ASPECTS ABOUT THE PROPERTIES OF A BAINITIC DUAL-PHASE S.G. CAST IRON

Ioan Milosan*, *PhD
Professor, Transilvania University of Brasov, Romania

Abstract:

The paper presents a study about the influence of some heat treatment parameters of austempering and annealing with tempering over the structure and values of hadness, tensile strength, elongation and impact strength of a low alloyed S.G. cast iron. It is pointed out the influence of some factors (the temperature and the holding time at the isothermal level) on the phase transformation and properties in the studied cast iron.

Keywords: Materials science, cast iron, heat treatment, dual-phases

Introduction:

Over the last few years, a number of thermal processes have been developed to modify the matrix structure and thus the properties of ductile cast iron.

Earlier papers (Simon, 1996) have shown what a major importance represents the studies about the bainitic S.G. cast irons obtained by heat treatment, especially the isothermal hardening (Batra et. al., 2003). Being a variante of the classical isothermal heat treatment, the Dual-Phase bainitic heat treatment is using a certain type of S.G. cast iron, which is characteristic by a large and low A_s-A_f interval of temperatures.

After this heat treatment, the structure is composed of ferrite and bainite (in the case of cast iron, the bainite mean a structure composed of bainitic ferrite and carbon enriched austenite). The structures confer to material high values for the impact strength even at the low temperature (Eric et. al., 2006).

The studied materials are Ni-Cr low-alloy bainitic S.G. cast iron obtained by two heat treatments: the classical isothermal austempering heat treatment and the “Dual-Phase” bainitic heat treatment.

Research objectives

This research has a number of objectives which can be started as follows:

1. To determine the mechanical properties: hardness (HB), tensile strength (R_m), elongation (A) and impact strenght (KCU) at the isothermal temperature.
2. Identify the effect of heat treatment over the structure and properties.

Materials

The studied cast iron has the following chemical composition (% in weight): 3.61% C; 2.67% Si; 0.53 % Mn; 0.011%P; 0.005%S; 0.06%Mg; 0.45% Ni; 0.20% Cr. This cast iron was made in an induction furnace. Nodular changes were obtained with the "In mold" method, with the help of prealloy FeSiMg with 10-16% Mg, added into the reaction chamber in a proportion of 1.1% of the treated cast iron.

Heat treatments

The parameters of the heat treatment done were the following: for the lots A, B, C , submitted to isothermal hardening, the austenizing temperature T_A = 900 [°C]. and for the lots: A_1, B_1, and C_1. submitted to Dual-Phase bainitic treatment, the austenizing temperature T_A = 830 [°C], the maintained time at austenizing temperature, τ_A = 60 [min] for all the lots.

The temperature at isothermal level, for all the lots was: T_{iz} = 300, 350 and 400 [°C]; the maintained time at the isothermal level, t_{iz} = 10; 20; 30; 40; 50 and 60 [min]. All these 6 experimental lots were performed at isothermal maintenance in salt-bath, being the cooling after the isothermal maintenance was done in air.

Experimental results

From this material, 48 typical of Hardness (HB), tensile strength (R_m), elongation (A) and impact strenght (KCU) test specimens was done and after the heat treating, it was determined these properties. The values of the mechanical results are presented in table 1 and figures 1 - 4.

Table 1: The experimental values of mechanical properties, for various T_{iz} and τ_{iz}

Lot	T_A [°C]	τ_A [min]	T_{iz} [°C]	τ_{iz} [min]	HB	Rm [N /mm ^{2}]	KCU [J/cm ^{2}]	A [%]
A	900	60	300	10	451	1435	40	1,1
				20	426	1420	45	1,5
				30	415	1350	53	2,5
				40	408	1300	63	3,2
				50	390	1280	69	3,5
				60	383	1130	85	4,5
B			350	10	420	1250	55	2,8
				20	408	1140	65	4,0
				30	390	1070	70	4,2
				40	331	980	90	5,4
				50	315	920	100	6,5
				60	311	910	120	7,6
C			400	10	375	950	85	5,5
				20	321	930	90	6,8
				30	306	890	98	7,9
				40	302	860	115	8,0
				50	298	850	134	8,1
				60	292	815	135	8,8
A_1	830	60	300	10	408	1290	58	3,5
				20	395	1270	65	3,7
				30	370	1200	74	4,9
				40	355	1160	88	5,5
				50	333	1100	95	6,4
				60	323	1010	106	7,2
B_1			350	10	381	1070	65	4,8
				20	355	1060	78	5,4
				30	344	1000	85	5,6
				40	337	920	93	5,9
				50	311	880	105	7,2
				60	303	780	137	8,8
C_1			400	10	311	920	70	7,1
				20	306	900	93	7,6
				30	302	870	107	8,4
				40	298	850	118	9,5
				50	285	800	137	10,2
				60	268	720	145	11,5

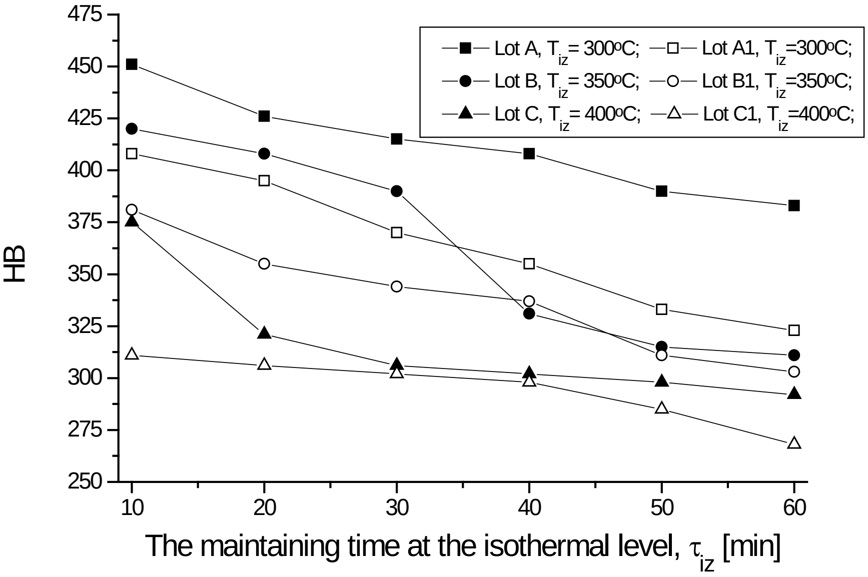

Figure 1: The influence of the heat treatment over the hardness (HB) properties, for different maintaining time

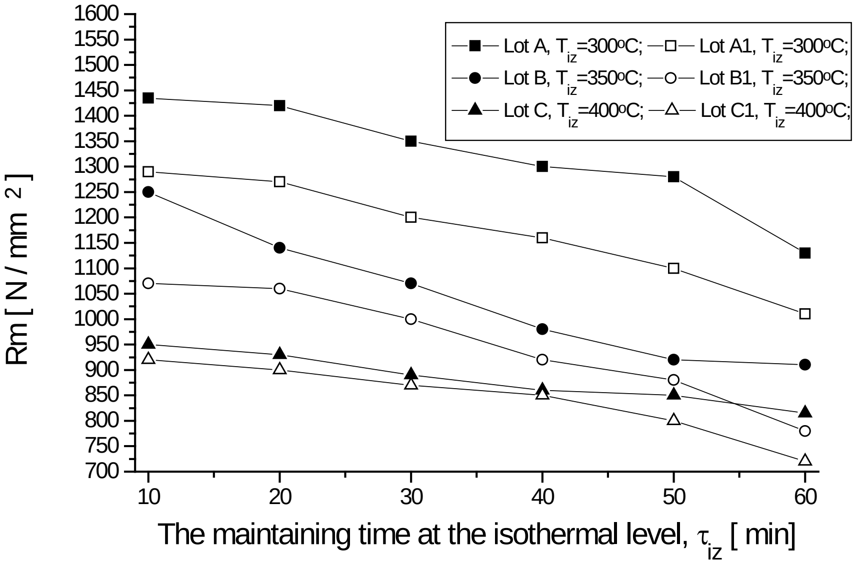

Figure 2: The influence of the heat treatment over the tensile strength (R_m) properties, for different maintaining time

It can be certainly observed a normal evolution of the values for mechanical characteristics :

-when maintaining time at the isothermal level for both heat treatments is growing then Rm and HB are decreasing and A with KCU are increasing.

-when maintaining time at the same temperature of the isothermal level for both heat treatments is increasing than Rm and HB are decreasing , A and KCU are increasing.

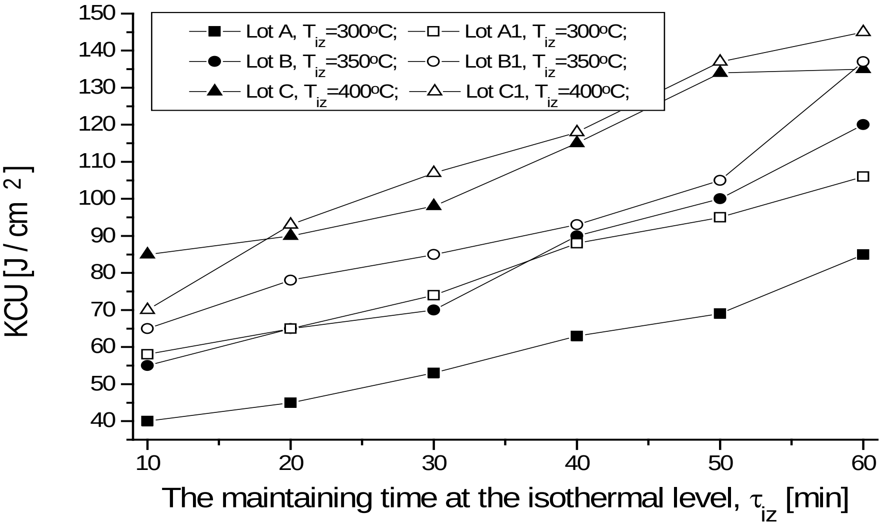

Figure 3: The influence of the heat treatment over the impact strenght (KCU) properties, for different maintaining time

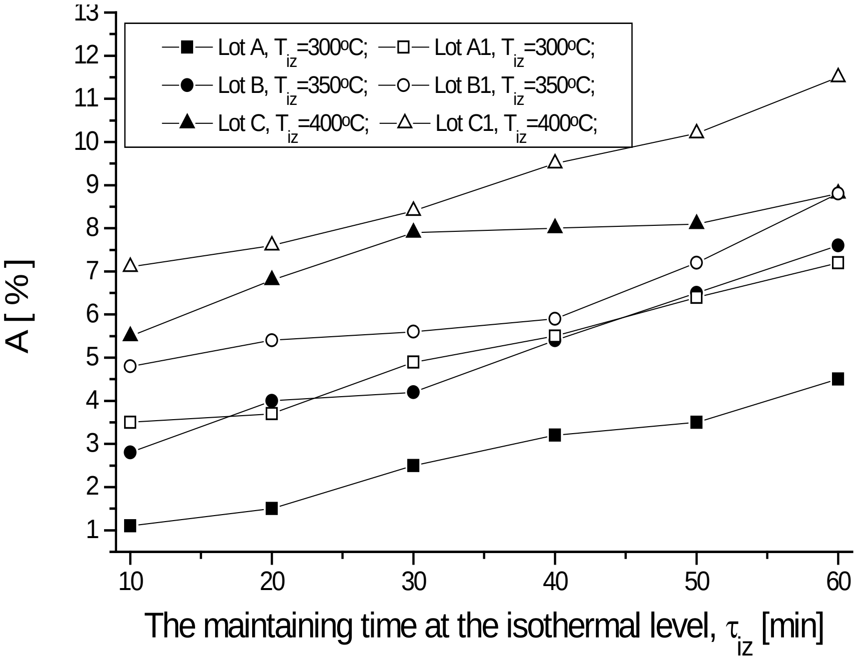

Figure 4: The influence of the heat treatment over the elongation (A) properties, for different maintaining time

-comparing the values of the mechanical properties for both heat treatments in the case of the classical isothermal austempering heat treatment, at the same time and temperature, the isothermal level determining high values for Rm and HB and low for KCU and A comparing with the “Dual-Phase” bainitic heat treatment.

This evolution of the mechanical properties is determined by the structural changes reported to the parameters of the heat treating. This evolution of the mechanical properties is determining by the structural constituents for each heat treatment (Chou et. al., 1992).

In the case of lots A and A_1 structure can be constituted of inferior bainite, residual austenite and martensite .These constituents are determining high values for Rm and HB, and less high for A and KCU (Guilermany et. al., 1990).

Comparing the both lots suppose a high value of inferior bainite and martensite in lot A comparing to lot A_1 (see the values of the mechanical properties Rm and HB). Together with increasing the level of the isothermal maintenance temperature inside the structure will appear the superior bainite and the martensite will disappear (lot C and C_1). The lot Cs characterize by the high values of A and KCU. This is because of the ferrite value obtained in the heat treatment. This constituent is characteristic for the “Dual-Phase” heat treatment and appears when we need superior values for and KCU, in the case of the for the samples that were maintained at 60 min.

In the same time there can be observed a general characteristic about the studied lots: less maintaining time for the isothermal variation provides higher values of HB and Rm but lower of A and KCU.

This can be explained by the time of the isothermal level maintenance, followed by air cooling at the room temperature, is increasing the proportion of martensite, a constituent which is determining higher values for Rm and HB and lower for A and KCU in the structure of the lots.

Conclusion:

The isothermal bainitic transformation in a Ni-Cu S.G. cast iron was studied in the temperature range of 300-400° C and with maintaining time between 10-60 minutes. The main results are summarized as follows:

(a) Utilizing the Dual-Phase bainitic heat treatment (lots C_1) combines a lot of superior attributes used in the automotive industry. The values of Rm = 720-930 [N/mm^2]; A = 7.1-11.5 [%] and KCU = 70-145 [J/cm^2], assure a good comportment to fatigue strength.

(b) Very important are the variations of the heat treatments' parameters for both treatments over the values of the mechanical properties.

(c) It is possible to obtain a acicular structure with high values for mechanical properties. That is a good reason for the replacement of the iron used by the moment in the automotive industry.

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