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Sulzer Pumps
Barrel Pump rerate increases refinery production

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The Heart of Your Process

Sulzer Pumps has over 135 years of experience in pump development and is committed to the needs of its customers. The company's process and application knowledge has allowed it to develop innovative pumping solutions for focus segments, including tailor made systems if required. Its active research and development supports this customer oriented approach.

Hydrocarbon processing industry

As one of Sulzer's core business segments, the hydrocarbon processing industry runs sophisticated production processes requiring reliable pumping solutions that meet stringent industry specifications. Its high quality product line is known for being able to meet these specifications consistently. Continuous product innovations such as the new line of hermetically sealed horizontal and vertical process pumps are helping the industry improve its operational efficiency.

All the pumps are engineered in line with the latest standards, including those issued by the American Petroleum Institute, in order to ensure reliable and safe production onsite.

Customer support service

Through Sulzer's worldwide network of over 50 service centres it provides its customers with a range of services for pumps and other associated equipment. The company address its customers' needs, providing support ranging from supplying spare parts to value creating solutions, in order to optimise equipment performance throughout its lifecycle. This broad capability delivers high quality, performance and availability of its customers' pumps and systems.

Barrel pump rerate increases refinery production

A major refinery in southern California is in a continuing process of evaluating and debottlenecking one of its units to increase the throughput. One of several factors limiting the production rate was an 11 stage double casing barrel pump (Figure 1). The pump was manufactured by Sulzer Pumps (US) in Portland, Oregon in 1989. The pump's inner case was refitted in 1998 with maximum diameter impellers to increase the flow from 32 500 bpd (950 GPM) at 4660 ft to 35 000 bpd (1020 GPM). Following this, other areas of the refinery were debottlenecked over the next 18 months to increase the potential production rate to over 38 000 bpd. As the pump was already operating at the maximum flow and head available with the existing inner case and impeller hydraulic design, the options were to either replace the pump or rerate it one more time to achieve the desired production rate. A replacement larger barrel pump is expensive and will require a new baseplate and high pressure piping modifications. Rerating an existing barrel pump minimises the cost of new equipment as well as significantly reducing the time required to complete the project.

Hydraulic rerate

Sulzer Pumps has had successful experience with rerating barrel pumps with internal hydraulics utilising both volute and diffuser designs. Sulzer's Southern California Service Centre was requested to explore the possibility of rerating the pump to 43 000 bpd (1255 GPM) at 5900 ft, while not exceeding the maximum hp rating of the existing three phase motor. An analysis by Sulzer's hydraulics department determined that this could be accomplished by replacing the low capacity inner case and impellers with high capacity components (Table 1). This was made possible by the wide range of performances that can be obtained with this type of pump without having to change the external dimensions, resulting in significant cost savings to the end user. The primary limitations are the rating of the pressure boundary components (outer case and end covers) and the size of the suction and discharge nozzles (Figure 2).

Mechanical review

The pump was originally manufactured to the requirements of API standard 610, 6th edition, material class S-5. In addition to the rerate, the customer requested that the pump be upgraded to API standard 610 8th edition standards. A review of the original design and manufacturing documents showed that the pump was in compliance with the following exceptions.

- The running clearances between the impeller and case wear rings were designed to Sulzer Pumps (US) standards which result in smaller clearances than those specified in API standard 610. The customer was presented with an analysis comparing the perfor-

Figure 1. Rerated pump with increased performance installed and operating at the customer's site.

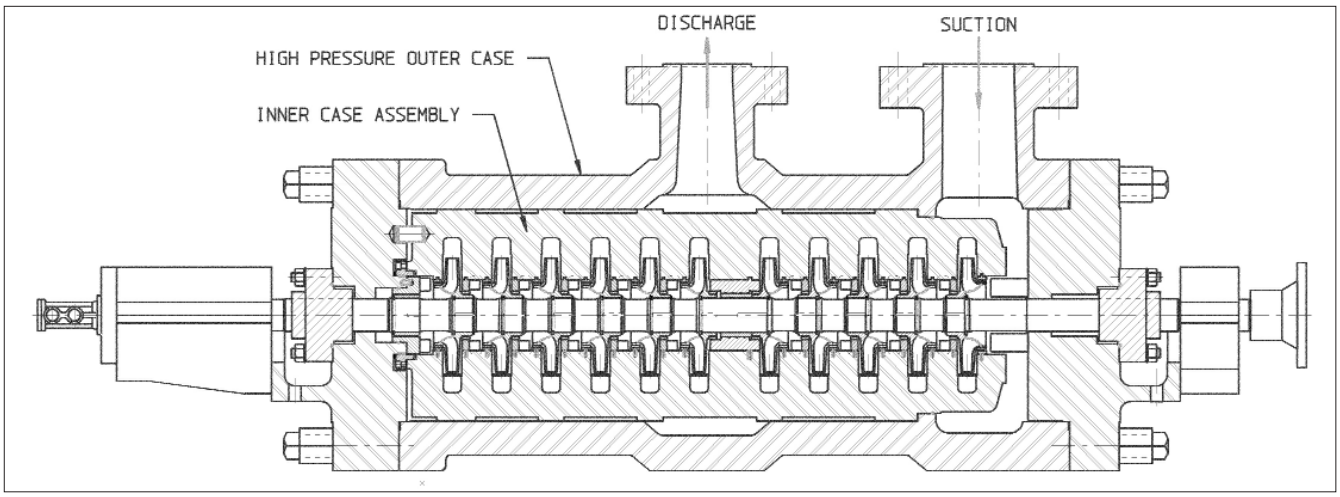

Figure 2. 6 x 8 x 10.5 CP high pressure double casing pump (API type BB5).

mance of the pump with both the manufacturers' standard clearances and those required by API standard 610. Based on this, the customer chose to have the rerated pump designed using the manufacturer's standard clearances. This was due both to the loss of efficiency and performance with the larger clearances and the history of dependable performance of the pump with the smaller clearances.

- The seal chambers in the high pressure end covers did not meet the dimensional requirements of API standard 682 (invoked by API standard 610) for mechanical seals. In order to comply, the end covers would require extensive welding and machining with a risk of distortion at the precision interfaces with the high pressure outer case and the new inner case assembly. Again, based on the satisfactory performance of the mechanical seals, the customer chose to not have the end covers modified to the new seal chamber dimensions.
- API standard 610 requires flexible couplings to be keyed to the pump shaft. This was superseded by the customer specified keyless hydraulic fit coupling for ease of installation and removal. This eliminates the use of torches to heat the coupling hub. This is a particularly important safety consideration in a refinery.
- The allowable nozzle loads for the pump as given on the original general arrangement drawing were twice those specified by API standard 610.
- The baseplate did not fully comply with minor details in API standard 610. Modifications to the baseplate were not included in the pump rerate proposal and would not be necessary unless the existing three phase motor was replaced with one having a power rating higher than 2000 hp.

With a major rerate such as this it is imperative to conduct a detailed engineering review to ensure a safe design. A stress analysis per the ASME code of the outer case and end covers demonstrated that they were acceptable for the higher operating pressures without additional reinforcement. The integrity of the pressure casing was verified by a customer witnessed hydrostatic test at a pressure equal to 1.5 times the maximum discharge pressure produced by the rerated pump.

The pump motor was rerated by the manufacturer from 1500 - 1750 hp. This was adequate for operation at the rerated conditions and within the power transmitting capability of the existing pump shaft. However, as the pump could potentially require upwards of 2000 hp if operated at higher flow rates, and to allow for installation of a more powerful motor in the future, it was decided to redesign the pump shaft with one suitable for operation with a 2000 hp motor. The larger shaft diameter, in turn, required replacing the journal bearings, mechanical seals, and pump coupling half.

Table 1. Comparison of operating conditions after rerate

Description	Original operating conditions	Operating conditions after rerate	Change
Capacity (rated)	950 GPM at 3560 RPM	1255 GPM at 3560 RPM	32%
Differential head	4660 ft at rated condition	4898 ft at rated condition	5%
Differential pressure	1775 PSID at 0.88 SG	1760 PSID at 0.83 SG	-0.8%
Shutoff head	5500 ft	5900 ft	7.3%
Suction pressure	32 psig at rated condition 93 psig maximum	50 psig at rated condition 85 psig maximum	56% -8.6%
Discharge pressure	1805 psig at rated condition	1810 psig at rated condition	0.3%
Temperature	285 ˚F at rated condition 310 ˚F maximum	350 ˚F at rated condition 420 ˚F maximum	65 ˚F 110 ˚F
Efficiency	75% at rated condition	79% at rated condition	4.0%
Driver	1500 hp induction motor	Motor rerated to 1750 hp	250 hp

Rotordynamic analysis

The customer's specification required that both a later-

al and torsional rotordynamic analysis per API 610 8th edition requirements and acceptance criteria are performed to ensure design integrity with respect to rotordynamic behaviour.

Lateral rotordynamics is investigated by means of non-linear static, damped natural frequency and forced coupling unbalance response analyses. The analyses were performed for design clearances and two times design clearances and an operating speed range of 25 - 125% of rated speed. The dynamic behaviour of the rotor results from the interaction between rotor and stator and considers supporting influences of journal bearings, annular seals and bushings, as well as the destabilising effect of impeller casing interaction. The analysis indicated that the calculated natural frequencies and damping factors met the applicable API 610 8th edition acceptance criteria.

Torsional rotordynamics is analysed by means of an undamped natural frequency calculation and comparison with various potential excitation sources. The analysis investigated the torsional behaviour of the entire shaft train consisting of electric motor, coupling and pump. The natural frequency analysis indicated sufficient separation margins between all torsional modes and the various excitation sources considered. No additional torsional forced response and stress analysis was required.

The pump was therefore shown to have design integrity with respect to both lateral and torsional rotordynamic behaviour.

Factory performance test

When doing a major rerate of this nature, Sulzer recommends a factory performance test. This ensures that the pump's performance is exactly what the customer wants. It also eliminates problems after commissioning should site instrumentation (which is rarely accurate) indicate insufficient performance.

The completed pump was subjected to a customer witnessed performance test at Sulzer's Portland, Oregon facility. This test proved that the rerated pump exceeded the customer's performance requirements and was within the 1750 hp limitation of the existing driver at the rated operating conditions. The test also demonstrated the improved efficiency of the pump, resulting in a large power savings over the operating life of the pump (Table 1).

Commissioning

After the successful performance test, the rerated pump was installed at the customer's facility (Figure 1). The commissioning of the pump was completed and successfully placed into service. The pump has exceeded the customer's expectations with respect to performance and low operating vibration levels.

This rerate was a success due to a good relationship and planning between the refinery, the pump OEM and engineering procurement and construction contractors (EPC). The requirements and expectations were clearly stated and met with 100% satisfaction.

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