Is Twin-Screw Pump Suction Performance Better Than Centrifugal?

An Engineering Perspective

For a considerable length of time, the received wisdom in the pump industry was that twin-screw pumps had better suction performance when compared to centrifugal pumps. As time went on, this wisdom was challenged and researched in-depth to find out if it held true in today's industry. The examination concluded that, overall, this wisdom has little basis, except in a few cases.

By Simon Bradshaw, Engineering Director, CIRCOR Industrial Group Americas

Pump suction performance is known by such interchangeable terms as Net Positive Suction Head Required (NPSHr) or Net Positive Inlet Pressure Required (NPIPr). After examining the twin-screw pumps and centrifugal pumps in relation to suction, it has become apparent that the industry's 'common knowledge' does not have much of a foundation, save a few exceptions.

Calculating Suction

NPSHr performance can be difficult to compare between multiple pump types, unless the flow rate and rotational speed is normalized. An easy way to do this is by computing the Suction specific speed, or Nss, according to the formula below, where:

- **Nss =** Suction specific speed (US or Metric units)
- **N =** Pump rotational speed (RPM)
- **Q =** Pump flow rate (USGPM or m^3/h)
- **NPSHr =** Pump Net Positive Suction Head Required (ft or m of H_2O)

$$N_{ss} = \frac{N\sqrt{Q}}{NPSH_r^{0.75}}$$

This formula will create a (mostly) dimensionless number that can be used to compare pump performances. One thing to keep in mind when talking about Nss is that a higher number indicates a lower NPSHr, and therefore better suction performance. Nss can be expressed in US units (based on USGPM and ft) or in Metric units (based on m^3/h and m).

For centrifugal pumps, an average Nss value would equal approximately 8,000 in US units (9,294 metric in Metric units), for a pump that was not optimized for suction performance.

For a centrifugal pump that was optimized to minimize NPSHr, 11,000 to 14,000 in US units (12,780 to 16,265 in Metric units), would be readily achievable, although many would be artificially handicapped to the lower figure due to the overreliance on 37-year-old pump selection guidance.[1]

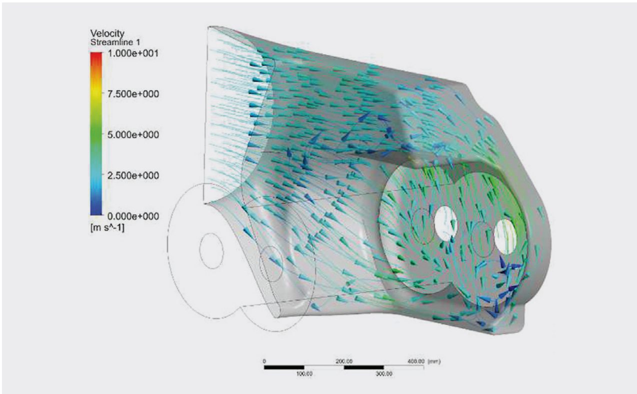

Figure 1.

Reviewing the Nss achieved by some major suppliers of twin-screw pumps on their tank stripping pumps, the following result appeared:

- **Supplier A Nss =** 3,758 to 12,602 in US units (4,366 to 14,641 Metric)
- **Supplier B Nss =** 4,476 to 11,345 in US units (5,200 to 13,180 Metric)

The higher Nss values are typically achieved on larger pumps. While they are generally competitive with centrifugal pumps, at least for low viscosity fluids, they are not aligned with the believed notion of being substantially better. So what is the origin of this belief?

Handling Gas

Sometimes, people will conflate NPSHr performance with the ability of a pump to handle large amounts of gas or vapor, or two-phase flow. However, these are two entirely different things. A standard centrifugal pump typically has only a modest ability to handle two-phase flow. The practical upper limit is approximately 5% gas.

In contrast, a standard twin-screw pump can handle in excess of 80% gas. The possible scenarios include:

GAS CONTENT	LOW NPSHr	APPLICATION
High	Not necessary	Multiphase pumping
Low	Critical	Vacuum bottoms
Possible in large volumes	Necessary	Tank unloading and stripping

Table 1.

It can be easily determined that the pump with the most universal applicability would be capable of delivering both really low NPSHr and robust gas handling. So how can manufacturers make a pump's suction power better?

Optimization

The answer in this case is to optimize and innovate. The manufacturers of twin-screw pumps have gradually started to use modern tools such as Computational Fluid Dynamics (CFD) modeling to optimize their products, but the progress can, at times, be considered slow. Looking at current twin-screw pumps versus those designed 30+ years ago, there is not be the same strong drive to optimize NPSHr performance that has been witnessed in centrifugal pump manufacturers.

When optimization occurs, it uses advanced suction geometry tools to determine how to feed fluid into the suction side of the pump in a way that minimizes the NPSHr, as seen in Figure 1.

Fortunately positive displacement technologies do exist that have been optimized in this way, including:

- Pumps specifically designed for tank unloading services requiring low NPSHr, capable of Nss values up 17,000 US (19,750 Metric) for the larger sizes.
- Pumps that utilize specific screw-to-casing geometry to deliver even better suction performance to yield Nss values of over 20,000 US (23,235 Metric).

This approach can be coupled with new smart systems that detect when damaging levels of cavitation are present in the pump and automatically find the highest flow rate the pump can deliver without risk of damage.

Final Thoughts

Gone are the days when operators had to rely on acoustic or vibration detection of cavitation, which required extensive fine tuning to match each pump, system and fluid. The new generation of smart systems use robust pressure sensing, allowing them to work with any system or fluid right out of the box. Combine all these technologies and there is finally a suction performance that matches the common knowledge learned in the industry.

Reference:

1. *Cowan, D., Bradshaw, S., Liebner, T., 2013, "Influence of Impeller Suction Specific Speed on Vibration Performance," Proceedings of the Twenty-Ninth International Pump Users Symposium*

About the Author

Simon Bradshaw is the Engineering Director for CIRCOR Industrial Group Americas in Monroe, North Carolina. His responsibilities include the design and execution of order related engineering activities for both pumps and valves. Prior to joining CIRCOR he worked for ITT Goulds Pumps, Sulzer Pumps and Weir Pumps, where he held various positions of engineering and contractual responsibility. Additionally, he has supported the Hydraulic Institute in the development of pump standards and best practice guides. Mr. Bradshaw has accumulated over 30 years in the pump industry. He attributes this to having never exhausted the fun inherent in moving fluid between two improbable locations. He holds a Mechanical Engineering degree from Heriot Watt University. He is also a registered Chartered Engineer in the United Kingdom and a member of the Institute of Engineering Designers.