

1[■] The "Transmountain Pipeline" starts at Edmonton (CDN) and ends at the Pacific coast. It takes 196 hours for a batch of oil to transit the pipeline.

Pipeline Pumps:

Efficient and Reliable

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Important variables in the design of a pipeline system are energy efficiency, equipment reliability and throughput flexibility. Conventional pumps are not capable of operating at the highest attainable efficiency at capacities outside of the BEP (Best Efficiency Point). This deficiency has led to the design of a new pump, the HSD (Horizontal Split Diffuser).

■ The energy consumed by pumps represent a major portion of operation costs in the pipeline industry, especially if the pipelines are very long (Fig. 1[■]). The "Transmountain Pipeline" (see box) which leads across the Rocky Mountains from Edmonton (CDN) to Vancouver (CDN) uses about 15 kWh to transport 1 m³ of oil from the starting to the final point. Expressed in liters of crude oil as energy units, it takes 1 liter of crude oil to transport about 600 liters. Efficient pumping systems contribute to the profitable operation of this pipeline (Fig. 2[■]). Conventional centrifugal pipeline pumps are designed to operate satisfactorily only at one capacity, the

Best Efficiency Point (BEP). Outside of the BEP, pumping efficiency decreases, wasting energy. The wasted energy is transformed into vibration, noise and heat energy. Vibration and noise energy contribute to premature and unpredictable pump failures. In addition to reducing pipeline availability, replacement and repair costs have a direct impact on operating costs.

THE HSD PUMP

The Horizontal Split Diffuser (HSD) type pump of Sulzer Bingham Pumps Inc. is a single-stage, double-suction, volute/diffuser pump which can be fitted with a series of impeller-diffuser combinations in order to vary BEP

capacity and head over a selected range (Fig. 3[■]). A single model of this type of pump can be fitted with six to ten different impeller-diffuser combinations.

The impeller-diffuser combinations are equally divided into two groups: the low-head and the high-head. In pipeline terminology, the high-head is classified as 100% head pumps and the low-head as 75% head pumps. To minimize the number of components, the high-head and low-head impellers are made from the same casting. The low-head impeller has a smaller diameter than the high-head impeller.

The capacity range of the impeller-diffuser combinations is such that



2 The "Sumas Pump Station" – 60 km southeast of Vancouver – is one of the pump stations of the "Transmountain Pipeline". It uses HSD pumps, the new pumps of Sulzer Bingham.

the BEP of the low capacity combinations is 100% and of the high capacity combinations is 175%. The BEP of other impeller-diffuser combinations will be equally spaced between these two capacity values. The low capacity combination will cover the range down to 50% flow, while the high capacity combination will cover flows up to 220%.

DESIGNED FOR MAXIMUM CAPACITIES

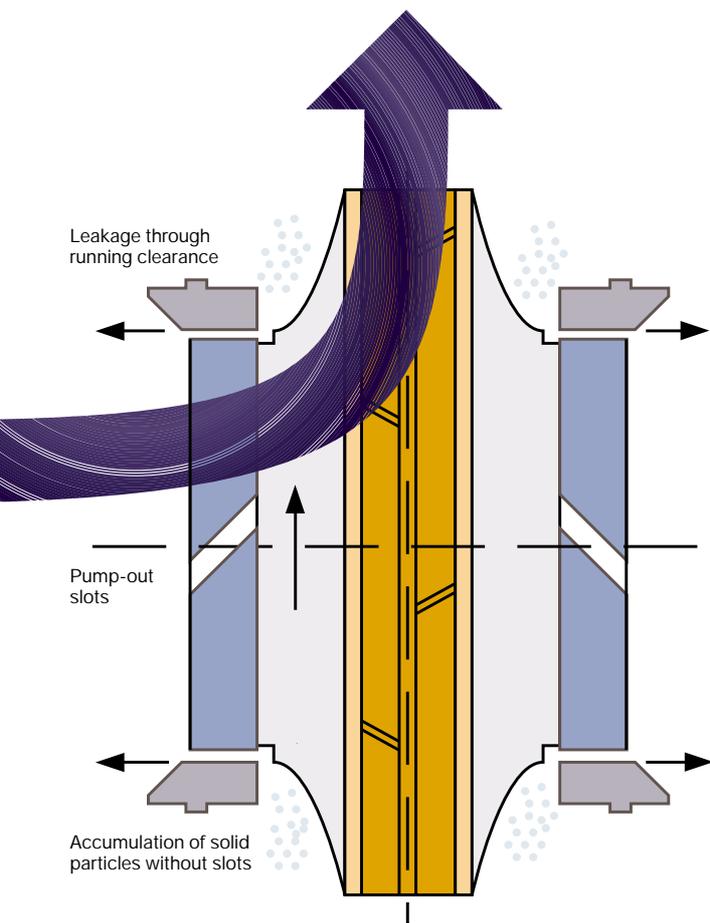
By selecting the proper impeller-diffuser combinations and the correct number of pumps, a pipeline system can be operated close to BEP capacity under most conditions, which results in significant energy cost savings. Pipeline pump sizes can vary from 750 kW to 3700 kW. Based on energy cost of 0.1 Canadian Dollar (CAD) per kilowatt hour, estimated potential savings are approximately 350 000 CAD per pump per year. Due to reduced vibration and noise, there will also be a reduction in pump component damage, which will improve pump reliability. The key hydraulic parameters of

the impellers and diffusers of the HSD pump have been carefully selected to provide high overall efficiency. This has been accomplished without sacrificing the hydraulic stability of the pump. Because the HSD pump is designed to handle a wide operating and product range, certain pump components, which are common to all the impeller-diffuser

combinations like the driver, mechanical seals, bearings, coupling, base plate and shaft, have to be designed for maximum capacities. Also the pump volute case is designed for the highest capacity and heads of the impeller-diffuser combinations it houses. This can only be economical if the larger capacity and head impeller-diffusers are used frequently.

3 HSD pumps inside "Sumas Pump Station": The HSD type pump is a single-stage, double-suction, volute/diffuser pump that can be fitted with a series of impeller-diffuser combinations.





4 Sectional drawing of the HSD pump: To prevent accumulation of solid particles between the casing and the impeller, the HSD pump incorporates pump-out slots on the impeller wear rings.

TRAMP SOLIDS

The liquids handled by certain pipelines contain high percentages of tramp abrasive solids. Although most of the solid particles entering the pump would flow out the discharge at BEP, some particles would inevitably migrate to the area between the impeller and pump casing. If the particles are larger than the radial clearance between the impeller and case wear rings, they would become trapped in this vicinity (Fig. 4[■]). Over time, the quantity of particles would increase, causing wear dam-

age to adjacent areas of the pump impeller and casing.

To prevent this, the HSD pump incorporates pump-out slots on the impeller wear rings. The slots are angled in a manner to provide easy sliding action to the particles with minimum resistance.

Initially, the internal recirculation of a pump with slots is higher than one without slots. This reduces the efficiency in the short range. But when the pumps are operated over a period of time, the efficiency reduction of the pump without the slots far exceeds the pumps with slots. Studies conducted on several pipelines have illustrated this. After a few years of operation, pumps without slots were found to have efficiency decreases of 4% in comparison to pumps with slots with a decrease of only 0.5%.

The mechanical seals in most pipeline pumps are cooled and lubricated by pumpage. Solids can accumulate in the stuffing boxes and cause wear damage. A replaceable sleeve made of hardened material is used in the HSD pump to minimize damage. The rotating throat sleeves also contains slots, similar to those used on the wear rings, to eliminate the accumulation of solids in the stuffing boxes. In addition, protective sleeves on either side of the impeller prevent wear damage to the pump shaft.



DIMINISH PRESSURE PULSATIONS

Pressure pulsations of specific frequencies and amplitudes are generated at the impeller discharge of a centrifugal pump. The amplitude of these pulsations must be minimized for smooth, trouble-free operation. Otherwise, high pump vibrations occur, causing premature failure of pump components. The impellers of the HSD pump generate very low levels of pres-

sure pulsations during operation. This is accomplished by staggering the discharge vanes of the two sides of the impeller to one another. As well, the vane at the impeller discharge has a twist of 20 to 30 degrees (Fig. 5[■]).

ADVANCED CONCEPTS

Although the HSD pump is a considerable improvement over the conventional centrifugal pump, there still remains room for design improvements. One area of potential improvement would be to replace the fixed vane diffuser with an adjustable one.

Such a design is based on the principle of changing the area ratio with changing capacity. The area ratio changes inversely with the specific speed of the pump, creating a variable specific speed pump. When this design is combined with a variable frequency drive, it maximizes pipeline flexibility to handle a variety of products and throughput rates at high efficiency and reliability with minimal downtime costs. Ω



5[■] A diffuser (left) and an impeller (right) of a HSD pump: The vanes at the impeller discharge have a twist of 20 to 30 degrees. This is one of the factors that facilitate smooth pump operation.

TRANSMOUNTAIN PIPELINE

The "Transmountain Pipeline" leads from Edmonton (CDN) across the Rocky Mountains to the Pacific coast. The terminals are near Vancouver (CDN) and Laurel (USA). The pipeline has a length of about 1250 km reaching from sea level to 1200 m above sea level. The maximum capacity is 52 800 m³ per day. The pipeline belongs to Trans Mountain Pipe Line Company Ltd., the American section to Trans Mountain Oil Pipe Line Corporation.

FOR MORE DETAILS

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