PRJ, Vol. 7 (January 1995); P. 107–109, 4 FIGS, 2 TABLES.

Short Note

OXYGEN CAUSES CORROSION FAILURE OF HEAT EXCHANGER

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ظاهـــرة إخفـاق أنبـــوب مبـادل حـــراري

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تم إجراء فحوصات مجهرية ودراسات ميتالورجية وبعض التحاليل الكيميائية لنوع المعدن ونواتج التآكل لتحديد سبب ونوع التآكل لأحد أنابيب المبادلات الحرارية المصنوعة من الفولاذ الكربوني ، هذا وأظهرت النتائج أن سبب التآكل هو وجود عنصر الأكسجين الموجود في الماء المستخدم في عمليات التبريد.

INTRODUCTION

Tubes of a shell and tube heat exchanger failed after one month of operation due to underscale oxygen attack despite chemical inhibition. Investigation revealed that localized oxygen attack caused severe operational problems associated with the exchanger unit frequent failure. Micro and macroscopic analysis of the problems are presented.

PROCESS DESCRIPTION

The heat exchanger is used to heat raw water pumped from a storage tank on the shell side. Hot crude oil as the heating medium is circulated through the tube side. The raw water is treated upstream of the pumps with corrosion, scale inhibitors as well as oxygen scavenger, (Fig. 1) is a schematic representation of the process.

The heat exchanger shell and tubes are made of cold brown seamless low carbon steel pipes as per ASTM A 179 [1–2]. The tubes are 19 mm in outside diameter with a wall thickness of 2.7 mm. The operational data of the exchanger are presented in Table 1. Table 2 gives the water chemical analysis.

FAILURE CASE

As received tube sample showed pitting to varying depth on its external surface. Fragile scale, black at some places and brown at others, is evident.

Cluster of pits were visible in some places, and their growth had led to coalescene resulting in a wider pits causing leaks. Macroscopic examination of transverse section through a pit revealed a hemispherical morphology. The internal tube side exposed to the heating oil did not show any corrosion attack.

Deep pits were found underneath the scale layer and filled with black scale indicative of bacterial growth. The top layer of the scale was brownish and soluble in HC1 acid confirming the formation of iron oxides.

Upon Microscopic examination it was clear that the grain structure in the tube steel had suffered elongation due to plastic deformation. Such deformation could be attributed to either the manufacturing process of the tubes, or to the localized internal stresses due to the volume expansion when the pits

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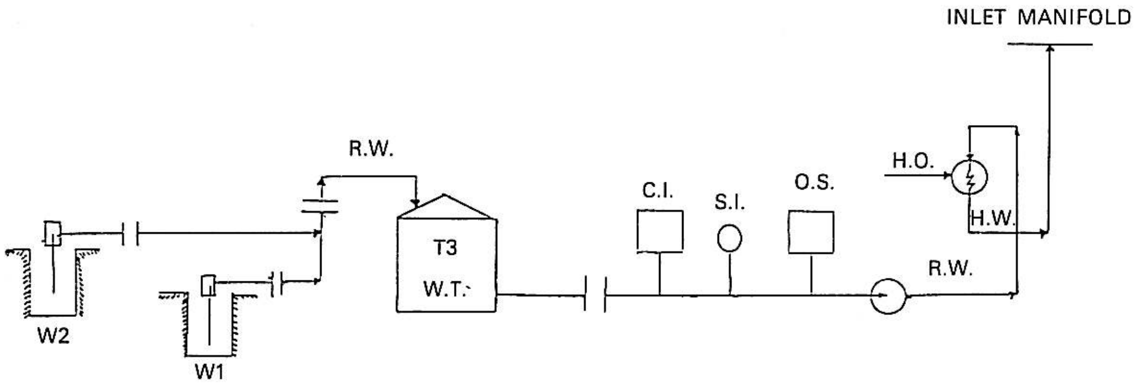

FIG. 1. Schematic exchanger flow diagram.

Table 1. Heat Exchanger Operational Data

Water side t emp. (inlet)	15 C°
Water side temp. (outlte)	60 C°
Hot oil side temp. (inlet)	120 C°
Hot oil side temp. (outlet)	110 C°
Discharge rate water pump	24 M^3/h
Tube outside diameter	19 mm
Tube thickness	2.7 mm

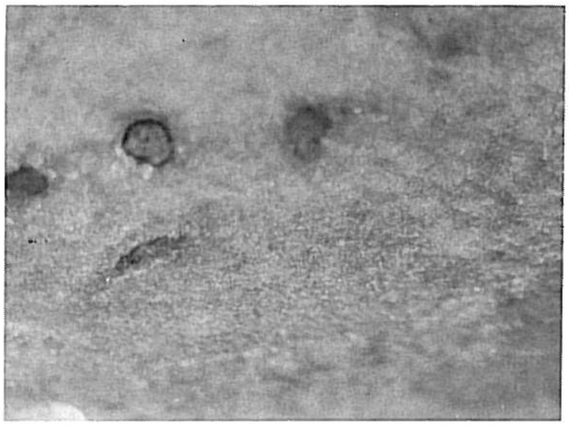

FIG. 2. Pitting corrosion of tube section.

Table 2. Raw Water Analysis

PH			7.51
Conductivity		(US)	5210
Salinity	(Nacl)	mg/l	2326
Total hardnees		F.C.	116
Chlorid	(CL)	mg/l	1411
Sodium	(Na)	=	710
Calcium	(Ca)	=	241
Magnesium	(Mg)	=	136
Sulphte	(S04)	=	600
Hydroxide	(OH)	=	NIL
Carbonate	(C03)	=	12
Bicarbonate	(HC03)	=	122
Iron (Total)	(Fe)	=	0.15
Oxygen	(02)	=	1.0
Hydrogen sulphide	(H2S)	=	NIL
Total suspended solid		=	5.19
Total dissolved solid		=	3232

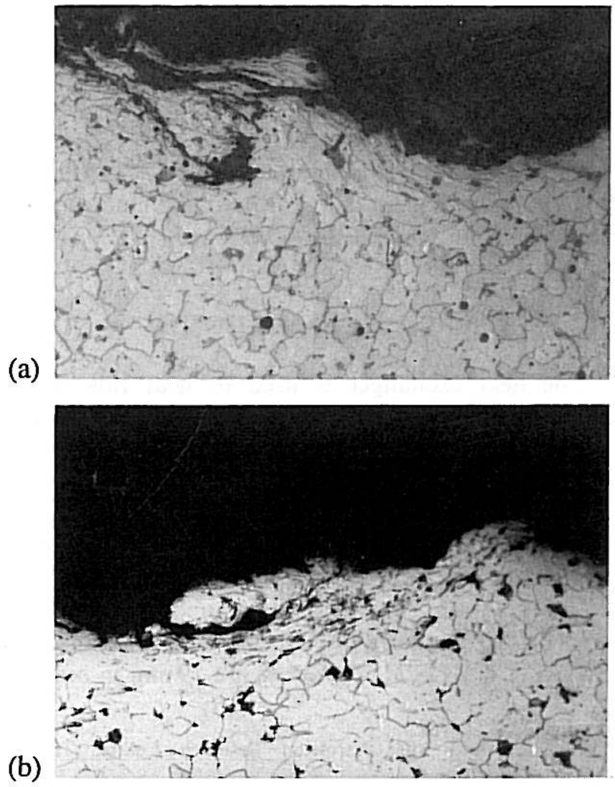

FIG. 3a, b. Deformed grain structure of tube section.

were filled with the corrosion products. (Fig. 2 shows pitting corrosion of tube section). Highly elongated grain structure is representative of high degree of deformation, as is the case shown in (Fig. 3a and Fig. 3b).

CONCLUDING REMARKS

Underscale oxygen attack of the external tube surface was mainly of the pitting type. The scale chemistry and the presence of soluble oxygen in the water confirm the oxygen attack. The severity of the attack is promoted with the setup of the oxygen concentration cells on the scale layer. The presence of layered scale has also activated sulfide reducing bacteria growth. The chemical treatment of the raw water is definitely ineffective and it is recommended that the oxygen ingress be eliminated at the source of entry prior to any inhibition program.

ACKNOWLEDGEMENT

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REFERENCES

[1] N.P. Cheremisinoff, 1984, Heat Transfer Pocket, Handbook, p. 119–121.

[2] ASTM, Part 1, 1979, Steel Piping, Tubing, fitting, p. 33–81.