Moly Does the Job

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Stainless Steel with 6% Mo Improves Equipment Efficiency and Eliminates Costly Repair.

SUMMARY

A major chemical company producing chemicals for the pulp and paper industry had been using jacketed process reactor vessels made from carbon steel on the water side and clad with 2% molybdenum-containing Type 316L (UNS S31603, EN 1.4404) stainless steel on the process side. These vessels required frequent repairs of the carbon steel cooling/heating jacket and vessel exterior. Corrosion testing and a cost evaluation resulted in the replacement of the clad vessel with a solid 6% molybdenum stainless steel vessel. It is expected to provide years of maintenance-free service.

THE PROCESS

The process vessel (***Figure 1***) is used to heat and cool a process stream. The chemical is heated with plant steam to a temperature of 275°F (135°C) and cooled with cooling tower water to a temperature of 50°F (10°C). The vessel is cycled through this sequence three times per day.

Type 316L stainless steel was chosen for the process side to provide corrosion resistance against the chemical and to maintain product cleanliness. Carbon steel was chosen for the water side to avoid chloride stress corrosion cracking (CSCC) at elevated temperatures and at steam and water chloride levels expected to exceed 150 ppm.

THE CORROSION

General and oxygen cell pitting corrosion occurred on both the carbon steel half pipe cooling jacket and the carbon steel exterior vessel wall. The attack occurred over the entire surface but was slightly more aggressive in weld areas where slag inclusions or lack of penetration was apparent.

Historically, the corrosion caused leaks in the carbon steel half pipe jacket and thinning of the carbon steel side of the stainless clad vessel wall. Frequent repair welding was required to stop the leaks and to build back the lost wall thickness. Eventually the problem became significant enough to downgrade the pressure rating for the vessel. A complete replacement of the vessel was required.

The Type 316L stainless cladding was fully resistant to the process side environment.

THE SOLUTION

Ideally, a construction material should be selected that withstands both CSCC on the steam side and the chemical on the process side. Type 316L stainless steel does provide sufficient resistance to the process environment, but, based on extensive field experience, cannot be expected to resist CSCC on the steam side. ***Figure 2***, which summarizes field experience in Types 304 / 304L (UNS S30400/30403, EN 1.4301/1.4307) and 316/316L (UNS S31600/S31603, EN 1.4401/1.4404) and extrapolates from laboratory tests for higher alloyed grades, shows that Type 316L will suffer from CSCC at the heating temperature of 275°F (135°C) at chloride levels below approximately 10ppm. Even duplex stainless steel such as 2205 (UNS S32205 or S31803,EN 1.4462) which generally provides much better resistance to CSCC than Type 316 is expected to stress crack under the operating conditions. Based on this figure, the group of super austenitic 6% molybdenum stainless steels (e.g. UN S31254, NO8926 or NO8367; EN 1.4547, 1.4529), should provide sufficient resistance to CSCC under the operating conditions. They should also be at least as resistant to the process environment as the lower-alloyed Type 316L stainless steel and were therefore selected as a candidate material.

Figure 1: *Process vessel constructed in 6% molybdenum stainless steel.*

Corrosion coupons of 6% molybdenum stainless steel were installed in the existing equipment for a one-year period to determine if it was a suitable replacement material. The 6% molybdenum grades showed corrosion rates of less than 2 mpy (0.05 mmpy) and no initiation of CSCC.. One of them was therefore selected as material for the replacement vessels.

THE COST SAVINGS

Use of the higher strength 6% molybdenum stainless steel provided a significant reduction in the required vessel wall thickness. This resulted in cost savings of almost 30% in material and fabrication cost compared to a clad vessel. Additionally, operating advantages were gained since the reduced wall thickness results in better heat transfer. The improved corrosion resistance on the process side, while not initially required, provides flexibility for future process changes. Finally, the jacket side corrosion resistance provides a significant savings in long-term maintenance cost. It is estimated that the repair cost of the carbon steel exceeded $500,000 every five years.

Note: 254 SMO, AL-6XN, Cronifer 1925hMo – alloy 926 and INCOLOY alloy 25-6MO are 6% molybdenum stainless steels. Their names are registered trademarks of AvestaPolarit, ATI Properties, ThyssenKrupp VDM and Special Metals, respectively.

Figure 2: *Limits for chloride stress corrosion cracking in cooling waters as a function of chloride content and water/steam temperature. The 6% Mo stainless steel curve is also valid for super duplex stainless steels such as 2507. (UNS S32750, EN 1.4410) (Adapted from Nickel Development Institute Reference Book Series No 11 021, High Performance Stainless Steels, Figure 63).*

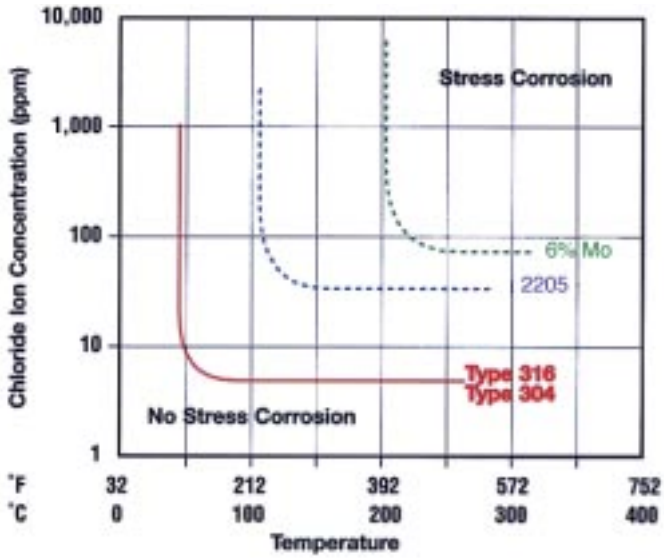


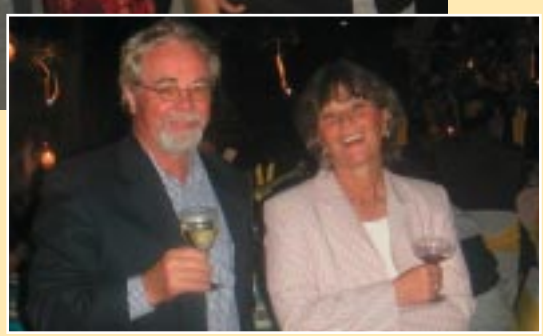
Table 1: *Typical chemical composition of stainless steel grades in this article in weight-percent.*

Common Name	UNS Number	Approximate EN Number Equivalent	Molybdenum	Chromium	Nickel	Nitrogen
Type 304/304L	S30400/S30403	1.4301/1.4307	-	18	9	-
Type 316/316L	S31600/S31603	1.4401/1.4404	2	17	11	-
2205	S32205/S31803	1.4462	3	22	5.5	0.16
2507	S32750	1.4410	4	25	7	0.27
254 SMO®	S31254	1.4547	6	20	18	0.2
AL-6XN®	N08367	-	6	20	24	0.2
Cronifer®1925hMo – alloy 926 INCOLOY®alloy 25-6MO	N08926	1.4529	6	20	24	0.2

Annual General Meeting 2002

The generous and lively hospitality offered by Molymet and Grupo Mexico, particularly an evening at Quinta Napoles hosted by Molymex and graced by the presence of the Sonora State Governor where tequila, music and dancing kept some delegates up until 3 a.m., was only matched by the high quality of the presentations (listed in the last Newsletter) at the AGM.

▲ *Andreas Keller apparently not satisfied with just one dancing partner.*



Hans and Gisela Imgrund. ▶

Thanks to Dieter Strathmann for the photos