API Process Pump Innovation Results in Significant Cost Savings

By Pumps and Systems Staff with W.E. (Bill) Murray, Split Flow, Inc.

Where process conditions incorporate high-head, low-flow slipstreams, such as in fractionator reflux services, the common practice is to oversize pumps to include the slipstream requirements. It is often not cost-effective to use separate small pumps. A recent innovation makes it possible to modify API Standard 610 process pumps and use them for particular applications to save capital and operating costs in either of two ways:

1. Reduce the number of pumps by combining services.
2. Reduce the installed motor size by minimizing discharge control valve throttling.

Split Flow™ is a unique design modification wherein a pump inlet flow is separated into two outlet flowstreams: a high-flow, low-head main stream and a lower-flow, higher-head slipstream. The pump effectively becomes two pumps in one with a common suction and both primary and secondary discharges. The design enables each impeller to be optimized for each flowstream's discrete process requirements. The auxiliary impeller simply separates the slipstream from the mainstream. This avoids the usual practice of sizing a pump to include the lower-flow, higher-head slipstream and using a control valve to throttle excess head to the mainstream (Figure 1). The approach saves energy and makes it possible to use a smaller motor.

Pumps with the Split Flow feature are sized based upon the total rated capacity of both flowstreams and the TDH of the main flowstream. The size of the booster impeller is determined by the head-capacity rating of the higher-head, smaller-flow slipstream. While any low-flow impeller is inherently inefficient, note that approximately half of the TDH required by the slipstream is produced by the more efficient primary impeller. The modification uses less horsepower than a separate small, low-efficiency pump.

Photo 1. Auxiliary disk impeller used with prototype pumps

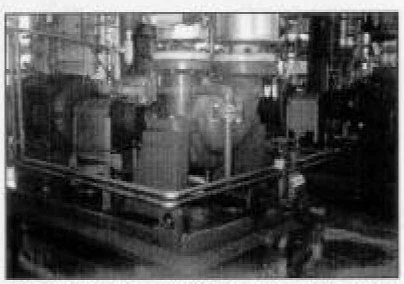

Photo 2. The auxiliary discharge from the booster impeller of a Split Flow modified pump in fractionator reflux service

The smallest API pump—one inch—typically has a Best Efficiency Point (BEP) of 50 to 80 gpm @ 3550 rpm. Since operating pumps at flows below BEP is not good practice, this small pump would be too large for some slipstream conditions. Incorporating a bypass so the pump can operate near BEP is generally not practical. Moreover, the higher heads required can complicate the process of finding a good hydraulic fit. Where it is not cost-effective to use a separate small pump, common practice is to oversize the main pump to include the slipstream requirements. This single-pump system saves the cost of using a separate low-flow, high-head pump by enveloping the slipstream head-capacity requirements into the main pump. This, however, requires wasteful throttling of the mainstream control valve to produce the higher head slipstream.

Construction details of the Split Flow innovation are illustrated in Figure 2. Note that the pump case, primary impeller and bearing bracket are all standard API designs. Only the case cover and shaft are modified to accommodate the auxiliary (booster) impeller with its concentric volute. The cover accepts any style of API standard mechanical seal, and the external interconnecting piping is socket-welded and flanged in accordance with API Standards. The Split Flow modification can be incorporated into any standard horizontal or vertical in-line API overhung pump, regardless of size.

A drilled-hole auxiliary disk impeller was used with the prototype pumps (Photo 1). It is simple to manufacture and minimizes shaft overhang. Its maximum diameter and TDH capability are the same as the primary impeller, and its rated flow is adjusted to suit particular requirements by varying the number and size of the holes. Because of internal bypass, the auxiliary impeller can be run dead-headed without duress, provided that the primary impeller operates above its prescribed minimum flow.

The Split Flow modification does not result in a conventional two-stage pump where both impellers pump the same flow in series. The API Standard rejects the use of two-stage overhung units because excessive shaft deflection can compromise seal life. The Split Flow design reduces dynamic shaft deflection at the seal because the booster impeller enables the use of a smaller-diameter, lower-head primary impeller. The pump rotor is also stabilized due to the Lomakin Effect, which results from the running clearances at the eye and hub of the disk impeller (Ref. 2). This is evidenced by two years of trouble-free operation with the prototype pumps.

The Split Flow pump innovation was first used in the field in June 1996. Two modified 4", 60 hp, 3560 rpm pumps, manufactured by Flowserve, are operating in fractionator reflux service in a major California refinery (Photo 2). Conventional larger pumps for this service would require 125 hp motors. The lower motor horsepower requirements of the Split Flow modification results in a $26,000 per year electric energy savings for this particular installation, and the lower primary discharge pressure mitigates wear on the discharge control valve. Moreover, if the larger pump had been selected, the impeller diameter would exceed 13 inches. User standards would have required that a more costly between-bearing type of pump be used. Overhung API pumps are typically available with top or end suction nozzle orientation. This particular installation uses top suction. The circuits from the primary impeller discharge connect to the auxiliary impeller inlet. The mechanical seal is a dual type with recirculation per API plan 23.

Summary

Split Flow technology can be applied to save significant capital and operating costs for API pump installations. Most applications will use overhung type pumps up to 200 hp, with slipstreams up to 80 gpm. For larger sizes, future plans anticipate two-stage, between-bearing type API pumps adapted to take advantage of the cost savings associated with the two-pumps-in-one, Split Flow concept. ■

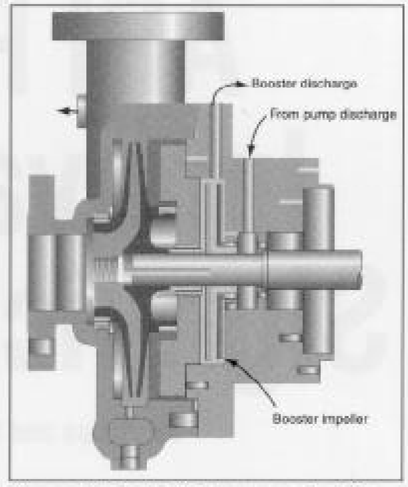

Figure 2. The Split Flow construction details

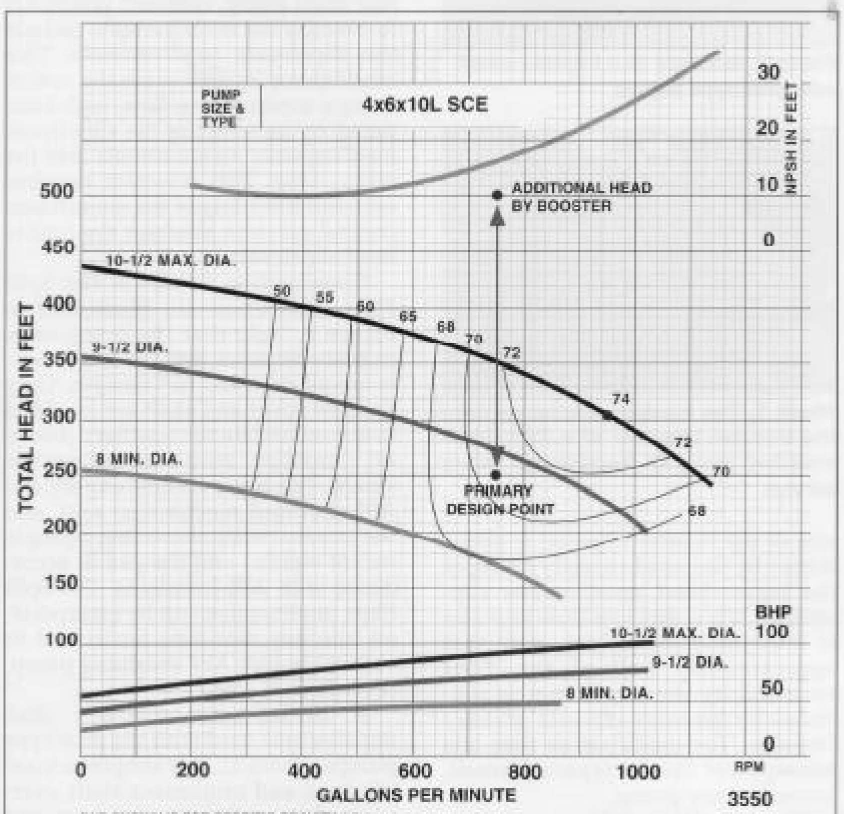

Figure 1. Select a pump by using the primary design point and select the booster impeller for slipstream flow at the required extra head.

References

1. *API Standard 610*, "Centrifugal Pumps for Petroleum, Heavy Duty Chemical, and Gas Industry Services" Eighth Edition (August 1995).
2. S. Gopalakrishnan, *ASME 82-GT-277*, "Critical Speed in Centrifugal Pumps" (references the Lomakin Effect).
3. *Pumps and Systems Magazine*, "Low Flow Options" (September 1994).
4. United States Patent 5,599,164, "Centrifugal Process Pump with Booster Impeller" (February 4, 1997).

W.E. (Bill) Murray has more than 40 years of experience in the pump industry. He is President of Split Flow™, Inc. (281-565-6768), and is the inventor and U.S. Patent owner of the Split Flow innovation, which is licensed to various API pump manufacturers. He holds a Bachelor of Science degree in Mechanical Engineering from Lehigh University.

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