Expert Speaks

Case Studies of Centrifugal Pumps

At first sight, a centrifugal pump seems to be one of the simplest machines. In practice however, it is capable of posing an enormous spectrum of different problems. Occasionally one comes across problems that seem to defy everything we know about centrifugal pumps.

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The selection of the right pump for the right job is very important and results in minimum maintenance of pumps. But this calls for knowledge of not only what happens within the pump but also what happens behind and beyond the pump. Therefore, it has to be a joint effort between the hydraulic expert and the process specialist. Selection of the right pump itself rewards. Start up, operating problems, maintenance cost etc. are minimised.

The performance of the pump is very much dependent on the performance of the overall system.

Case Study-1

Two identical slurry pumps, installed side by side, to pump bauxite slurry from same source. Each pump provided separate suction and discharge pipe. Two pumps were operated simultaneously. Everything about these two systems seemed to be identical except that one pump performed perfectly and second one with great noise, vibration. This led to frequent failure of the shaft and faster worn out of impeller and wear plates. The troublesome pump was dismantled several times but nothing wrong could be found out.

Since, these pumps are identical running for same duty conditions and were under warranty customer claimed free replacements as one pump was giving satisfactory operation.

The problematic pump was reconditioned with new spares and put back into operation. After a particular period of time, customer reported again of shaft breakage. When the problem was attended by the Service Engineer during third time, he could see the pump operator, throttling the suction valve for varying the flow. And the Service Engineer concluded the problem. He noticed in the successful pump, the discharge valve is provided near the pump discharge, ie in a reachable position. In the problematic pump, the discharge valve was provided at a greater distance which the operator could not reach and had to go to the first floor to control it. Since the suction valve was provided in a reachable position, the operator controlled the flow with suction valve without knowing the effect of this operation. When the suction valve was kept fully open and discharge valve was used to control the flow, the problematic pump started giving satisfactory performance as that of the successful pump.

Conclusion

It is never recommended to throttle the pump suction in order to reduce the capacity, as the effect is to change the pump head-capacity curve through cavitation and operation in the so called break. The pump efficiency is seriously affected in such operation but most important of the ill effects are the erosion and premature destruction which are caused by a cavitations which would reduce capacity as drastically as desired.

Case study-2

Two identical pumps, installed side by side, to transfer liquid from same source in to the same pressurised container. Each pump provided separate suction and discharge pipe. Two pumps never operated simultaneously. While one ran, other served as a stand by. Everything about these two systems seemed to be identical except that one pump performed perfectly and second one with great noise and vibration. The troublesome pumping system was dismantled several times but nothing wrong could be found out.

The successful pump loop had a 2 inch discharge with a reducer connecting directly to a 1 ½ inch pipe line. However the troublesome loop had a 6 feet 2 inch pipe connected to pump discharge and only after this length, pipe line was reduced to 1 ½ inches. When 2 inch diameter was replaced with 1 ½ inch pipe, the problem causing pump operated satisfactorily.

Up to a certain flow rate, the Net Positive Suction Head (NPSH®) increases approximately as the square of the flow. Above this capacity, it starts to increase at a much faster rate. In this case the frictional losses in the pipe line constituted a very significant part of the total head, against which each of these pumps had to operate. In the discharge line, that consisted exclusively 1 ½ inch, the resistance to flow was adequately high. This kept the total head well above the critical pumping head. This in turn limited the flow rate to well below critical capacity. In the other pipe line, however, the reduced resistance of the 2 inch diameter pipe section, brought down the total head well below the critical head. This increased the NPSH® of the pump well above the NPSH(A). Consequently cavitation developed within the pump. This in turn, gave rise to the noise and vibration.

Case Study-3

Head in storage tank

The pump transferred fuel from a storage tank to oil delivery truck. Whenever the oil level was low ie when the NPSH(A) is less, the pump operated satisfactorily. However, when the storage tank is full, ie when the NPSH(A) is more, the operated with extreme noise and vibration.

The total head against which a pump is operated is defined as the difference between the total head existing at pump outlet and the total head available at inlet. In this particular application, the discharge head tends to be practically constant. This means that an increase in the suction automatically reduced the total head against which the pump has to operate.

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When the storage tank is full the pump operated well below the critical head. This however meant that the pump delivered a flow rate significantly higher than the critical capacity. However the flow meter installed in the pipe line and the measurement of time required to fill the truck, indicated that the rate was well below the critical capacity. There seemed no solution to this puzzle.

The most important factor that determines the NPSH® of a pump at a given speed is the rate of flow through the impeller. The flow rate through the impeller is usually greater than that through the pipe line owing to leakage through the wear rings. However, if a wear ring is missing, this short circuits the impeller discharge to the impeller eye. In such case, the flow through the impeller may easily be 30 percent to 40 percent higher than the flow through pipe line. In this case, this would have brought the total flow, through impeller, well above the critical flow rate, The pump was opened and the front wear ring was found to be missing. A new wear ring was installed in the casing and solved the problem.

Technical Notes: