

Gas handling

Using hybrids for flow maintenance

Frank Hassert discusses why many applications benefit from using multifunction hybrid pumps, which combine side-channel technology with standard centrifugal pumps. The side-channel pump hydraulics enable the pump to achieve pump heads many times higher than those generated by a centrifugal pump.

The majority of processes in the chemical and petrochemical industry are 100% stable all of the time. With unstable conditions most pumping units find it difficult to maintain an upright flow. In particular, when liquids need to be pumped near their boiling point, there are problems with entrained vapour and gas bubbles. Common centrifugal pumps have a low level capability to handle entrained gas. Five to eight percent is the maximum for these machines. Higher proportions mean, in most cases, a total cessation of flow, due to the build-up and clogging of one big gas bubble in the suction mouth of the impeller. With SERO's S-series (SRZS, SEMA-S and SEMIS), a permanent fifty-fifty fraction of gas and liquid is possible. With a modicum of liquid in the pump, they can prime their suction piping leading to a temporary 100% gas.

The S-series are multifunction hybrid pumps which combine side-channel technology with standard centrifugal pumps, which are designed for extreme situations. With the side-channel pump hydraulics it is possible to achieve pump heads many times higher than those generated by a centrifugal pump (e.g. 30 m per stage with a 4 in impeller), and to transport gas-liquid mixtures in any proportion. In symbiosis with the radial flow centrifugal pump hydraulics of the inlet stage, the required NPSH is extremely low and gently inclining to maximum flow rate.

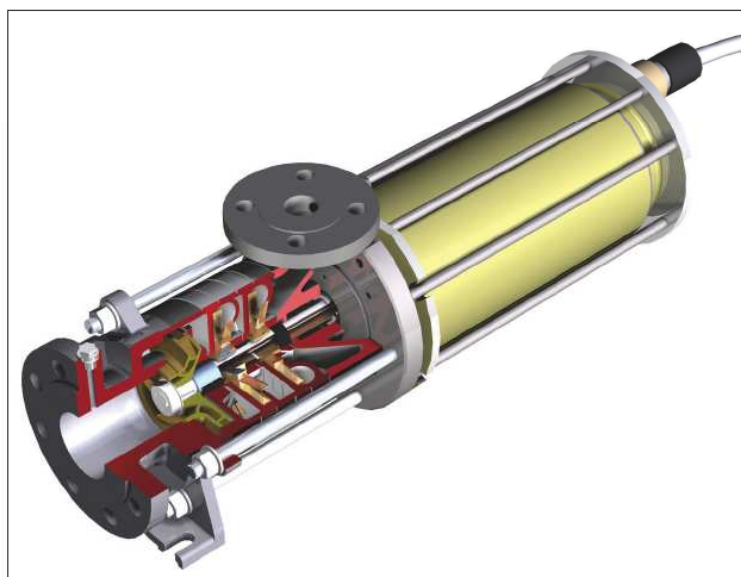


Figure 1. Cutaway of SERO's SEMIS canned motor side-channel pump.

During the self-priming process, operation of the side-channel pump is similar to that of a gas handling liquid ring vacuum pump. It works temporarily with the same principle of a circulating liquid ring. It generates from the pre-filling, with the centrifugal effect collecting the heavier liquid on the outer region of the stage. The lighter fraction (gas/air) separates in the inner region. Due to a specially formed geometry – the casing stop or breaker – the liquid ring has an eccentric 'position' in the stage. In addition, the separated gas and liquid is completely

enclosed within the vanes of the impeller in the breaker area. The liquid ring has a piston-like displacement effect on the gas, which compresses. On reaching the gas exit opening, the sudden expanding gas generates a small under-pressure in the cell, which is transmitted to the suction side and provides uninterrupted evacuates of the suction piping. The non-supply of any further auxiliary liquid leads to a gradual heating of the pre-filled liquid and its vaporisation, so the priming process should be completed in approximately one minute. In this small timeframe the

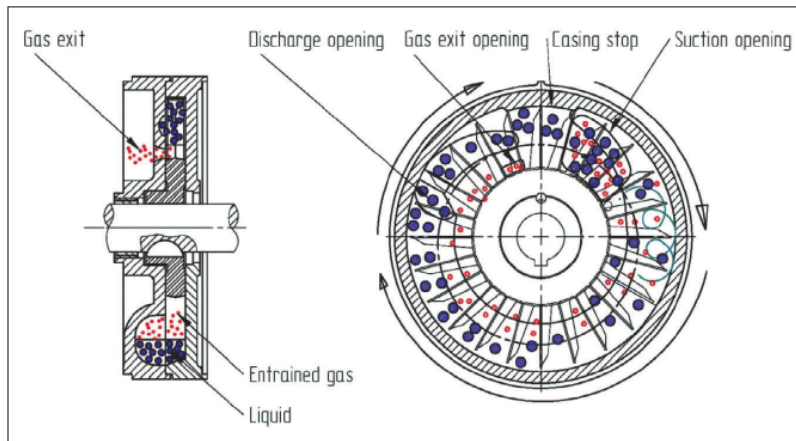


Figure 2. Principles of operation (priming/gas separation).

pump is able to generate an absolute pressure of 0.3 bar (7 m suction lift), and in the majority of cases this is more than enough to vent an adequate suction piping.

Coming to the end of the priming action means mixed mode operation. Process liquid enters the suction casing and the pumping action starts, with a strong but declining percentage of entrained gas. The media pumped at this time is foam-like – millions of micro-bubbles in the fluid, each 30-50 microns. For some applications such as floatation, customers appreciate these characteristics. Once blown in at the bottom of a wastewater tank, floating particles stick to the bubbles and rise to a floating layer on the surface, which can be easily deposited of. Of course, this is more like a by-application – side-channel pumps are designed for pumping pure liquids.

When completely filled with liquid, the side-channel pump can be considered as a normal centrifugal pump; at least, it is following the same laws of affinity. When the speed is doubled, the flow doubles, the head quadruples and the power consumption increases eight times. In contrast a side-channel pump has the highest energy consumption at the lowest flow; Low flow – high head is a good description of the dedication for side-channel pumps. One frequently asked question is why it is possible to generate such high heads with such small centrifugal pumps, even if it is a one-stage version. The answer is called the inner multistage effect.

On its way through the side-channel stage the fluid is propelled by an open star impeller (see Figure 3. (1)) with typically 20 to 24 vanes. The fluid enters at the stage casing (Figure 3. (3)), and takes a spiral wound vortex path to the exit at the end of the side-channel casing (Figure 3. (2)). There is a repeated interaction of the fluid

with the impeller in this stage, and the pressure is created as a sum of individual impulses during one revolution in a multi-time conversion of energy. Depending on the flow rate (the lower the flow, the more interaction), up to nine of these interactions take place before the fluid leaves the stage. Nine interactions are equivalent to nine flow exchanges between impeller and stage, therefore there are eight more compared with a radial flow centrifugal pump. With higher flows, the number of exchanges decline to two or three at maximum flow. The influx of energy to the fluid with a side-channel pump is higher compared to a radial flow centrifugal pump at the same diameter and speed. It should be noted that, due to the differing numbers of interaction the paths for the fluid through the stages are widespread in effective length which

means an equally widespread percentage in losses due to wall friction. Depending on the duty point, process or plant planners may experience reduced efficiencies in the mid twenties, which isn't a good value, but is even higher than a normal centrifugal pump in partial load at low flow – high head. Advantage: side-channel pump! As a rule, a side-channel pump is the best choice – only considering efficiency – if the specific speed n_q is approximately 8 - 15 min^{-1} .

Typically, side-channel pumps are radially-split multistage pumps with up to eight or nine stages, and are able to generate 300 to 350 m of head. With their steep and linear performance curve, they are suited for a pressure-controlled flow in the process, the next big advantage of a side-channel pump.

The biggest benefit you can get with a SERO S-series pump is due to its extremely low NPSH values. It is an affordable luxury to combine best-working side-channel hydraulics with a specially designed radial flow centrifugal impeller, which has only one function: minimize the NPSH over the whole flow range. In a flow-friendly suction casing with an oversized axial inlet, the flow speeds are lowered against the suction impeller, whose engineering effort is to generate no more head as needed to avoid cavitation in the first of the side-channel stages.

With NPSHr (=NPSH required) values far below 1 m (e.g. NPSH=35 cm at duty point $Q=16 \text{ m}^3/\text{h}$ and $H=350 \text{ m}$) are required, there is a smooth incline from one end of the flow range to the other. NPSH values of

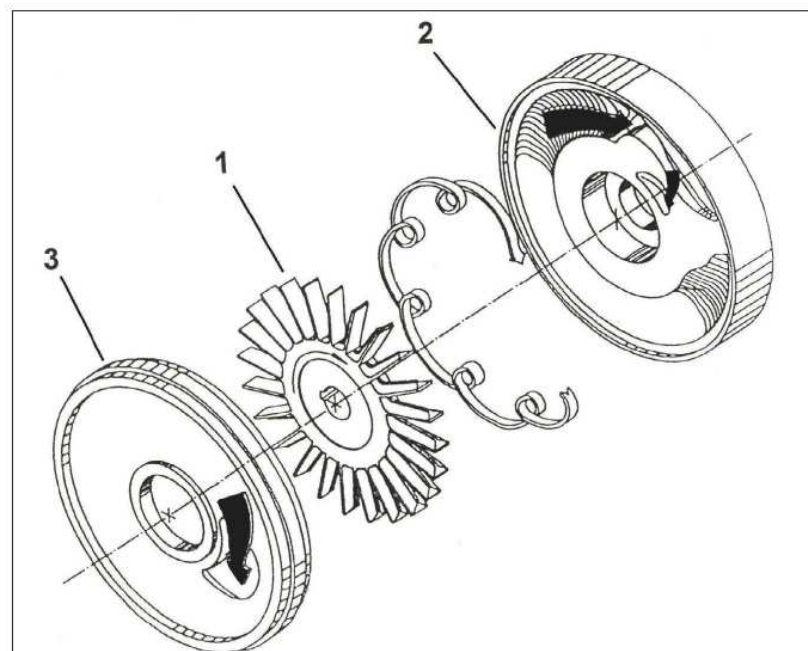


Figure 3. Side-channel stage (exploded view).

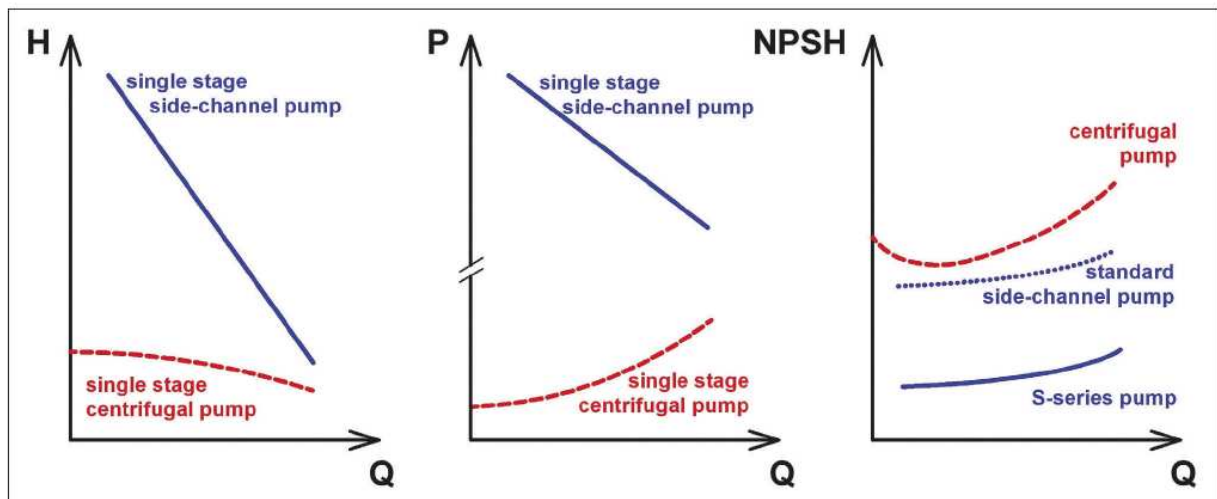


Figure 4. Comparison of performance curves (equal impeller diameter at the same speed).

three or four metres for centrifugal pumps are common, which means an accordant tank has to be positioned at least one floor above. With an S-series side-channel pump it is possible to have the same tank on an equal level to empty it to the same liquid level. For any installation this distinguishing feature over centrifugal pumps can be used for substantial savings. The S-series pumps are gas handling by design, so there is no clear-cut operation limit due to cavitation, in comparison to a centrifugal pump, which has a much higher susceptibility to that phenomenon in fluid dynamics. This means increased operational safety and a trouble-free production process.

With S-series pumps, transport and filling processes with liquefied petroleum gases (LPG) such as propane or butane are easy to control at slightly higher liquid temperatures, and at reasonable costs. Partial out-gassing has no

influence on the stability of the process. This is important for handling all kinds of refrigerants like hydrocarbons or liquid carbon dioxide (CO₂) in a cooling circuit, where the generation of a high differential pressure is needed. The same occurs at higher temperatures up to 220°C in boiler feed or condensate pumps, distillate columns and condensate recovery systems, or for hot water circulation which has to handle gas-liquid mixtures in varying portions. Closed loop steam turbine systems operate at better efficiencies, omitting the condenser, keeping the temperature of the condensate (with entrained vapour) high, and feeding the boiler pressure vessel with a side-channel pump. The low NPSH values provide insusceptibility to cavitation, which make them a profitable choice for these applications.

In the SERO product line-up, side-channel pumps are available in six different series, varied materials, vertical or horizontal

configuration and differing numbers of stages, coupled with or without a standard motor on a common baseplate, or as compact close-coupled version with extra small footprint. Also available are common sealing systems, with stuffing box, single and double acting mechanical seals, as well as seal-less versions such as magnetically driven and canned motor side-channel pumps.

Not knowing about the immense advantages of the side-channel pump technology, many plant planners apply auxiliary systems to their process pumps. For example, the planners install an additional compressor when the chosen centrifugal pump is not self-priming and the suction tank is on a lower level, or apply additional partly loaded inefficient booster-pumps to get high coefficients of pressure. Often, complete plants are planned as multi-floor, just having sufficient geodetic pressure from the liquid level to the process pump – higher than the required NPSH value to prevent cavitation.

SERO believes that for many applications side-channel pumps are the better choice – technically and economically. Process or plant planners should know about the advantages – the self-priming and gas handling capability, low NPSH values and the steep performance curve of side-channel pumps and consider them for the low flow – high head applications. ■

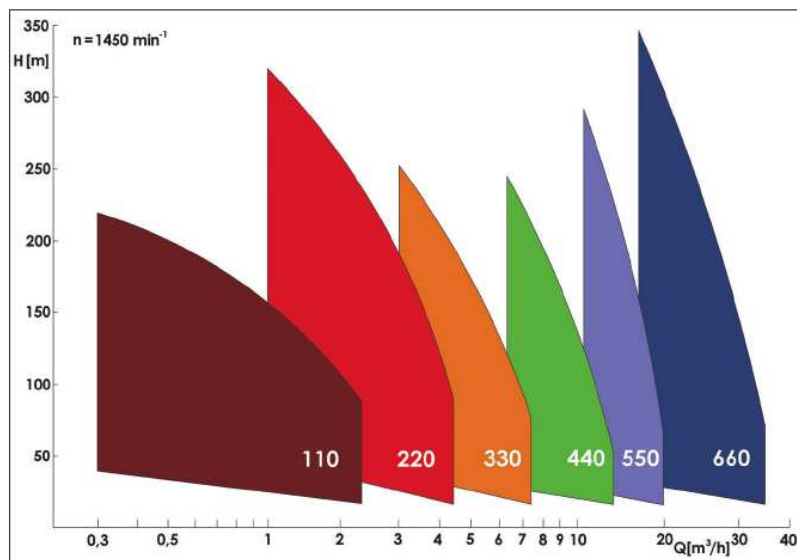


Figure 5. SERO's Performance range in six different series.

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