Understanding pigging and pigging valves

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This particle starts with a short overview about why pigging of pipelines is done as well as discussing the different types of scrapers and spheres and how they are used (i.e. drying, cleaning, separation, gauging, inspection etc.) Afterwards a general overview is given about different methods of launching and receiving pigs in high pressure pipeline systems. The pros and cons of pig trap installation in comparison to the pros and cons of special valves are then presented. The next section presents and discusses different types of so-called high pressure pig valves which are currently available. The discussion will be focussed on safe operation and handling of these special valves.

Finally, examples of field installations are presented.

Note: This paper focusses on high pressure pigging systems as found in the oil and gas industry. Additional methods are available, especially for low pressure applications.

The first pigging operations in the oil and gas industry were undertaken at the end of the 19th century in the USA. In those days the main purpose of the pigging operation was to maintain the capacity of production flow lines.

Without any maintenance the diameter of the pipeline will decrease, due to solids such as minerals or paraffin which settle at the wall of the pipeline. The settlement of solids will cause a reduction of the inner diameter of the pipeline which can be prevented if scraper pigs will be sent frequently through the pipeline. Such a scraper pig will remove the solids from the wall of the pipeline.

Today pigging is used for the following operations:

- Cleaning
- Calibration
- Draining / Drying
- Inspection
- Internal Cladding
- Separation
- Batching

Types of pigs

Depending on the purpose of the pigging job, different types of pigs may be used. Cylindrical pigs of different materials and with a lot of different shapes are used for all the above mentioned jobs. The short cylindrical cup pigs are mainly used for cleaning and sometimes for separation purposes. Spherical pigs are more or less used for separation purposes. However, there are special spherical pigs which are used for cleaning as well.

Beside the above-mentioned pigs, many different kinds of cylindrical foam pigs are used for a wide range of applications. Furthermore, so-called 'intelligent' pigs are used to inspect pipelines. Intelligent pigs are cylindrical pigs, typically with a length that is at least twice the nominal diameter (D). These pigs are available for various different tasks such as:

- Leak detection
- Surface crack detection
- Examination of internal shape
- Check of wall thickness

For more information about pigs please visit the website of the pig manufacturers.

Pig trap versus pig valve

A standard method to launch to receive a pig is a pig trap installation. A scheme of how piging is done using a pig trap installation is shown in Figure 1. Such an installation requires a lot of valves and further equipment. The advantage of a pig trap installation is the fact that it may handly longer pigs as well. On the other hand a pig trap installation is a complex system. It needs some space, is quite expensive and not very easy to operate. The integration of a pig trap into an already existing pipeline may become a demanding exercise. Undre these points of view, it is worth considering other possibilities to get

a pig in to or out of the pipeline. Alternatives to a pig trap installation are so called pig valves. Via these special valves pigs can easily be launched and received. How simple such an installation may be is shown in Figure 2. Instead of all the various components which are necessary for a pig trap installation, just two pig valves are required to do the job. However, a pig valve can only handle spheres or short cylindrical. pigs. The allowable length of these short cylindrical pigs depends on the individual design of the pig valve. Typically, valves are able to take 1 D or 1.4 D pigs. Special designs will allow a length of up to 2.2 D.

High pressure pig valves

In fact, a pig valve is a modification of a quarter-turn shut-off valve, i.e. a shut-off valve where the closure member needs to be turned by 90^0 from its open to its closed position. However, for a safe operation a pig valve needs to have needs to some features which are not necessarily included in shut-off valve designs.

Necessary features

Figure 4 shows a typical sketch of a pig valve which is based on a top-entry shut-off ball valve. Pig valve should have the following featues/ accessories:

- A pig trap closure perpendicular to the axis of the pipeline. Most common design: Quick opening closure.
- The ability to isolate the cavity or the pig trap of the valve from the pipeline at least if the valve is closed. Without this feature it is not possible to depressurise the cavity and to open the trap door.
- A very reliable ball to seat seal. When opening the trap closure, the seat to ball seal is the only isolation against the line pressure.
- A drain port to depressurise the cavity or pig trap
- A safety locking device or a pressure warning device which will ensure, that the trap closure will never be opened with pressure being still in the cavity.
- A stop device, which will catch the pig at the receiver valve.

Safety locking device

As per PED (AD-2000) and ASME Boiler and Pressure Vessel Code, quick opening closures shall be equipped with a pressure warning device or a safety locking mechanism. This safety device has to fulfil the following:

- Opening of the closure is only possible after the safety device has been opened.
- The safety device can only be closed, if the closure is fully closed as well.
- With the safety device being closed it shall be impossible to close the closure.
- An example of a safety locking device which fulfils these requirements is shown in Figure 5.

How to operate a pig valve

The sequence of how to launch and to receive pigs by using a pig valve is as follows:

- The pig valve will be closed.
- The cavity of the pig valve will be drained and depressurised by opening the drain device.
- After having disengaged the pressure warning device or the safety locking mechanism, the trap closure may be opened.
- Now the pig will be inserted into the bore of the closure member with its rear part first.
- The closure will be closed.
- The pressure warning device or the safety locking mechanism will be engaged.
- The drain will be closed.
- The closure member will be turned into its open position, so that the flow will take along the pig.
- At the receiver valve the pig will be caught by a stopping device at the end of the bore of the closure member.
- After having turned the closing member in its closed position, the pig can be removed from the valve by implementing the above procedure in reverse order.

Types of high pressure pig valves

The majority of all available pig valves are ball valves. There used to be a manufacturer who produced high pressure pig valves with a cylindrical plug and a rising stem. However, this product is no longer mentioned at the menufacturer's website.

Pig valves which are based on the ball valve design are available as top-entry or split-body designs combined either with a floating or a trunnion-mounted ball. A cross-section of a top-entry pig valve with a trunnion-mounted ball is shown in Figure 4. Another important factor for the design of a pig valve is the maximum length of pig which can be handled

by the valve as well as th fact whether the inner diameter of the ball shall be considerably larger then the inner diameter of the end connection. The outer diameter of the ball of a pig valve for cylindrical pigs with a length of 1.4 D and a considerable enlargements of the inner diameter of the ball will be much lager (see Figure 3) than the outer diameter of ball which can take only spheres and does not have an enlargement (see Figure 8, standard ball type). Consequently the whole valve will be smaller for the latter as well. The different basic designs described above can in theory be further modified according to the specific purpose of each pig valve, namely standard, bypass or separation.

Standard type

A standard high pressure pig valve is shown in Figure 5. In order to allow a certain flow across the arrived pig in the receiver valve, the cross-sectional area of the bore of the ball is approximately 25% larger than that of the end connection of the valve. The advantages of such an enlargement are the following:

- The flow is not totally stopped when the pig has arrived.
- Debris is flushed out of the valve into a slag catcher.

Bypass type

The standard type acts as a shut-off valve if is closed. Consequently, every time a pig has to be brought into the pipeline or removed from the pipeline, the flow will be totally stopped. However, there are processes where it is unacceptable to stop the flow simply to get a pig in to or out of a pipeline. In such cases the bypass type will solve the problem. In open position there are no differences between the standard type and bypass type, but in the closed position the flow will not be stopped totally. This is eithere achieved by channels integrated in the ball as shown in figure 6 or by special seat to ball seals, which are located in line with the axis of the pig trap. Therefore they isolate the pig from the pipeline without stopping the flow.

Separation type

The separation type is a special modification of the standard type. In order to prevent a mixture between the media in front and behind the separation pig, the pig has to stop totally the flow, once it has arrived in the receiver valve. This will be achieved by a sealing bevel in the closure member as shown in Figure 7. The position of the sealing bevel depends on the shape of the pig. If cylindrical separation pigs are used, that sealing bevel has to be very closed to the stop device.

How to select a pig valve

When selecting a pig valve first of all the pigging operation should be analysed in order to determine whether a standard, bypass or separation type should be used. The type (sphere or cylindrical) and length of the selected pig as well as the question whether a bore enlargement of the ball is necessary, will determine whether a standard ball type pig valve may be used or not. The need for a trunnion-mounted ball may also be answered by the pervious question, as the available pig valves for cylindrical pigs with a length of 1.4D pig valves always have a trunnion supported ball. If not, the decision regarding this issue depends on the size and pressure class of the valve in question or on general considerations.

The question of whether a top-entry design is preferable should be based on the operation conditions, keeping in mind that a tight seat to ball seal is very important for a safe operation of a pig valve. A refurbishment of the seal to ball seal is much easier when using a top entry design.

A very important factor for the selection of a specific design should be the safety level of the quick opening closure. If the available products are compared regarding this issue, it is obvious that there are considerable differences regarding the safety levels of the offered quick opening closures.

Especially when using larger sizes (the largest pig valve built so far is 30" class 600) the weight of the used pigs will reach a level such that cannot be handled manually. In such a case it is important to select a manufacturer who is able to equip the pig valve with the necessary pig handling devices.

Summary

For many pigging applications, pig valves are a good alternative to pig trap installations. Where only short cylindrical pigs or spheres are needed, pig valves are an easy to use method to launch and to receive pigs. Since pig valves are only a little larger than ordinary shut-off valves, they are predominated used where space is limited. This is one of the reasons that pig valves are increasingly being used on offshore installations such as FPSOs. Even in vertical lines, pig valves may be used without any problems provided some minor modification are made.

Another field of application includes flow lines for oil and gas production, where frequent pigging operation will maintain the original inner diameter of the production flow line or will prevent corrosion caused by media trapped in certain sections of the flow line.