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INFLUENCE OF CHROMIUM CONTENT IN TEMPERING STEELS ON PHASE TRANSITION TEMPERATURE A_1 AND A_3

For the three species of quenched and tempered steel (C50, 50Cr3, 51Cr6) dilatometric studies were conducted. They allowed the determination of transition temperatures Ac_1 and Ac_3 during heating and Ar_3 and Ar_1 during cooling. It was observed that increased the chromium content in steels tested resulted in an increase in transition temperature for heating and cooling. It was also observed narrow range of temperature from the beginning to the end of the transition with increasing chromium content.

Key words: phase transitions, heat treatable steels, dilatometer tests, alloying elements.

Phase transition in low carbon steel. Both the eutectoid transformation of austenite to pearlite and pearlite to austenite called A_1 and A_3 allotropic transformation associated with the secretion of ferrite from austenite in carbon steels are important in the heat treatment. Precise temperature setting these changes in heating and cooling, it is important to choose the appropriate parameters for heat treatment of steel.

Alloying elements occurring in structural steel and tempering machine temperature changes cause changes. Some of the elements cause the temperature changes A_1 and A_3, the other will decrease the temperature, a certain increase in temperature causes a reduction in the transformation temperature while the other transition [1]. Most of the alloying elements dissolved in austenite and therefore Ti, Mo, Si, W, Cr give rise eutectoid reaction temperature and only Mn and Ni cause the reduction. In turn, the lower the temperature changes affect alotropic alloying elements such as Cr, Mn, Ni, Cu, Pt, Au, C, N and the temperature elevation changes affect alotropic such as Co, Al., Si, W, Mo, V and Ti [2].

In addition, alloying elements are two ways to affect the stability of the austenite. Some elements e.g. Mn, Ni, Cu, Pt, Au, Co extended field of gamma phase. Another elements e.g. Al, Si, W, V, Ti, Cr narrowed gamma phase field.

Analysis of the chemical composition of the tested materials. The tests were three types of steel having similar carbon content and a varying chromium content.

The test materials were subjected to analysis of chemical composition by using arc spark spectrometer PMI - MASTER PRO.

The study confirmed the compliance of average concentrations of elements with the following standards: PN - EN 10250 - 3: 2001, PN - EN 10297 - 1: 2003, BS - EN 10305 - 1: 2003. The results are given in Table 1.

Dilatometer tests. To determine the allotropic transformation temperatures and phase are used dilatometric tests. In these studies utilizes the phenomenon of thermal expansion. Changes in volume of metals and alloys under the influence of temperature changes caused by the interatomic distances. As the temperature increases the amplitude of oscillation around a medium position carbon balance in the crystal

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lattice. The reconstruction of the allotropic transformation and the associated abrupt change of interatomic distances in the transition temperature cause a significant change in the dimensions of the test body. When the phase change (occurring in a certain temperature range) – on the dilatometric graph (Figure 3) the temperature of the beginning and end of the transformation are reflected by the collapse of the curves obtained upon heating and cooling of the sample.

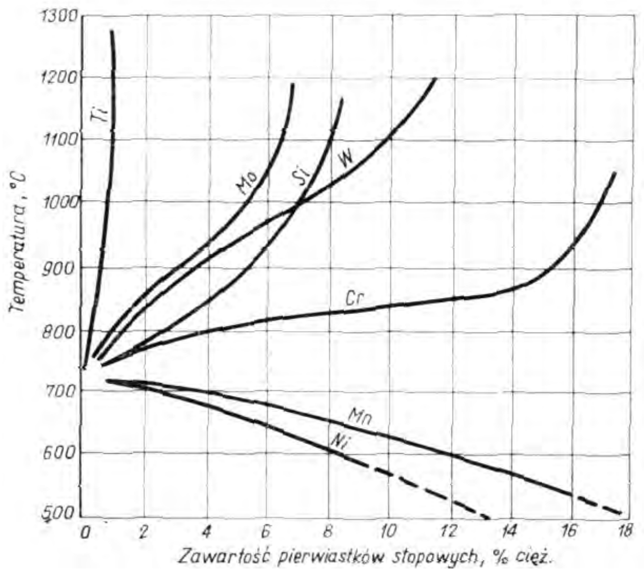

Fig. 1. Effect of alloying elements on the eutectoid transformation temperature [1]

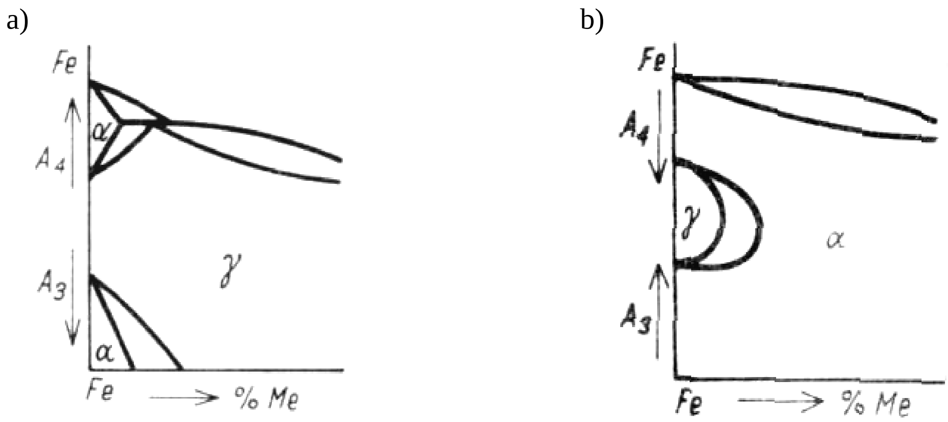

Fig. 2. Influence alloying components on the stabilization of the gamma phase [1]

Table 1

The chemical composition of the tested materials

Material	Content %				
	C	Cr	Mn	Si	Fe
C50	0,51	0,063	0,7	0,43	rest
50Cr3	0,50	0,810	0,8	0,40	rest
51Cr6	0,52	1,660	0,65	0,37	rest

The study used an automatic dilatometer DA-3. Edited program allowed to conduct tests on the changes of temperature from ambient temperature to a temperature of 1000°C with different rates of heating and cooling. In clinical samples were used in the shape of a cylinder with a diameter of 6 mm and a length of 40 mm. In Figure 4 presents the program conducted dilatometer tests.

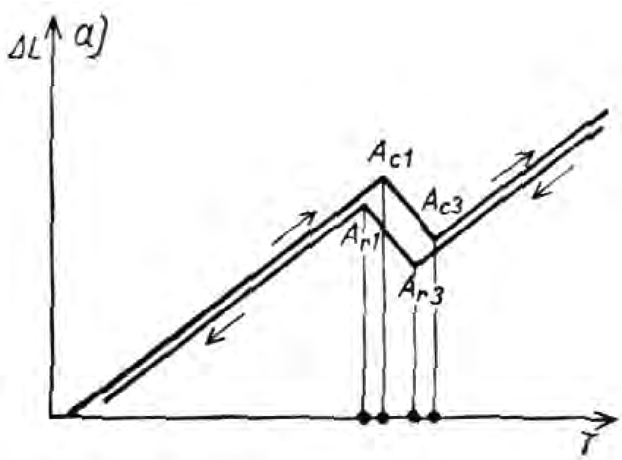

Fig. 3. Schematic dilatometer curve for low carbon steel [3]

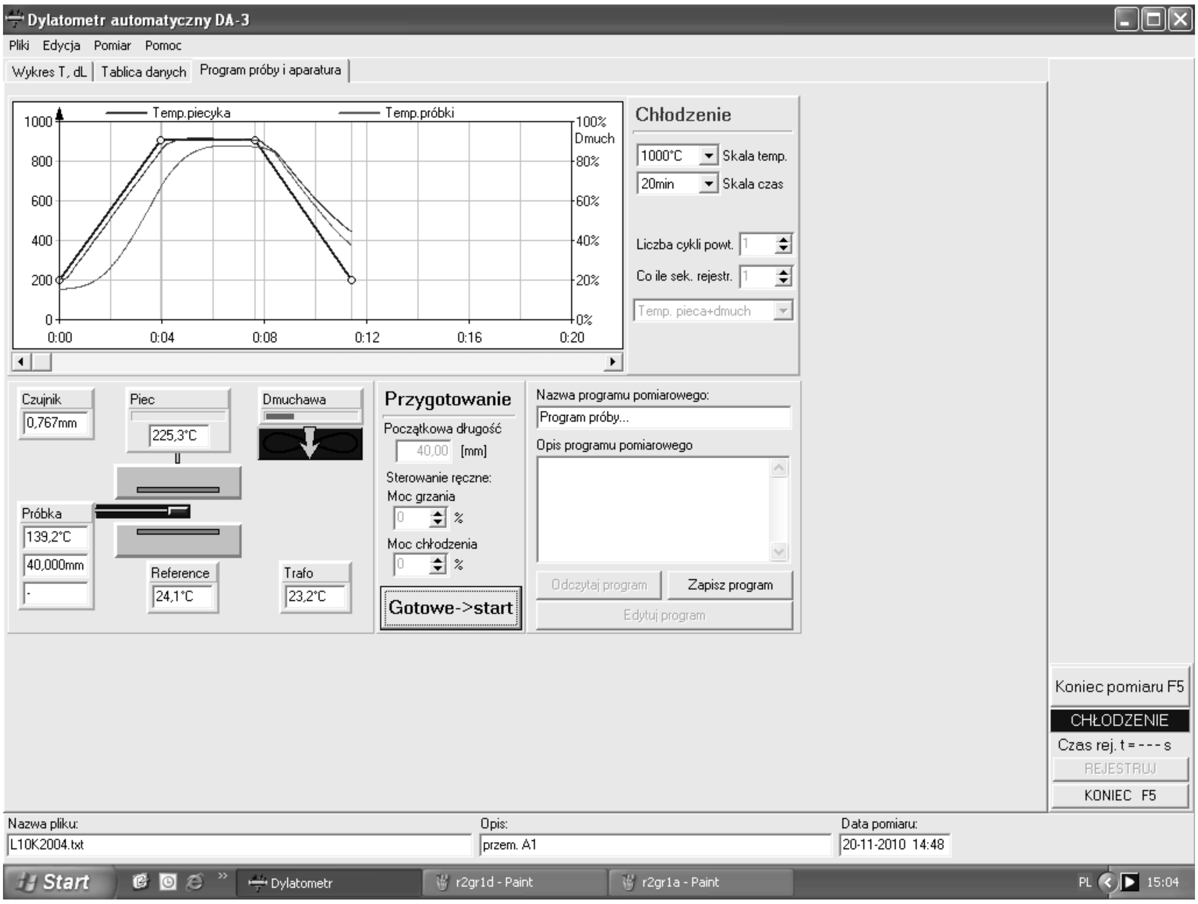

Fig. 4. The dilatometer tests program

Dilatometer test results and analysis. Each test material was 5-fold sample heating and cooling. The resulting graphs allow the determination of temperature changes Ac_1, Ac_3, Ar_3 and Ar_1. Method of determining these temperatures is shown in Figure 6. The calculated average temperature of transition showed in Table 2.

Table 2

Average temperature of transition

Material	temp. Ac_1	temp. Ac_3	temp. Ar_3	temp. Ar_1
	^oC			
C50	741	870	801	652
50Cr3	745	866	792	660
51Cr6	760	859	785	665

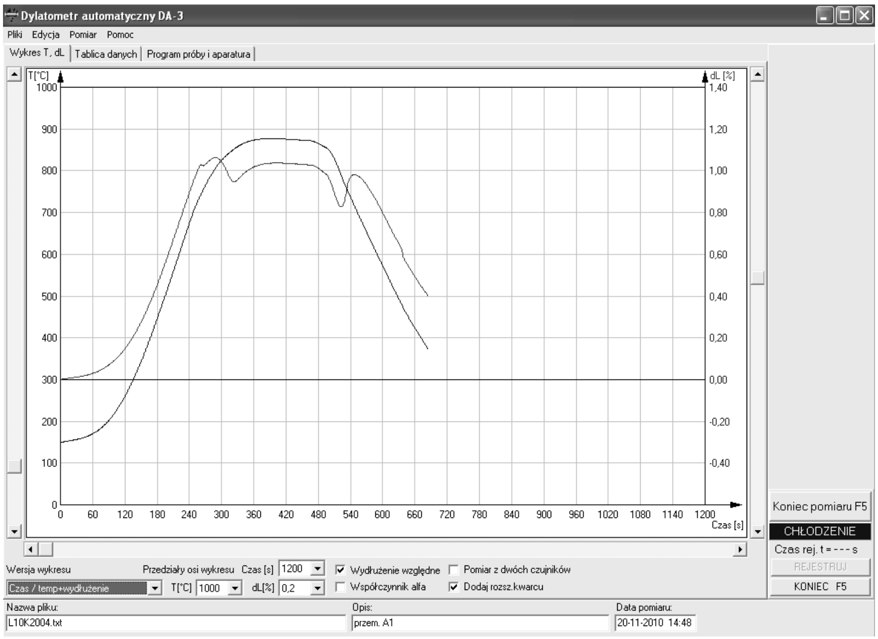

Fig. 5. Graph of temperature and the length of the samples as a function of time

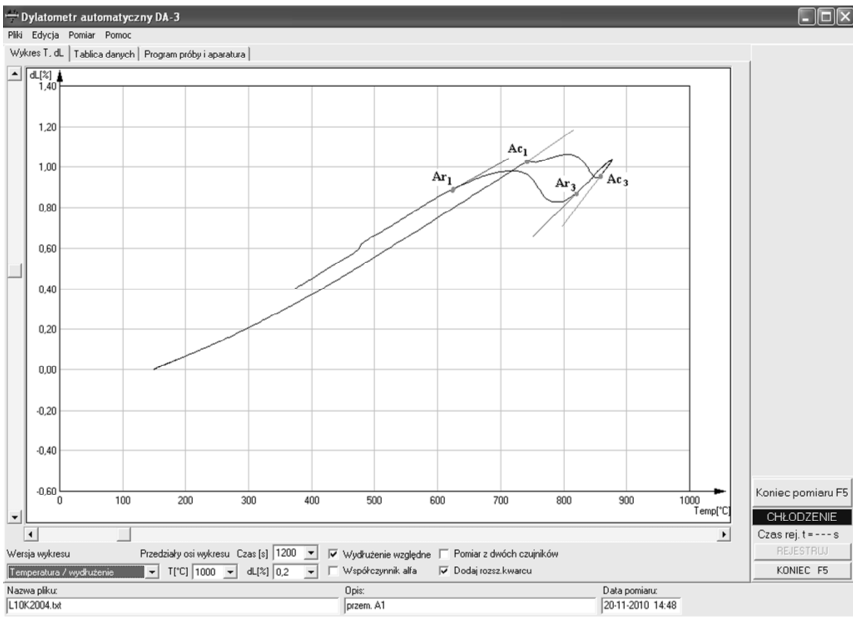

Fig. 6. Figure sample length changes depending on the temperature and the method of determining the transition temperature

In the studied material carbon, manganese and silicon was at a very similar level and only the chromium content varied significantly. Therefore, different transition temperatures in different materials must be attributed to the variable factor. Eutectoid transformation temperature A_1, both when heating and cooling were increased with increasing chromium content. However, A_3 transition temperature during heating and cooling during decreased. Furthermore, it was observed that increased chromium content in steels cause narrowing of the temperature range from the beginning A_1 transformation to the end of A_3 transformation in heating and also reduce the range of temperature from the beginning A_3 transformation to the end of A_1 transformation during cooling. This was probably due to the fact that chromium eutectoid point moves to lower carbon content in the steel and thus steel containing 0.5 % carbon and increased chromium content has a structure similar to the eutectoid. As a result, the range of changes in temperature between A_1 and A_3 is reduced.

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