Careful consideration of pump dynamics during design produces reciprocating plunger pumps with higher reliability and longer life

Ruhrpumpen

Ruhrpumpen is a global supplier of innovative centrifugal and reciprocating pump solutions for the oil and gas, petrochemical, chemical, process, industrial, water, power and mining markets.

Pumps are designed and manufactured to the most demanding quality standards and industry specifications, including API, ANSI, ISO and Hydraulic Institute Standards. When a standard pump is not suitable for a challenging application or duty, Ruhrpumpen engineers will design and manufacture a bespoke pumping solution, drawing on the company's breadth and depth of skills, expertise and technology. Quality is managed and controlled through the company's own integrated foundries, machine shops, service centres, and manufacturing plants located around the world.

Reciprocating Plunger Pumps

The Ruhrpumpen RDP series of high-quality triplex and quintuplex reciprocating plunger pumps are designed in the United Kingdom and used for high-pressure duties across the oil and gas, petrochemical, process, industrial and mining markets where low leakage, high reliability and reduced running noise are paramount.

The pumps fully meet API 674 3rd edition and ISO13710, and can handle pressures up to 1,000 bar (14,500 psi) at temperatures between -40C (-104°F) and 200C (392°F). Bespoke pumps can be engineered to meet customer specific requirements and duties.

Ruhrpumpen has designed its reciprocating plunger pumps for a wide range of applications and through careful consideration of the pump dynamics has reduced noise, vibration and reliability issues that are often associated with these type of pumps

Reciprocating plunger pumps move the fluid through the action of plungers pushing the fluid as they pass along the cylinders. The plungers are driven from a crankshaft and are attached to this via connecting rods. As the plungers move through their stroke they accelerate creating a pressure wave within the liquid that stimulates flow (see Figure 1).

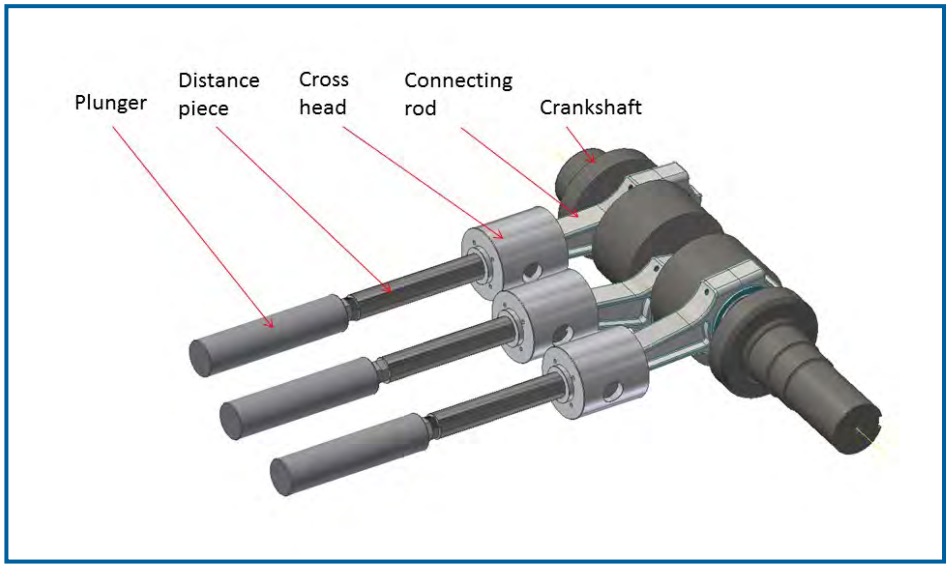

Figure 1 - Internal components of a reciprocating plunger pump

Acceleration and connecting rod length to stroke ratio

When a reciprocating plunger pump is designed, the engineer can vary the relationship between the connecting rod length and the crank diameter to deliver the required duty. If a short connecting rod is attached to a crank this will produce a compact design but the plungers will undergo high acceleration peaks. This creates large dynamic forces in the system which is transmitted as "pulses" through the pump and the surrounding pipework and plant which can result in increased noise, vibration and wear of the pump adding to the maintenance requirements. High plunger acceleration also causes lower pressure troughs potentially causing cavitation which can lead to further wear in the plungers, cylinders and seals and ultimately premature failure of the pump.

Conversely if a long connecting rod is attached to a crank then up to a point this can reduce the intensity of the "pulses". However, there are usually practical issues regarding how long the connecting rod can be for a pump as many have to fit within in a defined footprint, which in some applications, such as on an oil platform for example, can be particularly compact.

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RUHRPUMPEN
Specialist for Pumping Technology

Traditionally “designed to fit”

Many reciprocating pumps from other manufacturers are simply designed to fit within a footprint and the relationship of connecting rod length to crank is basically set to keep the maximum angle between the connecting rod and the plane of the plunger (the crosshead angle) within a given parameter, such as ±10 degrees.

The consequence is a pump that is not optimised resulting in a higher plunger acceleration than necessary which may lead to increased levels of noise, vibration and wear than could be achieved through a more optimised design. In addition, the higher than necessary dynamic forces would be transmitted into the connecting pipework and plant, which over time could be detrimental to the overall system.

Determining optimum ratios

Going back to first principles, Ruhrpumpen developed a mathematical model for position, velocity and acceleration of the plunger with respect to time and found that, contrary to expectations, the optimum acceleration curve of the plungers is not simply in a linear relationship to the length of connecting rod and crank ratio. As the connecting rod / crank ratio increases the acceleration of the plungers reaches a minimum value before starting to increase again. Using this information, Ruhrpumpen has been able to configure all of its reciprocating plunger pumps with the optimum connecting rod length to stroke ratio for a given duty (see Figure 2).

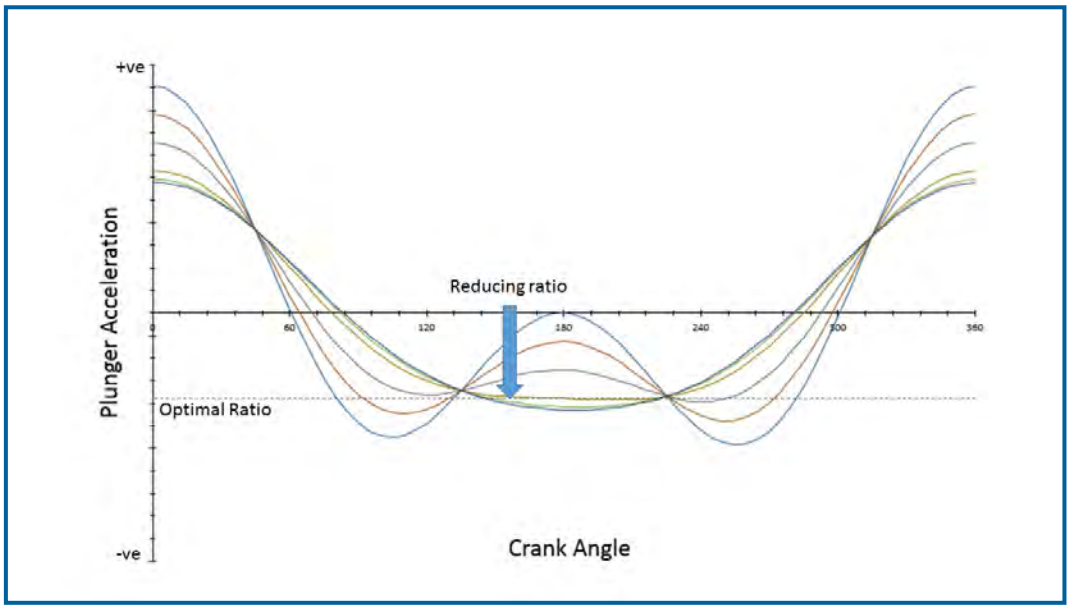

Figure 2 - Effect of stroke to connecting rod length ratio

Summary

When designing a reciprocating plunger pump for a given duty, Ruhrpumpen uses the model it has developed to carefully analyse the relationship between connecting rod length and stroke to find the optimum ratio for minimum acceleration of the plungers. This ensures that a Ruhrpumpen reciprocating plunger pump will always have the lowest levels of noise and vibration possible, reducing wear of the pump components and minimising cavitation of the fluid, leading to reduced maintenance requirements and a longer pump life.

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