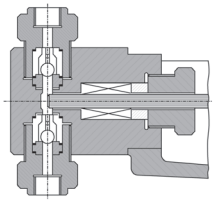

New innovative pump system monitoring for high-pressure reciprocating pumps with non-invasive sensor technology

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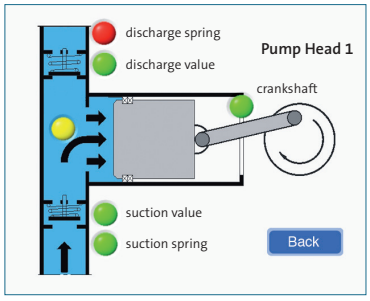
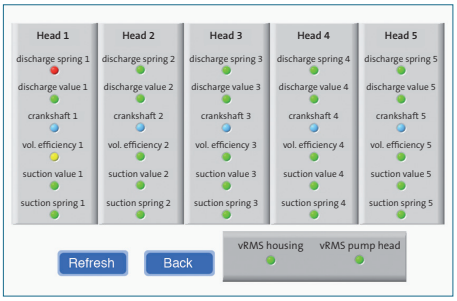
In modern pump engineering, early fault detection systems are well established, however, due to the costs they entail, they are hardly ever used or only in case of high probability of damage. And the desire for such a system often arises only after the occurrence of an incidence. Therefore, simple retrofittability and, at the same time, reliable functionality are indispensible for detection systems.

Meaningful with regard to the early fault detection system are mainly pressure measurements with high sampling frequency. Unfortunately, pressure sensors, particularly at high pressure, are often not fatigue endurable, but nevertheless relatively cost-intensive. Moreover, this invasive technology produces notches in components with inner wall stress, which significantly increases the component's risk of fatigue failure. The invasive sensor technology of most of the early fault detection systems and the effort required for individually guiding the sensors to the control room, often renders the required retrofitting too difficult and too expensive. Furthermore, an early fault detection system must not only be able to detect a fault, but also to identify damaged components exactly and at an early stage, without triggering exaggerated alarm reactions. Moreover, an unnecessary standstill of a pump or deviant, non-repetitive operating behavior is not acceptable. Thus, the early fault detection system must differentiate between harmless and serious pump faults and display the current state clearly and unambiguously. Low costs for retrofitting, high sensitiveness not only for the pump, but also for the pump system and the non-evasive technology were the reasons for the development of the system described below.

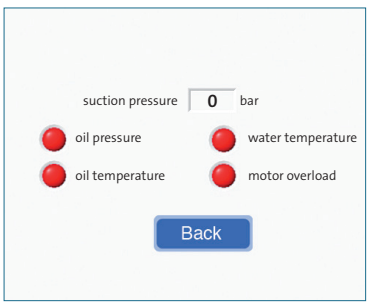
The question about the best sensor technology was based on the idea of measuring such values that enable a direct statement without requiring conversion. Of course, pressure sensors fulfill this requirement, since all effects in pumps have a direct effect on the pressure course in the working rooms or on the pulsation dynamics and characteristics. For reasons of fatigue strength, strain gauges were chosen instead of pressure sensors. They can be easily retrofitted and are simply screwed to a support component with small screws. This technique proved to be highly sensitive and is able to detect modifications in the suction phase even at pump heads for high pressure of up to 2000 bar. Since, moreover, the pressure courses in the pump heads also depict the situation in pressure or suction line, depending on the work phase, the functional monitoring of the whole pump system



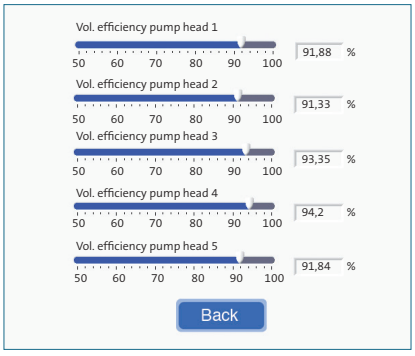
Control view 1



Control view 2



Control view 3



Control view 4

is possible. This has now been realized for the first time, because it seems almost certain that a pump is mostly damaged by system-dynamic effects. Unfortunately, there are also defects the system cannot detect. They result from component-mechanical interactions and require a global signal, which shows the overall state of the machine. Since such faults are mostly expressed by increasing noise or sounds – a machine which works silently is not damaged – structure-borne noise measurement is the suitable method. An easily mountable structure-borne sound sensor is installed in the pump head area, a second one at the drive mechanism. The first one provides all data from the fluid-contacting area, the other one for all drive mechanism effects. Due to the correlation with pressure signals, they represent a perfect complement, yes even a certain redundancy.

Thus, two structure-borne sound sensors, one clock generator as well as one strain gauge per piston are installed at the pump to be monitored. In a control box connected to a computer via network cable, which is equipped with the respective software, the lines of the sensors are joined with measurement amplifier and A/D-converter.

This early fault detection system is able to monitor pump systems completely online, to constantly analyze the current state, and to display it graphically on a panel computer, which is directly installed in the control box. For the convenient monitoring of the normal operation of the pump, the respective rotational speeds and operating pressures as well as the aRMS and vRMS at pump head and pump housing can be read on the user interface of the panel-PC. Moreover, it is possible to record the state of the pump over a certain period of time in order to analyze it later on, offline, using the software of the early fault detection system (trend analysis).

Thanks to the high-resolution combination of structure-borne noise and pressure measurement, the early fault detection system is able to detect a large number of interfering situations in each pump head of a multiple piston unit. The early fault detection system can even distinguish between the signals of the pistons in the structure-borne noise curve, despite superposition. The following damages can be detected extremely early:

– Damages at the valve body and valve spring of suction and pressure valve
– Damages at a piston rod
– Changes of the volumetric efficiency, for example due to gas portions or leakage currents through the piston packing
– Pressure surges and pressure pulsations in the system as well as problems with the pulsation dampener
– Pump system monitoring by monitoring of dynamics in the pipelines in order to sustainably prevent possible damages.

If the early fault detection system detects a possible damage at one of these places, an incrementing system ensures that misinterpretation is prevented and warnings are only sent in case of repeatedly occurring faults. The state of the different pump parts is clearly shown on the viewing surface of the early fault detection system.

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