PROCESS SYSTEMS, Inc.
A Ruthman Company
Manufacturer of Deming® VTP

WHITE PAPER

Benefits of Thrust-Absorbing Designs for Vertical Turbine Pumps

Reduce cost, simplify installation, maximize operating efficiency and minimize downtime

When selecting a vertical turbine pump, the type of discharge head design chosen can make a critical difference in its capacity to manage the thrust loads inherent in vertical turbine pump operation. Failure to properly account for thrust loads can lead to increased wear, shortened pump component life, increased downtime and eventually, pump failure.

The majority of vertical turbine pump installations use a hollow shaft motor to manage thrust loads. A lesser-known method gaining more widespread adoption is the use of thrust-absorbing discharge head designs. These designs carry all the pump thrust loads, enabling the use of standard C-face motors. The combination results in lower initial and lifetime cost, easier installation and more efficient operation with fewer repairs.

Vertical Turbine Thrust Loads

Vertical turbine pumps create a large amount of vertical thrust. At startup, there is a brief period of upthrust as the motor gets up to speed and pressure builds up. After this momentary upthrust, the vertical thrust load then transitions to a very large continual downthrust force due to the difference in pressure surrounding the impellers.

Figure 1 diagrams the effect of pressure and thrust as the fluid flows through the pump. When the pump is started and fluid is drawn into the pump, this suction at the inlet draws the fluid through the impeller eye (blue arrows in Figure 1). Under normal operation, this upthrust, while a strong force, is very brief and dissipates once the pump gets up to operating speed.

As the impellers spin, fluid flows out of the vane openings, towards the discharge, creating downthrust (orange arrows). This pressure on the discharge side of the pump combines with the substantial pump rotor weight to create a downward thrust that acts toward the low-pressure suction side of the pump This thrust load is considerable and continues as long as the pump is operating.

In addition to these expected thrust loads, changes in operating conditions may cause thrust loads to vary. Pumps continuously operated at very high capacities will experience continual upthrust. Pumps that are used in processes involving loading or other periodic shutoff will experience very high downthrust loads when operated against closed valves. A pump can experience both upthrust

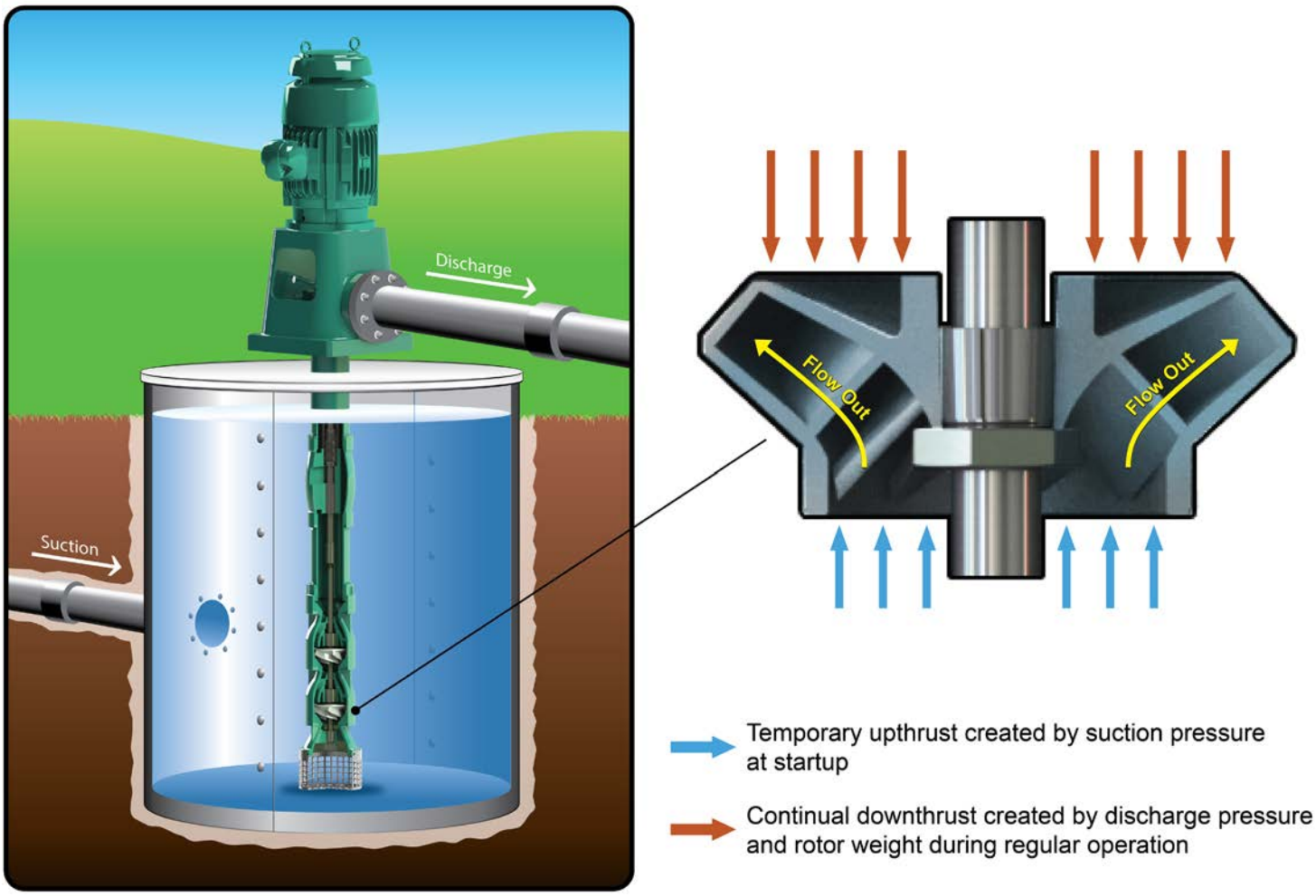

Figure 1. The effect of pressure and thrust as fluid flows through a vertical turbine pump.

and downthrust simultaneously. Both forces must be properly managed at all times.

When these thrust loads are not properly managed a host of problems can result:

- Motor radial bearing failure
- Thrust bearing failure
- Mechanical seal leakage
- Excessive shaft vibration
- Bearing spalling
- Impeller and bowl erosion
- Lineshaft buckling
- Increased vibration that wears on all components

Hollow Shaft Motors

Historically, vertical turbine pump thrust loads have been managed with the use of hollow shaft motors. These motors are fitted with special high load bearings able to withstand the thrust loads of the pump during operation.

While these designs are effective, hollow shaft motors require intricate machining and heavier bearings to carry the loads, which drive up the cost. Depending on the size of the motor, a hollow shaft motor may cost as much as 20% more than a comparable standard C-face motor. This factors into both initial pump cost and the cost of replacement motors.

In addition to increasing cost, this more involved manufacturing also extends lead time. Limited availability from a smaller number of specialty manufacturers further increases delivery time. This impacts not just the initial delivery of a new pump, but downtime waiting on a replacement in the event of failure in the field.

An additional drawback of hollow shaft motors is a more complicated installation process. During the installation of a pump using a hollow shaft motor, the pump shaft is locked to the motor sleeve in the field. At this time, the

shaft and impellers must be raised and properly adjusted to provide adequate clearances within the pump housings. Proper impeller clearances are absolutely crucial to safe and efficient pump operation.

Even in the best case scenario, improper impeller clearance adjustment causes significant damage. The continuum of negative outcomes starts with increased vibration that prematurely wears bearings (Figure 2). If the improper settings cause drag, the damage can be much more significant. Impellers that are set too low will drag on the bottom of the bowls and erode both the impellers and bowl casings. Impellers that are set too high will drag on the upper bowl casings.

Figure 2. Failed thrust bearing, caused by excessive radial loading.

Over time, this wear causes horsepower loading to increase, which can trip motor overload relays. In the worst case scenario, the drag can be significant enough to snap the shaft before tripping the motor overload.

Impeller adjustment requires skill and knowledge of the pump construction and operating conditions. Impeller type, construction material, operating temperature and other condition points all need to be accounted for to determine the minimum allowable clearance. Setting impeller clearances in the field increases the risk of damage.

Thrust Absorbing Discharge Designs

To answer these major drawbacks of hollow shaft motors, Process Systems, Inc. has developed exclusive discharge head designs to transfer the work of thrust load management from the motor to the head. These designs completely eliminate the need for a specialty motor.

PSI manufactures both the Process Systems brand of vertical turbine pumps for industrial use, and the NSF-certified range of Deming® VTP brand pumps used in municipal and water applications.

For the Process Systems pumps, PSI offers the Thrust Head discharge head design (Figure 3). This unique single casting design incorporates both the discharge head and thrust head in one piece. For the Deming VTPs, PSI offers the Hi-Thrust Base (Figure 4). The stand is inserted between the discharge head and motor, precisely aligned at the factory and bolted into place with rabbeted fits.

Both designs integrate a single thrust bearing capable of carrying the pump's thrust loads. With the thrust forces managed within the discharge head, these pump designs utilize a standard C-face motor.

The use of standard motors lowers initial pump investment and the cost of any replacements needed during the life of the pump. This also allows a much wider selection of off-the-shelf motors to speed initial delivery and minimize downtime waiting on replacement motors.

While slightly different in construction, these designs offer the same major advantages. With the all-in-one design of the Thrust Head and precise factory placement of the Hi-Thrust Base, concentricity of the entire

Figure 3. One piece Trust Head design available on Process Systems' Inc. vertical turbine pumps.

Figure 4. Hi-Thrust Base paired with discharge head on PSI-manufactured Deming® vertical turbine pumps.

assembly is assured, including the shaft and thrust bearing. This eliminates any possibility of misalignment during installation. Over the life of the pump, this concentricity limits vibration to improve pump operation and limit wear of pump coponents.

Figure 5. PSI VTPs with Thrust Head design installed at Detroit automotive plant.

The other significant installation benefit of this design is that with the thrust bearing located in the discharge head, rather than the motor, the impeller clearances are preset at the factory by knowledgeable technicians, rather than in the field at installation. This removes the risk of improper shaft adjustment resulting in the potential damage outlined above.

PSI's vertical turbine pumps with Thrust Head construction were chosen for this automotive plant's water test systems (Figure 5). The Thrust Heads manage the pumps' fluctuating thrust loads as the systems run through test cycles, simulating conditions from a light mist to torrential rain.

Conclusion

High thrust loads are an inevitable part of vertical turbine pump operation. Thrust-absorbing discharge head designs reduce initial and lifetime operating costs, speed pump delivery, assure proper motor to pump shaft alignment and concentricity, simplify installation and extend overall pump life.

Process Systems Inc. was founded in 1972 as a distributor of pumps and other process equipment. As a representative of several large vertical turbine pump companies, we found that general service pumps used in the automotive industry's severe duty applications required constant repairs and had significantly shortened pump life.

We knew we could do better for our customers. Applying the lessons learned from repair of these pumps, we manufactured the first Process Systems Vertical Turbine pump in 1978. These "tough breed" pumps have withstood the test of time, the true definition of a superior pump.

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