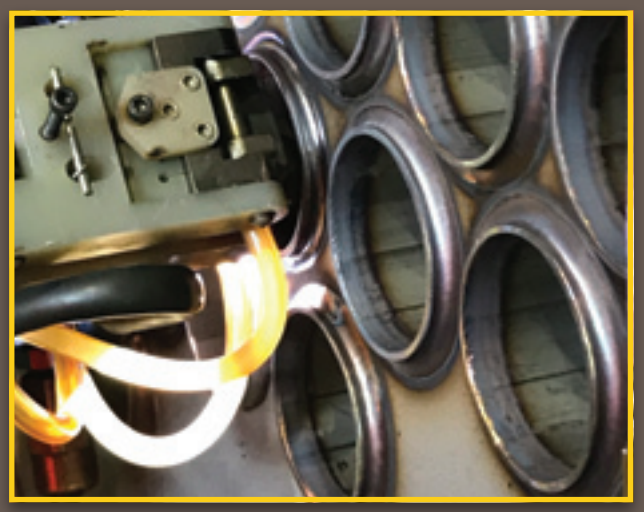
COVERING BEST PRACTICES FOR THE INDUSTRY

Sulfuric Acid TODAY

www.H_2SO_4Today.com

Spring/Summer 2020

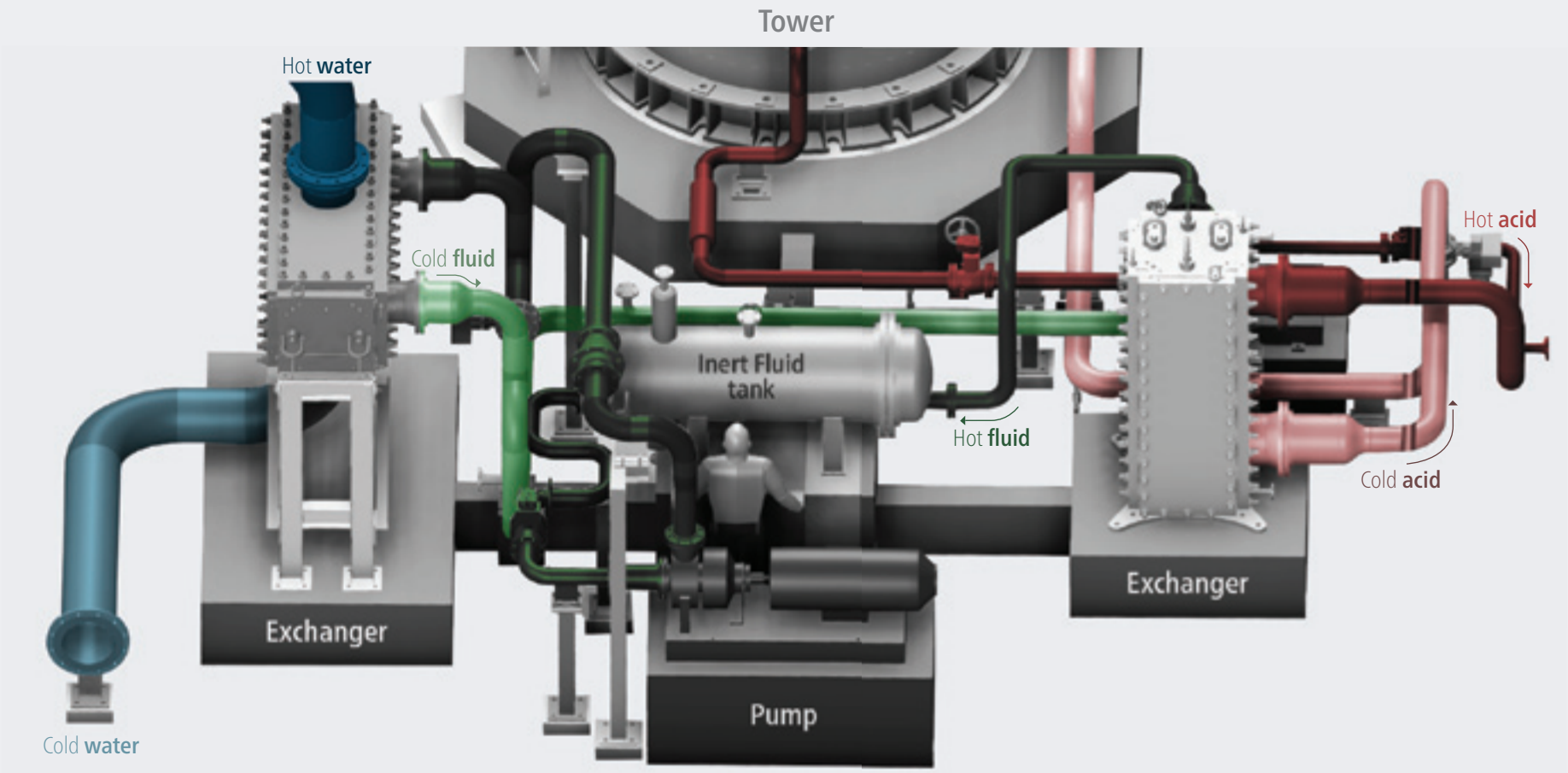


Simplot ups its game at Wyoming acid plant Page 7

IN THIS ISSUE > > > >

SAFEHR

HEAT RECOVERY **TECHNOLOGY**



- **Failure safe**
- **Waste energy recovery**
- **Cooling water demand reduction**

Recovery more energy

Clark Solutions SAFEHR® is a patented sulfuric acid heat recovery technology which can increase high pressure steam generation in an acid plant by almost 20% and total energy recovery by as much as 35%, while addressing issues such as safety and corrosion in an absolutely innovative way.

Learn more: **clarksolutions.com**

USA
411 SE Minzer BLVD #72
Boca Raton FL 33432-6001

Brazil
91 Dn. Joaninha - Moinho Velho
São Paulo / SP 06807-690

Chile
Volcan Lascar 801, 2H
Pudahuel - Santiago - Chile

China
Tian An Chuangxin Technology Plaza
Futian District, Shenzhen

Clark solutions
Thermal and Mechanical Separation Solutions

/clarksolutions.com | /clarksolutionsoficial | /company/clark-solutions-brasil | /@clarksolutions

CSX™: A modern solution for sulfuric acid plant piping

By: Nelson Clark and Bruno Ferraro of Clark Solutions; and Dimitrios Tsiaprakas and Ricardo Moretti of Elekeiroz

Ever since its development in the mid-80s, the use of high silicon stainless steel (HSSS) alloys in sulfuric acid applications has increased. Clark Solutions CSX™ HSSS equipment, manufactured with UNS S32615 and designed for a wide range of sulfuric acid applications, shows enormous advantages over cast iron piping and is steadily becoming a new industry standard.

To further explore CSX™ HSSS piping advantages and benefits, the following sections examine some common sulfuric acid industry piping configurations and the reasons why high silicon stainless steel alloy piping is the best choice for most strong sulfuric acid systems.

Cast iron piping

A broad range of different acid piping materials have been used over the years, evolving with plant design and development of more sophisticated materials. The most common piping solution is either ductile or nodular gray cast iron systems, which themselves have a wide range of material composition and metallurgy.

Cast iron, however, corrodes readily when placed in sulfuric acid service. Pipe or fitting lifespan is therefore a function of wall thickness, and consequently, thicker and heavier piping or equipment is necessary to counterbalance this disadvantage. In fact, pipe thickness in sulfuric acid industry is usually twice as bulky as standard values found across other industrial applications for the same pressures.

Sulfuric acid piping corrosion is a very important issue. It is naturally related to maintenance, strongly relevant to safety, and has a direct impact over the acid quality produced in terms of iron content in acid. Piping corrosion byproducts form sulfate fouling, which can plug and restrict valve maneuver. Even worse, small amounts of iron in acid can radically change product appearance, giving it a milky, turbid coloration.

In addition, fittings tend to corrode more easily due to higher local velocities caused by fouling, especially because cast iron is not resistant to erosion. Because of lower erosion resistance, ductile cast iron pipes are designed for lower velocities, which increases diameter, weight and thus material and installation costs.

Acid leakage in cast iron piping

Although corrosion is a very important issue, the greatest concerns regarding cast iron piping are acid leakage, maintenance, and safety. Consider the example of pipe spools manufacturing, which can be either centrifugated or cast.

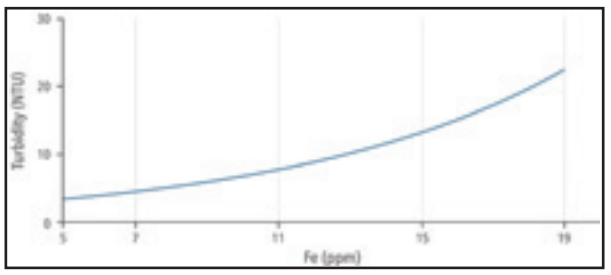
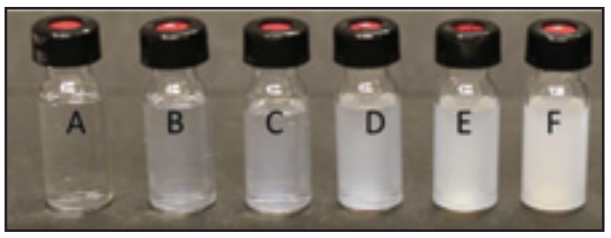


Fig. 1: Experimental results on 98.5wt% sulfuric acid: turbidity (NTU–Nephelometric Turbidity Units) vs Fe concentration (ppm).



Turbidity Standards for reference (not sulfuric acid). From left to right, in NTU: 0, 50, 100, 250, 500 and 1,000 [1]

CSX™ HSSS piping supplied by Clark Solutions.

Centrifugated spools can be as long as six meters. Centrifugation guarantees air free homogeneous walls. But flanges are threaded. Conical threads and adhesives are used to mitigate leakage risks, but they cannot completely remove leakage potential.

Cast spools are usually limited to two meters in length and rely on integral flanges to minimize leak risk. The static casting process does not fully guarantee wall thickness uniformity, eventually keeping air and contaminants in the bulk of the wall and multiplying by three the number of flanges and gaskets needed on an equivalent length.

Whether cast or centrifugated, welding is not possible. The system is designed with standardized parts that usually require a special adjustment spool to the final assembly, creating extra potential leakage points.

Cast iron fittings, tees, elbows, and reductions are also cast. The manufacturing process uses two molds, between which the molten metal is poured. To prevent the core mold from floating, chaplets are used to hold each mold piece in position. Temperature at this stage must be controlled because if it is too hot, the chaplets would completely melt, and the core mold would float, generating a decentralized pipe. On the other hand, if the temperature is too low, a partial melt of chaplets cannot be achieved, which generates weak points from both corrosion and metal uniformity standpoints. This manufacturing temperature for partial chaplet melting and proper bounding is difficult to control, and lapses in the proper conditions are the cause of most leaks [2].

A leaking spool or fitting is a condemned piece; it cannot be welded and cannot be reused. When an acid leakage occurs, maintenance time may be long, sometimes taking days, depending on the size and diameter of the failed pieces. A new adjustment spool will be needed, all gaskets will have to be re-tightened and some replaced. Also, very heavy equipment handling requires extra safety precautions.

As cast iron parts are unique, it is not feasible to cut small spools from a standard spool. The plant must have a large spare parts inventory. Sometimes, fittings are specially sized, or the pipe supplier is from abroad and there is a long shipping lag. Day-long stops mean plant cooling. Moisture and condensation occur, and corrosion will take place. Re-heating may be necessary. When shipping takes longer than the maintenance shutdown, some plants have to emergency fit parts that differ in size from the originals, so that the plant can continue operating until the correct parts arrive. This often leads to a change in line flexibility. Size difference and altered thermal expansion for this temporary solution may cause the system to behave in ways that create more leakage points.

Leakage maintenance costs are another factor. A study performed by Elekeiroz in 2017 reveals that during the previous year, their production availability losses due to maintenance shutdowns were strongly related to acid leakage, and the main sources were acid pipelines.

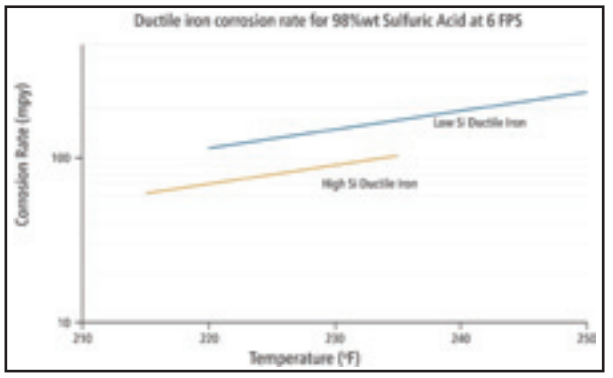


Fig. 2: Corrosion rate for low and high Si ductile iron piping for 6 FPS 98% acid flow.

The maintenance expense of acid pipe repairs, plus production availability losses with secondary factors such as temporary loss of acid quality control during downtimes, increase the economic advantages of a more reliable piping solution using CSX™ HSSS. Also, a huge advantage is the added safety benefit that goes along with avoiding acid leaks.

CSX™ piping

In recent years, much has been done to develop new, more efficient and affordable materials. In this context, CSX™ HSSS provides several advantages when compared to ductile cast iron for acid piping systems, including significantly reducing failures and consequently production losses and maintenance costs.

The key to the success for CSX™ HSSS is the formation of a very resistant passive layer of silicon oxide on the material's surface in the presence of a strong oxidant. This brings a very high resistance to strong sulfuric acid at typical process temperatures. This provides additional beneficial properties to the alloy, such as high pitting and erosion corrosion resistance, the latter being especially attractive for piping systems since fittings are more susceptible to erosion damages.

CSX™ piping is fitted together through welding, which eliminates the need for flanged connections by up to 80 percent, drastically reducing acid leak problems and therefore risk to personnel and property. Since the alloy is much more corrosion resistant, pipe thickness is also significantly reduced, substantially reducing weight, the cost of the pipe and its supports, as well as installation costs.

Greater alloy erosion resistance also makes it possible to operate with acid at higher velocity, up to five times greater than cast iron, reducing pipe diameters, retained acid pipe inventory and overall cost of installation.

Table 1 shows the corrosion rate comparison between two types of ductile iron pipes and CSX™ HSSS, all for 98%wt sulfuric acid at 6 FPS.

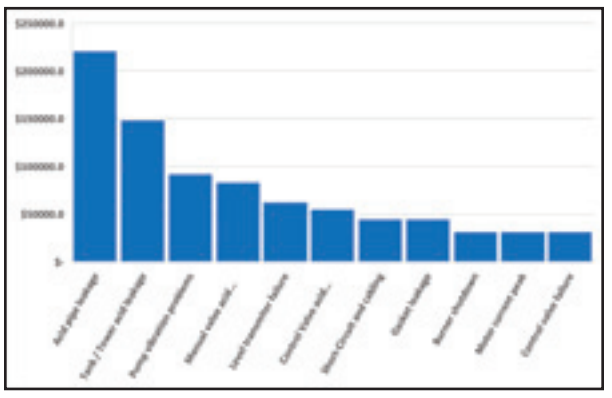


Fig. 3: Losses by production unavailability (Elekeiroz maintenance data, 2016).

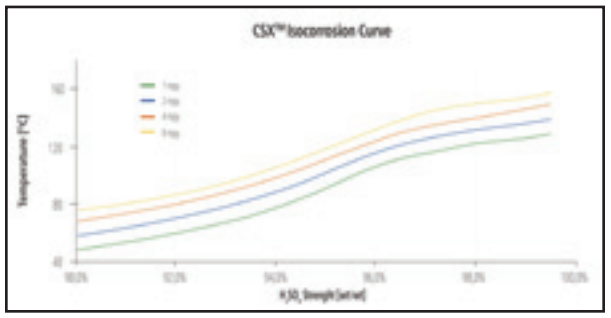


Fig. 4: CSX™ HSSS isocorrosion curve as a function of sulfuric acid strength and temperature.

Temperature (oF)	Corrosion Rate (mpy)		
	Low Si Ductile Iron	High Si Ductile Iron	CSX™ HSSS
190	50	30	<1
200	65	35	<1
210	90	45	<1
220	100	70	<1
230	105	90	<1
240	110	100	<1
250	115	105	<1

Table 1: Corrosion rate comparison for 98%wt sulfuric acid at 6 FPS.

Given a 200 MTPD sulfuric acid plant acid with 98%wt acid flowing at 6 ft/s at 250oF, and CSX™ piping measuring 60 ft long by 6 inches in diameter, the iron concentration would be 0.3 ppmw on the product acid, while a high silicon cast iron piping would have 30 ppmw iron concentration. Therefore, cast iron piping is limited to low sulfuric acid temperature and velocity to achieve a decent turbidity standard, whereas CSX™ has no such limitations.

The system can normally have reduced diameters even when accounting for pressure drop concerns. The reason for this is that the surface roughness of passivated stainless-steel is smoother than cast iron, and thus increased velocity is compensated by reduced rugosity and fewer singularities. In practice, typical upper limit CSX™ flow velocities are limited not by erosion itself, but by the resulting similar pressure drop equivalent of the piping system project.

Moreover, since the system can be welded, any bore or crack can be repaired with simple welding and a short stop, which is a huge benefit in comparison to cast iron systems that require spools, fittings, or connections to be completely replaced via disassembly by crane.

The combination of qualities brings a huge range of benefits to CSX™ piping solutions:

Clark Solutions CSX™ piping systems are manufactured by pre-conforming metal sheets by automatic stamping machines. Welding, procedures, qualifications, and tests are performed in accordance to ASME BPVC IX. Manufacturing standards such as ASME B31.3, ASME B16.9, ASME/ASTM SA-403/A-403, ASME/ASTM SA-240/A-240 and others are followed according to the client requirement. The system is quality controlled by complete liquid penetrant, radiographic and hydrostatic tests and, if requested, heat treatment and SNQC-qualified inspection can be performed. All information is compiled in a complete data-book to provide a reliable and advanced solution for sulfuric acid piping systems. In cases of piping replacement, Clark Solutions also provides new isometric drawings per client request.

DN (in)	Cast Iron Weight (kg)	CSX™ HSSS Weight (kg)
3	109	38
4	159	65
6	278	97
8	388	127
10	523	159
12	685	190
14	862	208
16	1043	356
18	1244	401
20	1498	446
24	1971	537

Table 2: Weight comparison of flangeless 6-meter-long pipe.

CSX™ High Silicon Alloy	Ductile Cast Iron
Low number of flanges = Low leak potential (up to 80% quantity reduction)	High number of flanges = High leak potential (flanged connection on every piping piece)
Lower thickness = Lower weight and installation costs (typically 3 to 6 mm thick)	High thickness = Heavy weight, high installation costs (typically 15.5 to 22.3 mm thick)
Higher final product quality (elimination of iron sulfate)	Lower final product quality (inherent presence of iron sulfate)
Low maintenance cost and length due to welding	High maintenance cost and length due to cranes
Minimal inventory of spare parts	Large inventory of fittings
Higher design velocities = Lower pipe diameters (practical limits up to 5 m/s due to system pressure drop limitations)	Low velocities = Large pipe diameters (typical desired range around 1 m/s or higher, per example of 1.5-2.0 m/s on more sophisticated cast iron systems, but limited by acid temperature due to erosion)

Table 3 - Advantages of CSX over cast iron on sulfuric acid plant applications

Other applications

CSX™ HSSS provides such resistance to corrosion and erosion from hot, strong sulfuric acid that it is used for many other applications.

Acid distributors made with CSX™ HSSS have many benefits over cast iron. Besides corrosion resistance and weight aspects, CSX™ HSSS acid distributors, such as MaxiFlow™, offer less cross-sectional area blockage and more irrigation points due to reduced thickness. The thick troughs of cast iron acid distributors create high gas velocity zones that increase acid mist generation. Also, thinner CSX™ HSSS downcomers allow more irrigation points, up to 4 pts/ft2 against 1.5 pts/ft2 in cast iron, which enhance mass transfer.

Meshpad mist eliminators, such as MaxiMesh®, commonly applied in drying towers can be manufactured with knitted CSX™ HSSS mesh in addition to co-knitted fiber glass or PTFE, for higher droplet collection efficiency.

Drying and absorption tower shell material can either be brick lined carbon steel or CSX™ HSSS, the latter providing a tower with smaller diameter. A lighter and brickless tower represents less maintenance and lower civil basis load requirement.

Acid coolers manufactured in CSX™ HSSS grant important benefits over the stainless steel anodic protected solution. The latter requires a cathode replacement sporadically (roughly every two years) and have acid temperature limitations to guarantee passivation; limitations that CSX™ HSSS doesn't have.

Many other parts, such as filters, vortex breakers, and custom made pieces are also possible applications.

Conclusion

Acid leakage is a relevant concern in the sulfuric acid industry, in terms of both personnel safety and the economics of increased maintenance. High silicon alloy stainless steel piping systems are becoming more popular since their proven maintenance and safety advantages shows their cost-benefit for long term operation.

High corrosion resistance, reduced wall thickness, and weldability are benefits that allow higher acid flow rate, smaller diameter, lower weight, quicker maintenance, fewer flanges and fewer leakage points, all of which increase plant reliability and facilitate operation.

For more information, visit the products page at www.clarksolutions.com.br. ❑

Cast iron piping replacement with CSX™ HSSS (Elekeiroz, 2020).

Welding of CSX™ HSSS.

CSX™ HSSS acid distributors.

References

[1] Frahm, G. E. et al (2016). Evaluation of Microflow Digital Imaging Particple Analysis for Sub-Visible Particles Formulated with an Opaque Vaccine Adjuvant. doi: 10.1371/journal.pone.0150229

[2] Louie, D. K. (2005). Handbook of Sulphuric Acid Manufacturing. Ontario, VIC: DKL Engineering, Inc.