STUDY OF THE INFLUENCE TYPE HEAT TREATMENT ON THE HARDNESS OF A GRADIENT MATERIAL BASED ON IRON

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Abstract

Heat treatment is the most widespread treatment of metal products. The modes of heat treatment are developed for most existing metals. However, in the case of processing new types of gradient metals based on iron, the typical modes are not suitable. The article describes a method for producing gradient materials based on iron with a nonequilibrium structure. The results of experiments on the development of heat treatment regimes, as well as studies of micro structures, the dependence of mechanical properties on the species and the mode of heat treatment are presented.

Keywords: Metallic melt, dispersed particles, gradient material, heat treatment, micro structures, mechanical properties

1. INTRODUCTION

More and more strict conditions regarding providing them with express properties present to materials with development of technology and technologies. Wear resistance, thermal stability, rust resistance, fatigue properties, resistance to beam influences, etc. It is possible to allocate among such properties. Micro structuring of materials by method of injecting of the ultra dispersible particles demanded on morphology in the crystallizing melt [1, 2] is the most perspective direction of creation of materials with a high level of properties. It gives the chance to receive heterogeneous gradient dispersible reinforced became with not expressed demarcation of layers. Feature of such steels consists that the entered ultra dispersible micro particles are built in a crystal lattice of the formed material, increasing quantity of crystallization centers that leads to the significant increase in mechanical characteristics, increase in its specific density (due to crushing of structure) [3], more fine grain is provided. Properties are also introduced, the characteristic of the entered particles to those volumes of material where they settle down. The arrangement of the particles injected in a melt in ultra-dispersible can be operated that allows to predict and to set various properties to various volumes of the received steel [4]. Development of the mode of a heat treatment of the received materials for the purpose of increase in variability of giving of properties and characteristics to the developed class of gradient materials is necessary, for this type of a material as in view of a nonequilibrium of structures the existing modes of heat treatment are inexpedient to be applied.

2. CARRYING OUT EXPERIMENTS AND RESEARCH OF EXEMPLARS

3 preparations of the experimental gradient materials for a research of influence of a type of a heat treatment on properties of gradient materials were made. The technology of receiving included fusion of burdening materials in an induction furnace and further pouring of the received metal melt on installation of centrifugal casting. Heating of steel-pouring of a trench of installation was made to 550-600 ºC before pouring, in order to avoid welding in of molten metal to it and, as a result, loss of volume and speed of filling of a metal melt. Giving of dispersible particles of TiC was made in the course of pouring on a metal stream by means of a batcher. 3 mold pieces of gradient materials were made during the experiments:

1) mold piece without introduction of dispersible particles of TiC (a comparison exemplar);
2) mold piece with the maintenance of TiC = 1 mass. % of the total portion of metal;
3) mold piece with the maintenance of TiC = 2 mass. % of the total portion of metal.

TiC for modifying of metal had density of 3.21 g / cm^3 and dispersion of 1-3 microns.

Cutting on exemplars of various configurations was made after receiving the gradient strengthened preparations, for carrying out various researches and the experimental works. Carrying out different types of a heat treatment of exemplars from all preparations was the first stage then the research of their microstructure and hardness was carried out. These types of researches were carried out in 3 areas on exemplar section: outer edge, central part and inner edge. It is caused by the fact that the structure of this type of preparations is uneven when receiving centrifugal and cast preparations in view of various conditions of a crystallization of a metal melt [5-7]. The entered dispersible particles of TiC have density below, than at iron-carbon of melts (3.21 and 7.8 g / cm^3 acc.) and under the influence of Archimedean forces will aspire to an inner edge of mold pieces. Received approved samples and the exemplars which underwent a heat treatment were polished for a microstructure research then their microstructure was investigated on an optical microscope "Axio Observer D1m", the system of the analysis of the image was used by "Thixomet" [8], and then the obtained data were confirmed by means of the scanning electron microscope Jeol JSM-6460 LV. In each exemplar the area of 3 μm in size 20 × 20 areas for calculation of quantity of dispersible particles was chosen: outer edge, central part and inner edge of preparation. The found particles were allocated by means of the tools which are available in system of the analysis and then counted. Dispersible particles were not entered into an approved sample therefore their calculation in exemplars from preparation No. 1 was not made. Hardness of exemplars was measured similarly in 3 areas of each exemplar then mean value was counted; measurement was performed by means of Brinell's hardness gage of TP5014.

The first type of a heat treatment was the following mode: heating to 780 °C, endurance, sluggish cooling (with the furnace) to 500 °C, then - on air (exemplars 1.2 - 3.2). The following sample party was maintained at a temperature of 1050 °C then it was cooled in oil (exemplars 1.3-3.3). These exemplars after the researches were located in the furnace similarly above to the shown operations, were maintained at a temperature of 225 °C then were sluggishly cooled (exemplars 1.6-3.6). Results of calculation of quantity of particles and hardness of exemplars after this type of a heat treatment are presented in (**Table 1**).

Table 1 The results of counting the number of dispersed particles [pcs] and measuring the hardness [HRC]

Results of calculation of quantity of particles																		
Field of calculation	Numbering of exemplars																	
	1.1	2.1	3.1	1.2	2.2	3.2	1.3	2.3	3.3	1.4	2.4	3.4	1.5	2.5	3.5	1.6	2.6	3.6
Outer edge	-	3	12	-	9	17	-	8	10	-	7	3	-	7	11	-	4	3
Central part	-	2	12	-	14	28	-	11	12	-	11	5	-	8	15	-	5	4
Inner edge	-	3	28	-	19	42	-	14	13	-	12	9	-	11	21	-	8	5
Mean value	-	3	17	-	14	29	-	9	12	-	10	6	-	9	16	-	6	4
Results of measuring the hardness																		
Field of calculation	Numbering of exemplars																	
	1.1	2.1	3.1	1.2	2.2	3.2	1.3	2.3	3.3	1.4	2.4	3.4	1.5	2.5	3.5	1.6	2.6	3.6
Outer edge	66	56	61	34	26	36	58	50	51	22	25	22	55	53	47	45	44	42
Central part	66	57	59	38	30	28	53	56	52	30	23	26	54	56	49	50	48	46
Inner edge	66	67	61	37	35	29	50	60	57	30	28	27	53	53	50	53	48	47
Mean value	66	60	60	36	30	31	54	55	53	29	25	25	54	54	49	49	47	45

The obtained data were processed, and for the sake of clarity the diagrams of the change in the number of particles and hardness were compiled, depending on the type of heat treatment (**Figure 1**).

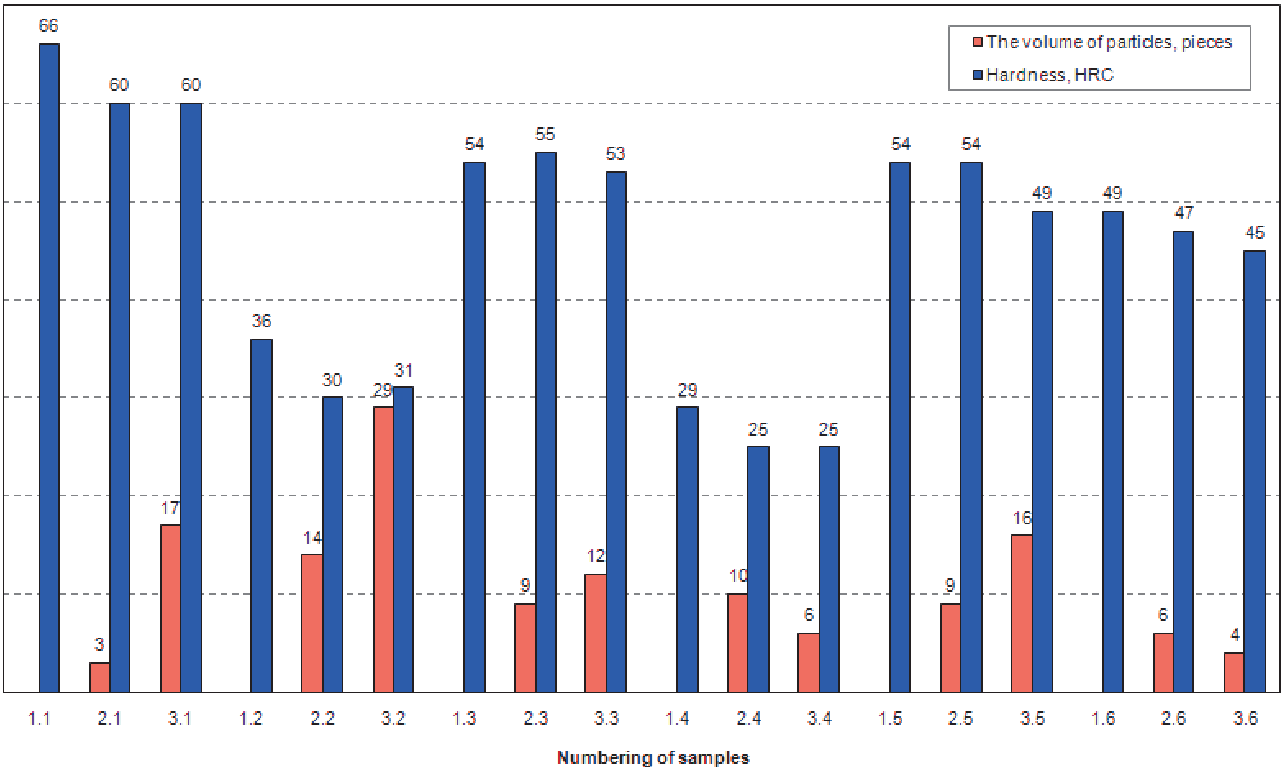

Figure 1 Charts of dependence of quantity of particles and hardness of exemplars of gradient materials from a type of a heat treatment

3. CONCLUSION

The carried-out heat treatments on various modes allow drawing the following conclusions when comparing results of researches with an approved sample:

- the heat treatment on the "heating to 780 °C, endurance, sluggish cooling (with the furnace) to 500 °C, then-on air" mode (exemplars 1.2-3.2) reduces hardness by 48-50 %, at the same time the quantity of dispersible particles increases by 2.1-2.2 times;
- the heat treatment on the modes "heating to 1050 °C, endurance, cooling in oil" (exemplars 1.3-3.3) reduces hardness by 10-15 %, at the same time the quantity of dispersible particles does not change (+3…5 %); the subsequent annealing at a temperature of 640 °C (exemplars 1.4-3.4) lowers values of hardness for 49-53 %, and the quantity of dispersible particles slightly decreases - by 1.1-1.2 times;
- the heat treatment on the "heating to 1050 °C, endurance, cooling on air" mode (exemplars 1.5-3.5) reduces hardness by 12-16 %, at the same time the quantity of dispersible particles increases a little (+2…3 %); the subsequent annealing of these exemplars at a temperature of 225 °C (exemplars 1.6-3.6) reduces hardness on average by 9-11 %, the quantity of particles at the same time remains decreases by 2.4-2.6 times.

Falling of hardness is bound in all cases to a metal recrystallization, removal of internal stresses in structures of material, dissolution in a solid solution of injected dispersible particles. The structure of gradient materials becomes more uniform when carrying out a heat treatment the structure of gradient materials becomes more uniform, and particles drop out in a secondary phase (increase in their quantity) reduces degree of their liquation in volume of metal, providing thereby evenly strengthened structure. The analysis of change of quantity and morphology of particles showed that the hardening mechanism as a result of a heat treatment changes: the dispersible strengthened material becomes dispersion strengthened, or the mixed type (at inexact dissolution in a solid solution and partial secondary loss).

On the received result it is possible to draw a conclusion that optimum the mode for processing of gradient material of TiC containing dispersible particles in the structure in number of 1 or 2 %, is the "temperature of endurance is 1050 °C, cooling on air" mode, and if necessary spending vacation of these exemplars is possible at a temperature of 225 °C.

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