Case Study 300

Energy savings by reducing the size of a pump impeller

The high pressure evaporator

Case Study Summary

Salt Union Ltd produces white salt by the multistage evaporation of brine. A by-product of the process is condensate, which is exported to a nearby power station to feed the boiler.

Operational analysis showed that the pressure generated by the condensate export pump was considerably higher than was necessary. The high degree of throttling that was consequently needed had led to instability in the system, resulting in mal-operation and high maintenance costs.

After discussion with the pump manufacturer, Salt Union decided to trim the diameter of the pump impeller. This eliminated the instability and resulted in significant energy savings. Reducing the power required by the pump also allowed a smaller motor to be fitted, which produced further energy savings.

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Case Study Objective

To demonstrate the energy and maintenance cost savings that can be achieved by modifying pumps to match the load.

Potential Users

Any user of pumps.

Investment Cost

£260 (1993 prices)

Savings Achieved

Energy savings: 710 GJ/year, worth £8,900/year (1994 prices)

Savings in repair and maintenance costs: £3,000/year

Overall total savings: £11,900/year

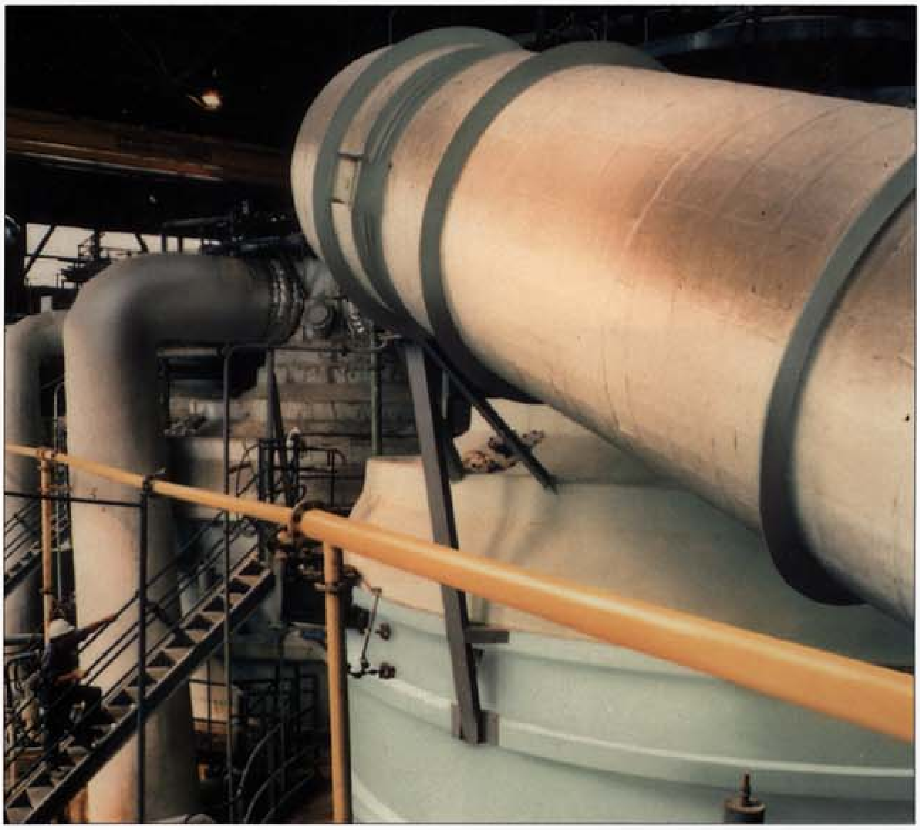
Payback Period

The payback on the impeller trim was achieved in eight days.

"We believe that many companies could benefit from following this low-cost exercise."

Mr D G Mullin, First Line Engineering Manager, Salt Union Ltd

ENERGY EFFICIENCY



The evaporator house

Condensate distribution pump

Background

Salt Union has a six-effect brine evaporator plant producing salt and condensate. It is driven by steam which is imported from the intermediate pressure stage of a nearby power station. The evaporators are in continuous operation and work in series to allow the brine to evaporate at progressively lower temperatures and pressures. An end suction centrifugal pump is used to distribute some of the condensate within the plant, and the balance is returned to the power station for use as boiler feed. This pump, with a nominal rating of 230 m^3/hour against 112 m generated head at 2,960 rev/min, is driven by a 110 kW induction motor.

An open break-tank balances the flow to and from the pump, and a pneumatically operated control valve, situated on the return line to the power station, maintains the level in the tank within a set range. The control system is shown in Fig 1.

Investigations into water hammer on the condensate line between the plant and the power station showed that the delivery pressure created by the pump unit was excessive and caused instability in the control system. This instability caused the break-tank to drain, producing cavitation at the pump resulting in premature pump failure. Water hammer resulting from the instability also caused pipe hanger failure and joint leaks on the line to the power station.

Dynamic testing established the minimum pressure needed to maintain the required flow, and showed that the pump delivery pressure could be reduced considerably.

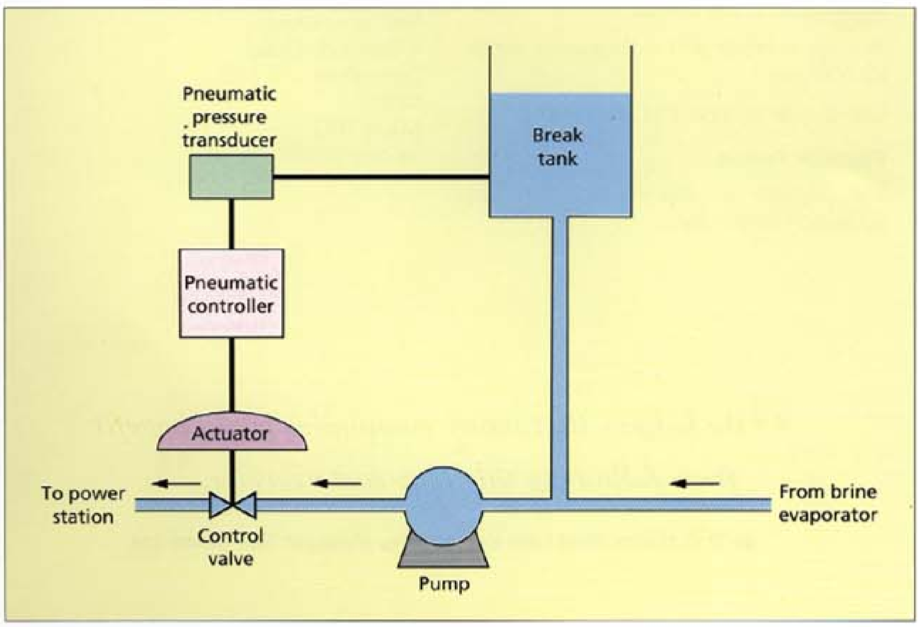


Fig 1 Control system for condensate distribution

Pump Modification

With the assistance of the pump manufacturer, Salt Union measured the pressure needed from the pump to produce the desired flow. This was done by throttling the pump discharge valve and measuring the pressure downstream. As a result of these tests, the pump manufacturer recommended that the impeller diameter should be reduced from 320 to 280 mm, which would reduce the need for throttling by the control valve. The impeller was therefore removed from the pump and machined by a local engineering company. On refitting, the power requirement fell by nearly 30%, allowing a smaller motor to be fitted.

Monitoring Results

Motor power consumption readings were not available before the changes were made to the pump and motor. The energy savings were therefore deduced from the output and motor and pump efficiency.

After fitting the trimmed impeller to the pump, the average flow was recorded daily and analysed over an eight-month period. The recorded results are shown in Fig 2. The rate of flow is shown in 40 m^3/hour flowbands between 60 and 220 m^3/hour, and the number of hours run at each band is shown as a percentage of total time. The annual running hours and power reduction at each flow band were used to calculate the total energy saving. For instance, in the 160 m^3/hour flow band, the annual energy consumption fell from 324,000 kWh to 241,000 kWh (before the change in motor size).

The impeller after trimming

Savings Achieved

Analysis showed that the energy saved by trimming the impeller was 197,000 kWh/year, equivalent to 710 GJ/year.

The site average electricity tariff was unusually high (14 p/kWh), although a change in power source was under review. A more typical average price of 4.5 p/kWh was therefore used to determine the savings. At typical 1994 prices, the cost savings achieved by trimming the impeller were £8,900/year.

The previous instability of the system meant that around £3,000/year were spent on maintenance of the pump, valve and pipeline. These repairs had included erosion of the pump casing, breakage of the control valve stem, breakage of pipe hangers and leakage at pipe flanges. Stabilising the system eliminated these repair costs and brought the total savings achieved to £11,900/year (1994 prices).

Other Benefits

Reducing cavitation at the throttling valve also reduced the level of internal trim erosion, excessive vibration and unacceptable noise.

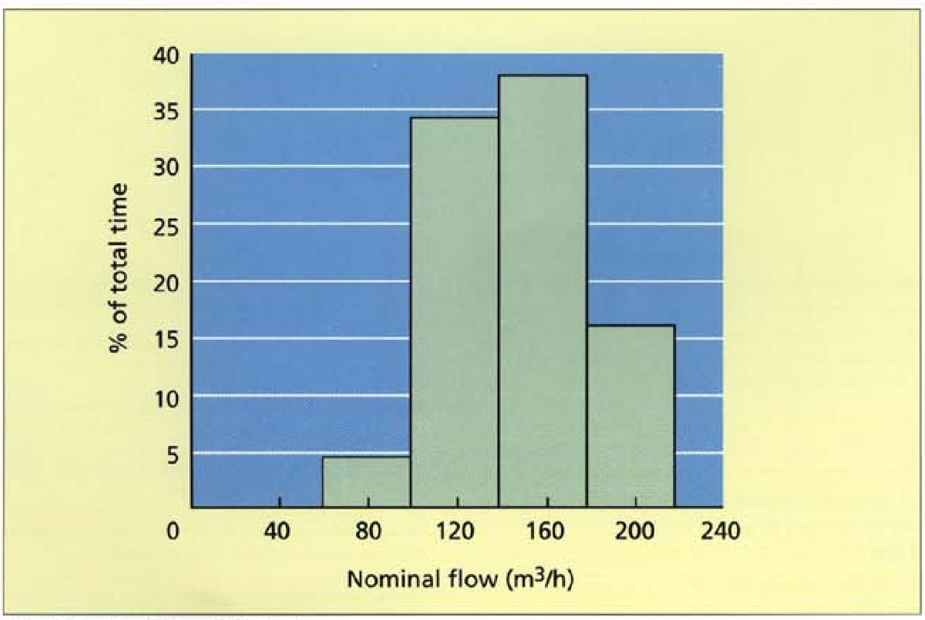


Fig 2 Typical flow distribution

(The flow is not shown for the 6% of the time that either the pumps were running for only part of the day or the plant was shut down.)

Payback Period

Decisions on trimming pump impellers are usually straightforward, particularly if specialist help is available. The work involved in uncoupling, stripping and rebuilding a small pump is modest, and machining the outside diameter of a small impeller is a simple job within the capabilities of most machine shops. The £260 total cost of this charge is broken down into £100 for feasibility/design work, £60 for manpower, and £100 for the actual impeller trimming.

The payback on the energy savings of £8,900 is eleven days. The total payback on overall savings of £11,900 is just eight days.

Motor Size Reduction

The power consumption of the pump after impeller trimming fell by nearly 30%. This meant that the 110 kW motor could be replaced by a 75 kW motor. This smaller motor, operating closer to its peak efficiency, produced further savings of £720 or 58 GJ/year for a total additional investment of £2,520. Thus the payback on fitting this motor (after impeller trimming) is 3.5 years.

The overall combined payback on both the impeller trim and motor size reduction is therefore 11.5 weeks, calculated from annual savings of £12,600 on a total investment of £2,780. This is equivalent to an annual energy saving of 768 GJ.

Opportunities for Impeller Trimming

Most radial and mixed flow pumps in industry are oversized, due mainly to conservatism in assessing system requirements and in choosing the impeller diameter. Inaccurate system analysis can result in the need to throttle flows, which even when the pump itself is operating efficiently leads to energy wastage. However, if in such a system the pump is not throttled, it is in any case likely to be operating at less than its optimum efficiency.

Pump cavitation as a result of operation at excessive flow rates can also lead to energy wastage.

As this Case Study shows, impeller trimming can be very cost-effective. However, there are some important points to remember:

- The axial flow impeller, which is typically found in low head, high flow pumps cannot be trimmed.
- Impeller trimming is irreversible and, if a return to the original duty is anticipated, the cost of a new impeller must be allowed for. However, this cost will usually be modest in relation to the savings made by trimming.
- Users should always seek advice from the pump maker. If this is not available, a pump specialist should be consulted.

Comments from Salt Union Ltd

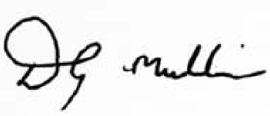
At Salt Union Ltd we are committed to continuously improving both production techniques and services to our customers through the application of the principles of total quality management. A key part of this policy is to look for ways to reduce the large energy bill incurred in running the plant.

In the past, a lot of time and money have been spent on the maintenance of the condensate line pump and the associated pipework. However, an investigation found that excess pressure was causing pump cavitation resulting in damage to pipe hangers and joints because of water hammer.

Of all the options considered for reducing the pressure, pump impeller trimming was the most attractive, with the manufacturer helping us to decide on the new impeller diameter. The reduced pump power consumption also allowed us to fit a smaller motor, which led to further savings.

The Salt Union plant at Runcorn

The result of these changes was a significant saving in electrical energy, a reduction in maintenance, the elimination of cavitation and water hammer, and better process control. We believe that many companies could benefit from following this low-cost exercise and realise substantial energy savings.



Mr D G Mullin
First Line Engineering Manager
Salt Union Ltd

Salt Union Ltd

Salt Union Ltd is the largest salt producer in the UK. The company is part of the D. George Harris group of companies, which includes the North American Salt Company, the third largest salt producer in North America.

Started in 1910, the plant has grown to its capacity and incorporates multistage evaporators that utilise steam supplied from a nearby ICI power station for the evaporation process. A by-product of the process is condensate, part of which is exported back to ICI and used in the steam raising plant.

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