

Multi-stage slurry pump applications

Introduction

Over the past 30 years, financial and environmental pressures have contributed to increased use of transporting commodities through pipelines in slurry form. For many applications the multi-staging of centrifugal slurry pumps has a number of advantages over other pumping methods and should be considered whenever a slurry is transported by pipeline.

If the head required for a pipeline application is too high, a single centrifugal slurry pump is not always suitable. Wear may become a problem due to correspondingly high pump rotational speed. The developed head for a single pump is generally best up to 55m for coarse particle slurry, although heads up to 80m have been used for fine particle slurry.

It is sometimes necessary to use more than one pump 'in series'. The inlet of the second pump is connected to the outlet of the first pump. The same flow rate passes through each pump, but the heads generated by the two pumps are added together.

Multi-stage pumping refers to two or more pumps being used 'in series'. The high heads generated by multi-staging allow slurries to be pumped through long pipelines — typically up to 20 km in length.

This bulletin outlines some of the advantages of multi-staging centrifugal slurry pumps over other pumping methods. Typical design features of centrifugal high-pressure slurry pump are described and some aspects of pipeline application are discussed.

Two basic centrifugal pump arrangements may be used for pipeline transportation duties:

1. Low-pressure pumps spaced evenly along the pipeline.
2. High-pressure pumps multiple-staged at only one or a few stations.

Although arrangement (1) is commonly used, only arrangement (2) for high-pressure staged pumping will be considered here.



Figure 1. 8 stages of Warman®10/8 T-AHPP pumps on tailings disposal direct coupled at 740 r/min.



Figure 2. 4 stages Warman® 20/18 TU-AHP on tailings

Table 1 - Typical pump pressure ratings

TYPE	MAX ALLOWABLE WORKING PRESSURE (kPa)
AH	1,400 (rubber lined)
AHP	3,450 to 5,000 (rubber lined)
AHPP	4,100 to 6,890 (rubber lined) - (depends on pump size)
SRH	1,600 to 3,450 (depends on pump size)
HTP	3,450 (metal lined)
HTTP	5,500 (metal lined only)
HH	3,450 (metal lined only)
HP	6,900 (rubber lined)

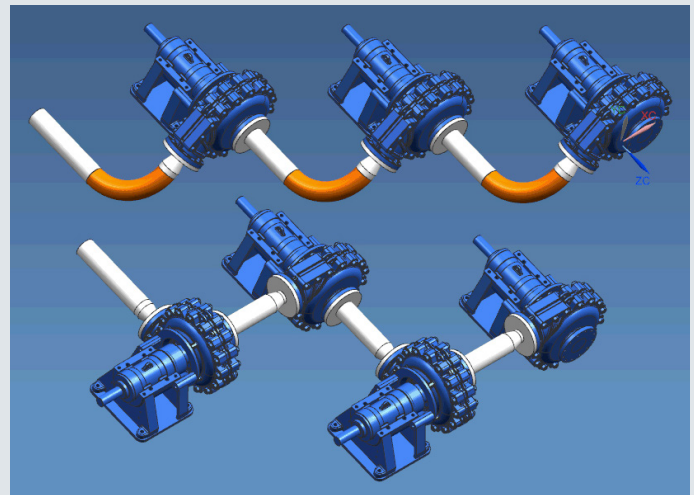


Figure 3. (a) parallel shafts and (b) right angle shafts

Advantages of centrifugal slurry pumps

Positive Displacement (PD) pumps, both piston and plunger type, are sometimes used for long distance pumping. For many applications multi-stage centrifugal slurry pumps offer advantages over PD pumps. The following gives some indication of these advantages.

- The ability to handle larger flow rates

High flow rates are often required for heterogeneous slurries, which need to be transported at sufficient velocity to avoid solids settling in the pipe. Centrifugal pumps can handle up to 7,000 m³/h at discharge pressures of 7,000 kPa. PD pumps generally need to be placed in parallel for flow rates greater than 1,000 m³/h.

- The ability to handle larger solids and viscous slurries

High pressure centrifugal pumps have handled run of mine coal with a top size of 150 mm and non-Newtonian slurries with slurry yield stress up to 200 Pa in some cases. There is a wide range of centrifugal pump impellers available (including high efficiency and flow inducer types) to suit the particular solids being pumped. PD pumps are typically limited to a maximum of minus 3 mm particle size.

- The ability to withstand high discharge pressures

This allows a large number of pumps to be located at a single station. Smoother pressure characteristics: Compared with centrifugal pumps, PD pumps have large cyclical pressure fluctuations requiring damping devices or accumulators to be installed on the pump or in the pipeline.

- Longer wear life

This is especially so with coarse, abrasive solids. Centrifugal pumps have in certain applications been run for approximately 5,000 hours before the replacement of any wearing parts.

- For certain applications large cost savings are possible

The capital cost of multiple staged centrifugal pumps and drives can be significantly less than for PD pumps when handling large flow rates. Also, when centrifugal pumps use more pumping stations than the PD pump alternative, thinner walled (and thus less costly) pipe can be utilised

as maximum station pressures are less. The use of high efficiency centrifugal pump impeller types further lowers the operating costs.

Design features of high pressure centrifugal pumps

Weir Minerals have different ranges of pumps, Warman® AH® centrifugal slurry pumps with modified casings are capable of withstanding high operating pressures. These are known as types AHP and AHPP. Warman® hydrotransport (HT) centrifugal slurry pumps also have high pressure pump types. These high-pressure pumps allow an increased number of pumps to be located at a single station. The following features ensure safe, reliable and economic operation.

- Encased liner design

This feature is essential for high-pressure slurry pumps. By designing the outer casing to support the inner liner and take all loads due to internal pressure, the liner can be utilised until it is completely worn out, rather than having to be replaced earlier because of insufficient strength. If the liner is worn through the outer casing will largely contain high-pressure leakage (only weep hole leakage being allowed). This is an important safety feature when handling abrasive and corrosive slurries. Additionally, liner replacement cost is significantly less because the liner does not require the strength (and thus the weight) of a single shell casing. Generally, all stages of a multi-stage installation would be of the same design so that the same components can be fitted to any pump or bearing assembly and thus interchangeable between stages and thereby minimising spares holding.

- Ability to interchange pump liners

This is a major benefit when selecting the most suitable material to resist abrasion. Hard white irons (Ultrachrome®A05, Hyperchrome®A61, to name a few) are generally the most abrasion resistant for coarse slurries. However, chrome / moly steels (A25) can be used when a less brittle material is required. Either natural or synthetic elastomers provide the best wear resistance when handling fine slurries. It should be noted that the use of elastomer liners is limited to the double wall pump types. Pumps need to be designed to prevent rubber liner extrusion around the casing joints under high pressure.



Figure 4. GEHO® positive displacement pumps used in a 245km long bauxite pipeline in parallel operation.

- Heavy duty pump bearings

These are required as the axial thrust in some stages of a multi-staged scheme may be of high value, due to the combined discharge pressures of the previous pumps acting over the shaft area (taken at the stuffing box). Bearings can be either grease or oil lubricated depending on the pump speed and the application.

- Ability to accept either packed gland or mechanical seal

High pressure packings are suitable for pressures of up to 7,000 kPa. Mechanical seals should only be considered for slurries with very fine particles and low solid concentrations. Single cartridge or double mechanical seals would be selected on the basis of pressure and application.

Pump station layout

Two basic layouts exist for arranging a number of pumps 'in series':

1. Parallel shafts (consecutive pumps side by side)
2. Right angle shafts (consecutive pumps at 90 degrees)

There are a number of advantages and disadvantages for each layout (Figure 3). Generally pump station size and configuration determines which arrangement is used. The "Parallel" layout allows access from the rear of the pump units. The arrangement is compact and all pumps can generally be left unsupported to take up small deflections

in pump casings. Wear in the inter-stage piping may be a problem with abrasive slurries.

The "Right Angle" layout has straight inter-stage piping, which normally provides good wear life. Straight inter-stage piping can also be designed to be telescoping which is an advantage for maintenance. Alternating pump units need to be raised, and discharges vary from top horizontal to bottom horizontal.

Conclusion

Pipeline transportation of mineral slurries is a viable alternative to other modes of transportation, especially when terrain is unsuitable for other methods. The demand for multi-staged centrifugal slurry pump and pipeline installations will only increase in the future as environmental pressures intensify and the need for more efficient, higher density and lower water usage slurry systems is required.

Weir Minerals centrifugal slurry pumps provide safe, reliable and economic operation when used in multistage applications. The continuing development of these types of pumps has resulted in greater customer choice and reduced ownership costs.