DETERMINATION OF CORROSION CAUSES IN INTER-SUPERHEATED PIPING

V. ŠIJAČKI-ŽERAVČIĆ, A. MILOSAVLJEVIĆ,
A. MARKOVIĆ and Z. STAMENIĆ
Faculty of Mechanical Engineering, Belgrade, Yugoslavia
K. KOVAČEVIĆ
Iron and Steel Institute, Nikšic, Yugoslavia
B. ANDELIĆ
Technical Faculty, Čačak, Yugoslavia
D. MILANOVIĆ
"Janko Lisjak", Belgrade, Yugoslavia

ABSTRACT

This paper introduces results obtained from examination of corrosion appearance in inter-superheated piping. A crater-type corrosion has been registered within a considerable number of inter-superheater steam pipes (primary inter-superheater), located on lateral area relative to pipe, which are arranged horizontally in 22 rows. Crater-type deterioration is cone-shaped with a diameter 8-12 mm for inner tube surfaces, and 3-6 mm for outer surfaces. Damages are distributed individually over a major part of the pipe surface area. Corrosion products have been reported around damaged area of the inner tube wall surface. For determining causes of damage, optical and scanning electron-microscopy (SEM) has been carried out.

KEYWORDS

Fossil power plant, inter-superheated steam piping, standing corrosion, galvanic attack

INTRODUCTION

Fossil power plants are exposed to extreme working conditions which influence service lifetime and structural behavior of their components. Power plant components are designed to fulfill their function on high temperatures and pressures, as well as in the environment which for particular components can be of aggressive nature. All project calculations were done considering that all thermoenergetic system during exploitation are exposed to the unpredictable breaking, i.e., shorter or longer standing period.

During the reparation period it is necessary to perform some prevention steps for the component corrosion protection, so the unbeneficial influence on structure and properties is minimized. In ordinary service conditions protective mechanisms are acting. However, if system protection, during unpredicted breaking or planed standing, is not performed in the regular manner (wet and dry conservation), negative following effects are occurring, as an example corrosion on the most threatened spots, i.e., least protected system parts.

The aim of this work was to shed some more light on the inter-superheated steam pipeline corrosion appearance.

BACKGROUND

Pipes of the primary inter-superheater system, arranged horizontally in 22 rows, mainly on the lateral pipe side, corrosion appeared in the shape of singular cone shaped craters with diameters of 8-12 mm for inner tube surface and 3-6 mm on outer surfaces, Fig. 1. On the inner pipe side in the crater region, yellow coatings are visible. Corrosion deterioration occurred during a long standing period.

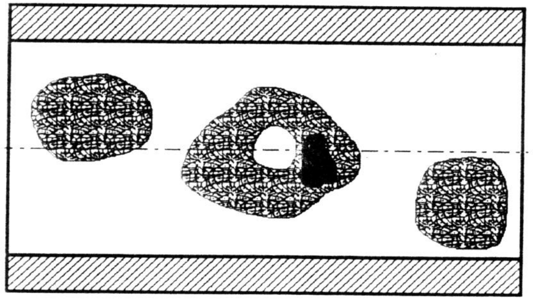


Fig. 1. Schematic view of corrosion damage

Pipelines were manufactured of 15121 (ČSN) steel with ϕ60 x 3.6 mm and exposed to the following service conditions: 410 → 540^{o}C and 31 → 27 bars. According to the standard, basic structure should be of ferrite type with small amounts of bainite or perlite, depending of product state, and carbide phase. Position of the inter-superheater steam pipeline is presented on block diagram, Fig. 2. In the purpose of corrosion appearance determination in investigated pipeline, chemical analysis, optical microscopy and scanning electron microscopy were carried out.

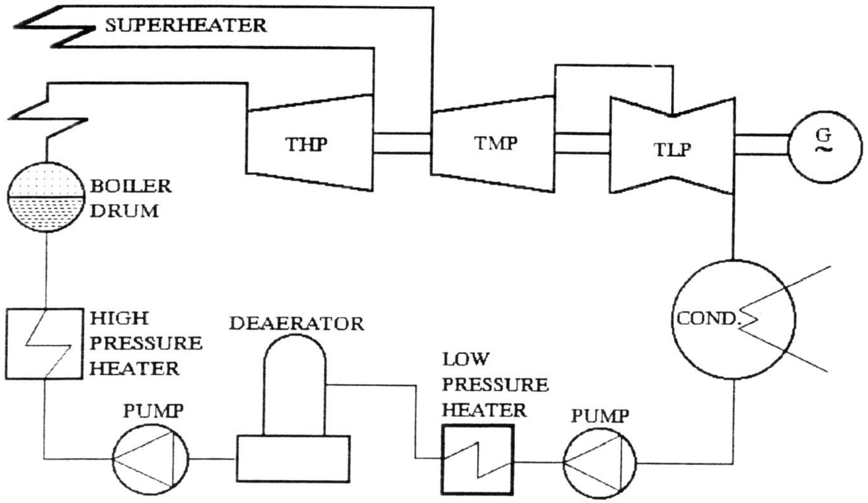


Fig. 2. Functional block diagram

EXPERIMENT

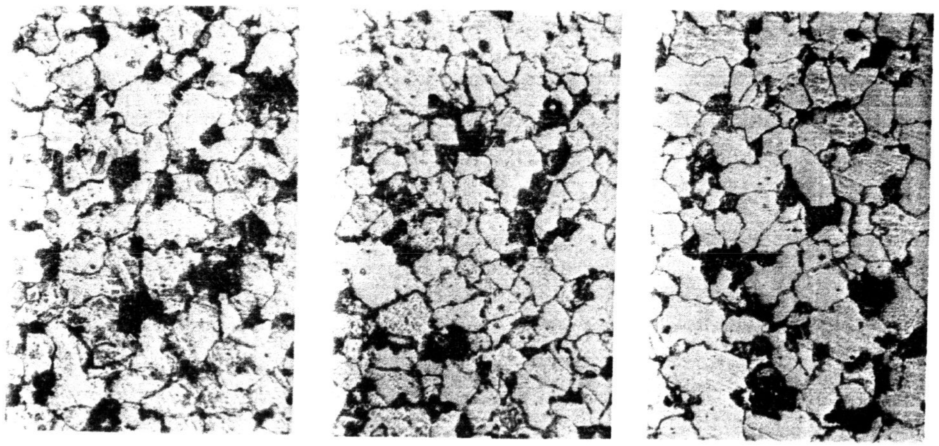
Chemical analysis. Material composition analysis was carried out by spectroscopic method in vicinity of corrosion damage and in the undamaged area. Acquired data, together with standard data, are presented in Table.1.

Table 1. Chemical composition

element	C	Si	Mn	Cr	Mo	Ni	Cu	S	P
near crater	0.11	0.26	0.55	0.21	0.50	0.11	0.15	0.027	0.022
undamaged area	0.12	0.26	0.55	1.07	0.50	0.11	0.15	0.027	0.022
15121 ČSN standard	0.10-0.18	0.15-0.35	0.4-0.7	0.7-1.0	0.40-0.50	0.20-0.40	0.50	max. 0.035	max. 0.035

On the basis of the obtained results it is obvious that in the crater area local chemical composition change is present, i.e., the amount of chromium is lower than in undamaged area, as well as standard data.

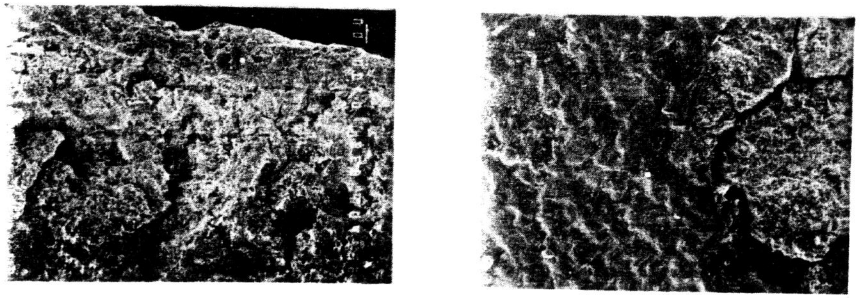
Optical microscopy. Specimen preparation for optical microscopy was done according to the standard procedure and the resulting microstructures are presented in Figs.3-5.



Figs. 3-5. Microstructures of corrosion areas

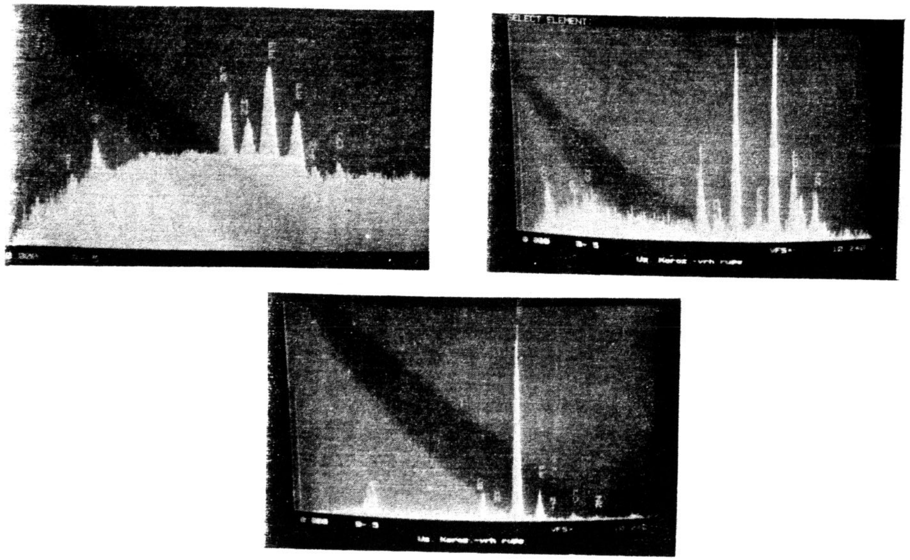
Order of presented microstructures respond to the following damaged area positions : Fig. 3 - near to the crater top, Fig. 4 - in the vicinity of the crater bottom and Fig. 5 - 5 mm collateral from crater. Basic structure is ferrite, but with complete degradation of the grain boundaries. Immediate crater vicinity had not been observed due to great corrosion deterioration. Area 10-15 mm around the crater presents grain boundary degradation.

Scanning electron analysis and EDAX. It was necessary to conduct gold coating before SEM and EDAX analysis because crater area had heavily expressed corrosion products. Corrosion area around the crater is shown in Figs. 6 and 7, with typical intercrystal destruction.



Figs. 6 and 7. Intercrystal destruction with corrosion coatings

Respective EDAX analysis revealed the presence of: Si, S, Ca, Cr, Mn, Fe, Ni and Cu (Fig.8), Si, Mo, S, Cr, Mn, Fe, Ni, Cu and Zn (Fig.9) and S, Cr, Mn, Fe, Ni, Cu, Zn (Fig.10).



Figs. 8-10. EDAX from corrosion region

DISCUSSION

Inter superheated steam pipeline corrosion, analyzed in this paper, belongs by the origin in the standing corrosion type, and by the mechanism to the electrochemical corrosion, i.e., galvanic attack.

Standing corrosion may originate if power plant, after process breaking, is stopped for a prolonged period and if appropriate system conservation had not been done correctly. It is well known /1/ that in such cases electrochemical destruction mechanism followed by products of FeO(OH) is usually taking place.

However, investigation applied in this case indicates that the galvanic attack, precisely, creation of the composition cell provoke corrosion deterioration. Composition cell, or dissimilar metal corrosion is developed in this case because two metals/alloys, such as iron and copper have a different anodic, i.e., cathodic tendencies in existing environment of empty steam boiler /2,3/. Also, ferrite is anodic to cementite in steel, which means creation of small microcell and existence of another independent corrosion source.

Beneficial conditions for microcell development, in investigated case, are created because the system was in standing state so there was not fluid flow, and thin oversaturated water film arise immediately after, which had not been removed due to the non-appropriate conservation. On other side, during the exploitation, coated Cu or brass particles on the inter-superheated steam pipeline walls formed through the water film lot of local electrolytic cells with low alloyed steel.

Copper and zinc presence inter-superheated steam pipeline was revealed by EDAX, Fig. 8-10. Very strong copper line, whose origin was not in material (lower amount then standard), as well as the zinc line, indicate that the particles, probably brass, were brought by working fluid into the inter-superheated steam pipeline system. Further analysis presented that primary water heater, made of brass, was possible particles source. Inquiry confirmed that inner surfaces of brass water heater are visibly damaged by erosion abrasion. Independent of the physical separation of primary water heater and primary inter-superheated steam pipeline, small brass particles, were infused by the working fluid in steam boiler. Beside the steam boiler has the filtering mechanism, it is possible that the particles smaller then 5mm reach the inter-superheated steam pipeline system and stop irregularly on the pipeline wall.

The possibility for that of corrosion appearance, could be minimized, if the inter-superheated steam pipeline system conservation had been done correctly. Considering that the damages perforates the pipe wall, serviceability of this super heater system until repaired.

CONCLUSIONS

On the basis of performed investigations, it can be concluded:

- corrosion in the investigated inter-superheated steam pipeline system belongs to the standing type, and by mechanism it is electrochemical galvanic;

- galvanic micro cell are created between steel, as pipe material and brass particles, as primary water heater material, through the water film;

- brass particles are created by erosion abrasion processes in primary water heater, and they are infused into the inter-superheated steam pipeline system by working fluid flow;
- corrosion deterioration could have been minimized if proper conservation had been done.

REFERENCES

1. Iovchev M., Korozia teploenergeticheskogo i iaderno-energeticheskogo oborudovania, "Energoatomizdat", Moskva, 1988
2. Corrosion resistance of metals and alloys, Ed. LaQue, Copson, Reinhold pub.co., NewYork, 1983
3. Struktura i korrozia metallov i splavov, Atlas, Spravochnik, Metallurgia, Moskva, 1989.