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Effect of sodium chloride level on atmospheric corrosion of steel

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Effect of build up of sodium chloride on the atmospheric corrosion behaviour of plain carbon steel has been investigated. Corrosion rate 'r' was found to fit into an equation $r = kt^n$ where t is duration of exposure in days, k and n are constants.

Key words: Carbon steel, salt solution spray, corrosion rate equation

INTRODUCTION

The present study aims at investigating the action of chloride ion on corrosion of steel. Studies were conducted with different constant amounts of NaCl as well as cumulatively increasing the chloride on the surface of the steel, in the open atmosphere as well as for accelerated test with water sprays. Results are analysed on the basis of empirical equations obtained from the plots.

EXPERIMENTAL

Mechanically polished ISI-C10 hot rolled 2mm thick plain carbon steel panels of 100mm × 150mm size were used in this study. The site was so chosen that sea breeze and hence the presence of chloride particles in the environment was almost nil. Monthly averages of the temperature and relative humidity prevailed at the site during Dec'87 to March'88 were in the range of 300-296K (min.) and 304-307K (max.) and 71%-63% respectively.

One set was sprayed with 5% NaCl solution. Another set was sprayed with NaCl solution and fresh water alternately. Third set was sprayed once with 5% NaCl. The 4th set was sprayed with fresh water only. Constant amount of NaCl was incorporated by dipping the steel panels in solutions containing 27%, 13.5%, 6.5%, 3%, 1% and 0% NaCl. Sprays and sprinkling were done twice a day. Triplicate panels were withdrawn from each set at regular intervals and the corrosion rates were calculated.

RESULTS AND DISCUSSION

The cumulative build up of sodium chloride on panels and the corrosion rates for different sets are presented in Figs. 1 to 4. The results can be fitted to an equation $r = kt^n$ where r = the corrosion rate in mdd, t = duration of exposure in days, k and n are constants. The constants k and n as evaluated, are presented in Table I for different conditions. NaCl acts as catalyst of corrosion reaction through a cycle implying the formation of HCl. Oxygen diffusion through the semiporous rust formed on the steel surface to the rust-metal interface or the reaction front for the formation of stable oxide determine the further corrosion rate as the duration of exposure extends. The increase of NaCl on the surface, proportionately catalyses the reaction, hence the rate is increased. Also it is observed that water increases the corrosion rate considerably. This is reflected in increasing value of k with the amount of NaCl in Table I.

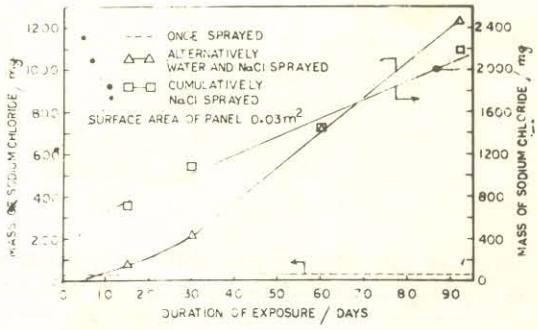

Fig. 1: Building up of sodium chloride on the surface of steel panels

CONCLUSION

NaCl catalytically enhances the corrosion rate. For fixed amount of NaCl present on the metal surface, the corrosion rate decreases exponentially with the duration of exposure. The corrosion rate is getting accelerated with duration of exposure as the amount of NaCl on its surface increases.

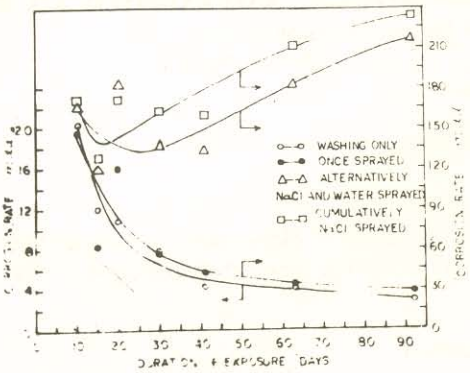

Fig. 2: Corrosion rate of steel under different conditions of sprayings

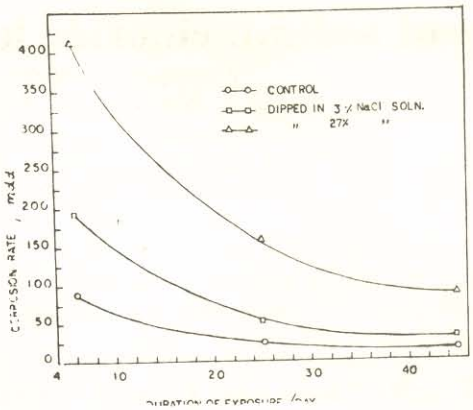

Fig. 4: Corrosion rate of steel with different amounts of salt (incorp. by dipping) on its surface - Accelerated with water sprays

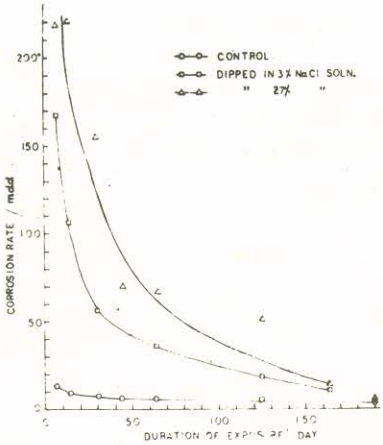

Fig. 3: Corrosion rate of steel with different amounts of salt (incorp. by dipping) on its surface - Natural atm. exposure

TABLE–I: Values of constants k and n of equation $r = kt^n$

k	n	Conditions
Under normal atmospheric exposure		
20.89	−0.295	No chloride ion on surface
446.68	−0.79	Panels dipped in 1% NaCl solution
895.36	−0.820	Panels dipped in 3% NaCl solution
1303.17	−0.895	Panels dipped in 6.5% NaCl solution
1883.65	−0.895	Panels dipped in 13.5% NaCl solution
1510.08	−0.737	Panels dipped in 27% NaCl solution
Under accelerated conditions		
431.52	−0.88	No chloride ion on surface
653.13	−0.87	Panels dipped in 1% NaCl solution
954.99	−0.91	Panels dipped in 3% NaCl solution
1078.95	−0.890	Panels dipped in 6.5% NaCl solution
1129.80	−0.840	Panels dipped in 13% NaCl solution
1599.56	−0.740	Panels dipped in 27% NaCl solution
138.04	−0.880	Regularly washed with water
1364.58	−0.885	Once sprayed with 5% NaCl solution