Corrosion of Potential Heat-Exchanger Materials in Singapore Seawater

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The petrochemical plants in Singapore are gathered on Jurong Island; as such the local seawater has a relatively high pollution level compared to other locations around the island. Furthermore the shortage of fresh water means that seawater has to be used in heat-exchangers. This coupled with the tropical climate of Singapore, which means high inlet temperatures, represents a high risk environment particular with respect to pitting and crevice corrosion. The effect of temperature on corrosion behavior of seven materials in Singapore seawater has been investigated. The test materials were Al-brass (ALB), a 70:30 Cupro-Nickel alloy (CUP), titanium, the austenitic-super stainless steel UNS S31254 (SMO), the duplex-super stainless steels S32900 (329) and S32750 (2507) and type 316L austenitic stainless steel. Weight loss coupons revealed that corrosion rates of all nearly all the materials tested were neither sensitive to temperature nor stirring conditions. However, potentiodynamic polarization tests revealed the seawater around Singapore's Jurong Island appears to be more aggressive with respect to pitting corrosion than standard artificial seawater, despite the former having a chloride content of only about 13,000 ppm. This is thought to be due to its total organic carbon content, which arises from a mixture of biological and pollution sources. At low temperatures only the type 316L stainless steel suffered pitting corrosion, however, at 80^{o}C all grades showed signs of pitting with a strong correlation being found between the pitting potential and the pitting resistance number, PREN. As for the copper alloys the CUP showed the unusual behaviour of being more resistant to pitting at 80^{o}C than at lower temperatures (Table 1), whilst the ALB was found to suffer selective leaching during the potentiodynamic polarization tests. Standard multiple crevice corrosion tests showed that titanium was almost completely resistant to crevice attack, however, this was not the case for the various grades of stainless steels with the types 316L and 329 fairing particularly badly and type (Fig. 1). Preliminary data from a mock-up heat exchanger (Fig. 2) confirmed the susceptibility of the high grade stainless steels to crevice corrosion in Singapore seawater. Under expectantly crevice corrosion was worst around the tubes formed from type 2507 than around their 329 counterparts. However, it will not be possible to determine whether the source of the crevice corrosion is the tubes or the tube sheet tube, which was fabricated from type 329, until after the facility has been dismantled. Explanations for these observations will be discussed in the paper.

	Pitting potential (mV vs SCE)		
Material	40°C	60°C	80°C
CUP	225	-53	450
Ti	-	-	-
SMO	-	-	1007
329	-	-	735
2507	-	-	936
316	553	405	282

Table 1: Influence of temperature on pitting corrosion of test materials.

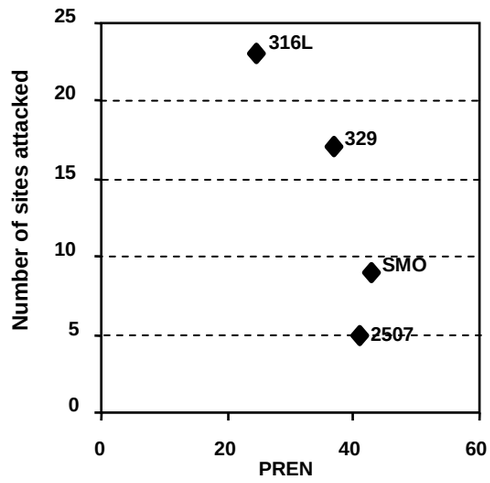

Fig. 1: Number of crevice sites attacked on different grades of stainless steels as a function of their PREN. There were a total of 40 crevice test sites on each specimen.

Fig. 2: Mock – up heat exchanger located inside a petrochemical plant on Jurong Island.