7. Naučno-stručni skup sa međunarodnim učešćem
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EVALUACIJA KVALITETA CEVI PREGREJAČA IZRAĐENIH IZ ČELIKA 14MoV6 3

EVALUATION OF QUALITY THE SUPERHEATER TUBES MADE OF STEEL 14 MoV 6 3 IN VIEW OF MICROSTRUCTURE

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REZIME
U termoelektranama, mikrostruktura visoko temperaturnih komponenti postepeno se mijenja. Cevi pregrejača u elektranama se projektuju sa ciljem da zadovolje period eksploatacije od 100000-200000 radnih sati. Nakon dužeg vremena u površinskom sloju materijala cevi pregrejača su uočene mikrostrukturne promene koje se javljaju pod uticajem pritiska i temperature u uslovima puzanja. U ovom radu je predstavljena procena kvaliteta cevi pregrejača sa aspekta mikrostrukture, u skladu sa preporukama Evropske komisije, korišćenjem svetlosne mikroskopije. Rad obuhvata kratak opis metode replika.

Ključne riječi: kvalitet, toplopostojani čelik, metoda replike, strukturne promene

SUMMARY
In power plants as well as high temperature parts the microstructure will gradually change. Superheater tubes in power plants are projected in order to meet their construction period 100000-200000 exploitation of working hour . After long time the surface layer of superheater tube materials microstructural changes are observed that occur under the influence of pressure and temperature in creeping conditions. In this paper, presented evaluation of quality the superheater tubes in in view of microstructure, according to the recommendations of the European Commission, using light microscopy. The paper includes a short description the replica method.

Keywords: quality, heat-resistant steel, replica method, structural changes

1. INTRODUCTION

Some components in thermal power plants are in the period of exploitation operation continuously elevated or exposed to high temperatures, different strain and creep, which makes them a lifetime limited [1,2]. Under the influence of temperature and load, heat-resistant steels also exhibit a tendency to creep. At the same time in the microstructures of these materials there are a phenomena of diffusion movement, precipitation of carbide, forming micro-cavities and micro-and macro-cracks [3]. The material in thermo power plant

is exposed to various stresses during its operation, must be considered as a system that is changing under the influence of external influences, which are subject to the laws of the thermodynamic irreversible process. Change the properties of materials is an internal process in the material, which is reflected, among other things, on microstructure.
The size of pores or cavities largely depends on the type of steel and it is one order of size of one micron, often less, and thus is often called "micro-pores or micro-cavities". Because of their small size, micro-pores can not be detected by a conventional non-destructive method such as ultrasonic, radiography, magnetic methods, etc., but can be reliably detected by the method of replicas. In this case, to identify micro-cavities and the evaluation of damage due to creep was applied replica method as a non-destructive method [4-8].

2. STEAM SUPERHEATER

Steam superheater is a device that converts saturated into overheated steam, used to produce electricity or in other processes. Steam superheaters were incorporated in the locomotives, vehicles stationary steam and steam turbines at the early 20th century. Today the superheater is an important part of a power plant around the world. The operating equipment such as steam turbines have a superheater in order to increase the thermal efficiency and to prevent damage of turbine blades from condensed water droplets. For better thermal efficiency, the thermal plant with high pressure steam superheater rather is used. Superheater may vary in size from a few meters to several hundred meters. Figure 1 shows a water tube boiler with a superheater.

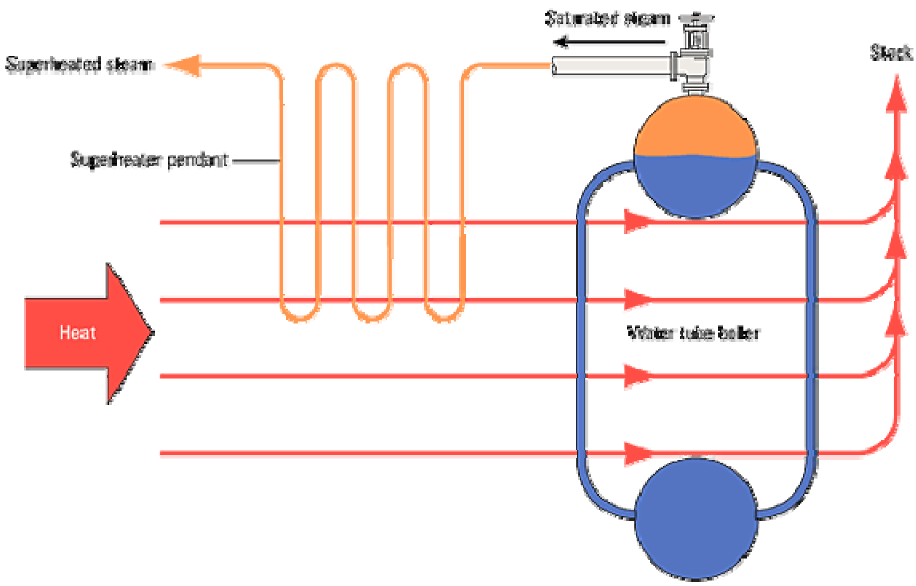

Figure 1. A water tube boiler with a superheater

In thermal plants, depending on the type of fuel and the size, superheated steam the temperature is ranging from 420 ° C up to 570 ° C. The development of thermal plant is going to the direction of increasing the working temperature, above +600 ° C. This development is going very slowly because the durability of materials at these temperatures and pressures (about 250 bar) is still subject of researching.
Superheater tubes may have outer diameter about Ø273mm and wall thickness ≈20mm. Operating temperature is 440 ^{o}C, and the working pressure 158bar. The material from which

pipes is made corresponding to the quality 14MoV6-3 [7] according to the European norm EN 10216-2/2002, which chemical composition corresponds to data given in Table 1.

Table 1. Chemical composition of steel 14MoV6-3 for super heater tubes

Chemical composition, wt. %										
C	Si	Mn	P	S	Al	Cr	Cu	Mo	Ni	V
0.10-015	0.15-0.35	0.40-0.70	≤0.025	≤0.020	≤0.040	0.30-0.60	≤0.30	0.50-0.70	≤0.30	0.22-0.28

3. MONITORING CREEP

The monitoring of microstructure by using a replica method could give more informations about the diffusion along the grain boundaries. So, the using replica method for monitoring the microstructure will has the sense only by periodically investigation and comparison of obtained with previous results. Coalescence of micropores also could be registered by replica method. This method belongs to metal surface methods as non-destructive testing, and is used to detect metallurgical inhomogeneity on the surface of metals.

In such testing the metal surfaces are thoroughly cleaned and degreased [4-8]. After removing the replica from the surface, the replica as monitored in the laboratory, see Figure 2.

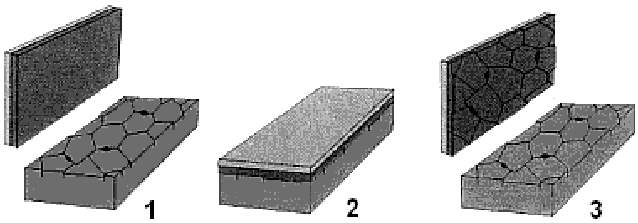

Figure 2. The replica method as principle

In this case, the replicas were examined in the light optical microscope, using magnification from 100 to 500x.

4. EXPERIMENTAL RESULTS AND DISCUSSION

4.1. Hardness measurements of superheater tubes

Fully testing for materials degradation due to overheating will often include a test of current mechanical strength. Basically mechanical strength can only be found by destructive testing.

Several types of transportable hardness testers have been developed for on-site, non destructive testing. Some of these testers follow the standard principles for hardness testing that is Vickers, Brinell and Rockwell.

The results of hardness measurements obtained from superheater tubes, at same positions where replicas were taken, are shown in Table 2.

Table 2. Hardness values at the superheater tubes

Measured values, HB
138 - 143 - 154 - 146 - 140 - 155 - 152 - 144 - 145 - 139 - 160 - 140 - 139 - 148 - 155

Figure 3 shows an example of measuring the hardness of the replica taken place.

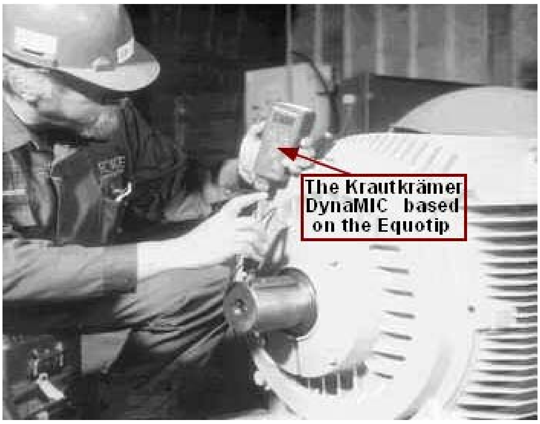

Figure 3. The Krautkrämer DynaMIC based on the Equotip principle

Results of hardness measurements indicate that some changes into the structure of superheater tubes metal were happened.

4.2. Evaluation of material degradation of creep

The material 14MoV6-3 developed creep damage on grain boundaries. According to German TRD 508 and VGB guideline VGB-R 509L [1] in-service inspections are required to start at the earliest of about 70 000 operating hours for 14MoV6-3 steel.
Replica tests, allow the making a classification of material degradation (Table 3). Other NDE tests also may be conducted for material characterisation during in-service inspections.

Table 3. Evaluation of material degradation of creep exposed components according to VGB-TW 507 [1,3]

Assessment class	Structural and damage conditions
0	As received, without thermal service load
1	Creep exposed, without cavities
2a	Advanced creep exposure, isolated cavities
2b	More advanced creep exposure, numerous cavities without preferred orientation
3a	Creep damage, numerous orientated cavities
3b	Advanced creep damage, chains of cavities and/or grain boundary separations
4	Advanced creep damage, micro-cracks
5	Large creep damage, macro-cracks

An advance of the metallographic analysis of superheater tube material, is in ability of ranging the appearance of isolated cavities to numerous cavities without preferred orientation, also numerous orientated cavities and chains of cavities and/or grain boundary separations.
Micrographs of superheater tubes made from steel 14 MoV 6-3 when creep has happened, are shown in the Figures 4-7. Those micrographs may serve for an evaluation of creep process development: isolated cavities, advanced creep damage, oriented cavities, chain cavities or grain boundary precipitations, etc.

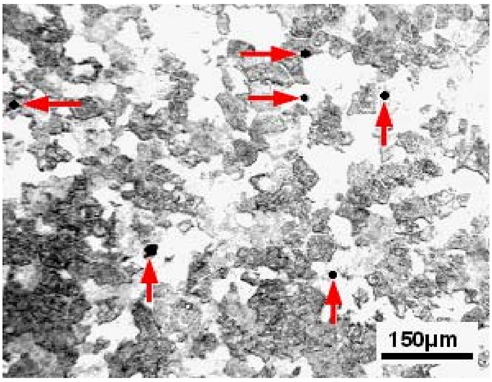

Figure 4.

Assessment class 2a:

Structural and damage conditions:

Advanced creep exposure, isolated cavities.

4% nital.

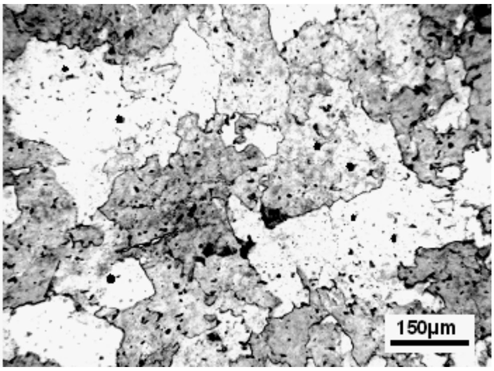

Figure 5.

Assessment class 2b:

Structural and damage conditions:

More advanced creep exposure, numerous cavities without preferred orientation.

4% nital.

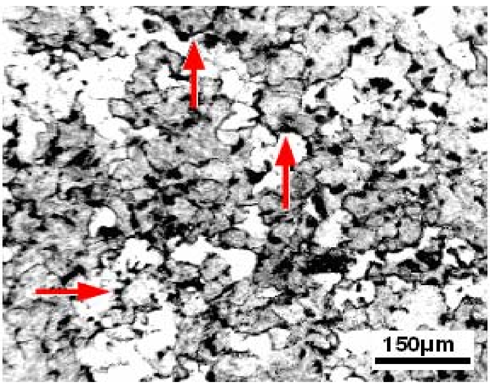

Figure 6.

Assessment class 3a:

Structural and damage conditions:

Creep damage, numerous orientated cavities.

4% nital.

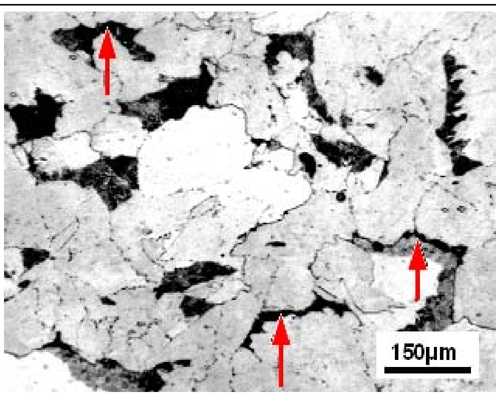

Figure 7.

Assessment class 3b:

Structural and damage conditions:

Advanced creep damage, chains of cavities and grain boundary separations.

4% nital.

5. CONCLUSION

On the basis of provided inspections and analyses, the following can be concluded:

- Knowledge of the microstructure and the class of damage are of crucial importance for the evaluation of quality or estimation of remaining life of thermal components.
- The microstructural changes formed during servicing period at elevated temperatures and thermal stresses.
- From the standpoint of monitoring and evaluating the quality of the microstructure components, the replica method applied here certainly represents one reliably technique.
- Identified micropores formed in the exploitation of superheater tubes show negative affect both on physical and mechanical properties of materials.

6. REFERENCE

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