The light microscopy study by heat tinting of austempered ductile iron microstructure transformation at low temperatures

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A new advanced engineering material produced from ductile cast iron by austempering heat treatment is currently, extensively used. It is called: Austempered Ductile Iron (ADI), and it possess a unique microstructure of ausferrite, which is a mixture of ausferritic ferrite (AF) and carbon enriched retained austenite (RA). Due to the unique microstructure, the ADI have a wide range of mechanical properties: a remarkable combination of high strength, ductility, and toughness, combined with good wear and fatigue resistance. The ADI materials are used increasingly in many wear resistant and critical components of machinery that work in all weather conditions. However, at low temperatures retained austenite, might transform to a mixture of ferrite and carbides (bainite) or to martensite, resulting in loss of ductility [1, 2].

In this paper microstructure at low temperatures of unalloyed austempered ductile iron have been studied. Two different ADI materials were produced by austenitization at 900°C for 2h, followed by austempering at 300°C (ADI-300) or 400°C (ADI-400) for 1h. To study microstructure a special heat tinting procedure [3] was used. The heat tinting procedure (oxidation on 260°C for 6h) tints the microstructure reveling the following colors: purple (the higher the carbon content, the darker the purple color) - reacted, carbon enriched RA; light blue - metastable austenite (MA); beige - AF; white to cream - carbides; and light to dark blue - martensite (M). The microstructure has been examined by a "Leitz-Orthoplan" light microscope.

The ADI microstructure, after heat tinting, is presented in Fig.1 and 2. The ADI-300 and ADI-400 microstructure was fully ausferritic, consisting of a mixture of ausferritic ferrite and retained austenite, with 16 and 31.4% of RA, respectively (Fig. 1a and 2a). However, the carbon content in RA, which influences stability of austenite has an opposite trend. The ADI-300 with lower RA is more stable due to carbon content of 2.08%C, while the ADI-400 with higher RA and 1.64%C is less stable. After the ADI-300 is cooled to -196°C, the stable, high carbon enriched RA content decreases to 10.6%, while the light blue color area of low carbon enriched MA increases, Fig.1b. Moreover, finely dispersed carbides appear, as carbon content decreases to 1.61%C. In the case of the ADI 400, after cooling, the less stable RA transforms into MA, bainite (B) and lenticular martensite (M), Fig.2b. Namely, the RA decreases to 16.7% and carbon content to 1.5%C.

Finally, to conclude, after cooling the stable retained austenite becomes thermally unstable and trough diffusionless decomposition transform to metastable austenite (MA), bainite (B) or even martensite (M), hence causing brittleness of ADI.

[1] D. Rajnovic et al., J. Microsc. - Oxford, 232 (2008) 605-10; [2] L. Sidjanin et al., Mater Sci Tech-Lond, 26 (5) (2010) 567-71; [3] B.V. Kovacs, Modern Casting, 41 (1987) 34-5

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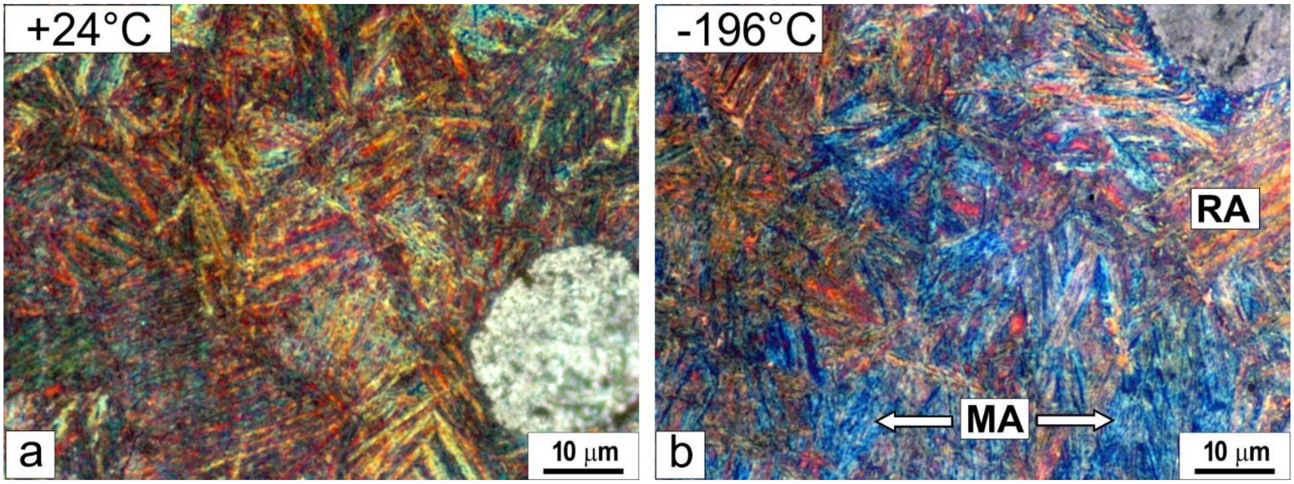

Fig. 1 The ADI 300 microstructure revealed by heat tinting: a) room temperature, b) -196°C (RA - retained austenite, MA - metastable austenite)

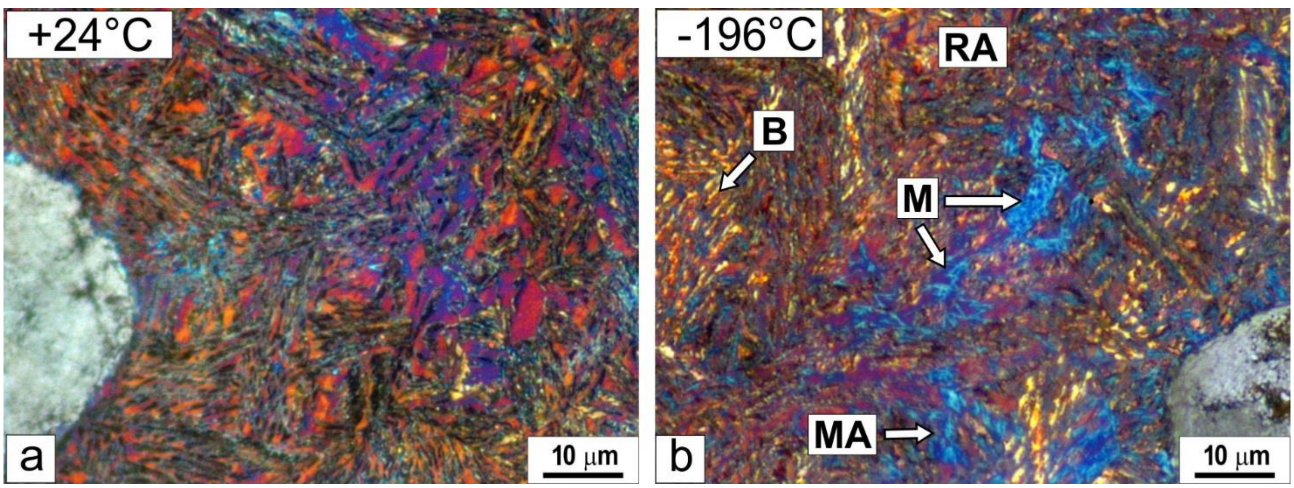

Fig. 2 The ADI 400 microstructure revealed by heat tinting: a) room temperature, b) -196°C (RA - retained austenite, MA - metastable austenite, B - bainite, M - martensite)