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Selctive heat treatment of the gearbox component

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Abstract

Nowadays there are setting more and more demanding requests for the products of engineering industry from the points of the parameters of load, durability and reliability. They are followed by higher demands for construction materials with high strength and tough enough as well, with higher wear resistance. Volume isothermal heat treatment of graphitic cast irons is normally used technology at present, what is impossible to say about isothermically heat treated surface layers. The hardness of such structures is lower in comparison with martensitic structure, its toughness is considerably higher. The advantage of isothermal surface heat treatment in comparison with volume heat treatment are most of all economic reasons, which considerably influence on the application of new technologies into the practice.

The submitted paper deals with the advantages and disadvantages of selective heat treated parts made of graphitic cast irons. It is experimentally verified the possibility of isothermal surface hardening of cast irons and it is shown the possibility of following usage in practice at concrete parts for automobile industry.

Keywords: Heat treatment; Striker fork; Ausferritic surface layer; ADI.

1. Introduction

The ausferritic surface layers have lower hardness of surface, but also higher toughness and wear resistance in comparison with martensitic surface layers. Share of ausferrite in the structure of isothermally heat treated surface layer is influenced by initial structure of graphitic cast iron and the depth of overheating of surface to austenitic temperature.

Short holding time at the temperature of ausferritic transformation gives blending ausferritic-martensitic structure after following cooling to the temperature of environment. Vice versa, adequate long holding time provides the transformation of austenite to ausferrite without the presence of martensite. The structure of surface layer consist of ausferrite, martensite and retained austenite. The share of retained austenite in the surface layer is lower than in the structure of ADI. There is lower danger of crack creation by isothermal heat treatment of graphitic cast irons in comparison with the surface hardening to martensite.

2. Surface heat treatment of the striker forks

Casting of striker fork for gearbox of lorry were chosen for practical verification of material properties. The casting delivered by the Czech firm SECO Group Jičín (Fig. 1) was as a basic material.

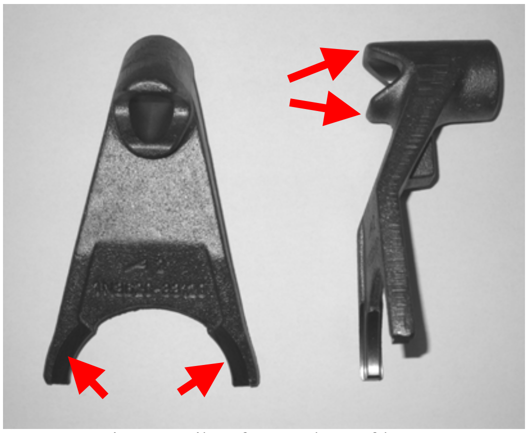

Fig. 1. Striker for gearbox of lorry

Arrows point the places for surface heat treatment because of increasing of hardness and wear resistance according to the customer´s requests.

3. Characteristic of the striker fork

Casting material is required according to the Japanese industrial standards. It concerns the ductile iron FCD 600-3. It is a pearlitic-ferritic matrix with globular graphite. The pearlite content is 70-80%. Figure 2 shows the microstructure of the basic material.

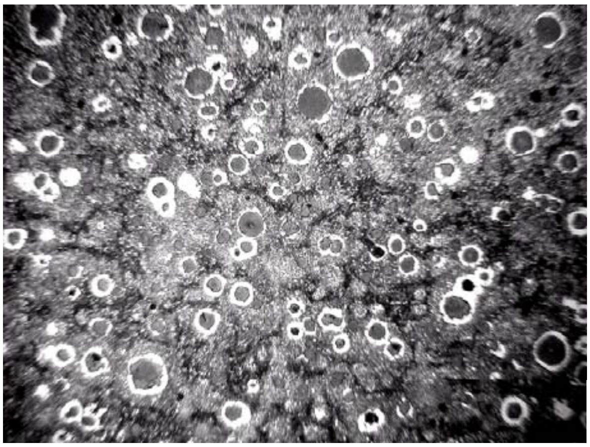

Fig. 2. Microstructure of basic material FCD 600-3, etch, 3% NITAL, magn. 100x

Induction heating was used for making of surface layers. This technology enables fast heating of material surface and achieving of high temperature gradient between surface layer and the inner part of the casting. It means, that the surface is heated to the austenitic temperature with following recrystallization and inner parts contain basic metal material without recrystallization. As the first one there was applied standard technological process of heat treatment (water hardening) with the aim to get martensitic structure surface layer. Then the striker forks were isothermally heat treated at different temperatures of the salt bath and different holding periods at the temperature of ausferrite transformation. Some of striker forks were pre heated to avoid heat removal into cold core and creation of martensite as well.

4. Heat treatment conditions

The generator GV 201, installed in AVC a.s. Čadca, was used for induction heating. There was used a single – turn coil formitting to the ends, which were heated, with the section 6x6 mm. The austenitizing temperature was 920°C and the speed of heating to this temperature was designed according to the subjective observation of the worker following of color scale for temperature estimation within the range from yellow – red (900°C) to orange (950°C).

The striker forks 11; 12; 13 were cooled into the solution Castrol Aquasol 2000-1 with the temperature 20°C (creation of martensitic structure). The striker forks 21; 22; 23 were used for isothermal heat treatment i.e. induction heating of chosen surface to the austenitic temperature and following cooling in the salt bath AS 140 for 5; 10; 15 minutes and the stricker forks 31; 32; 33 were heat treated by isothermal heat treatment i.e. induction heating to the austenitic temperature, cooling into tha salt bath, holding time for 90 minutes and free air after – cooling.

5. The hardness evaluation

At the strikers forks there was measured the Rockwell hardness (HRC) according to STN EN ISO 6508 (1, 2, 3). The resultant hardness is an average value from six measurements on both parts of the fork end the hardness values are shown in table 1.

Table 1.
Measured hardness of the surface layers

Specimen number	**Average value (HRC)**
11	**58**
12	**56**
13	**58**
21	**37**
22	**44**
23	**47**
31	**46**
32	**48**
33	**47**

This table shows that the highest value of hardness were measured at the striker forks 11, 12, 13 where was the presence of martensite in the surface layers. There was fulfilled the requirement of standard hardness 52 ÷ 59 HRC.

At the strikers forks 21, 22, 23 the hardness is rising with the lowered temperature of the salt bath what is the evidence that the resultant hardness is influenced by the cooling speed. At the same time we can see, that the hardness of ausferritic structure is gently lower than the hardness of martensitic structure. The striker forks 31, 32, 33 were pre heated, achieved hardness values are quite higher than at the striker forks without pre heating. Considerable increasing of hardness was not possible to reach not even by 90 minute long holding time.

a)

b)

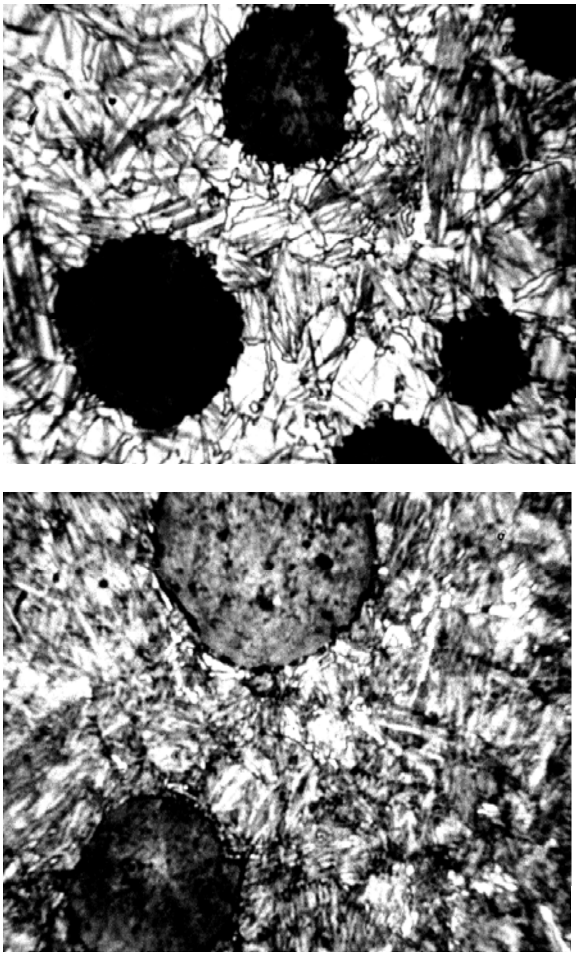

Fig. 3. The ausferritic surface layer: the specimen from the striker fork 23 and 32 just under the surface, etch. 3 % Nital, magn. 1200x

6. The metallographic evaluation

The structure of the surface layer of isothermally heat treated specimen from the striker fork 23 (Fig. 3a) is created by ausferrite, martensite and retained austenite. The detail of ausferrite structure taken just under the surface shows, that in the case of higher magnifications it is possible to identify also typical morphological signs of ausferrite, which is created by very slight platy formations. If we direct from the surface into the inner parts of the specimen, we can see a greater amount of non transformed ferrite in the surrounding of graphite parts – under the influence of faulty austenitization. Just near the surface of graphite grains there was the start of enriching of ferrite by the carbon, the graphitic elements are in disconnected cover of ausferrite structure.

The specimen from the striker fork 32 was isothermally heat treated, the structure of the surface layer (Fig. 3b) consist of ausferrite, a small amount of martensite and the retained austenite.

7. Conclusion

A lot of cast irons with higher mechanical values have higher wear resistance. It concerns most of all the cast irons with the needle, martensite or ausferritic structure, achieved right by casting or adequate heat treatment.

The ausferritic structure after isothermal heat treatment is similar to the structure of high carbon steels. It is possible to reach this structure also in the surface layer by means of induction surface heating and following cooling into the hot bath. The advantage of the structures created after heat treatment is in lower wearing at the deformations, what is the result of higher toughness, the next advantages are also lower structural tensions and higher homogeneity of the structure.

Isothermal heat treatment is demanding on the production as standard heat treatment (hardening and tempering), but in spite of financial demands it is more advantageous for higher wear resistance of the material made this way. The ausferritic structure is more favorable and has lower tendency to the crack creation in comparison with the martensite structure. That is why the ausferritic materials are possible to use for the parts of complicated shapes without the problem of early wearing. They have a lot of advantages compared with the other (heat treated in different ways) cast irons and they could replace them in some cases – most of all at dynamically stressed parts where non heat treated cast irons are not suitable because of their fragility.
However, nowadays ausferritic surface layers have not applied in engineering industry yet in spite of their advantages in comparison with martensitic surface layers.

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