Seal of Approval: Seal-Less Pumps Make Their Case

Design improvements enable EnviroGear® Seal-Less Internal Gear Pumps to deliver on the leak-free promise of sealless-pump technology costs

By Brian Sandore

INTRODUCTION

The stable of industrial pumping technologies welcomed a significant new addition around 30 years ago when pumps that could be termed, interchangeably, as seal-less, seal-free or leak-free were introduced to the chemical-processing market. Early iterations of seal-less pumps were required to perform one primary task: better prevent the leakage of hazardous materials than sealed pumps through a seal-less design. However, these first-generation seal-less pumps were not readily embraced in the beginning for two main reasons.

- Potential users were leery that the early seal-less designs could, in fact, live up to their leak-free promise
- Seal-less pumps were generally more expensive than their sealed counterparts

Faced with this conundrum, the early developers of seal-less pumps went back to the drawing board and began searching for ways to improve their products. The result was that by the turn of the 21st century, seal-less pump technology had evolved to the point that its claims of increased reliability and totally leak-free operation were no longer merely hyperbole.

The improved designed and operational capabilities of seal-less pumps also meshed at that time with a notable change in the mindset of the industrial-pump user. The change in thinking centered around the fact that pump users had become less willing, or capable, of dealing with seal failures than they were 30 years ago. This meant they became open to turning to leak-free pumps not just when they were handling hazardous materials, but also when handling basic liquids like water. The simple fact was that even a "nuisance" water leak would require the pump to be taken offline, which would result in expensive downtime and maintenance costs. The solution obvious solution in this case became turning to a seal-less pump that would never (theoretically) need to be maintained or repaired because of a leak incident.

With that mindset becoming increasingly embedded in the thinking of chemical processors and other industrial

manufacturers, the past 15 years have seen steady growth in the sale of seal-less pumps. In fact, today the global seal-less centrifugal pump market is valued in excess of $4.5 billion, while sales of seal-less ANSI centrifugal pumps have the potential to even exceed those of the sealed pump market in future years.

While the dominant technology for seal-less pumps in chemical-processing applications has been centrifugal pumps, this white paper will illustrate how seal-less internal gear pumps can be a first-choice alternative to traditional centrifugal pumps. Seal-less gear pumps can take product sealing to a new level of reliability while eliminating the unacceptably high ownership, maintenance and environmental costs that can hamper the performance of other sealless-pump designs.

CHALLENGE

Early seal-less pumps relied on the pumped product to lubricate the pump's bearings, with some of that product – which could contain hazardous or toxic materials, or volatile organic compounds (VOCs) – being introduced to the atmosphere, but that amount was so small (generally less than 500 ppm) that it was not considered a safety hazard. To eliminate any type of leakage, a secondary seal system was developed, but the secondary containment fluids required for this type of system could contaminate the product being pumped. Plus, the secondary fluids would have to be disposed of at some point, which created another headache for the plant operator.

So, with secondary containment an unacceptable solution to solving product leakage in seal-less pumps, no matter how miniscule, the ultimate challenge in creating a reliably operating seal-less gear pump was finding a way to optimize its overall design, especially as it concerned the makeup of its interior components.

Traditional seal-less gear pumps were designed with a cantilevered load where a large rotor gear is attached to the end of the pump shaft. The inherent shortcoming in this design is that as hydraulic force is applied to the rotor during pump operation extra pressure is put on the shaft and bearings. This pressure can cause shaft deflection and increased bearing wear, which in turn results in more rotor-to-casing or rotor-to-head contact wear. The operational result is reduced pressure and flow rate.

Additionally, the leakage that occurs in traditional seal-less pumps can result in two types of prohibitive costs for plant operators: maintenance and environmental.

The leading causes of high maintenance in seal-less pumps is wear that can damage the pump shaft by scoring it and making it more difficult to seal, and the premature wear of the bushings and close-fitting metal parts due to insufficient support of the pumping elements. There is also an environmental cost of leakage in terms of cleanup and potential local, state or federal fines that may need to be paid in extreme cases – as well as the often incalculable cost and reputational damage that bad press can result in.

The main point is that leaks cost money. It costs money to replace the raw materials that are lost. It costs money to replace the finished goods that are damaged. It costs money to pay a firm to clean up the spill. It costs money to dispose of the cleanup. It costs money in potential slip-and-fall hazards. It costs money to pay environmental-compliances fines and fees. And it costs money in lowered worker morale, or the need to replace workers who may choose to seek employment elsewhere.

Secondly, traditional seal-less gear pumps featured two fluid chambers – a hydraulic chamber where the gears work and a second chamber for the mag-drive coupling unit – that are joined together by a bracket, which also serves as a barrier between the two chambers. This complicated design requires that a portion of the material being pumped through the hydraulic chamber must be used to cool the magnets in the other chamber. These requirement results in a long, complicated pump with elongated, narrow flow paths and the need for more parts, which makes the pump more expensive and difficult to maintain, while limiting the viscosity of the liquids that can be pumped, as well as the types and sizes of solids that can be handled

THE SOLUTION

The approach to finding an ultimate solution to the seal-less gear pump quandary had to remove the word "seal-less" from the development process. When Henry Ford was going about inventing the car as we know it today, he did not start with a vision of how it should look. He just knew that he possessed the technology, know-how and components to create a motor vehicle and his task was to piece them together in a way that best utilized their benefits and features. The result was the Model T, which was the first affordable automobile, one that opened travel for middle-class Americans and set the standard for generations of automobiles to come.

So, when looking to create a gear pump that is affordable, controls leaks, and reduces maintenance costs and environmental concerns, the first step was to identify the areas where seal-less pumps fall short and look to improve on them. As mentioned, the No. 1 area where traditional seal-less pump operation is compromised is the bearings and how they interact with, and are affected by, the pump's cantilever load. The second step was to find a superior replacement for the two-fluid-chamber design that complicated the pump's operation and limited its fluid-handling range.

Taking these main concerns into account, and approaching the design process with an open mind, the result is the EnviroGear® Seal-Less Internal Gear Pump. The EnviroGear pump line is seal-less, not because its designers and engineers felt that it needed to be, but because its design enhancements led them to the conclusion that it would operate most effectively as a seal-less pump.

The pump's two major design enhancements, which overcome the long-time challenges of excessive bearing wear and a fluid-chamber design that complicates operation while at the same time limiting product range, set a new standard in safe, cost-effective and environmentally friendly sealless-pump design and operation. They are:

- **Between-the-Bearing Support System:** As opposed to the performance-robbing, one-sided support found in the cantilevered-load design that exists in traditional seal-less pumps, the EnviroGear pump supports the rotor and idler gears at three locations through the creation and incorporation of:
    - A patented **Eccentric Spindle** that is supported in the head, the crescent location and the back of the containment canister, eliminating much of the effects of cantilever load. In tests where 200 psi of pressure was applied to the rotor, there was only 0.005" of shaft deflection in the EnviroGear pump, compared to 0.056" of shaft deflection in a traditional seal-less pump, giving the EnviroGear 11 times less shaft deflection.
    - **Larger diameter materials** that provide more rigid support for less shaft deflection and bearing wear. For example, a traditional 3" seal-less pump will have a shaft that is 1-7/16" in diameter; the diameter of the EnviroGear eccentric spindle is 2".
    - **Large, long radial bushings** that support the entire length of the rotating element, which spreads out the hydraulic forces and allows the bushings to last longer. The bushings are also constructed of premium-grade carbon graphite that will last up to eight times longer than more common bushing materials.
- **One-Fluid-Chamber Design:** As noted earlier, traditional sealless-pump design features two fluid chambers that are separated by a bracket; this design creates operational deficiencies while limiting the types of fluids that can be handled. The EnviroGear design has only one fluid chamber with the pump's magnets placed on the back of the rotor and close-coupled, or "piggy-backed," on the rotor gear. This design gives the pump a much shorter, simpler flow path. It also allows the pump to easily handle viscosities in the 20,000 to 30,000 cPs range, and as high as 50,000 cPs, while still maintaining the ability to handle thin liquids like caustics and various solvents. These redesigned pumps can also pump liquids and slurries that contain solids.

A third feature that the EnviroGear pump offers is dimensional interchangeability. The pumps have been designed to be interchangeable with 95% of the other gear pumps that are currently available in the market. This means that a plant can be running a traditional sealed pump in the morning, have it pulled out in the afternoon and drop an EnviroGear seal-less pump into the footprint while reusing the same piping, gear box, motor and base plate, and still receiving the same hydraulic performance as what the previous pump was providing.

While the EnviroGear seal-less pump is designed to eliminate all of the operational concerns found in old-style seal-less gear pumps, its simple design – which consists of only seven primary parts: a magnet housing, containment canister, casing, rotor magnet assembly, idler gear, eccentric spindle and head – greatly reduces maintenance and environmental costs

CONCLUSION

In the end, the design of EnviroGear Seal-less Internal Gear Pumps makes it not a traditional seal-less pump, but, rather, an engineered solution for environmentally conscious fluid-handling that lowers maintenance costs and eliminates environmental costs. The result is a new family of seal-less gear pumps, one that does away with the operational shortcomings that helped stigmatize past seal-less-pump designs while remaining cost effective for the end user with a purchase price that is half that of traditional leak-free pumps. These pumps truly deliver on the promise that mag-drive seal-less pumps were prepared to offer the chemical-processing industry more than 30 years ago

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