LNG선 Dosing Valve 손상원인 분석 및 작동기준 정립

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Caustic Failure of Stainless Steel Dosing Valve in LNG Carrier

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1. Abstract

DSME Analyzed cracked dosing valve of LNG Carrier Boiler and carried out some test to find the causes of such failure.

2. Experimental Procedure

In our experience, this type of failure is shown to be LME or SCC typically. First, we considered the possibility of LME(Liquid Metal Embrittlement) because of very similar crack propagation rate and fractography to LME. In case of this stainless steel system, zinc should be detected at grain boundaries of cracked surface as LME evidence. So we tried to detect zinc using SEM and EDS, but could not detect any zinc in cracked surface. Second, we considerered the possibility of SCC as a cause of valve failure. The cracks were fine and branched, progressing at the grain boundaries and within the grains of the austenitic structure, showing evidence of SCC.

Austenitic stainless steels can be susceptible to SCC in certain chloride environment, whereas the ferritic and martensitic grades can be susceptible to hydrogen embrittlement.

We additionally tested the susceptibility of intergranular attack in austenitic stainless steel according to the test procedure described in ASTM A262. The microstructure of dosing valve shows annealing twins. We can not find any evidence related to the susceptibility, and in other words, there are no ditches or duals except steps in this microstructure of valve. Based on the examination of microstructure and hardness test, we can conclude that this valve is fully annealed at high temperature after forging and would show good resistance to SCC.

Although, there is no sensitization in stainless steel, SCC can also occur in NaOH environment. The caustic corrosion cracking related to temperature and NaOH concentration is not well understood. To avoid the attack of SCC, we must have very low NaOH concentration or must have low temperature. But in normal operating condition, that control may be difficult. In dosing operation, the concentration of the NaOH has to be controlled to very low level through rinsing. Because insufficient rinsing leads to failure in type 304 stainless steel, perfect rinsing is needed after caustic soda feeding. As a alternative, phosphate may be considered as final feeding material in every treatment, because phophate may not occur SCC at operation temperature.

In caustic environment, we recommend the low-carbon grade unalloyed nickel or Nickel 201 as alternative materials to prevent SCC regardless of any other design and manufacturing problems.

3. Conclusion

1. According to ASTM A262 test and hardness test, this material of chemical dosing valve showed high resistance to SCC
2. The cause of cracking in dosing valve would be caustic SCC.
3. NaOH should be always cleaned in dosing valve, or NaOH should not be fed at final stage.

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