



Whitepaper

Plunger Pumps and Crosshead Sealing Challenges

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Plunger pumps: a brief overview

A plunger pump is part of the positive displacement pump family, where one or more cylindrical plungers slides in and out of a bore to displace a fixed and constant volume of fluid. These pumps can also be known as reciprocating pumps. The plunger passes through a high pressure seal that allows the fluid to be contained (sealed) and forced through a discharge valve to achieve high pressure. This high pressure seal area is often referred to as the stuffing box. The movement of the plunger can be repeated several hundred times a minute, depending on the application.

The two main components of a typical plunger pumps are the power end and the liquid end, also known as the 'wet' end. The power end is responsible for converting the rotary movement of a drive motor into reciprocating plunger motion.

Plunger pumps can be employed in applications where pressures can reach 2,000bar, and indeed with specialist sealing elements, are able to perform regularly at over 3,000bar. Plunger pumps for these higher pressure ratings are also commonly referred to as Ultra High Pressure plunger pumps (UHP).

Plunger pumps vary in design to suit specific applications and most commonly consist of three or five plungers, known as Triplex and Quintuplex Pumps respectively.

FTL's introduction to plunger pump sealing solutions was at the high pressure sealing interface, but this expertise has since expanded to include the latest innovations in low pressure and crosshead sealing solutions.

Sealing Solutions for High Pressure Plunger Pumps



Figure 1: A cross-section representation of the sealing elements within a plunger pump

Typical applications

Sizes ranging from 8.5mm up to 140mm have been sealed successfully using FTL's range of sealing solutions. We recognise the variations in applications and, although we use common design influences for our solutions, we know that a single solution is rarely appropriate. Instead we take the time to fully understand the application and call upon existing solutions or tailor our design to provide optimum sealing performance to suit specific application parameters. Plunger pumps can be found in a wide range of sectors and applications, from industrial cleaning through to the handling of chemicals, hydrocarbons and abrasive slurries. The reliable high pressure performance of plunger pumps lends to uses in the oil and gas sector, including flushing, descaling and fracking.

Their versatility allows for the conveyance

of different flow rates and pressure levels, with design and material variations depending on chemical compatibility with media types.

FTL has three categories of wet end sealing solutions for plunger pumps - medium pressure (up to 450Bar), high pressure, (450 to 2000Bar), and ultra-high pressure (over 2000Bar).

Crosshead sealing

Effective sealing of the crosshead is of paramount importance to any plunger pump OEM, and end users across all the varied applications. The crosshead is the area of the plunger pump for which the sealing elements have two key responsibilities - keeping oil in the crankcase, and eliminating ingress of contaminant, including water, back into the crankcase.

SEAL TYPE	ADVANTAGE(S)	DISADVANTAGE(S)
All rubber seal	Easy installation in closed grooves	Limited to low speeds
Rubber fabric seal	Easy installation Improved wear	Limited to lower speeds Compression mould required
PUR seals	Lower friction	Limited compatability
Bellows	Cover crosshead area	Fatigue
PTFE seals	Low friction High running speeds Chemical compatibility	Open seal housing required Difficult installation
Rotary seals / Oil seals	Readily available	Not specifically designed for reciprocating applications

Table 1: Existing crosshead sealing solutions

Crosshead seals in traditional elastomers have been in FTL’s portfolio for many years. However, evolving technologies and the demand for faster running pumps, as well as changes in pump orientation from horizontal to vertical, have driven a need for a new innovative range of seals to meet these specific challenges.

Common problems and challenges

Similar to the variation in applications, the problems and challenges are also varied. Ultimately the performance and endurance of the pump is a primary challenge.

Within the crosshead area of a plunger pump, the most common seal failures occur because of a difficult combination comprising of high speed, pulsating pressure, misalignment and contamination. Contamination can also lead to surface damage of the running surface providing extra challenges to the seal. The purpose of the seal is to keep oil inside the crankcase and everything else out of the crankcase. Failure of the seal can lead to costly repairs due to cross contamination to the power end.

Increasing pump speeds and changes in the orientation of the plungers, i.e. vertical, both add to the challenges of the seal. Potentially with these changes we find ourselves with a combination of higher surface speed and the risk of reduced lubrication to the seal area. It is also the case that in vertical applications any leakage from the high pressure seal can collect around the Crosshead area with the increased potential for media ingress into the crankcase.

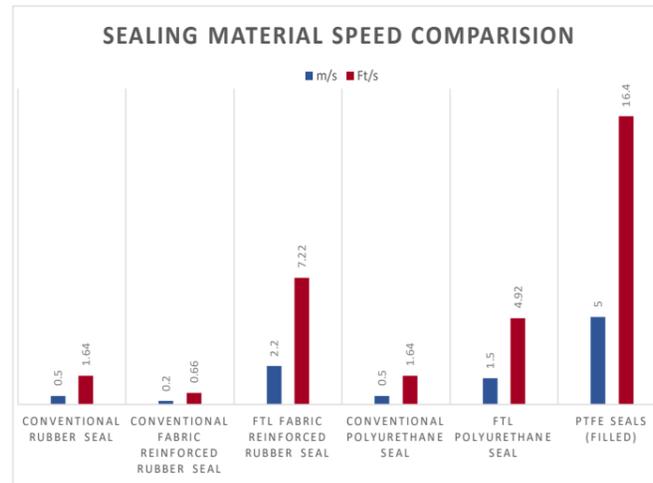


Figure 2: A visual comparison of sealing materials and speed

The running speed of the seal is always used to influence the material of the seal but the relationship between operating parameters, such as misalignment or runout, together with the running speed are further considered in concluding the seal design. It is important that the seal material satisfies the fundamental parameters, such as temperature and fluid compatibility, but it is the design of the seal, including seal geometry and pre-load that provide satisfactory performance during operation. Simply put, a seal made from the right material that doesn’t always maintain contact with the running surface will fail.

Crosshead seals, similar to most seals, rely on a film of oil between the seal and running surface to perform. Normally this film of oil passes beneath the seal without creating any accumulations. However, adding a wiper seal can adversely affect the film of oil and can detrimentally influence the performance of the seal. Continual development of materials and sealing geometry, supported by our in-house test facilities, ensure that the seal solutions performs under these challenging operating conditions.

Today, the repeatable, reliable first time performance of a plunger pump is now a base expectation, rather than a marker of exceptional engineering.

In today’s industrial landscape, there is a greatly increased level of technical demand on sealing systems, to keep up with the evolving nature of the work plunger pumps are being asked to do. As outlined earlier, the primary function of the seal is to provide a pressure drop from system pressure side to atmospheric pressure side to control leakage. However, the system side pressure is not constant. If a pump rotational speed of 300rpm exists, then the seal is subject to a potential pressure pulse 300 times per minute (five times per second). This represents a totally different kind of sealing challenge to those experienced within a purely hydraulic system.

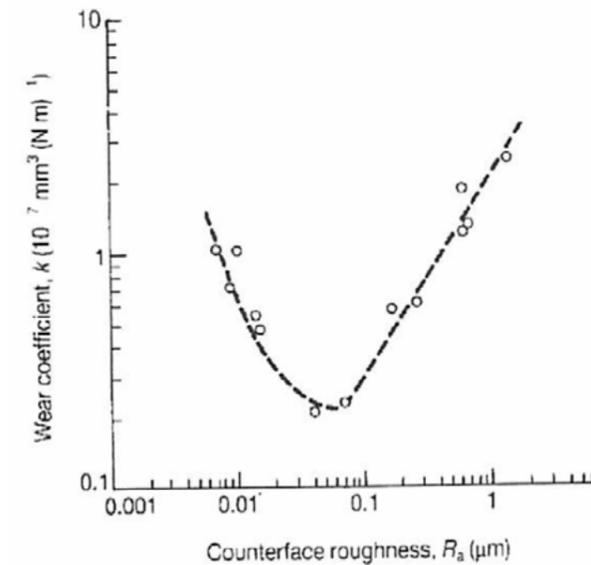


Figure 3: Graph depicting relationship between surface finish and seal wear.

Innovative solutions

Having the inhouse capability in order to validate the changes in material formulas and seal geometry has allowed FTL to push the operating capabilities, in terms of running speeds, above the limits normally associated with the base materials.

In house testing allows for proof of concept, validation and endurance testing to be completed under simulated real world conditions but our repeatability capability facilities benchmark testing and allows accurate comparison during changes to the sealing solution.

We know from experience that there is a relationship between surface finish and how this impacts seal wear, leakage rates and friction (see Figure 3). We also know that the surface texture of running surface during the life of the pump is likely to change and we need to be mindful as to how this will impact on the performance of the seal. Testing alternative running surface materials and surface textures provides both valuable data about seal performance but also reassurance that our sealing solutions are optimised to suit our customers applications.

Conclusion

To ensure reliable peak performance, plunger pumps require regular attention from sealing specialists capable of finding the right solutions to highly specified problems. Within a plunger pump, there are unique demands placed on the high and ultra-high pressure sealing elements, low pressure seals (also known as bypass, or wash-off seals), and crosshead seals - all of which are dependent on

the application, industry sector and operational conditions of the plunger pump.

Investment in specialist equipment for dynamic analysis of seals provides a wealth of relevant benchmark testing and the opportunity for critical operational performance. This, alongside innovation focused on materials, surface finishes and seal profiles, can give our engineers the knowledge they need to make the correct recommendations at the right time. This degree of support allows plunger pump OEMs and end users the opportunity to increase crosshead seal life, reduce equipment downtime, and optimise both the performance and cost efficiencies of their pumps.

In the case of plunger pumps, which are deployable in a wide range of applications, there is no 'one size fits all' sealing solution. The key starting point is finding a specialist sealing engineer able to work around the unique individual requirements of each pump. Through a well-defined consultation process comes the development of a tailored bespoke sealing solution, and the delivery of significant benefits through the lifetime of the pump.

To discuss challenges facing your array of plunger pumps with a specialist sealing engineer, consult Darren Thomas at 0113 252 1061.



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