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Some aspects of sherardizing implementation during anti-corrosion protection of heat-treated metal parts

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Abstract. The article reveals the peculiarities of obtaining Zn anticorrosive diffusion layers on heat-treated metal parts using sherardizing method. It is shown that sherardizing processes can be successfully used as a final heat treatment operation for some metal parts after hardening in a temperature gap between 350-700 °C. 380-450 °C are the most efficient temperatures of sherardizing process to reveal hardening stresses in details. At the same time, applying sherardizing method for anticorrosive protection of details subjected to final heat treatment may cause a weakening of metal accomplished by a reduction of working properties. This fact can be described by structural changes in metal caused by additional heat impact of sherardizing temperatures.

1. Introduction

Due to a range of specific coating properties, sherardizing is an actual alternative to traditional methods of zinc anti-corrosion protection. It is known, that sherardizing is widely used for anti-corrosion protection of hardware parts and, in contrast to other methods of zinc anti-corrosion protection, provides a formation of intermetallic diffusion layers. Mechanical and anticorrosive properties of zinc diffusion layers are far more exceeded than those of other zinc coatings without any diffusion interaction with metal substrate [1, 2].

Traditionally zinc anti-corrosion coatings are obtained after a final heat treatment of a detail. If it is necessary to use annealing operation as a final heat treatment of a detail, the most economically efficient way is to change traditional thermal heating by a sherardizing process. Such a replacement gives the opportunity to reduce costs on additional anticorrosive treatment of a detail as well as cuts down the amount of manufacturing equipment in the aggregate of efficient use of working area.

It is necessary to notice that a temperature interval of sherardizing processes lies between 350 and 700 °C depending on some technological characteristics of the process [3]. Such a wide temperature interval gives the opportunity to choose the necessary sherardizing conditions taking into account a prior heat treatment of a detail. The possible variants of sherardizing processes incorporation into the overall heat treatment cycle for some details are characterized in Figure 1.

Combining overstrain aging with sherardizing is efficient for steel part subjected to final thermal treatment using temperatures no less than 300 °C. The activity of sherardizing processes is extremely dependant on zinc vapor pressure inside a closed vessel as well as on the amount of oxygen inside it. The presence of oxygen inside a closed vessel may lead to formation of a thin oxide layer on metal surface that creates a diffusion barrier. To overcome these obstacles and ensure sherardizing process at minimum zinc vapor pressure it is necessary to use vacuumization or inert gas flushing with the aim to decrease the amount of oxygen inside a vessel.

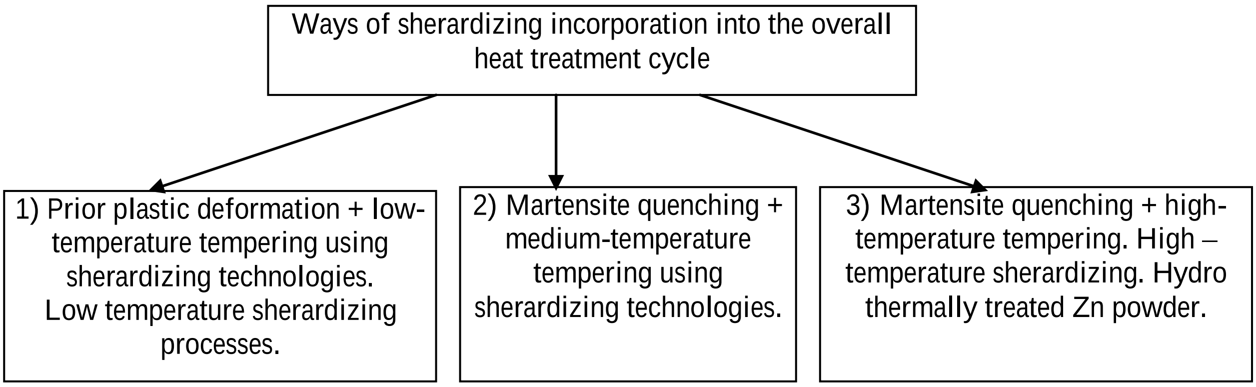


Figure 1. Incorporation of sherardizing processes into the overall heat treatment cycle for some details.

Combining martensite quenching and high temperature sherardizing processes is possible by using additional hydrothermal treatment of a zinc powder. As a result of this treatment a thin porous ZnO layer forms round the surface of each zinc globule. The ZnO layer prevents zinc powder from fritting at high temperatures and does not block zinc evaporation.

2. Experimental

The most efficient way to realize sherardizing processes is medium temperature tempering after prior quenching, which is the most widespread type of heat treatment for a range of spring elements. The implementation of sherardizing instead of tempering after prior quenching is possible using standard sherardizing temperatures (380-450 °C) without any additional treatment of zinc powder or saturating atmosphere control. Figure 2a exhibits an example of spring element with 20 μm zinc diffusion layer (Figure 2b) formed using integrated sherardizing technology.

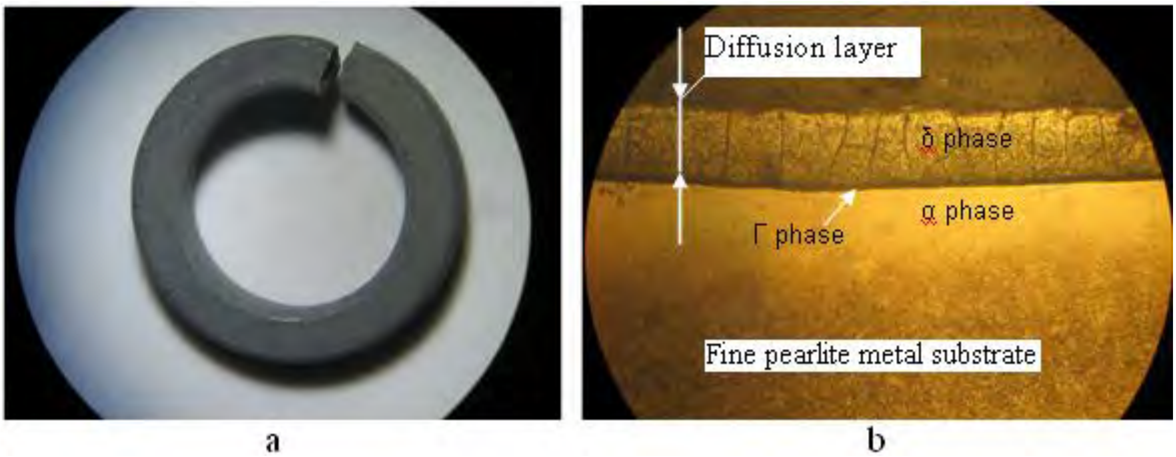
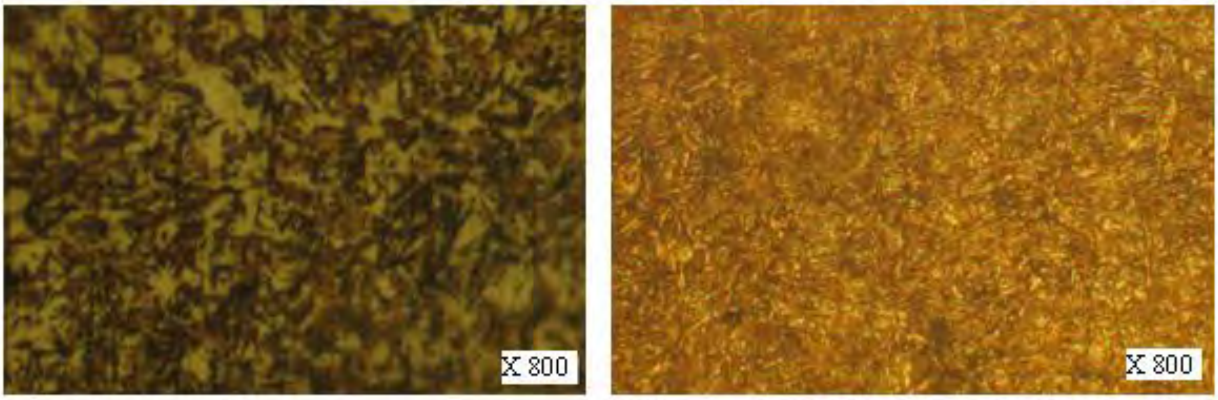


Figure 2. a) Spring washer, after sherardizing X10.
b) Microstructure of zinc diffusion layer, X400.

The final microstructure of the spring washer is formed during the sherardizing process. Sherardizing temperatures provide a breakdown of martensite and its transformation into a fine pearlite (Figure 3 a, b).



a b

Figure 3. Microstructure of spring washer after quenching (a) and sherardizing (b).

After sherardizing hardness of spring washer structure was 43-47 HRC that corresponds to the required hardness parameters, regulated by GOST 6402-70 [5].

It is possible to use any way of obtaining zinc anticorrosive coatings on details without heat treatment or special requirements towards strength rating. The choice of zinc anti-corrosion method depends on the types of items to be treated, their dimensions and shape complexity. However, using sherardizing for anti-corrosion protection of details after the final heat treatment with special requirements towards strength class may cause the strength reduction due to thermic influence of sherardizing on metal structure. Consequently, it is the necessity to investigate the influence of sherardizing on steel structure and mechanical properties of metal parts with regulated strength rating after their final heat treatment.

With the aim to determine a possible strength reduction tensile test of bolts with different strength rating were conducted. For the bolts with each strength rating there were determined a breaking point in state of delivery, in state of delivery and subsequent sherardizing as well as after subsequent tempering according to the regimes equal to the sherardizing temperatures. The number of tests was three for each strength rating and corresponding type of treatment.

The results of tensile tests exhibit the decrease of breaking point and conventional yield strength data for bolts after sherardizing and additional tempering. This fact can be explained by activation of diffusion processes in steel due to additional thermic influence of sherardizing and additional tempering that resulted in steel microstructure change. For the high-test fasteners with a fine pearlite structure and strength rating 9.8-10.9 an additional heat over 650 °C with further soaking leads to cementite plates globulation and formation of an equiaxed grains. It was determined that for the samples with strength ratio lower that 8.8 the decrease of breaking point and conventional yield strength didn't exceed the bounds data listed in special standard GOST R 52643-2006 [6]. It's significant that the softening effect showed up after subsequent sherardizing is lower comparing with one that after subsequent tempering. This fact can be described by a decarburization effect during the process of subsequent tempering as well as by the fact that after sherardizing an intermetallic diffusion layer forms round the outer surface of coated article providing a compressing strain effect (Figure 4).

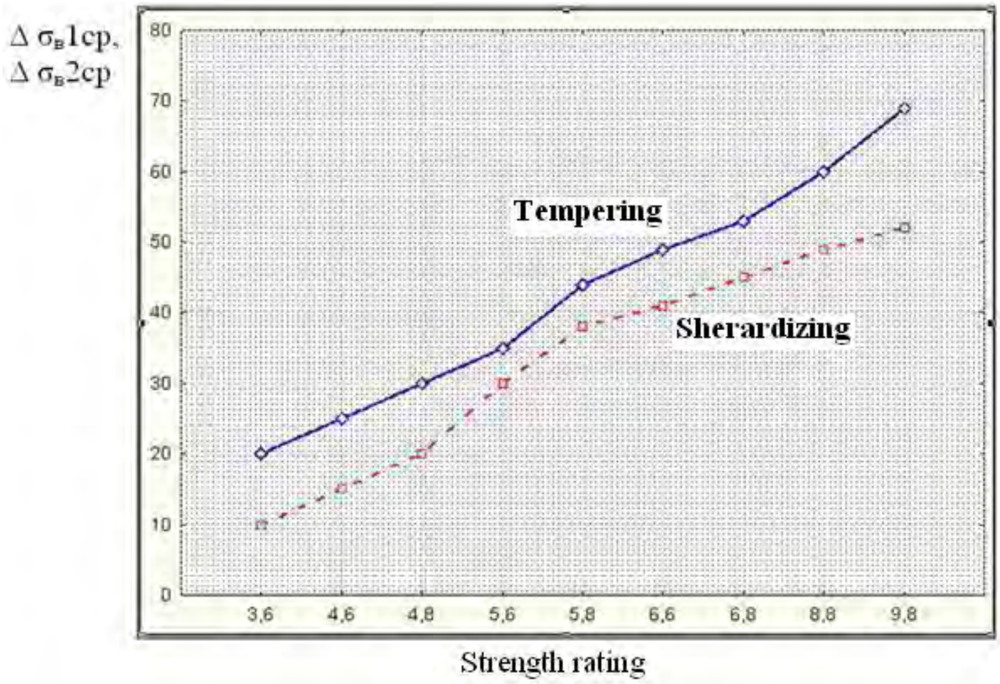


Figure 4. Variation dependence of breaking point data (average value) from strength rating for sherardizing and tempering at equal regimes (450^0C, 1h.).

3. Conclusions

Unlike the more widespread methods of obtaining Zn anticorrosive coating on metal articles known as hot-dip galvanizing or electrogalvanizing using sherardizing method may lead to a softening effect for some high-strength details. However, a rational choice of thermal treatment regimes and strength rating of a detail to be treated gives an opportunity to use advantages of sherardizing process for anti-corrosion protection. For some metal parts like spring elements, the most efficient decision is to combine the final stage of tempering with sherardizing. Such kind of complex heat-anticorrosive treatment gives an economy gain comparing to conventional ways of thermic and anticorrosion improvement of details. Using sherardizing to form an anticorrosive diffusion layer on details with a regulated strength rating over 8.8 is necessary to take into account the decrease of mechanical characteristics of the treated articles.

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