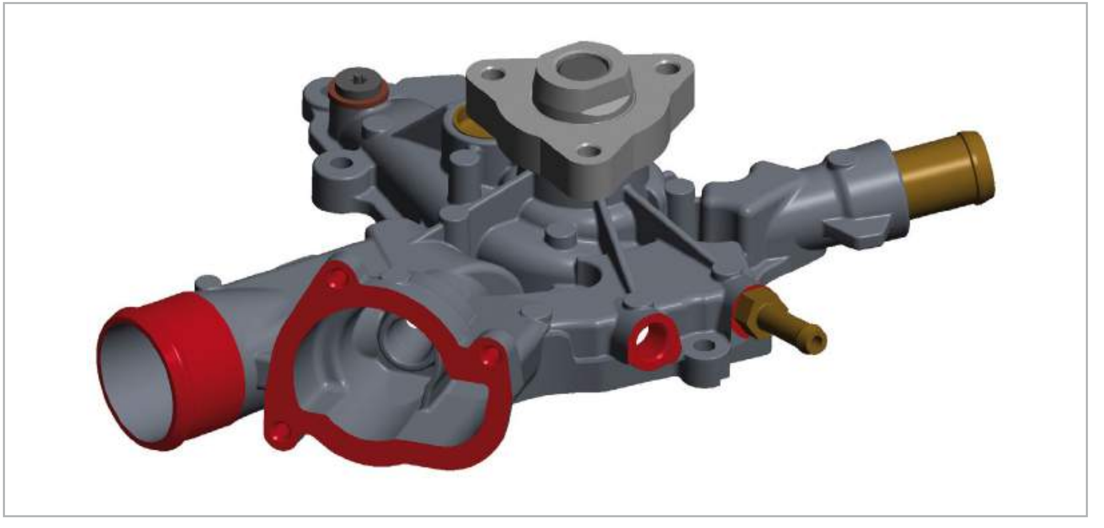
Provided with one or more radiators, with secondary circuits for heating the passenger compartment and in some cases also equipped with a circuit for the cooling of the turbine, the cooling circuits have the water pump at their centre.



1.4 Modern cooling system scheme

Operation of a water pump

Although in recent years, water pumps have undergone major changes related to changes in the engines onto which they are mounted, the vast majority of the water pumps have maintained a "classical" structure, where design rules have not undergone drastic changes.
There is always a mechanical drive, which is necessary to draw in rotation the shaft of the inner bearing to which the impeller is connected, which is the component that transfers mechanical power from the engine to the fluid. The highly specialized components such as mechanical seal and the bearing are now highly industrialized, made with high performance materials that have evolved over time to last longer and longer while withstanding higher and higher temperatures.



2.1 Water Pump with integrated thermostat housing

It is thanks to the action of the impeller that the coolant is able to overcome the resistance of the cooling circuit (usually very tortuous), flow and therefore be able to transfer heat from the engine to the radiator, which in turn transfers it to the external environment *(image 2.1)*.

Built in this way the water pump works from the first moment when we start the engine even when there is no real need to circulate the fluid. The only element that is able to ensure that no water passes through the radiator is the thermostat, whose housing can be located in the same body as the water pump *(image 2.2)*.

Due to its construction technology, the thermostat is made in order to open the flow of the coolant towards the radiator only after it has reached a specific temperature; this prevents the coolant from being cooled when in fact it is not still necessary (for example, when the engine is still cold).

Taking power from the engine belt, or by other similar mechanisms, the water pump has the number of revolutions which is directly related to the number of engine revolutions; this also means that the water pump works from the moment the engine starts even though it is cold, that is the reason for the presence of the thermostat.

2.2 Modern thermostat

Power take-offs

The drive of the water pump is mechanical; this means that the pump absorbs torque from the engine to rotate the impeller which circulates the coolant, in what way? In most cases, the pump has a pulley which is driven by a toothed belt, it is generally the same belt that moves the camshafts of the engine *(image 3.1)*.

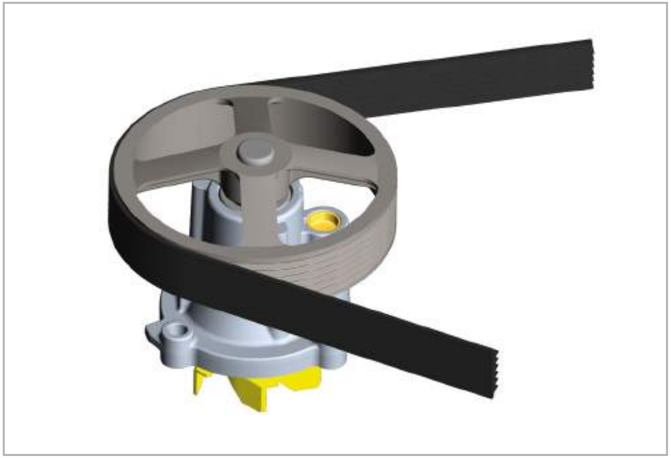
In some cases, for reasons related to the route of the belt, the water pump has a pulley without gear teeth, because the motion is transmitted only by friction with the back of the belt *(image 3.2)*.

The use of the timing belt is not the only case in which the water pump receives power from the belt indeed there are

3.1 Water pump with drive on engine belt teeth

3.2 Water pump with drive on the back of the engine belt

a large amount of engines that, due to the layout of the various auxiliaries have a belt dedicated exclusively to all these services such as the oil pump, the power steering pump, the high pressure oil pump, the air conditioner compressor, and of course also the water pump.
In these cases the belts used to provide the power to services is of type Poly-V; quieter and easier to use than the toothed belt, is capable of ensuring a smooth operation at all speeds of rotation *(image 3.3)*.
As design was now been abandoned the classical V-belt typical engine of a certain age whose performance has been widely surpassed by Poly-V belt.
The many different design choices that characterize modern engines are also reflected in the water pumps, so much so that the solutions to power a water pump are not limited only to the engine belt (or to the poly-V belt when the camshafts are driven by chain). There are indeed a series of variants in which there is an actual mechanical coupling that uses shafts with splined profiles *(image 3.4)*.
The solutions that are actually used can be many (gears, drives the camshaft chain, etc.), but these are found in very few cases: engines of a certain size like those used for industrial applications (generators, etc..) or engines for industrial vehicles.



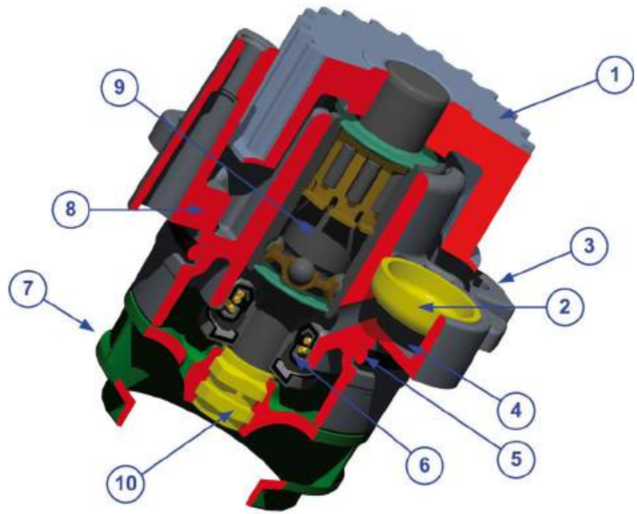
3.3 Water pump with a Poly-V power take off

3.4 Water pump with drive by splined shaft

Section of a water pump: main components

Every water pump, however different it may seem, when reduced to minimal terms can be equated to a small number of principal components that perform the same function *(image 4.1)*:

1. Toothed pulley for coupling to the engine belt and transmit motion
2. Cap of the tank that collects small leaks from mechanical seals, which are physiological
3. Hole, in the pump body, for one of the fastening screws to the engine
4. Tank to collect coolant leaks from the mechanical seal
5. O-ring seal in the assembly location of the water pump
6. Mechanical seal
7. Impeller, in this case made of techno-polymer, of the type with closed spaces
8. Main housing of the water pump, in this case made of die-cast aluminum
9. Integral bearing, in this case, roller-ball
10. Metal insert co-molded into the impeller



4.1 Section of a water pump and its components

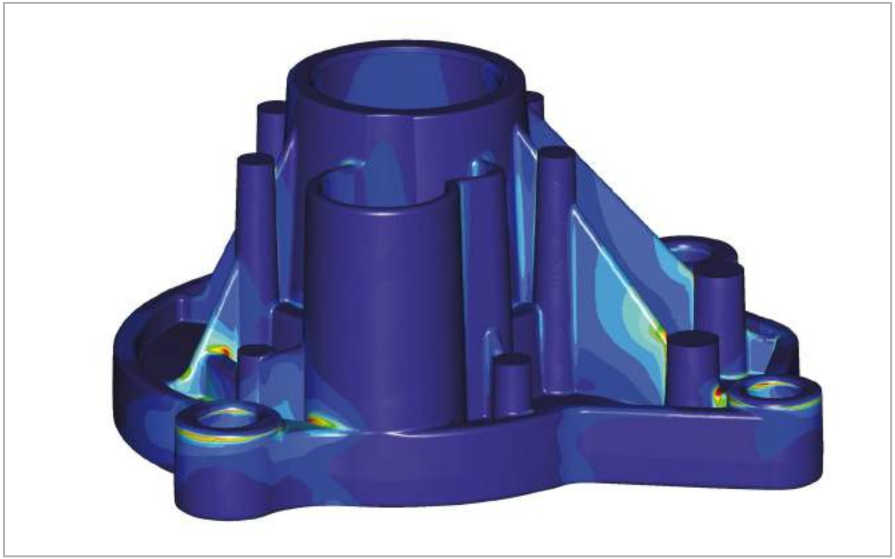
Water pump design

The factors which contribute to literally give shape to a water pump are many: performance, reliability, durability, combined with the highest overall quality levels are the characteristics we seek in the development of all our products.

The geometry of the pump housing is the result not only of technical considerations, related to the stress to which the body itself is subjected, but also the result of the morphology of the entire cooling circuit.

Often the water pump is in the meeting point of the “secondary” coolant circulation circuits such as passenger compartment heating, cooling turbine, etc..

Inserted in the majority of cases in a space directly in the engine block, the water pumps have to operate in a difficult environment; high temperatures of the coolant and the air under the hood, together with the continuous vibration of the engine, is the usual work environment for a water pump.



5.1 Structural analysis of water pump housing

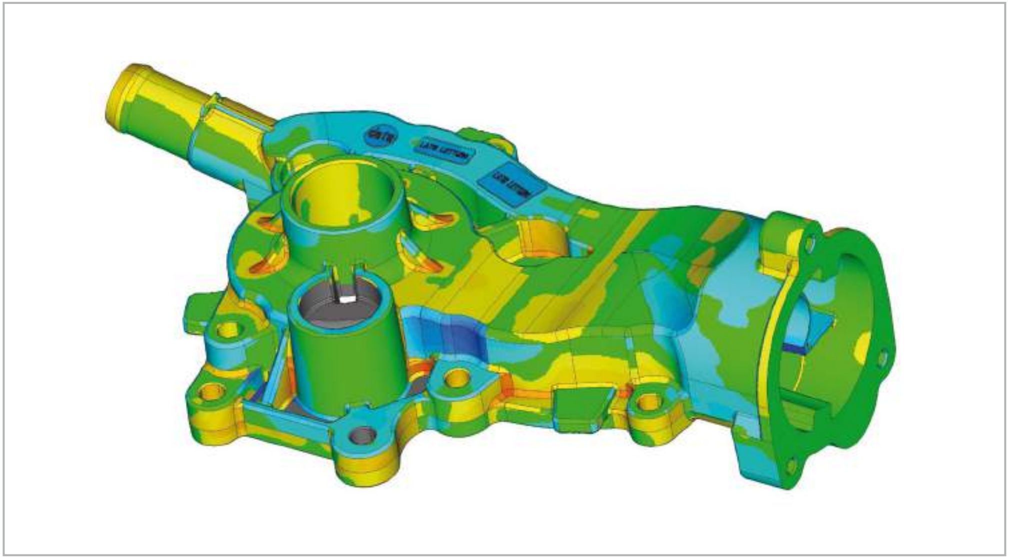
All this is reflected in a design process tailored to each specific reference. Every water pump is developed according to common design criteria refined during a business experience that has now reached half a century.

Finite element analysis is performed to ensure that water pumps, subjected to the worst combination of conditions, are still able to withstand the stresses while maintaining a further adequate safety margin *(image 5.1)*.

Often a number of additional rotating masses are assembled on the water pump (viscous coupling units, fans, etc.); these masses may constitute an additional burden on the operating conditions of the pump (when these masses become eccentric).

This is a further aspect that must be taken into account when sizing; the presence of rotating masses, which can give rise to additional stress, is a source of considerable increase of the forces acting on the pump housing, added to those already present.

The strict observance of the size limitations of the project is another crucial aspect, a complete optical inspection conducted in 3 dimensions ensures that the geometry is consistent with the requirements in the design *(image 5.2)*.

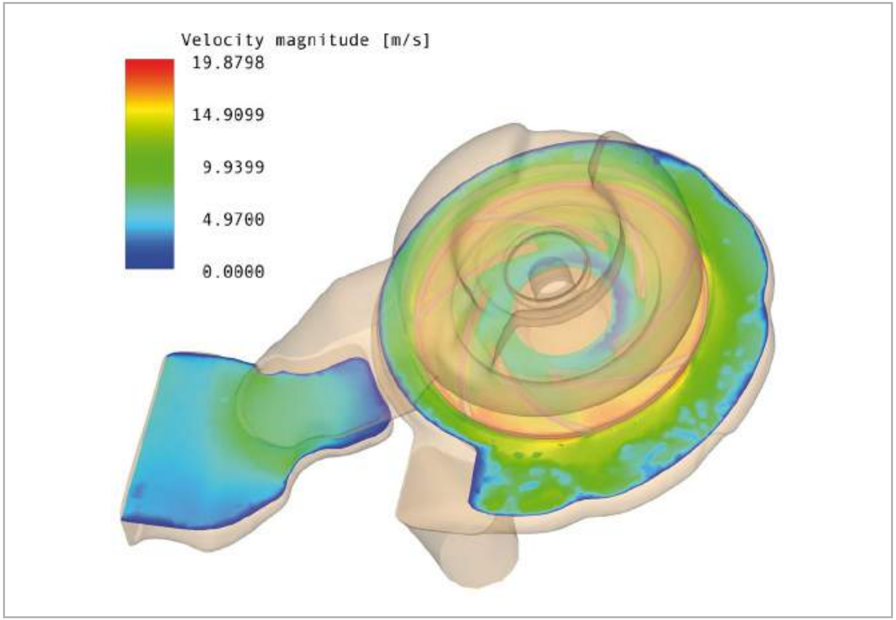


5.2 3D dimensional control water pump housing

Testing to ensure performance of the water pump

The main function of a water pump is to ensure the circulation of the coolant in each part of the circuit; this results in the fact that the pump must be capable of giving sufficient energy to the fluid to circulate inside all the pipes of the circuit. The water pumps have a rotation speed which is closely tied to the number of the engine revolutions, therefore variable, which means that the water pump must provide the adequate coolant pressure and delivery in every operating condition.

To achieve this the component that is primarily responsible is the impeller which, by absorbing mechanical energy from the shaft of the bearing,



6.1 Fluid dynamics analysis of a water pump

transfers it to the coolant in terms of kinetic energy.
The design of the impeller and the volute (when this is part of the water pump) is closely connected to the resulting fluid dynamic performance.
These performances are predetermined by our computational procedures; subsequently a 3D model of the impeller is created, sized accordingly and all the geometry in contact with the fluid (volute, ecc.); the latter is then verified by simulation programs.
Fluid dynamic analyses are carried out in order to validate the calculated geometry of the impeller and to have a performance prediction of the water pump in any condition considered to be significant for the project, including verification of the absence of the cavitation phenomenon in the worst working conditions *(image 6.1)*.
Once the calculations and simulations have given indications on the quality

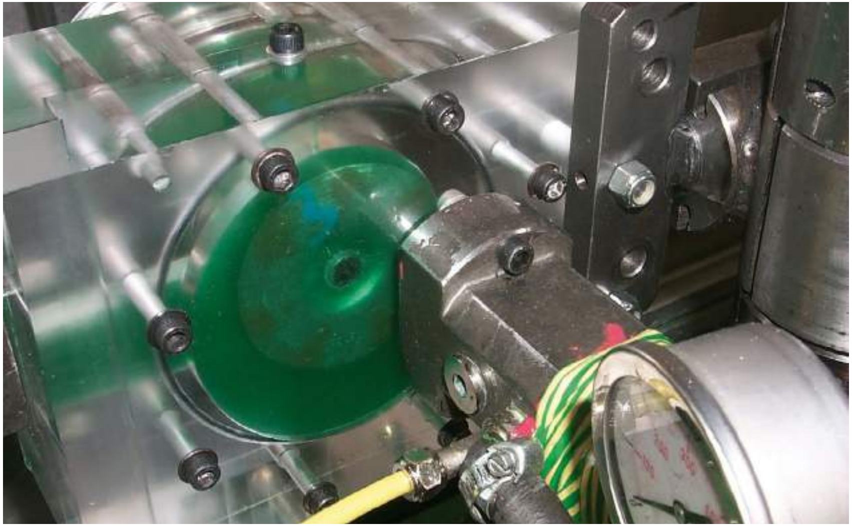
6.2 Water pump prototype with components made of resin of the geometry, the whole is physically realized by means of rapid prototyping techniques, which allow obtaining the physical components in a special resin, starting directly from the 3D CAD model without the need for any of the traditional production tooling *(image 6.2)*.

For each water pump intended for a performance test, special tooling is developed, based upon fluid dynamics calculations, whose purpose is to allow the impeller to operate in the correct conditions, only in this way the tests performed give reliable results *(image 6.3)*.

The ability of being able to verify the occurrence or absence of certain particular phenomena is extremely important, for this reason the test fixtures reproduce, in an extremely accurate way, the working conditions that the pump will meet once assembled in the engine *(image 6.4)*.

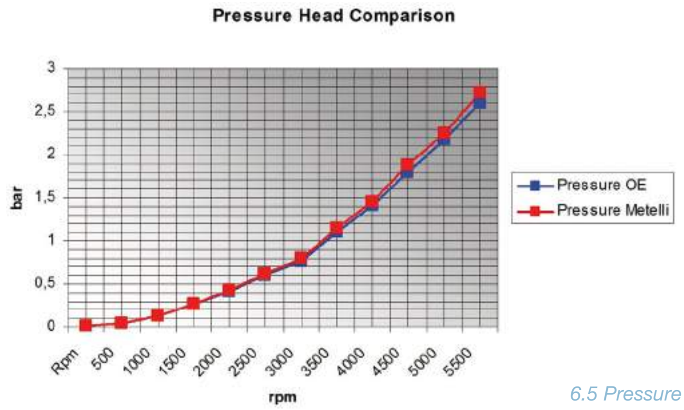
Real tests, carried out under strictly controlled conditions on our test benches, all undertaken directly according to our specifications, provide the evidence of the ultimate

6.3 Flow rate test fixture

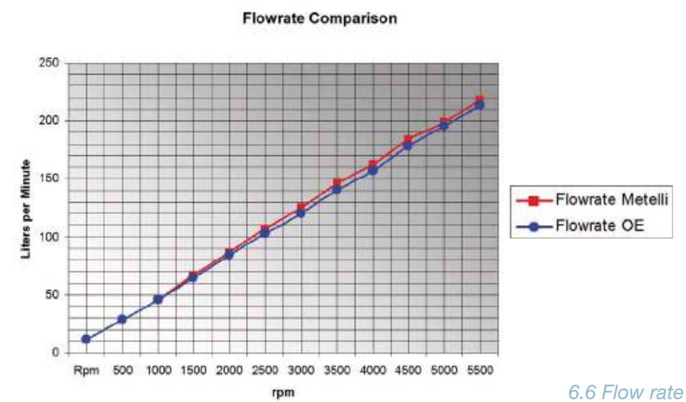


6.4 Transparent test tool

success of the entire design process. This assures us of the actual achievement of the hydraulic performance of our products in every possible condition of use *(image 6.5)*.
The ability to validate and properly test the products is essential.
Thanks to our long corporate history, we have the in-house capability to perform an extensive set of tests at every level in order to fully characterize the hydraulic performance (and not only) of our products *(image 6.6)*.



6.5 Pressure Comparison Chart



6.6 Flow rate comparison chart

The coolants

In the cooling circuit of the engine not only water is circulated! What is commonly called coolant is a mixture, in varying percentages (generally however is 50% -50%), of water and a substance composed mainly, but not only, of ethylene glycol.

The reasons for this particular mixture are multiple:

- Raising the boiling point beyond the normal threshold of 100 ° C at atmospheric pressure (in fact, pure ethylene glycol boils at about 200°C).

- Lowering of the freezing point well below the temperature at which pure water normally freezes

7.1 Impeller completely corroded due to incorrect fluid (modern antifreeze fluids lower the freezing point to temperatures of -30°C and below).

- Increasing the specific heat of the liquid which allows, with the same rise in temperature of the fluid, to remove a greater amount of heat.
- Inhibition of the corrosion processes that can be activated within the engine.

7.2 Two different coolants

While on one side the ethylene glycol can influence a change in the boiling point, freezing and the capacity of the fluid to remove heat, the protection of cooling circuits from corrosion deserves a separate mention.

In the engine, and more generally in the entire cooling circuit, there are a wide variety of metals, each of these has its own chemical characteristics and, brought into contact with each other, can

trigger corrosion phenomena *(image 7.1)*.
The presence in the cooling circuit of a liquid that can contain chemical elements which favor this phenomenon leads to a rapid degradation of some components of the circuit itself (eg, head gasket, radiator) with consequent problems of different nature.
To avoid the onset of galvanic corrosion, modern coolants have special substances which act as oxidation inhibitors.
The presence of these substances gives coolants many properties that are useful to the motor (corrosion inhibitors, inhibitors of the deposit of incrustations, antifoaming properties, etc.) and are also the reason for which all liquids have their own particular color *(image 7.2)*.
A mixture of water and ethylene glycol, would in itself be perfectly transparent, but these are colored by different producers because the presence of several inhibitory agents, makes these fluids not always suitable to be used together.
The reason for this lies in the so-called bases of the inhibitors, which can be of three different types: organic, inorganic and mixed; these bases are chemically incompatible with each other and therefore, although the function of protection of the motor is the same, a liquid refrigerant must be used in the cooling circuit that is produced with the same type of base as the antioxidant agent.
The liquids, from the point of view of inhibitor additives they contain, can be divided into three main groups:

- IAT= Inorganic Additive Technology (with inorganic additives)
- OAT= Organic Acid Technology (with additives in organic acid)
- HOAT= Hybrid Organic Acid Technology (with hybrid additives)

The colour given to the different types of liquids serves precisely to avoid mixing liquids not compatible with each other which would lead to the formation of substances derived from chemical reactions and the effect of antioxidants and corrosion inhibitors would be annulled.
It must be underlined that every coolant manufacturer has adopted his own colour criteria, meaning that fluids of the same color are compatible only when they are from the same manufacturer!

Focus on main components

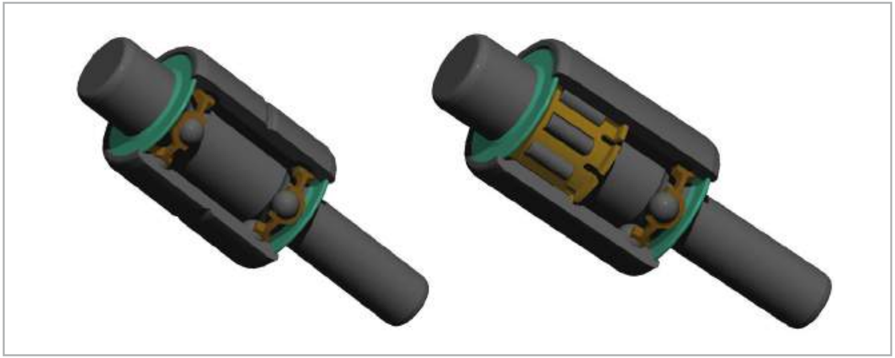
Each component in a water pump must perform a specific task and should therefore have characteristics according to clear requirements. Although the water pump, like any other mechanical member, is subject to normal wear, the use of high quality components, combined with a production process always under strict control, ensures a high degree of reliability and a long life product.

Before introducing a new component, our technicians perform selective homologation tests in order to ensure that the component's performance is in line with expectations, only after a successful result the component becomes part of the details that designers can use in our product.

Bearings

The bearings are directly responsible to withstand the loads coming from the belt tension. Created as a branch of the classical bearings in common use, water pump bearings have been designed on specific dimensions, and are made to last as long as the expected life of the water pump, without being subject to any maintenance.

Manufactured already containing the right amount of long-life grease and the rolling elements protected by sealing rings against both grease losses and the infiltration of water and dirt, modern



8.1 Ball-ball and roller-ball bearing

water pump bearings, once mounted in the water pump, do not require any maintenance.

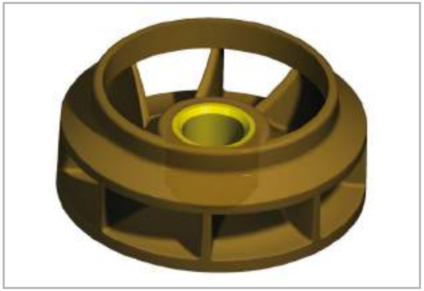
They are assembled by interference in the housing and the accurate control of tolerances of the coupling, together with the real-time monitoring of the assembling forces, ensure an optimal fit with the proper maintenance of the radial clearance of the bearing *(image 8.1)*.

Made according to two main types of construction, they differ in the entity of load they can withstand.

The bearings designed to withstand higher loads, have in fact one of the two crowns of rolling elements consisting of rollers instead of the normal spheres; this allows increasing the contact surface between the rolling elements (the rollers) and the other parts of the bearing and therefore increasing the forces that the bearing is able to withstand.

Impellers

The impellers are the components that actually ensure the hydraulic performance of a water pump; they are specifically designed and manufactured to ensure adequate pressure and delivery to the engine where the pump must go.



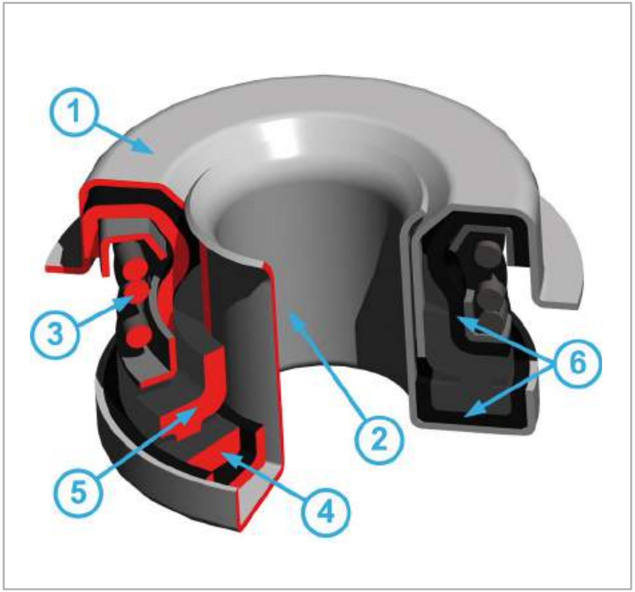
8.2 3D model of a water pump impeller

8.3 Impellers manufactured in different ways

The geometry of each impeller is the result of precise calculations, it is CAD designed in the smallest detail and the performance is verified on our test benches *(image 8.2)*.
Made with technologies ranging from sheet metal (including stainless steel) punched and drawn, to die-cast brass, cast iron and even the most modern engineering plastics, the impellers are produced with technology considered to be the most suitable in order to obtain a component that offers the best performance possible, without ever compromising reliability *(image 8.3)*.
Such technical freedom, derived from an experience achieved in half a century, allows us to have great freedom of choice by identifying the most suitable manufacturing process in order to obtain the project geometry.

Mechanical seals

The modern mechanical seal is a highly industrialized component, compact and built entirely with top quality materials, it is the component that ensures no leakages from the water pump.
Regardless of the technical solutions of details, the components that constitute the mechanical seal are almost always the same *(image 8.4)*.

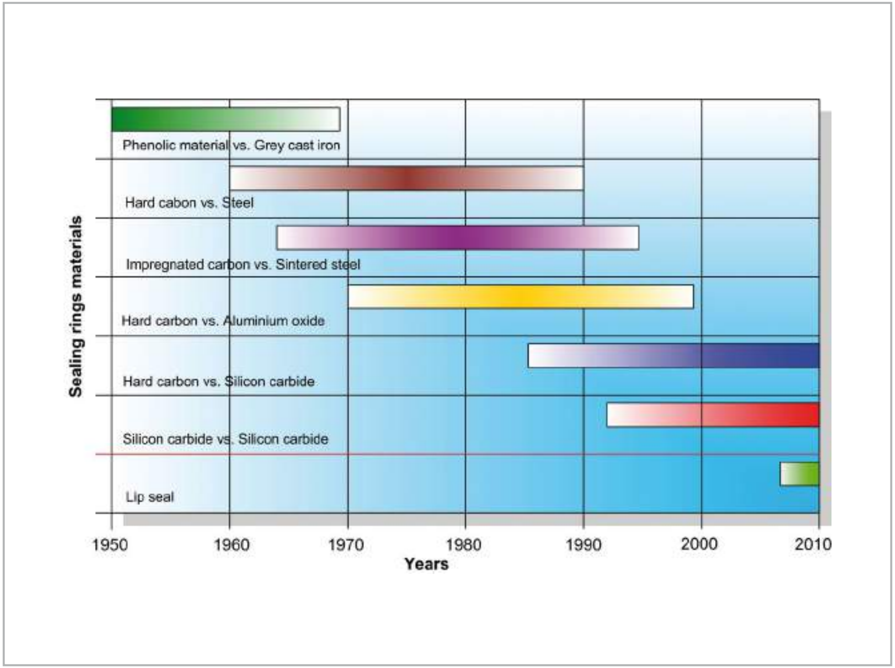


1. Stationary part
2. Rotating part
3. Helical spring
4. Slip ring
5. Counterface
6. Bellows

8.4 Section of a typical mechanical seal

It can have an apparently different shape, but the principle on which it is based is always the same. The development which it has been subjected to over the years, have led this to be more compact and have a greater duration; nowadays the mechanical seal is able to perform continuously even for many thousands of kilometers *(image 8.5)*.
Extremely hard materials such as silicon carbide, which until a few years ago were considered “esoteric”, are nowadays considered as being normal in the manufacture of slip rings for all high quality modern mechanical seals; this thanks to continuous efforts in the development of the materials of these components *(image 8.6)*.

8.5 Some mechanical seals types



8.6 History of the materials of the rings used in mechanical seals

Hubs and pulleys

The pulleys, which receive the mechanical power from the belt or in rare cases from the chain, are the components which actually keep the bearing shaft and consequently the impeller, in rotation.

The hubs perform the same function, they are used when, for design reasons, the overall dimensions of the pulley are greater than the area in which there are fixing holes of the water pump in its seat; from the functional point of view they are considerable on a par.

Mounted by interference on the upper part of the bearing shaft, they must be properly secured to withstand the stresses that come from the engine belt *(image 8.7)*.

The external geometry of the pulleys is according to strict tolerances; only this way is it possible to guarantee the perfect coupling between the pulley and belt; this results in a vibration and noise-free operation and a belt life in line with the highest standards.

8.7 Hubs and pulleys for the water pump

Pump housings

The main housing of the water pump, made in the great majority of cases in aluminum alloy, must simultaneously fulfill several duties.

- It must be able to withstand all the mechanical stresses.
- Casting must be perfectly airtight because the housing is an integral part of the cooling circuit.
- It must be correctly coupled with the interface on the engine base and must ensure a perfect seal of the fluid.
- It must hold the bearing and the mechanical seal properly with the correct tolerances.

It is without doubt the component that requires the greatest amount of skill in its development, because each pump is literally a case on its own *(image 8.8)*.

8.8 3D model of a water pump housing

Precautions and instructions for proper installation

The operations for installing a water pump in replacement to one at the end of its life, must be performed carefully, taking care to execute everything in the best possible way and not forgetting to do all the necessary checks in relation to components also directly related to the water pump.

1. Always work in conditions of safety and respecting the environment.

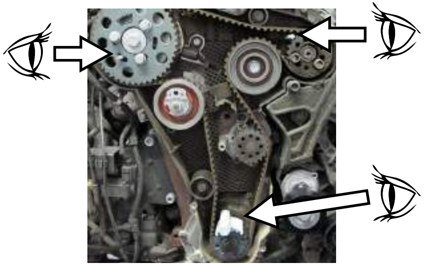
2. **Allow the work area to be accessible,** if necessary remove the pieces in order to allow the correct access to the water pump area.

3. **Keep strictly to any instructions from the manufacturer** for the assembly of the water pump.

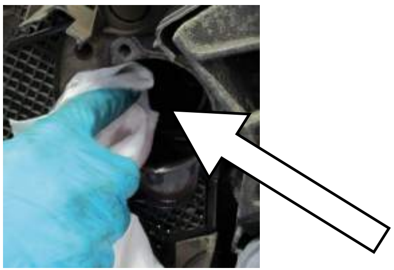
4. The cooling circuit must be drained **completely, carefully cleaned and rinsed**; particles present in the circuit ruin the faces of the sealing rings, jeopardizing the functioning in a short time.

5. The coolant should be entirely replaced with a **new coolant, which will fully meet the characteristics required by the manufacturer.**

6. If the water pump is part of the distribution circuit, the first operation is **blocking the motor phase using any special tools devised by the manufacturer.**

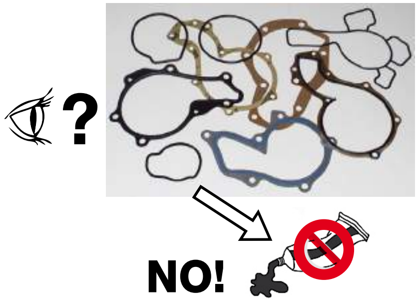


7. Once the pump has been removed, **the surface of the crankcase must be cleaned very well** from any residues of sealant and gasket pieces that have remained glued, so that the metal surface is perfectly clean, degreased and dried.

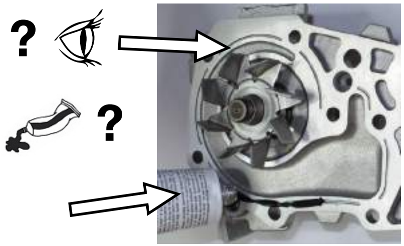


8. Before doing anything else check that the replacement water pump is interchangeable with the new one.

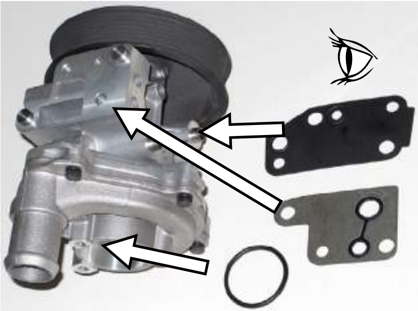
9. If the pump has a gasket, metal or other type, the sealing paste should not be used; the gasket supplied with the pump is adequate to ensure a perfect seal, make sure the mounting surface on the crankcase is perfectly clean.



10. In the case in which the pump is intended for an installation with sealing paste, always take care to use the correct amount only on the water pump surface **without using too much**; excess paste in fact often ends up in the mechanical seal causing leakages.



11. Each seal that has been removed should be replaced with a new one, never reuse gaskets used even if they seem in good condition.

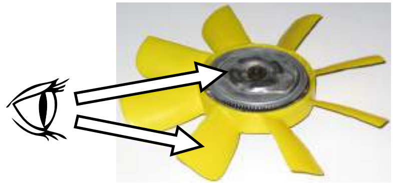


12. The mounting screws should be tightened crosswise and, before tightening them completely, **you must ensure that the pump is centered correctly and can rotate freely in its housing.**

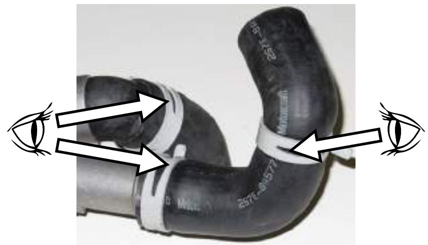
13. Strictly observe the tightening torque of the screws indicated by the manufacturer.

14. Always wait for about 1 hour with the cooling circuit empty to allow the sealant that is inside the volute to polymerize properly.

15. Check the good condition of any joint (viscous and other) **mounted on the water pump and relative fans;** when viscous joints with unusual clearances or bent fans or fans missing even only parts of a blade are found, replace them.

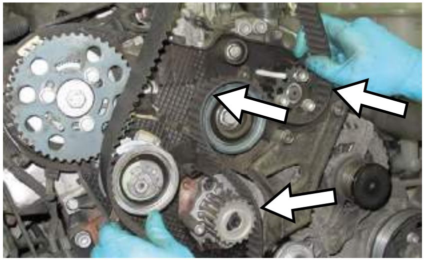


16. The hose clamps that have been removed should be checked and if necessary replaced with new clamps.



17. Concurrently with the water pump replacement, in addition to the belt, all components within the belt system must also be replaced (pulleys, rollers and / or cylinder tensioners and other parts related to the system).

18. Place the belt correctly following the manufacturer's instructions, especially when this concerns the timing belt, if special tools are required, use them.



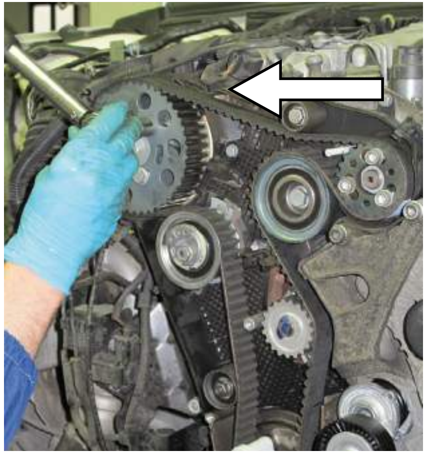
19. Some water pumps have gears and spline shafts as drives; ensure the good condition of the gear teeth and splines and have the foresight to put a small amount of specific grease on the groove before insertion into the housing.

20. Check the condition and the proper operation of the thermostat.

21. Check the operation of temperature probes.

22. Check the good condition of the cap of the expansion tank; it should not be clogged by various incrustations.

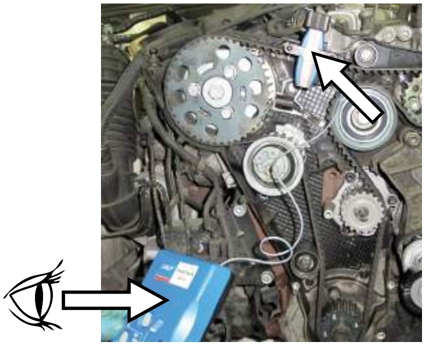
23. Cam Shafts must be locked before disassembling the timing belt otherwise it's needed to **restore the correct engine timing by carefully following the tasks recommended by the manufacturer.**



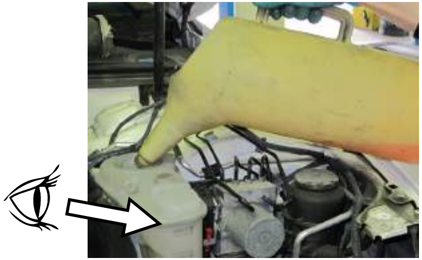
24. **Tighten the belt respecting the value recommended by the manufacturer;** avoid excessive tension, allow the engine to run

manually and check that the position of the belt is stable; restore the correct tension if necessary.

25. To check belt tension **use the appropriate instruments** that are able to provide reliable data on the tension value applied.



26. Once the pump has been installed and the circuit re-sealed, ensure its first filling with a **liquid coolant in compliance with the recommendations from the manufacturer.**



27. Start the engine and leave it to idle, turn on the heating in the compartment and continue to refill the coolant from the highest point of the circuit (generally the expansion tank) until the level does not drop any more, wait for the opening of the thermostat so as to properly fill also the radiator.

28. Be sure to leave as little air as possible in the circuit before starting the engine; dry operation even for a few seconds of the water pump can ruin the mechanical seal, causing a subsequent noisy functioning and/or loss of liquid.

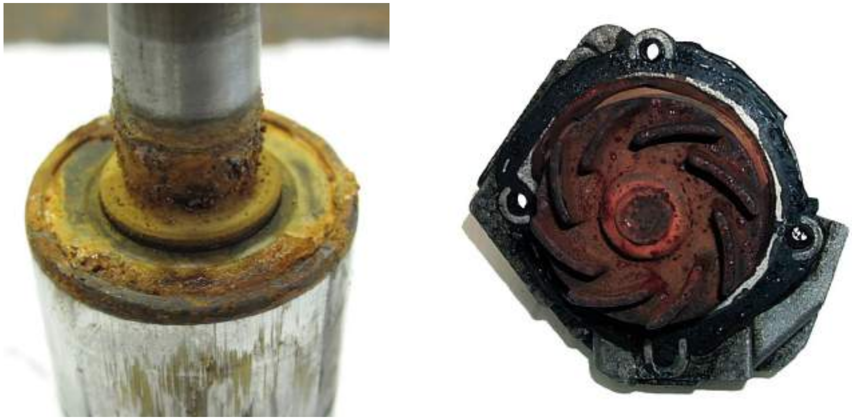
The most common damage to a water pump: causes and analysis

A preparation on the engine in the area that is intended to accommodate the water pump, together with the state-of-the-art execution of assembly operations, are the basic steps so that the pump, once in operation, behaves as expected.

Avoid making a series of common errors related to installation operations undertaken incorrectly, this leads to trivial but annoying drawbacks, such as.

Non suitable coolants

The use of unsuitable cooling liquids can not only create problems to the engine from a thermal point of view, but even worse, does not protect from corrosion that can arise in the entire circuit. This is due to a corrosion of



10.1 Rusted components due to unsuitable coolants

the circuit metals, according to their chemical aptitude; the result is a rapid degradation of all the surfaces of the cooling circuit.
The use of unsuitable coolants, polluted or contaminated by particles, in addition to corrosion, leads to the limited duration of the mechanical seal.

Leaks of liquid accumulate close to the bearing, often causing the leakage of grease and the consequent bearing failure *(images 10.1 and 10.2)*.

10.2 Mechanical seals damaged by unsuitable coolants

Air bubbles remaining in the circuit

It is very important to completely eliminate air bubbles from the cooling circuit. Residual air bubbles that cannot end up in the upper expansion tank make the circuit, at best, work with reduced section; the presence of air bubbles that are not removed can compromise the correct operation of the water pump *(image 10.3)*.

10.3 Sign of operation with air trapped inside

Overheating

When air occurs in substantial amounts in the circuit, the mechanical seal works dry; this has as the initial effect of mirror-polishing the surfaces of the sealing rings causing subsequent leakages, and if the phenomenon lasts in time the heat developed is such as to melt the rubber parts of the mechanical seal and also leave a trace of the heat on the pump housing itself *(image 10.4)*.

Unbalanced viscous coupling unit

It is important to make sure that the viscous coupling unit is in good condition before reassembling it on the water pump. A viscous coupling unit with a damaged bearing rotates unbalanced and therefore represents

10.4 Surfaces with signs of overheating

10.5 Damaged viscous coupling unit

a high stress that is added to the belt tension. This easily leads to water pump bearing failure *(image 10.5)*.
In the cases of more serious imbalance, the stresses reach values so high as to cause even the breakage of the pump housing *(image 10.6)*.

Replacement of other components of the drawing system

The great majority of water pumps are driven by a belt, distribution or service. The first thing to do is a careful inspection of the belt, if it shows signs of wear or aging of the material (cracks in the rubber, shiny surfaces, etc..), must certainly be changed. When replacing the water pump it is always preferable to replace the pulleys and idlers also, as when they malfunction they are often the cause of water pump bearing failure as a result of an overload in the belt tension *(image 10.7)*.

10.6 Complete failure of the pump casing due to unbalanced masses

10.7 Idler and tensioner pulleys

Bearing overload

The belt tension with load values beyond those recommended is due to working conditions of the bearing being particularly severe. The result is a life of the component that is extremely reduced and in some cases it leads to a complete failure thereof *(images 10.8 and 10.9)*.

10.8 Bearing shaft damaged by excessive load

10.9 Bearing components damaged due to overload

Improper use of sealing paste

The use of sealing paste, is expected on some references, and on these should be used in the correct way. Specific products should always be used, never generic or other sealants and it is equally important that they be used in the correct amounts. The use of improper sealants or worse still, used in excessive amount always causes problems, the accumulation of sealant residue that ends up in the mechanical

10.10 Improper use of sealing material seal causes immediate leakages and there may be lumps of hardened sealant that end up in the pipes of the cooling circuit *(image 10.10)*.

If a water pump has been provided with a metal gasket, O-rings, or other, this solution is sufficient to guarantee the seal; sealing paste should not be applied, it would only jeopardize the operation of the gasket supplied with the part *(images 10.11 and 10.12)*.

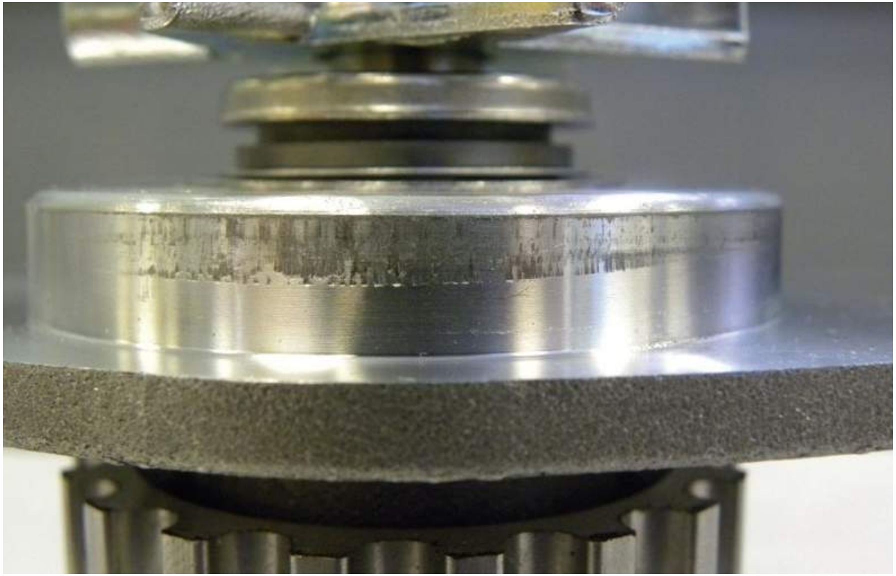
10.11 Sealant paste incorrectly applied on metal gasket

10.12 Sealant paste Sealant paste incorrectly applied on O-rings

Improper installation

It is important that the water pump assembly operations in the housing are done properly, carefully following any special instructions attached.

An installation performed incorrectly can easily bring the water pump to work badly or even worse can damage some sensitive components such as seals, or in some cases even the water pump housing itself *(image 10.13)*.



10.13 Damage caused by incorrect installation

Assembly of components on the water pump

Some water pumps carry other components that must be installed after the water pump has been assembled on the engine. Correctly executing the assembly operations of these components is crucial; in particular it is extremely important to absolutely avoid hitting the bearing spindle, this would damage the sliding grooves of the bearing balls and in some cases could even break the shaft itself *(image 10.14)*.

10.14 bearing shaft broken due to incorrect assembly operations

Foreign objects in the circuit

Perform an accurate cleaning of the entire circuit when replacing the water pump. It is possible that there are foreign objects inside the housing space which, when they are moved by the coolant flow, can cause considerable problems.
When the impeller encounters a foreign object it is irreparably damaged, creating potential problems not only to all the cooling circuit, but it is possible that damage will occur even to the timing system *(image 10.15)*.

10.15 Impeller damaged by foreign object in the circuit

Trends

Never before in recent years there has been a process of innovation related to this component, whose design criteria have remained unchanged for decades.
The need to reduce fuel consumption and emissions, the need to reduce the weight of components, the longer life required from products, have led to changes in water pumps in many of its aspects and have spawned a whole new generation of water pumps, born with entirely new design concepts.

Materials

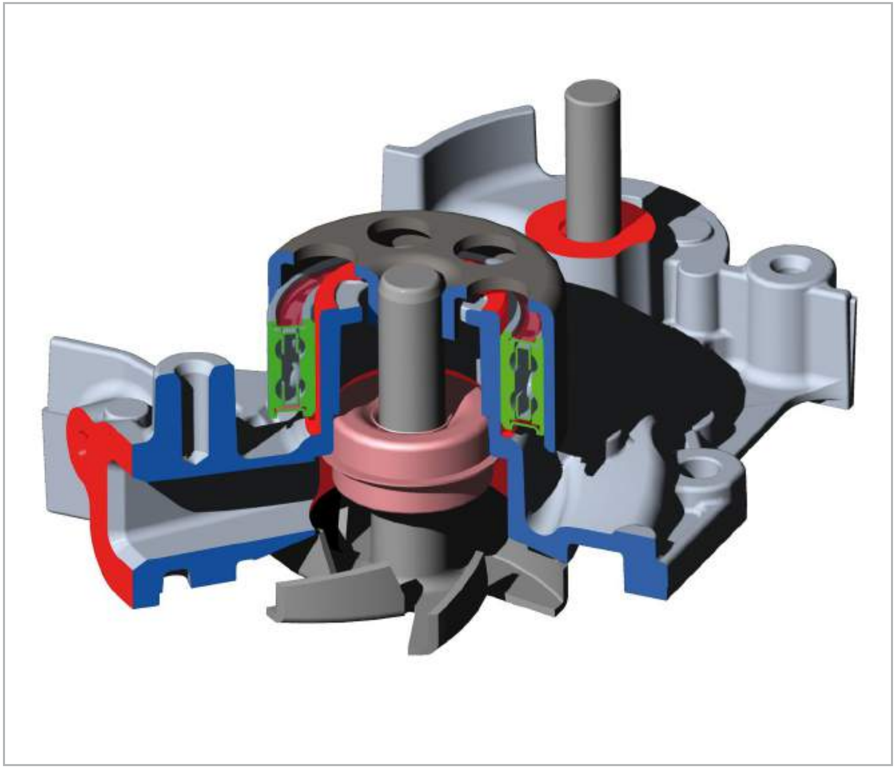
Besides the materials considered more "traditional" such as die-cast aluminum for pump housings, we are witnessing an increasing introduction of polymers. Materials similar to those now used in impellers have, in recent years have been increasingly used in the construction of the water pump housing *(image 11.1)*.

Characterized by a light weight, good dimensional stability and good chemical compatibility, the introduction of these materials in the water pump housing is still limited to a small number of references.

11.1 Pump housing made of thermosetting material

Bearings

Along with specific water pump bearings that the market has been used to seeing for many years, due to continued increases in power that the engines undergo during their life on the market, belts are more and more stressed and have led to the introduction of a new generation of bearings, more similar to the bearings we find in the air conditioner compressor pulleys *(image 11.2)*.
Unlike bearings assembled inside the pump housing, these bearings are to be mounted externally to the housing; this allows having a larger bearing which is able to withstand higher stresses and thus to guarantee a trouble-free operation also with those motors which during their development have seen considerable increases in the values of the belt tension.



11.2 3D Model of Water pump with bearing (green section) outside the housing

Mechanical seals

The monobloc mechanical seals have evolved steadily over the years in the geometry and materials employed especially in sealing rings; this progress has made them more compact and more durable at the same time.

Recently an entire generation of newly developed mechanical seals has made its appearance on the market *(image 11.3)*. More similar to oil sealing rings than to the classic mechanical seals, this new generation of components has the seal along the bearing shaft surface.

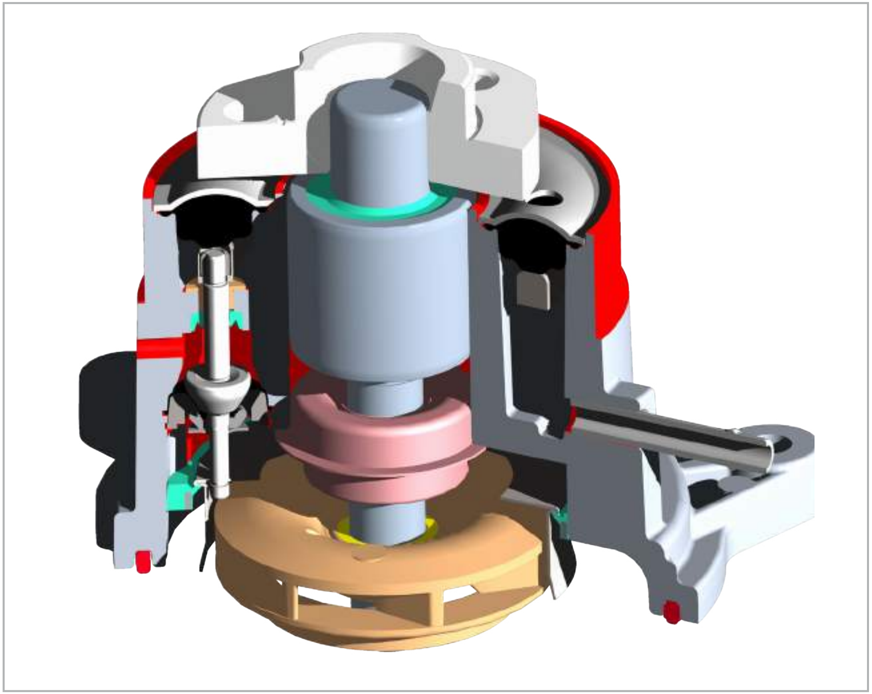
Provided with an higher resistance to dry operation, and a lower resisting torque, these are seals that use innovative solutions and materials and due to their geometry their dimensions have been really reduced to the minimum.

11.3 Lip seal for water pump

Solutions

The development trends of today are bringing onto the market a wide range of newly designed water pumps, whose purpose is to meet the new needs of pumping efficiency and reduce engine emissions. Due to its natural characteristics, a traditional water pump is designed to dissipate heat from the engine when it is operating at maximum performance. This type of operation is, in the real condition of engine usage, not very common; for an automotive engine top performance is requested from the engine less than 10% of his entire life.

The solutions that the designers have developed to meet the need of having a water pump that is adequate for proper engine cooling, but more optimized to meet the multiple needs of a modern



12.1 *Section of the switchable water pump patented by Metelli* engine, are very different.

These solutions have led to a new generation of water pumps that are 'switchable'. This innovative model, even though it is still driven by the belt, allows the flow of water in the cooling circuit to be interrupted in different ways: by closing the pump lines, or by disconnecting the pulley and blocking the rotation of the impeller.

Metelli has optimized its product line, introducing an innovative, EU-patented solution – the most reliable on the market today.

This solution makes it possible to interrupt the flow of liquid in the cooling circuit thanks to a pneumatically activated gate valve.

The gate valve is actuated when a depression is created in the 'vacuum chamber' of the pump. The name of this chamber reflects the fact that the depression produced by the vacuum pump of the brake servo is used.

From the outside, the switchable water pump resembles an ordinary water pump with a slight enlargement in the area where the bearing is located. Here, in this enlarged area, is the entire mechanism responsible for actuating the gate valve around the impeller.

This mechanism is potentially harmful for the motor because it can interrupt the water flow in the cooling circuit. For this reason it was designed to be 'fail safe', that is to ensure the passage of fluid even if it malfunctions. One more way to guarantee the reliability of this innovative solution.

We are witnessing a true revolution in the way of designing a product that has remained fundamentally unchanged in 40 years.

These new approaches to the design of the water pump started to bring to the market a whole new generation of more sophisticated products, more efficient and with performances more in line with the requirements of modern engines.