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Energy savings and better performances through variable speed drive application in desalination plant brine blowdown pump service

Edoardo Garibotti

Termomeccanica Pompe Via Del Molo 3, 19126 La Spezia, Italy
Tel. +00390187552251; Fax +00390187552506; email: e.garibotti@termomeccanica.com

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Abstract

Brine blowdown represents an essential service for thermal desalination (both MSF and MED) and its operation is linked to the overall process reliability and availability.

Even if the brine blowdown pump represents a relatively minor utility in MSF plants, this utility is often the object of a service of very delicate nature. Different options are available in the market to design the blowdown pumping system, reducing EPC and operating costs and increasing reliability.

In this paper, the use of variable speed drive has been analysed for a centrifugal pump brine blowdown service in a desalination plant application. Today, the price of variable speed drive up to 250 kW is lower than 10 years ago, allowing the application of these devices in industrial applications with no price increase for the customer.

Due to the particular nature of the service (level regulation inside evaporator), the combination of low head and large capacity imposes the selection of high Nq hydraulics with consequently a flat performance curve. Under these conditions, regulation by throttling is awkward because a small variation in the system losses results in a large variation of pumped quantity. Moreover, high Nq hydraulics show a relatively narrower operating range that increases the regulation problem.

Therefore, the centrifugal pump selection is difficult because the machine works badly when too far away from the design point and, thus, the use of an inverter associated to the pump's electric motor could allow to regulate the pump speed according to the pump requested performances. This solution improves performance because it allows the machine to work not too far away from the best efficiency point thus reducing power absorption. In addition, the pump works at BEP with less vibration and requires less maintenance over time.

Briefly, the main characteristics of the most used pump in this kind of service have been analysed and a simple type of control logic has been proposed. Furthermore, the present paper aims at overviewing the different project options, comparing costs and taking corrective actions on the factors causing operational troubles.

Keywords: Vibration; Service factor; Reliability; NPSH; Specific number; Inverter; Best efficiency point

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1. Control schemes and technological trends

Brine blowdown pumps are normally controlled either by throttling through the level control valve located in the delivery pipe or by varying the speed of the pump in accordance to the signal of the level control in the last stage of the distiller. This is normally achieved through a variable speed motor. Fig. 1 shows the principle of operation and control of the pump according to the two control schemes indicated below.

Though blowdown pumps do not represent the largest power utility in MSF the reduction of the pump head has become of great interest for MSF turnkey contractors where MSF technology has resulted in larger unit size with capacity up to 10 MIGD and above.

Under these conditions, in fact, a lower head could enable the pump motor to remain below the threshold of 200 kW and, therefore, to still be driven by a low-voltage motor which allows to benefit from the obvious advantages in both installation cost and delivery lead time.

Fig. 2 correlates schematically the MSF desalination plant unit size to the brine blowdown flow rate and the power consumption at motor shaft with different delivery heads.

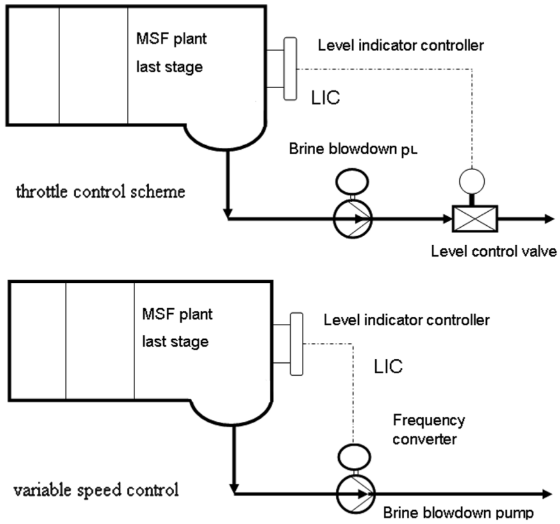


Fig. 1. Typical brine blowdown control schemes.

The comparison was made using statistical information on the brine blowdown flow rate according to the most recent installations and taking into consideration a standard value for

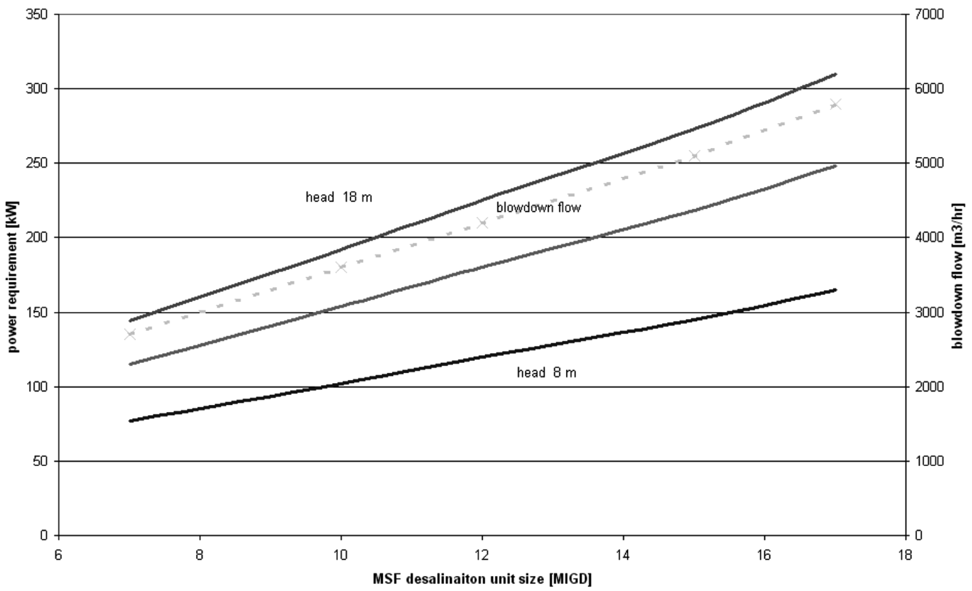


Fig. 2. Brine blowdown control flow rate and power requirement against MSF unit size.

pump efficiency of 85% with a motor efficiency of 93.5%.

However, the trend to increase the brine flow rate maintaining the same or even reducing the delivery head involves a further increase in the pump specific speed (NS) and therefore the tendency to adopt more and more axial pumps.

This is indicated in Fig. 3 where the pump specific speed (NS indicated in ISO units) is plotted against the pumped flow rate at different pump speed.

The main problem associated with this pattern derives from the locally flat configuration of the pump characteristic curve, due to the presence of an unavoidable inflection that is distinctive to this kind of high NS hydraulics.

In a situation where the pump is controlled by throttling, this implies minimal variations of head corresponding to extremely large variation of flow rate.

Obviously, under these circumstances, it becomes difficult to obtain an accurate flow rate control. The design of this equipment is further complicated if we consider the behaviour of the pump suction specific speed.

This parameter is defined as indicated in the following formula:

$$N_{ss} = \frac{\sqrt{\dot{m}}}{\text{NPSH}_r^{0.75}} \cdot n \qquad (1)$$

where

N_{ss}	[–]	pump specific suction number
NPSH_r	[m]	required net positive suction head
$\dot{m}$	[m^3/s]	flow rate
n	[rpm]	speed

As it can be seen from Eq. (1), with increasing pump flow rate, the pump suction specific speed increases in turn unless decreasing the pump speed while other parameters such as NPSH required remain constant.

This effect is shown in Fig. 4, which illustrates a suction specific speed against pump flow rate with the RPM as parameter.

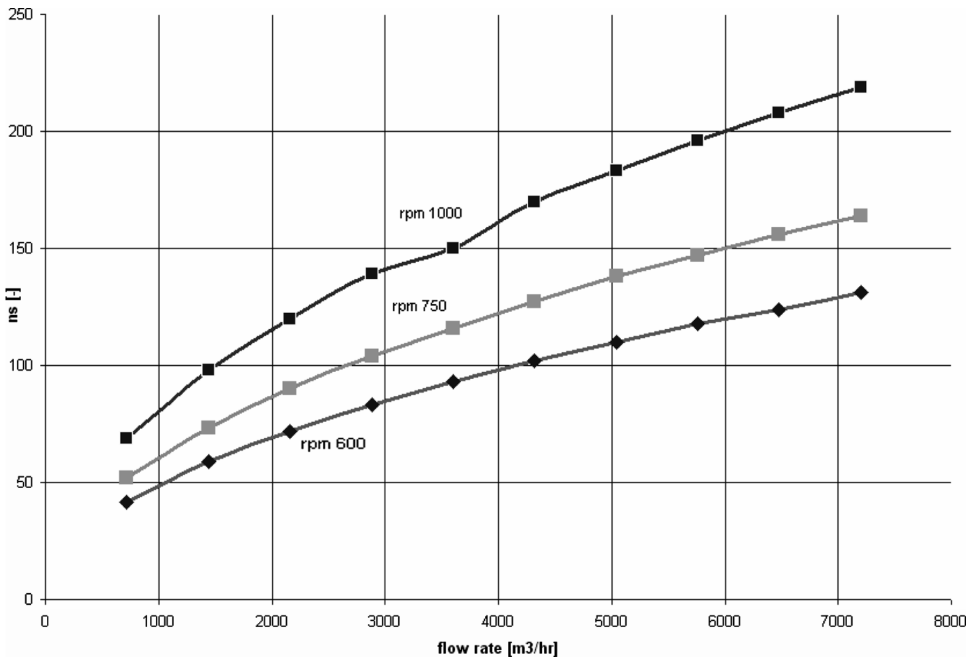


Fig. 3. Brine blowdown control flow rate and NS at different pump speed.

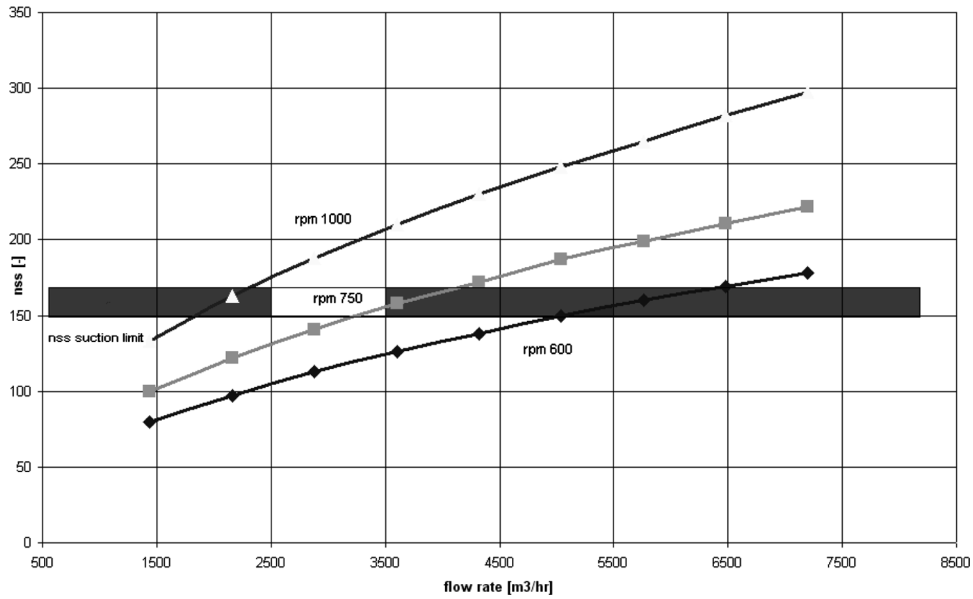


Fig. 4. Brine blowdown control flow rate and NS at different pump speed.

It is engineering good practice to limit the suction number between 150 and 180 (ISO units). This entails that, for fixed speed control pumps, speed selection becomes a very critical parameter.

Furthermore, MSF level control presents a further complication due to the continuous fluctuation of the level of the brine in the last stage of the evaporator.

These fluctuations and instabilities in flow control have, in some cases, resulted in damages in the pump rotating element.

In this respect, a variable speed flow control offers substantial advantages to the traditional throttling control.

These advantages are further enhanced by the possibility of reducing the pump power consumption.

Table 1 and Fig. 5 show the comparison between brine blowdown pumps operation through frequency converter or traditional throttle control.

Fig. 5 shows the break even analysis and total lifetime costs comparison between a brine blowdown pump installed with frequency converter and one with traditional throttle control at Dewa Jebel Ali Desalination Plant KII Station.

The analysis was made for a 15 MIGD MSF distiller and takes into account the difference in capital costs due to the selection of the LV compared to MV motor and the additional capital expenditures of a frequency converter installation against a control valve.

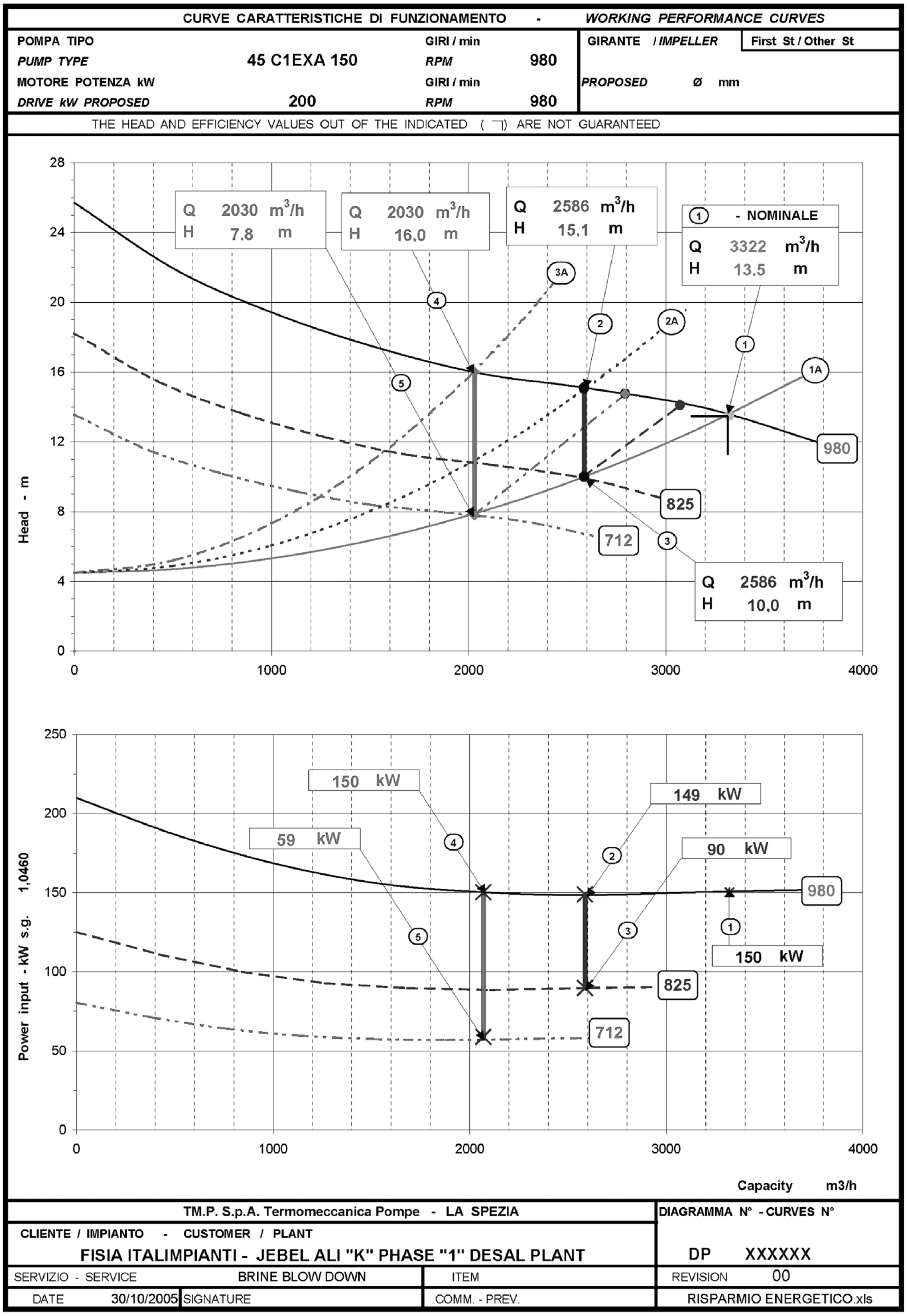
These are plotted against power consumption costs for each year of operation.

For comparison purposes, power has been considered at the cost of 0.042 € (Euro) per kW h.

2. Conclusions

The evolution of brine blowdown hydraulic requirements against the technological trend of increasing desalination unit size for MSF and MED desalination plants has been studied. The various options for flow control have been analysed and the advantages of variable speed control against traditional control valves have been demonstrated based on both technical and economic reasons.

Table 1



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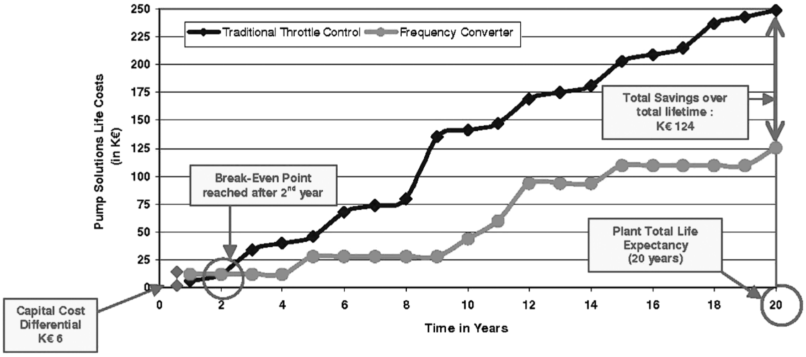

Fig. 5. Pump blowdown life cycle cost.