

## CHAPTER V

### CONCLUSIONS AND RECOMMENDATIONS

#### Conclusion

##### 1. Corrosion Result on CS Specimens

1) Immersion of CS specimens in three various corrosive medias, such as H<sub>2</sub>O, HCl in H<sub>2</sub>O and Hg in cyclohexane, gave the appearances on specimen surface to be small pits distributed over the whole surface area of specimens uniformly. Those corrosion results were in the form of uniform corrosion. The example of corrosion result by this group of corrosive medias is that result obtained by exposure of specimen in H<sub>2</sub>O, 150 ppm HCl in H<sub>2</sub>O, Hg in cyclohexane at the ambient temperature, which were 14.6595, 29.4480 and 0.6296 mdd, respectively. Corrosion rates obtained by these corrosive media increased with increasing the exposure temperature, especially, those immersed in H<sub>2</sub>O and aqueous acid solution giving trends of exponential.

2) immersion of the specimens in solvents, absolute CH<sub>3</sub>OH and PE corrosion appearances on the surface were not appeared by visual check and by photomicrograph scanned by SEM. Corrosion rates of specimens immersed in CH<sub>3</sub>OH and PE, for example at ambient temp., were 0.0764 and 0.3101 mdd respectively. These results were slightly increased with temperature, or independent on temperatures.

3) Immersion of specimens in the CH<sub>3</sub>OH + 150 ppm DMM and PE + 150 ppm DMM solutions appeared corrosion characteristics in the form of uniform corrosion, but was very low. PE + DMM provided more corrosion area distributed than CH<sub>3</sub>OH+DMM. The corrosion on specimens immersed in these solutions must be resulted from reaction with Hg because its appearances were



similar to that corroded by Hg in cyclohexane and also different from that corroded by H<sub>2</sub>O. Corrosion rates caused by these solutions, for example at the ambient temp., were 0.2737 and 0.2672 mdd, which were 3.6 and 0.9 times higher than those obtained by pure CH<sub>3</sub>OH and PE respectively. The corrosion rates were also independent on concentration of DMM.

4) The corrosion results corroded by the CH<sub>3</sub>OH + 150 ppm DMM/PE + 150 ppm DMM solutions added with 150 ppm HCl were opposite. Those resulted from CH<sub>3</sub>OH+DMM+HCl solution were uniform corrosion, which their appearances were similar to those corroded by the DMM solution without HCl, but its quantities are slightly more than those. Inversely, the appearances and quantities caused by PE+DMM+HCl solution seemed to be lower than those caused by the PE+DMM solution. The corrosion rates for both systems CH<sub>3</sub>OH+HCl+DMM and PE+HCl+DMM, for example at the ambient temperature, were 9.8690 and 1.6815 mdd, respectively, which were 34 and 6.3 times more than those results caused by the solution without HCl. The corrosion rates obtained by the CH<sub>3</sub>OH + 150 ppm DMM + 150 ppm HCl solution increased obviously with exposure temperatures, whereas, those obtained by PE+DMM+HCl expectedly increased. The corrosion rates caused by the CH<sub>3</sub>OH+DMM+HCl corrosive system increased with DMM concentration at the elevated temperature and were independent on the DMM concentration at low temperature such, as 10°C, whereas those by the PE+DMM+HCl were independent on DMM concentration.

Comparison of corrosion results obtained by the CH<sub>3</sub>OH + 150 ppm DMM + 150 ppm HCl corrosive system with those obtained by the CH<sub>3</sub>OH+HCl system indicated that their appearances scanned by SEM were more similar to each other. This implied that corrosive agent of the CH<sub>3</sub>OH+DMM+HCl corrosive systems were both DMM and HCl, whereas That of CH<sub>3</sub>OH+HCl was only HCl. The rate of the later at ambient



temperature was 6.90 mdd in comparison to 7.30 mdd resulted from  $\text{CH}_3\text{OH}+\text{DMM}+\text{HCl}$ .

The corrosion result caused by the  $\text{PE}+\text{DMM}+\text{HCl}$  system, for example at  $10^\circ\text{C}$ , was 1.74 mdd, which was lower than that caused by the  $\text{PE}+\text{HCl}$ , 3.18 mdd. The corrosive media in the corrosive system should rather be HCl than DMM. However, both showed similar appearances but different from those obtained from Hg in cyclohexane.

## 2. Corrosion Results on Aluminium Specimens

1) With three medias, namely,  $\text{H}_2\text{O}$ , HCl in  $\text{H}_2\text{O}$ , and Hg in cyclohexane, distilled water used showed corrosion on the Al specimen very little, 0.96 mdd, which might be caused by  $\text{CO}_2$  left in water. Its corrosion appearance was lots of small pits that was expected to grow as uniform corrosion. The corrosion rates obtained by the HCl-in- $\text{H}_2\text{O}$  and Hg-in-cyclohexane solutions were 3.96 and 0.092 mdd, respectively. The appearances caused by both corrosive systems were pitting obviously. The rates obtained by  $\text{H}_2\text{O}$  and HCl in  $\text{H}_2\text{O}$  solutions increased with temperature in exponential.

2) Absolute  $\text{CH}_3\text{OH}$  and pure PE corroded the aluminium specimens a little bits. Their appearances, shown by photomicrograph scanned by SEM was specified as uniform corrosion.

3)  $\text{PE}+\text{DMM}+\text{HCl}$ ,  $\text{PE}+\text{HCl}$  and  $\text{PE}+\text{DMM}+\text{H}_2\text{S}$  systems provided lower corrosion rates in comparison to those obtained by  $\text{CH}_3\text{OH}$  as solvent. The corrosion rate of the  $\text{PE}+\text{DMM}$  system at  $10^\circ\text{C}$  was 0.0991 mdd, 2 times more than that of pure PE at the same temperature and the rates of this system was slightly increased with the exposure temperature. Its corrosion appearances was uniform corrosion caused by reaction of Hg dissociated from DMM. Adding HCl into  $\text{PE}+\text{DMM}$  solution made corrosion rates increase because



HCl reacts with DMM to break C-Hg bond resulting in releasing  $\text{Hg}^{2+}$  to corrode specimen, for example at  $10^\circ\text{C}$ , its corrosion rate was 5.2594 mdd 53 times higher than that corroded by PE+DMM solution. The corrosion rates of the PE+DMM+HCl systems tended to decrease with temperature, which was due to small amount of PE leak out of reaction flask at the higher exposure temperature.

Comparison of corrosion caused by PE+DMM+HCl solution with PE+HCl solution showed that the corrosion rate of the former was little higher than that of the latter, for example at  $10^\circ\text{C}$  it was 1.6 times higher. The corrosion rates resulted from the PE+HCl solution were independent on temperature. The corrosion appearances obtained by PE+HCl system grew more in width than in depth, and was uniform corrosion, whereas the appearances obtained by PE+DMM+HCl grew in both width and depth.

In the PE+DMM+HCl corrosive system, the reaction of DMM with HCl generated  $\text{Hg}^{2+}$  to corrode the aluminium specimens, which the appropriate ratio of  $[\text{DMM}] : [\text{HCl}]$  was 1:1. Because the low solubility of HCl in PE, then varying DMM concentration was little different from 1:1. Its corrosion rate slightly changed, and slightly increased with temperature.

Corrosion rates resulted from the PE+DMM+HCl solution were also independent on agitation/velocity of the solution. Furthermore agitation made corrosion rates little lower than those with no agitation

Substitution HCl with  $\text{H}_2\text{S}$  in the PE+HCl+DMM corrosive system reduced corrosion rate.

4) For the systems having  $\text{CH}_3\text{OH}$  as solvent, the corrosion rates caused by the  $\text{CH}_3\text{OH}$ +DMM solution were higher than those caused by pure  $\text{CH}_3\text{OH}$ , slightly increased with the exposure temperature. Their corrosion



appearances on surface were lots of small pits distributed over the whole surface area of specimen with large holes at some positions.

Adding HCl into  $\text{CH}_3\text{OH}+\text{DMM}$  solution increased corrosion rate enormously, for example, at the ambient temperature, the corrosion rate resulted from the exposure in the  $\text{CH}_3\text{OH}+\text{DMM}$  200 ppm+HCl 150 ppm solution was 746.37 mdd, 700 times higher than that corroded by the  $\text{CH}_3\text{OH}+\text{DMM}$  solution, 0.115 mdd. Their corrosion appearances on the surface were in the form of uniform corrosion

Comparison of corrosion rates corroded by  $\text{CH}_3\text{OH}+\text{DMM}+\text{HCl}$  solution to those corroded by the  $\text{CH}_3\text{OH}+\text{HCl}$  solution show that its corrosion rates were much higher than that corroded by the  $\text{CH}_3\text{OH}+\text{HCl}$  solution, 8 times higher. The corrosion rates of the former increased with temperatures in exponential, whereas those of the latter increased with temperature in linear. The higher temperature, the difference of corrosion rates between the two corrosive systems. HCl added reacted with DMM to break C-Hg bond in DMM, however, not only this factor enhanced corrosion alone but also  $\text{CH}_3\text{OH}$  did that.  $\text{CH}_3\text{OH}$  attacked the aluminium amalgam, which resulted in elemental Hg generated and the mercury will form amalgam with aluminium metal.

If the ratio of concentration of DMM : HCl was lower than 1 : 1, the corrosion rates corroded by the  $\text{CH}_3\text{OH}+\text{DMM}+\text{HCl}$  solution were independent on concentration of DMM. Contrarily, if that ratio was higher than 1 : 1, these rates were increased enormously, but still independent on concentration of DMM.

Agitation of solution made corrosion rates slightly lower than those obtained by the without agitation solution because flowing of solution destroyed corrosion product shape like whisker, adhering to specimen surface, which the whisker was the place to keep elemental Hg and to evolve gas



product for reactions. The corrosion appearances on the surface near hole for mounting corroded by the solution with agitation were in form of intergranular corrosion around the hole for mounting and cavitation at the lower end of the specimens.

Adding  $H_2S$  into the  $CH_3OH+DMM$  solution in stead of  $HCl$  resulted in similar corrosion rates.

### **Recommendations**

Factors affected on corrosion except that concerned with corrosive media, should also be considered, such as resistance to corrosion of each material, types of material, types of solvents, exposure conditions, etc., as listed below ;


1) It should do the exposure test with the other materials such as mild steel, stainless steel and some kinds of plastic and etc. Moreover, using the commercial standard specimens in those experiments should be more appropriate than making the specimen.

2) It should do the experiments by exposure the specimens in the gaseous DMM solution because for some liquid solutions for example,  $H_2S+PE+DMM$ ,  $H_2S$  solubility in PE is very low, then reactivity between DMM and  $H_2S$  will be low too. It is expected that corrosion result would be higher in gas phase.

3) The semiwork test of the exposure of the various specimens in the DMM solutions should be do ether in gascous or in liquid solution because conditions of operation can be more widely varied in semiwork test than in laboratory test. Velocity of corrosive solution in this test is the most interesting factors of all in this exposure test. Agitation of corrosive solution in the



foregoing test will reduce corrosion rate a little because concentration of DMM that flow to contact specimen surface in each round is lower, whereas concentration of corrosive media that flow to contact specimen in semiwork test is always fresh. Furthermore, in semiwork test, it can adjust flow of corrosive solution not in circle, then concentration of corrosive media could be kept constant, which should lead to increasing of corrosion rate.



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