Corrosion of Printing Cylinder on Intaglio Press

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ABSTRACT

The Intaglio process is a security printing technique in which printing ink is carried in the grooves of a plate, accordingly, the excessive ink is wiped off to ensure that solely ink retained in the grooves has been transferred to the printing substrates. The wiping process, thus, is a very vital step consisting of the wiping solution and the blade allowing a direct contact between the wiping solution and the printing cylinder. Consequently, the wiping process affects greatly not only the printing quality but also the cylinder's life. One major problem possibly found is the corrosion caused by the reaction of iron and oxygen in the presence of water or moist environments resulting in a tremendous deterioration and damage to machinery. Accordingly, different types of wiping solutions including proper percentages of their two main compositions, namely sodium hydroxide and sulphonated castor oil were studied. The outcome shows that tap and soft water have the most influences on the rust formation while an increase in sodium hydroxide concentration in the range of 0.5 - 1% together with 0.5% of sulphonated castor oil can significantly inhibit the steel corrosion.

INTRODUCTION

The rusting of iron is formed by the reaction of iron with oxygen in the presence of water or moist environments. The chemical composition is typically hydrated iron (III) oxide ($Fe_2O_3.nH_2O$) with its appearance of brown mass. Rusting is an electrochemical process that the different parts of the iron surface act as cathodes and anodes and the moisture on the surface of iron plays a role of electrolyte between cathodes and anodes. Its phenomenon is shown in Figure. 1 and 2, and the electrochemical changes are as follows;

At the anodic site;
- Iron loses electrons (is oxidized) to form iron (II) ions. (Eq. 1)
- In the presence of oxygen the iron is further oxidized at the anode (loses electrons) to become iron (III) ions. (Eq. 2)

$$Fe\ (s) \rightarrow Fe^{2+}\ (aq) + 2e^- \quad (1)$$

$$Fe^{2+}\ (aq) \rightarrow Fe^{3+}\ (aq) + e^- \quad (2)$$

At the cathodic site;
- The oxygen in the air combines with water to form hydroxide ions. (Eq. 3)
- The iron (III) ions and the hydroxide combine to form rust (flaky brown substance). (Eq. 4)

$$O_2\,(g) + 2H_2O\,(l) + 4e^- \rightarrow 4OH^-\,(aq) \quad (3)$$

$$2Fe^{3+}(aq) + 6OH^-\,(aq) \rightarrow Fe_2O_3(s) + 3H_2O\,(l) \quad (4)$$

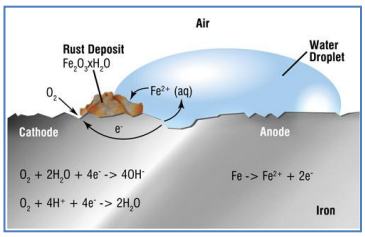


Figure 1. The formation of rust on iron or alloy

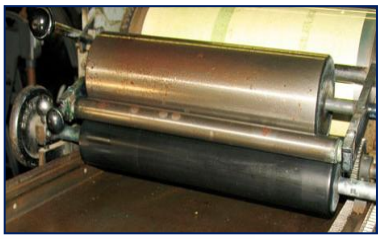


Figure 2. The formation of rust on printing cylinder

EXPERIMENT & EVALUATION

The experiments were carried out as follows,

Specimens	Steel sheets with a size of 5 mm x 30 mm x 38 mm
Wiping solution	NaOH + SCO + Soft Water
Experimental procedure	Steel sheets were immersed into the wiping solution Daily, then retrieved & let dry at room temperature

Evaluation criteria :

1. Evaluation criteria for rust formation and the wipability of the wiping solution

The evaluation criteria was categorized into 10 levels as shown in Figure 3.

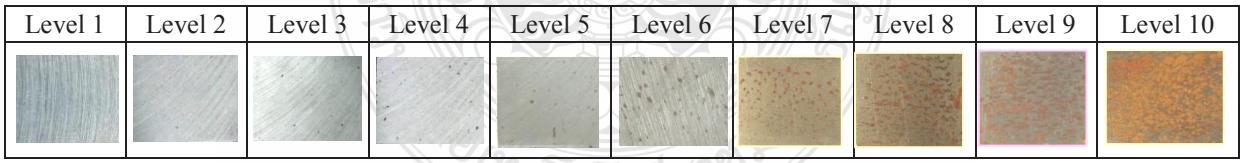


Figure 3. Evaluation criteria for rust formation

2. Evaluation criteria for the wipability of the wiping solution

$$\%\text{Wipablility} = \frac{(W_2 - W_1)\,x\,100}{W_2}$$

W_2 = Ink on chrome plate before testing
W_1 = Ink on chrome plate after testing

Standard criteria:

Pass = Wipablility > 80%

RESULTS AND DISCUSSION

1. The Influence of tap water and soft water on the rust formation

The results showed that the corrosion of steel sheet occured rapidly when contacting with tap and soft water. The rust formation by tap water is severe than that by soft water (Figure.4 and 5).

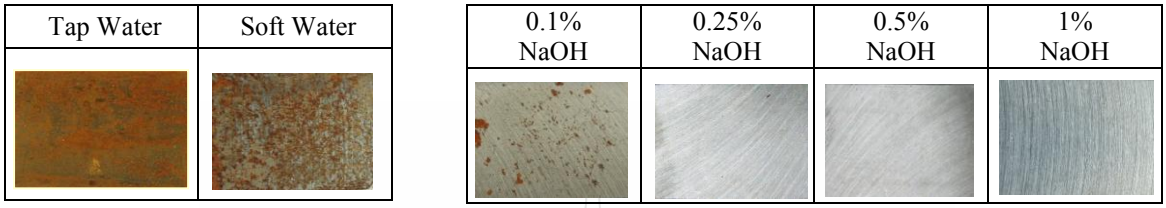


Figure 4. Iron rusting by pure tap water, pure soft water and different concentration of NaOH in soft water

2. The Influence of NaOH on the rust formation

An increase in the concentration of NaOH up to 0.5% resulting in a rise in a pH value to 12 helps reduce the rusting (Figure.4 and 5) as a high alkalinity prevents the iron from losing electrons to form iron (II) ions [1].

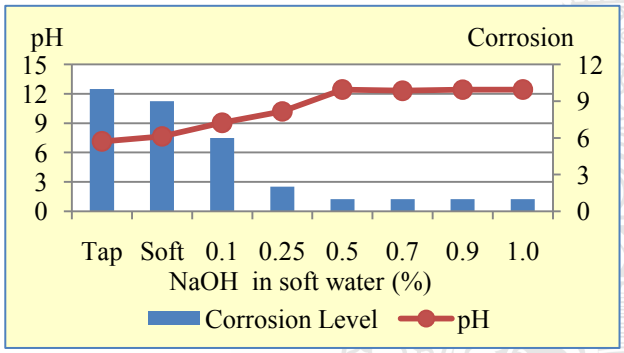


Figure. 5 Corrosion Level and pH value at different conc. of NaOH (%)

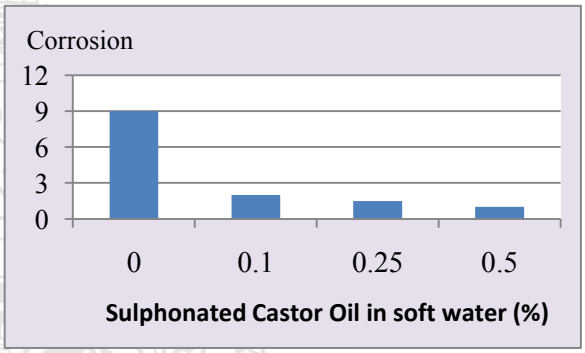


Figure. 6 Corrosion Level at different conc. of SCO(%)

3. The Influence of Sulphonated Castor Oil (SCO) on the rust formation

The effect of SCO was investigated, the result illustrated that, with its property of anionic surfactant, SCO could deter the rust formation by obstructing the functionality of oxygen[2,3] and be able to increase the wipability of the wiping solution. It was found that an addition of 0.5% SCO or more could prevent the rusting for the duration of one month, as demonstrated in Figure.6 and 7.

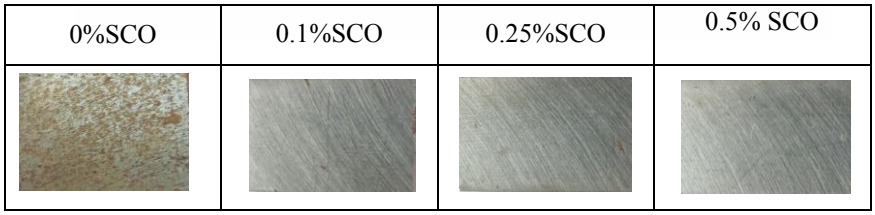
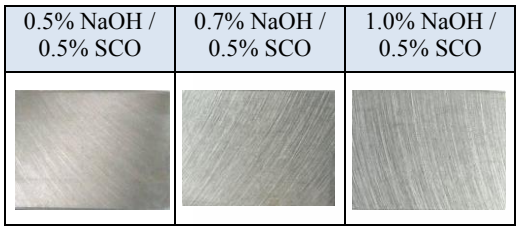


Figure. 7 Iron rusting at different conc. of SCO(%) in soft water

4. Rust formation and wipability

The pH value of the wiping solution is varied directly with the concentration of NaOH. Thus, at 0.5% NaOH, with a pH value of approx.12, the rust formation is greatly restrained as illustrated in Figure.8 and 9.

The wiping solution consisting of 0.5 - 1% NaOH and 0.5% sulphonated castor oil can prevent the rusting (level 1) while still possesses an excellent wipability as illustrated in Figure. 9.



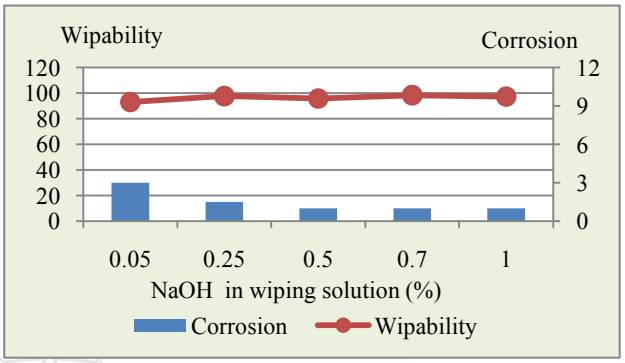


Figure. 8 Iron rusting and NaOH (%) in wiping solution

Figure 9. Corrosion level and wipability

CONCLUSION

The rust formation is occurred by the reaction of iron or an alloy containing iron, for example the steel printing cylinder, exposing to oxygen and moisture for a certain period. The usage of sodium hydroxide concentration in the range of 0.5 - 1% together with 0.5% sulphonated castor oil can greatly hinder the steel corrosion (level 1) for duration of a month while the wiping solution presents an excellent wipability.

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