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The hidden large-scale power consumers

Pumps are the heart of the engineering world

They live in the shadows. For most people it is enough for pumps to operate reliably and that on drive energy as low as possible.

By Georg Küffner

Rarely they are larger than a shoe box and are usually painted in green, magenta or grey. With little attention, circulation pumps operate in seventeen million boiler rooms in Germany. And yet, their life in the shadows stands in sharp contrast to their task. The role of these small machines, also referred to as heating pumps, is exceedingly important. After all they make sure that (heating) water heated to the required temperature in oil, gas or pellet fuelled boilers can flow through radiators fitted right up to the roof.

Small heating systems only are satisfied with one circulation pump, so that in total there are about forty million units, which consume about 3.5 per cent of the power produced in Germany. That does not sound a lot, but it is a lot as will be demonstrated by the following comparison: They consume about as much as all rail vehicles of the German Railway Service plus all regionally operated trams, suburban and underground railways.

Circulation pumps were and frequently are the largest power eaters in the household – ahead of the instant water heaters and refrigerators. Up to the 1980s, single-stage pumps with an output of 140 Watt were a standard, which (without night economy mode) caused energy consumption costs of up Euro 180 per year. Costs were reduced a bit with the follow-up models, i.e. the three-stage pumps. But, as heating engineers do not want to be called by their customers in winter due to freezing room temperatures, the savings potentials of the switching pumps were not used extensively. The engineers rather played it safe and set the units to maximum power. House owners were to save elsewhere.

It is only when infinitely variable pumps – using the pressure difference between suction and pressure side or the volume supplied - reached the market that conveying progress hit the boiler room. The fact that contributed to their success was that fitters in the gas and water trade could not fiddle around on the units. The results were even better with electronically controlled permanent magnet synchronisation pumps, which for some time now are offered by almost all manufacturers, termed "high-efficiency pumps" in a sales promoting fashion. As the magnetic field needed by the rotor does not have to be generated involving heavy losses, but is available "permanently" right from the beginning, power consumption of five Watt only is sufficient. Today, the use of these power saving pumps are recommended by the German set of regulations, and their installation is subsidised. In 2015, they shall become obligatory in Europe.

Geniax System presented by the pump manufacturer Wilo a few weeks ago plays in a totally different ligue. Geniax System puts an end to the central pump in the cellar, but relies on several mini pumps in the radiators, located where most thermostat valves have been installed usually. Putting into the words of Wilo engineers, the previous “heating on offer” is replaced by the “heating at request”, operating at the hydraulic optimum at all times in addition. This fact means that all radiators are supplied with the water amount which is required for the requested temperature in the respective rooms. And what is especially important: The mini pumps (maximum output 3.8 Watt) operate only when heat is required, which does not permit a direct comparison with previous solutions. Wilo is enthusiastic about this new system, and indicates that "another” twenty per cent in heating energy can be saved by fitting Geniax. As each mini pump requires a control and power cables, the system is of interest primarily for new buildings and total refurbishments. Otherwise it is complicated and causes costs of several hundred Euro.

However, pumps do not only supply heating water by any means. Almost everything can be pumped anywhere - highly viscous and highly fluid liquids, honey and oil, concrete, milk, petrol, ground coal, sewage sludge, gas and blood. The basic design for this fluid is the human heart, the most important pump of all, without the wide range of technical assortments made of plastic, stainless steel and grey cast iron would not exist.

Pumps, small and big ones, are important component parts for different production processes. Motor vehicles, for example, cannot do without fuel pumps. As to how important pumps are is revealed by their appetite for energy, which adds up to 300 tera Watt hours (TWh) per year in Europe - which corresponds to a share of more than ten per cent in European power generation, after all. But, as different as their way of functioning, as different they are in output capacity.

The supposedly smallest unit has been developed by scientists of Fraunhofer Institute for Solid-State Technology located in Munich. It is a piezo-electrical micro-membrane pump, which is 7 x 7 x 1.1 millimetres in size and can supply a maximum of two millilitres per minute. All its components are made of silicon which on account of the excellent elasto-mechanical properties promises a long life time. They are used where small amounts of fluid or gas are transported and have to be dosed precisely, such as in micro fuel cells. The fuel required for energy conversion – such as methanol – can be supplied to oxidation continuously in very small doses. This does not only increases the safety of the entire system, but also ensures energy-saving optimisation of the fuel cell operation. Other applications are conceivable, such as the dosage of odorous substances blown into the environment in case of interactive computer games where they complement the virtual reality as imitations of brake rubber or billows of smoke.

Completely other dimensions were involved – if the figure is correct – when King Louis XIV had 221 pumps operated by fourteen gigantic bucket wheels mounted on the river Seine to supply the waterworks of Versailles, Trianon and Marly. The displacement pumps at the time were able to pump 3,000 cubic metres of water per day. Their operating principle had been thought out by the Greeks already 600 years before Christ: The centre of their consideration was “horror vacui”, i.e. the abhorrence of vacuum as nature did not tolerate any voids.

Years later, Galilei still used this explanation to substantiate that even the most perfect pump could not pump a water column over a height of ten metres. Decades later, the interrelationship was recognised: In a suction pump, the ambient pressure is responsible for thrusting and thus rising of the water. The pump “only” vacates the space into which water can flow, which means that given an ambient pressure of one atmosphere the water only flows to the height said.

At the beginning, primarily water was pumped, usually using a piston pump which had been developed to perfection by the Romans. Due to the irregular to and fro of the working sequence and the resulting changeable delivery current, engineers sought different solutions. They developed the circumferential piston pump, in which two counteracting displacers draw the medium into the pump in order to thrust it out on the other side. Felix Wankel, the inventor of the circumferential piston pump, mentioned in his publication titled "Classification of Rotational Piston Pumps" no less than 332 different types of construction. Only a few of those could gain acceptance. And those are not trivial in their structure because after all they operate only on account of a more or less complicated mechanical system, which also requires a lot of material on top.

Centrifugal pumps attributed to Denis Papin permit much slender constructions. In his considerations, he was assisted in the right way by a drawing produced by no less than Leonardo da Vinci: As Leonardo's drawing can be interpreted, the delivery height required can be produced by stirring in a pot. The more you stir, the further the liquid rises along the edge.

Centrifugal pumps – and thus heating pumps – use this principle: Water, which flows into the pump on the suction side, is dragged along by the pump impeller which is rotated by several thousand revolutions per minute and is forced to the outside in a circular path. In the process, the water picks up kinetic energy which in the end is converted into pressure energy in the outlet area of the pump, and thus the water is pressed into the riser of the heating system. Even the smallest pumps can produce high delivery outputs.

Pumps are not really a centre of technical interest with Mr and Mrs Average. Like ball bearings or seals they have to operate reliably and if possible for a much longer time than required by the warranty. It is only in this way that manufacturers can acquire a reputation of producing something liable and thus have a change of winning follow-up orders. It is not easy to achieve this, in particular if no clean water has to be delivered, but a mixture of oil, gas and salt-water including any fine solids drawn along, nothing unusual in off-shore bores, for example. Given this rough application, reliability is required as changing a pump installed deep below the sea level is distinctly more complicated than changing a circulation pump. And they are operational for years on end as a rule.

Caption: The example: The human heart is the most important pump on this world by far. It produces extra heavy work permanently and beats most units in the pump assortment which can be used today for many different purposes.

Photo: medicalpicture GmbH.