

Each stage plays an important role – The use of multistage canned motor pumps

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INTRODUCTION

Single-stage centrifugal pumps are mainly being used in the chemical industry and in the carbon-working industry (refinery, petrochemical industry, etc.).

HERMETIC pumps without shaft seal are increasingly being used thanks to the implementation of environmental laws such as TA-Luft. Since pumps without shaft seal have already been installed with great success in the chemical industry during the last decades, the share in the HPI market (hydrocarbon processing industry) is continuously rising that originates from the implementation of the API 685 standard (1/1, 1/2). When selecting a hermetically canned motor pump, various application cases provide the possibility to use single-stage or multistage canned motor pumps. This article informs about the use of multistage pumps by taking into the account the life-cycle costs and the potential savings of energy. Actually, this has become of even more importance when looking at the dramatic price increase for primary energy (crude oil, natural gas, etc.) during the last months. This article also includes details about the conveying of liquid gas by using this pump series.

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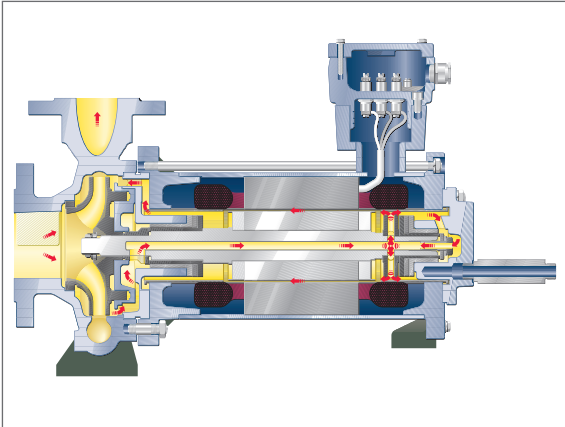


Figure 1: Single-stage HERMETIC pump type CNF

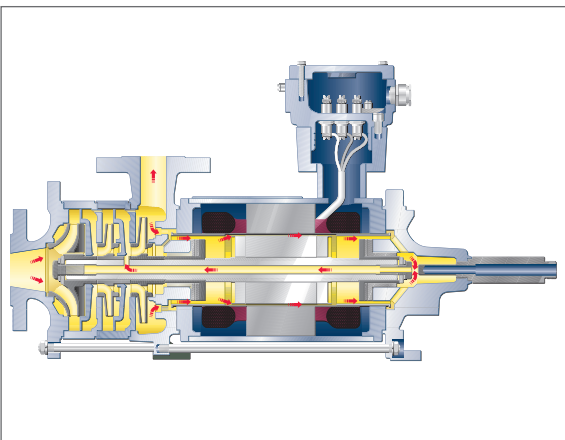


Figure 2: Multistage HERMETIC pump type CAM

PRINCIPLE OF CONSTRUCTION

Canned motor pumps are characterized by a compact, integrated unit without mechanical seal. The motor and pump form a unit with the rotor and the impeller fitted onto a common shaft. The rotor of these single-stage and multi-stage pumps is guided by two identical, medium-lubricated slide bearings. The stator on the drive motor is separated from the rotor space using a thin stator liner. The rotor cavity itself, along with the hydraulic section of the pump, creates a combined cavity which must be filled with pumping medium before commissioning. The heat loss from the motor is carried off by a partial flow between the rotor and the stator. At the same time, the partial flow lubricates both slide bearings in the rotor cavity. Both the can, which is a hermetically sealed component, and the motor casing are used as safety containment. [Figure 1 and Figure 2] Because of that, canned motor pumps always ensure a higher safety level when conveying dangerous, toxic, explosive and valuable media.

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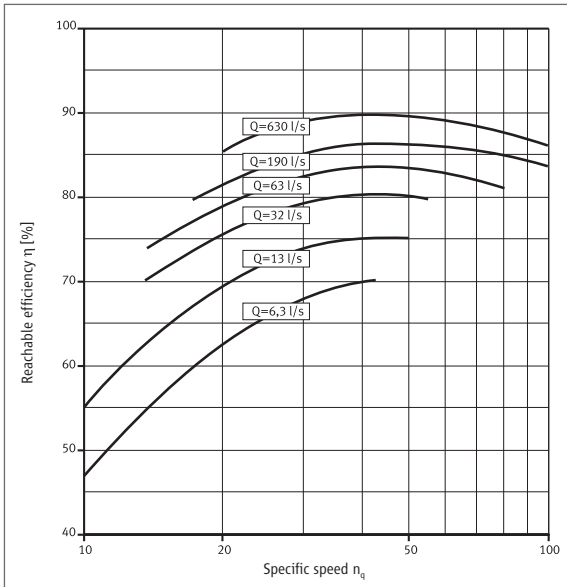


Figure 3: Reachable efficiency of multistage centrifugal pumps

SPECIFIC SPEED – EFFICIENCY

Multistage centrifugal pumps are generally the preferred choice when conveying small flow rates and at high differential heads. These pumps are available in multistage sectional design or in the so-called barrel design. The last mentioned is particularly used in case of high system pressures and/or in order to reduce the large number of the static sealing from several to only one sealing.

Multistage canned motor pumps are preferably used when the required differential head at approx. 2900 min⁻¹ cannot be achieved any more or when priority is given to the aspect of the maximum efficiency.

The generated saving of energy plays an important role when calculating the life-cycle costs (LLC), since, as a rule, it generates the most significant proportion of the costs. The efficiency of centrifugal pumps mainly depends on the specific speed n_q and the flow rate $Q/3$.

Illustration 3 shows the reachable efficiency of multistage centrifugal pumps as a function of the specific speed with the flow rate as parameters acc. to KARASSIK/4/. At approx. $n_q = 40$ the efficiency reaches its maximum which is rising as soon as the flow rate increases. The specific speed n_q is an important characteristic number of the impeller geometry, referring to the pumping data within the best efficiency point of the impeller. In case of multistage pumps, it refers to the pumping data to only one stage.

$$n_q = n \cdot Q_{opt}^{1/2} / H_{opt}^{3/4} \quad [\text{min}^{-1}] \quad (1)$$

with: n in min⁻¹
 Q_{opt} in m³/s
 H_{opt} in m



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Besides n_q and Q the course of the efficiency curve depends on the construction type and casing form. The physical reasons thereof originate from the impeller friction losses, the current losses as well as the inner friction losses in the impeller itself. If the required total differential head H_{ges} is distributed to several stages i , the specific speed can be increased in comparison with single-stage pumps and thus, the efficiency can be increased as well:

$$n_q = n Q_{opt}^{1/2} / (H_{ges} / i)^{3/4} \quad (2)$$

$$n_q = n i^{3/4} Q_{opt}^{1/2} / H_{ges}^{3/4} \quad (3)$$

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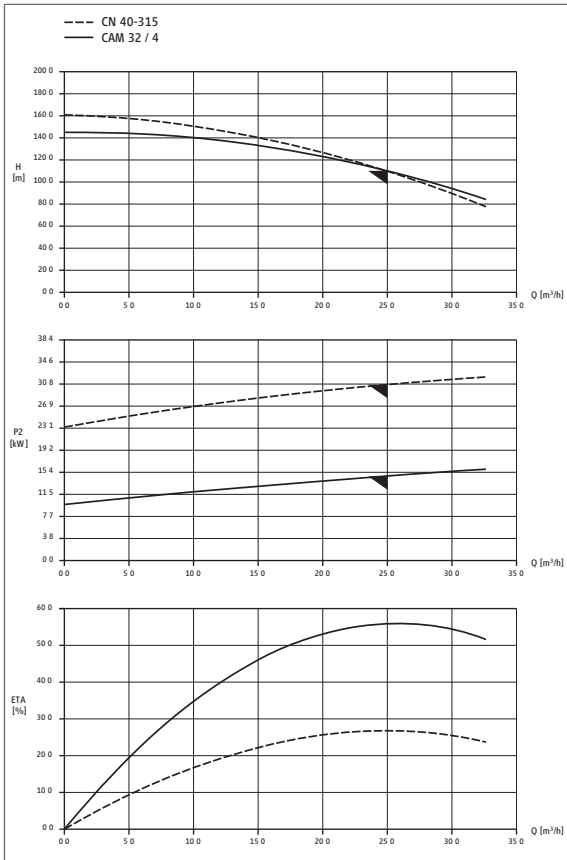


Figure 4: Performance curves for chemical standard pumps and linked pumps with canned motor

LIFE-CYCLE COSTS – SAVING OF ENERGY

The effects based on this consideration can be seen by taking the following example.

It is to find the best solution for a hermetically canned motor pump when having the following pumping data:

- Liquid to be conveyed: Formalin (40 %)
- Flow rate: 25 m³/h
- Differential head: 110 m
- Density: 1100 kg/m³
- Temperature: 50 °C

The first step is to select a single-stage canned motor pump with chemical standard hydraulics of construction size 40-315 with 2960 min⁻¹ [Figure 4]. The total power requirement is 30,7 kW according to the performance curve and at the efficiency of 26,8%. In accordance with the equation, the specific speed is (1) $n_q = 7$. If the total differential head is distributed to several stages, a pump with four stages as well as a canned motor of type CAM 32/4 and at a speed of 2955 min⁻¹ can be selected as an option. Thus, the specific speed increases to $n_q = 21$. The performance curve shows that the respective total power requirement only amounts to 14,8 kW since the total pump efficiency increases up to 55,8%!

The power difference to be saved is 15,9 kW that positively influences the energy consumption. The investments on multistage canned motor pumps compared to single-stage canned motor pumps are much higher due to their constructional characteristics. However, thanks to the required smaller motor, there is one portion of the additional costs that is compensated in such a way that the price difference is put in perspective. The average production costs for a canned motor are approx. 2/3 of the pump price. With this example, it is assumed that with 8.000 operating hours and by taking an energy price of 0,08 € per kWh into consideration, the yearly saving of energy costs will amount to approx. 10.176 €. Thus, the higher investment will be amortized within a short period.



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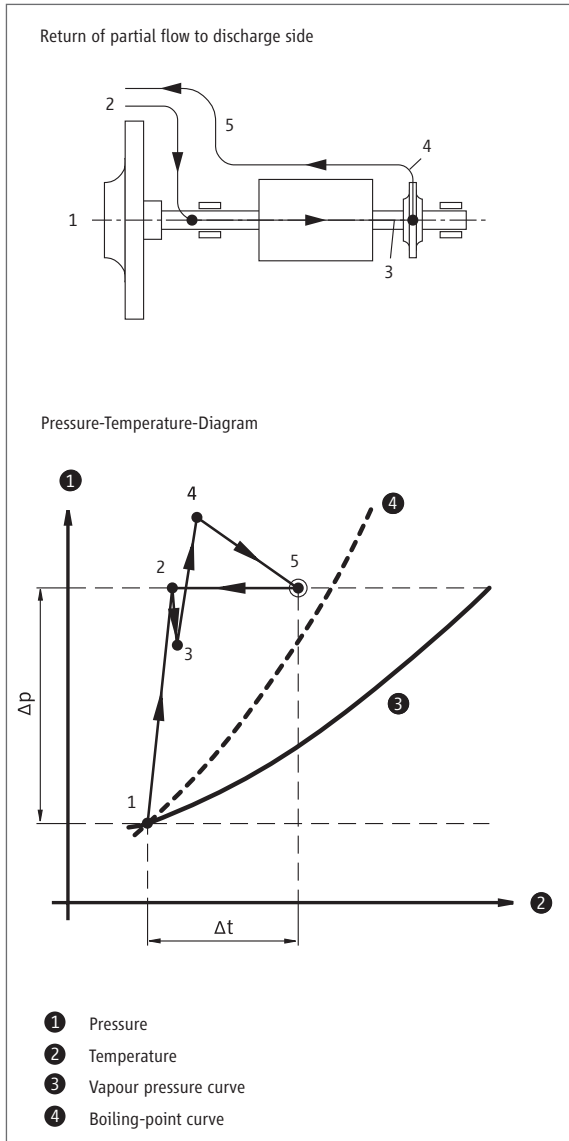


Figure 5: Diagrammatic view of partial flow return and effects on pressure and temperature conditions with single-stage canned motor pumps

LIQUID GAS APPLICATION

Multistage canned motor pumps additionally represent advantages based on hydraulic and thermodynamic aspects for conveying liquid gases due to their constructional characteristics

For conveying liquid gases the single-stage CNF type is used, which was designed especially for this application. [Figure 1] This pump design can also be used to convey liquid gases with extremely steep vapour pressure curve, however it is to take into account that no external pipe is required to return the partial flow to the supply tank or separator. The partial flow for cooling the motor and for lubricating the slide bearings is branched off at the periphery of the impeller and, after flowing through the gap between the rotor and the stator, is carried back again to the pressure side.

An auxiliary impeller serves to overcome the hydraulic losses encountered along the way. The return of the partial flow on the discharge side provides the advantage that the point 3 which corresponds to the highest level of heating as stated in the pressure-temperature-diagram [Figure 5] provides sufficient distance to the boiling point curve. Having the same conditions, the pump series CNF thus allows the convey of liquid gases with extremely steep pressure curves as it is to learn from the dashed vapour pressure curve in figure 5.

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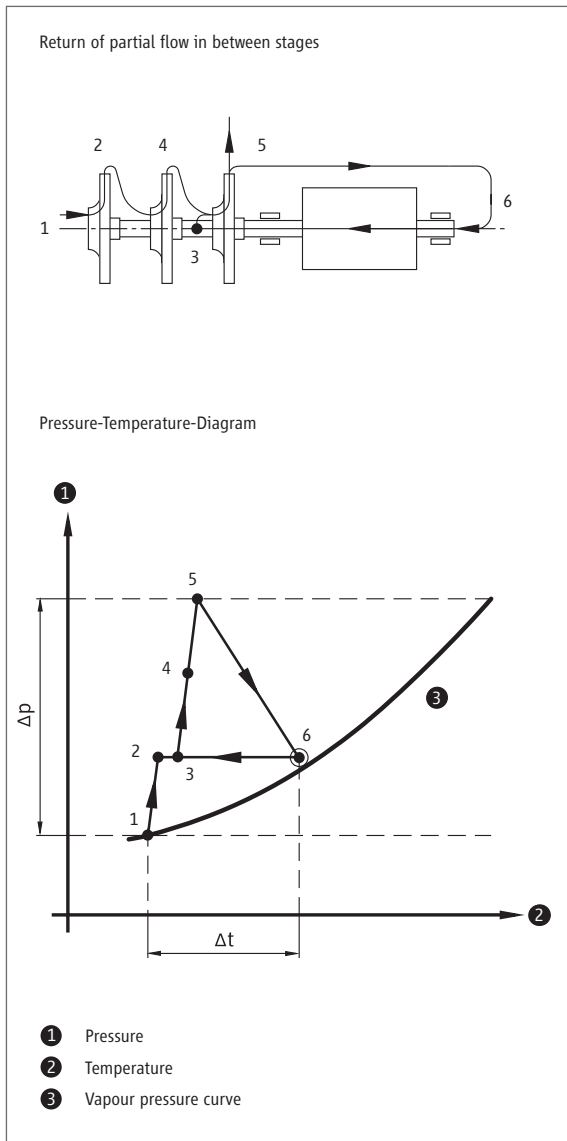


Figure 6: Diagrammatic view of partial flow return and effects on pressure and temperature conditions with multistage canned motor pumps

This problem does not exist with the multistage series CAM [Figure 2] due to their constructional characteristics. The partial flow is taken from the periphery of the last impeller and is carried through the motor cavity to absorb the created heating. After having lubricated the bearings, the partial current is conveyed through the hollow shaft to the pressure side between the last and next-to-last impellers. Thus, the heated partial flow is always conveyed in the range where a higher level of pressure is available than it is the case on suction side.

The point 3 corresponding to the highest level of the heating in the pressure-temperature-diagram [Figure 6] always provides sufficient distance to the vapor pressure curve in order to exclude any vaporization within the pump.

LITERATUR

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