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CORROSION OF LOW ALLOY STEEL IN HOT NAK

by

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ABSTRACT

Consideration is being given to the use of low alloy steels due to the difficulties encountered in the use of type 347 stainless steel for steam generating equipment.

As a preliminary experiment, to check the corrosion of such steels by liquid metals, a type 304 stainless steel loop was revised to accommodate a section of 1 in. OD tubing composed of 2 $\frac{1}{4}$ % Cr - 1% Mo steel. NaK (56 st.% potassium) at 850 F was circulated at approximately 8 ft/sec. through this tubing for four months. Four small samples ($\frac{1}{4}$ in. weighed sections of the tubing) placed in an in-stream expansion tank were removed after 1, 2, 3 and 4 months immersion time and showed penetration of 0.19, 0.09, 0.07, and 0.06 mils/yr respectively. The section of test tubing showed no detectable weight loss after the 4 month period. With the temperature of the NaK at 850 F the oxygen content was found to be 0.032 wt % O₂.

All results of the test run isothermally at 850 F indicated a rate of attack less than one mil per year.

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INTRODUCTION

The difficulties encountered in the use of type 347 stainless steel for steam generating equipment led to the consideration of low alloy steels. The purpose of this experiment was to determine the corrosion rate of 2 $\frac{1}{4}$ % Cr - 1% Mo steel in hot NaK (44% Na 56% K) for evaluating the possible use of this low alloy steel as a construction material for sodium heated steam generators.

TEST APPARATUS, PROCEDURE AND RESULTS

The loop was constructed as shown in Figure 1. The section of 1 in. OD X 0.171 in. wall 2 $\frac{1}{4}$ % Cr - 1% Mo steel tubing was bent to a 90° angle and installed to form a vertical and top horizontal leg of the type 304 stainless steel test loop. An in-stream expansion tank was used to permit insertion of four $\frac{1}{4}$ in. long weighed sections of the tubing.

The tubing was received from B&W heavily coated with grease which was removed as follows:

1. Swab with dry rag.
2. Wash with ethyl alcohol.
3. Degrease using 2 scrubblings of tri-sodium phosphate and Ajax.
4. Pickle 30 minutes at room temperature with aqua regia (17 HCl - 3HNO₃ - 80 H₂O)
5. Brush with stiff nylon brush.
6. Pickle five minutes with 20% HCl.
7. Drain and flush with H₂O, then wash with methanol to prevent rusting.

The above outlined procedure was used to clean both the tube for the leg of the corrosion loop and the samples which were immersed in the expansion tank.

NaK was heated to 850 F by external calrods and circulated by an EM pump at a rate of 8 ft/sec. The loop was operated for four months. Liquid samples for oxygen determination were not taken until the conclusion of the test because the hangers for the samples interfered. At this time the oxygen contents were found to be 0.032 wt % (saturation at 850 F). Table 1 gives weight changes and corrosion rates for the samples.

DISCUSSION AND CONCLUSIONS

Since a rate of attack of less than one mil per year is generally established as an acceptable corrosion rate, the test results indicate that 2 $\frac{1}{4}$ % Cr - 1% Mo steel should be a satisfactory construction material for sodium or NaK.

WHICH WAS REMOVED AS FOLLOWS:

1. Swab with dry rag.
2. Wash with ethyl alcohol.
3. Degrease using 2 scrubblings of tri-sodium phosphate and Ajax.
4. Pickle 30 minutes at room temperature with aqua regia (17 HCl - 3HNO₃ - 80 H₂O)
5. Brush with stiff nylon brush.
6. Pickle five minutes with 20% HCl.
7. Drain and flush with H₂O, then wash with methanol to prevent rusting.

Fig. 1 - Croloy 2 1/4 in Hot NaK Corrosion Test

Since the oxide content determined at the conclusion of the test was at the saturation point, these corrosion results should be more severe than that expected under more controlled conditions as in a full scale system.

The weight losses shown in Table 1 indicate that there was an initial weight loss due possibly to removal of scale or rust and that additional weight loss is almost independent of further time.

TABLE I

Table 1 Rate of Corrosion of 3/4 in. 2 1/4% Cr - 1% Mo Steel Samples

RESULTS

Sample	Time of Exposure to 850 F NaK (days)	Weight (gms)		Change	Corrosion
		Before	After		
1	30	14.7268	14.7206	0.0062 (loss)	0.437 mg/cm ² -mo 0.19 mils/yr
2	60	14.7628	14.7568	0.0060 (loss)	0.204 mg/cm ² -mo 0.09 mils/yr
3	90	14.7384	14.7318	0.0066 (loss)	0.155 mg/cm ² -mo 0.0684 mils/yr
4	120	14.7479	14.7403	0.0076 (loss)	0.134 mg/cm ² -mo 0.059 mils/yr
Steel Tubing	120	1.57#/ft	1.57#/ft	no detected change	
			51 1/8" (4.26 ft)		

Based upon the results of this experiment run isothermally at 850 F, the 2 1/4% Cr - 1% Mo steel seems satisfactory as a construction material for sodium or NaK. However, future work may be necessary with a temperature difference across the test specimen to fully evaluate the corrosive effect of hot NaK on the 2 1/4% Cr - 1% Mo steel.

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