

Pipelines: A Lifeline To The Fertilizer Industry



T.G. Krishnan,
Global Conveyor
Systems Pvt Ltd., India,
explains the crucial role
pipelines perform in
fertilizer plants.

In the fertilizer industry, pipelines are commonly used for transportation of fluids, such as acids and slurry, as well as natural gas. Each pipe has stub ends and mild steel (MS) flanges that connect to subsequent pipe sections. The size of the pipe is driven by the quantity of material to be moved, whereas the material of the pipe is driven by the type of fluids that are being transported. Hydrochloric acid, phosphoric acid, and slurry are key raw materials for the manufacture of various fertilizers such as NPK/APS/diammonium phosphate (DAP) and phosphogypsum.

Types of pipelines

In the fertilizer industry, pipes must be made from a material that has abrasion resistance, corrosion resistance, high strength and ductility. The pipes should be easy to handle and cost-effective for operation and maintenance. Mild steel rubber lagged (MSRL) pipes are commonly used in fertilizer plants. These pipes are rubber-lined on the inside surface to provide abrasion and corrosion resistance. The external surface is coated with rust-proof paint to provide corrosion resistance. They are available in sizes ranging from 0.125 in. to 20 in. internal diameter.



Scaling inside a MSRL Pipe

Figure 1. Scaling inside a MSRL pipe.



HPPE Pipe

Figure 2. HPPE pipe.



Figure 3. Scaling comparison between HPPE and MSRL pipe.

Stainless steel (SS316L) pipes are much more corrosion-resistant than MSRL pipes. However, they are expensive and used only in certain critical applications. They are available in sizes ranging from 2 in. to 20 in. internal diameter.

Pipes made with polymers such as high-density polyethylene (HDPE) overcome the problem of corrosion and are commonly available in sizes of 2 in. and above. However, HDPE pipes pose problems with material build-up (scaling) and joint failures.

Chlorinated polyvinyl chloride (CPVC) is a strong and rigid thermoplastic material. CPVC pipes are available in sizes ranging from 0.25 in. to 12 in. but are generally used for lighter applications such as carrying hot and cold water in residential constructions. CPVC has been trialed for the transportation of fluids in the fertilizer industry but challenges with cracking and joint failures have arisen.

Challenges

The major reasons for failure of pipelines are material weld joint failure and corrosion. An additional challenge in fertilizer applications is build-up of materials inside the pipe, which is known as scaling.

Corrosion

Corrosion can affect the pipeline both internally and externally. For steel pipes, external protection is provided using surface treatments. The internal surface is

protected by either rubber lining or by mixing some chemicals into the slurry. However, higher abrasion of the material conveyed eventually wears the rubber lining and exposes the metal surface. The external surface needs frequent re-treatment due to exposure to the atmosphere. Frequent maintenance of both internal and external surfaces of the pipes leads to higher costs and reduced downtime.

Scaling

Scaling is the deposition of solid minerals on the inner surface of the pipes (Figure 1). Scaling is a common problem in the transportation of phosphoric acid and slurry. Phosphoric acid is the main raw material for the manufacture of fertilizers such as DAP/monoammonium phosphate (MAP)/superphosphoric acid (SPA). Phosphoric acid is produced by mixing rock phosphate with sulfuric acid in a reactor, which generates a by-product – calcium sulfate, also commonly known as gypsum. Gypsum is a crystalline substance that sticks to the inner surface of the pipeline and gradually forms a hard crust, restricting the flow of the fluids.

It is a challenging task to remove or clean the gypsum scaling. The process involves brute force hammering of pipes, which can cause dents, thereby changing the shape and flow rate. This problem is common in MSRL and SS pipes.

Slurry is a mixture of liquid ammonia, phosphoric acid, scrubber liquor, dry powder of potash, urea and silica sand for the manufacture of NPK and DAP.

The flow of the slurry mixture through the pipes leaves a residue that builds up over time and restricts the flow rate.

Joint failure

The stub end of the pipe, which connects to other pipes or fittings, is generally a weak area of the pipeline. Stub end failure is common in HDPE pipes, as the joint is formed by a fusion or butt-welding process using a heating plate. This process causes scaling at the joint. Furthermore, the joint is weak and prone to getting detached due to surge load and hammering during the cleaning process.

For CPVC pipes, the stub joint is formed using cold PVC cement. This is also a weak joint, resulting in detachment due to surge loads and hammering.

Polymer pipes

Polymer pipes have the advantage of being non-corrosive compared to MSRL and SS pipes.

HDPE is a commercially available polymer in the market that addresses corrosion. However, scaling is still a concern when using HDPE pipes. The molecular weight of HDPE is very low (0.2 to 0.5 million gm/mol), and due to this, the surface finish is rough, allowing material to stick, leading to scaling.

The new polymer pipe

To overcome the drawbacks of outdated steel and polymer pipes, Global Conveyor Systems has introduced a polymer called HPPE™ (High Performance Poly Ethylene).

HPPE has a molecular weight of over 6 million gms/mol that provides a smooth pipe surface, preventing any build-up or scaling.

The smooth surface of HPPE pipes also provides a coefficient of friction of 0.2, compared to 0.3 for HDPE and 0.58 for steel, which assures a high flow rate.

The stubbing of these pipes uses a process whereby the stub end is an integral part of the pipe and provides a strong joint.

Properties

Properties of HPPE include:

- Light in weight, which reduces installation, handling and transportation costs.
- Molecular weight of over 6 million gm/mol that prevents scaling.
- It is non-corrosive, which eliminates rubber lining and rust-free painting processes.
- Ease of cleaning with standard commercial pressure washers.
- High wear resistance.
- High chemical resistance.
- High stub jointing.

Installation

Table 1. Comparison of physical properties of HPPE/HDPE/MSRL pipes.

Properties	HPPE	HDPE	MSRL
Molecular weight	6.8 million gms/mol	0.3 million gms/mol	NA
Surface finish	Very smooth	Rough	Rough
Rubber lagging	Not required	Not required	Required
Weight	Light	Light	Heavy
Temperature	Maximum 80 °C	Maximum 80 °C	No limit
Coefficient of linear thermal expansion	1.5	1.2	0.17
Coefficient of friction	0.2	0.3	0.58
Corrosion	No	No	Yes
Scaling	Negligible	Sticks to inner surface	Sticks to inner surface
Wear resistance	Extremely high due to high mol. Wt.	Very low due to low mol. Wt.	Very low due to low mol Wt. of rubber lining
Material flow	Zero scaling, uninterrupted flow, no drop in pumping efficiency, improved productivity	Scaling due to rough surface, reduced flow rate, cleaning process takes longer affecting productivity	Scaling due to rough surface, reduced flow rate, cleaning process takes longer affecting productivity

Global HPPE pipe has been successfully installed at multiple fertilizer plants producing phosphoric acid, NPK, MAP, urea, DAP, and ASP (Figure 2).

The performance of the pipes can be seen in Figure 3. The HPPE and MSRL pipes were opened for observation after three months. The former showed minimal scaling, whereas the MSRL pipe had significant material build-up and blockage.

Conclusion

Pipelines are one of the most economical ways to transport various materials in fertilizer plants. The maintenance department expects minimal downtime of these pipelines to improve productivity and reduce costs. There are many options such as MSRL, SS, and HDPE. However, each of them has their own drawbacks with regards to corrosion, scaling, and joint failures. The use of HPPE pipes can solve these problems and offer a lower total cost of ownership (Table 1). Pipelines are the true lifelines of fertilizer plants and it is crucial that this lifeline is never interrupted.

WF

Bibliography

- World Bank Group, 'Pollution Prevention and Abatement Handbook, Phosphate Fertilizer Plants', https://www.ifc.org/wps/wcm/connect/28a855d4-26ba-4fca-bd59-e0465698f5ed/phosfer_PPAH.pdf?MOD=AJPERES&CVID=jqevOOQ
- ANG, H.M., MURYANTO, S., and HOANG, T., 'Gypsum scale formation control in pipe flow systems', *Gypsum: Properties, Production and Applications* (2011), pp. 1 – 33.