13th International Research/Expert Conference
"Trends in the Development of Machinery and Associated Technology"
TMT 2009, Hammamet, Tunisia, 16-21 October 2009

HEAT TREATMENT OF NODULAR CAST IRON

Hasan Avdusinovic
Faculty for Metallurgy and Materials Science, Zenica

Almaida Gigović-Gekić
Faculty for Metallurgy and Materials Science, Zenica

ABSTRACT
Production of nodular cast iron in the world is constantly growing and according to literature data, today is over 20 million tons annually. Wide range of usage of this material is related to low production cost, good mechanical and ductile properties. Possibility of thermal treatment is additional advantage of this material. Applying an adequate thermal treatment regime gives the superior characteristics to the nodular castings that are in many cases substitution for expensive steel parts and other materials. Improvements are primarily related to the improvement of mechanical and ductile properties of the castings due to developing of new metallic microstructure i.e. ausferrite with nodular graphite.
Key words: nodular cast iron, austempering, ausferrite, austempered ductile iron, ADI

1. INTRODUCTION
Nodular cast iron is cast iron in which the graphite is present as tiny balls in metallic matrix. Nodular cast iron is also known as ductile iron, spherical graphite iron, and spherulitic iron. This type of cast iron has increased strength and ductility when compared with a similar structure of gray cast iron. Trough heat treatment, new microstructure can be produced with superior mechanical properties. Austempered ductile cast iron (ADI) is the newest among all common cast irons. There have been extensive interests in processing and developing ADI and huge research efforts are still being carried out for ADI investigation. If ductile iron is austenitized (850-950°C) and quenched in a salt bath maintained at constant temperature of 250-450°C, transformation to an ausfferite structure takes place and this is referred to as austempered ductile iron (ADI). In general during conventional heat treatment processes involving continuous cooling, austenite is either transformed into pearlite or martensite. During austempering processes second step of heat treatment, i.e. quenching to the austempering temperature must be fast enough to avoid perlitic transformation. Austempering is usually performed above martensite start (Ms) temperature. Austempered ductile cast iron shows following values of the mechanical properties:

- tensile strength (MPa) 800 to 1600
- hardness (HB) 250 to 550
- ductility (A-%) up to 10
- impact energy (J) 35-100 (values are for specimens without notches)

Factor that affect austempering process and subsequent microstructures as well as mechanical properties are summarized as:

- chemical composition and alloying elements
- austenitizing temperature and time
- austempering temperature and time
- alloy segregation
- casting quality and section size of castings

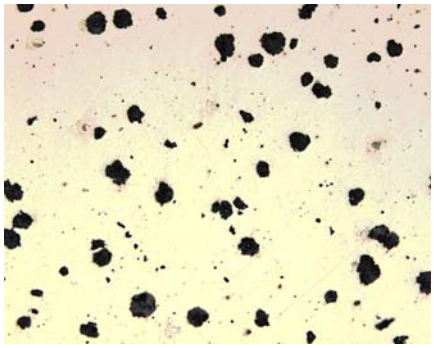
2. EXPERIMENTAL INVESTIGATION

2.1. Material

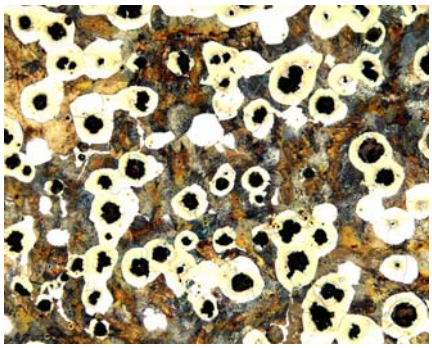
Nodular cast iron samples („U"samples) were provided by „Novi život"foundry. Table 1. reports detailed chemical composition of the used samples and picture 1 and 2 represents microstructure of the as-cast material. Several plates (10x50x100 mm) were cut from the „U"samples and heat treated.

Table 1. Chemical composition of the used „U"samples

elements	C [%]	Si [%]	Mn [%]	P(max) [%]	S(max) [%]	Ni [%]	Cu [%]	Mg [%]	Fe [%]
	3,29	2,53	0,308	0,015	0,013	0,81	0,51	0,031	remaining



Picture 1. X200 before etching



Picture 2. X200 after etching

2.2. Heat treatment

Heat treatment was carried out at the „Novi život"foundry and Faculty for Metallurgy and Materials Science.

All the samples were initially asutenitized at 900°C for 90 minutes and they are austempered in molten salt bath for 60 minutes. After heat treatment specimens for tensile test, hardness test, impact energy test, and metallographic from each tempered plates were taken.

Mechanical properties investigations were carried out at the Institute „Kemal Kapetanović" and metallograpy was finished at the home Faculty.

3. RESULTS AND DISCUSSION

For experiment nodular cast iron with increased content of Cu and Ni were used (tabela1.) with prelite/ferite as-cast microstructure (picture 2). Result of the microstructure and mechanical properties investigation is given at the table 2 and pictures 3 and 4.

Picture 3 shows microstructure after heat treatment with following parameters:

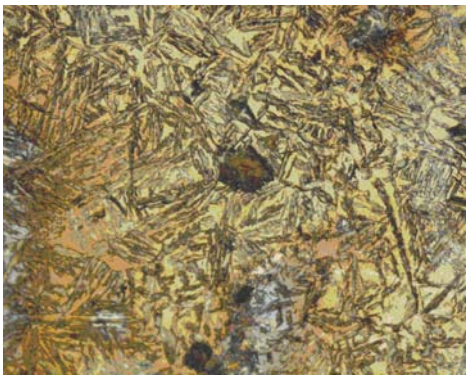
- Austenitization temperature/ time - 900°C/90 min
- Austempering temperature/time – 400°C/60 min

Picture 4 shows microstructure after heat treatment with following parameters:

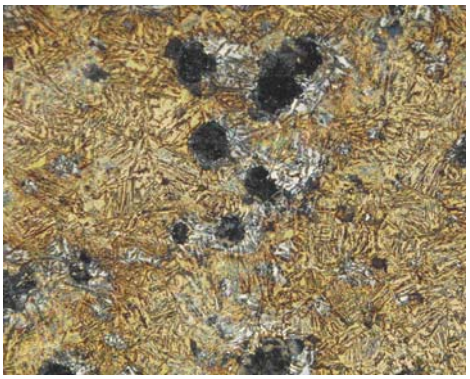
- Austenitization temperature/ time - 900°C/90 min
- Austempering temperature/time – 350°C/60 min

Table 2. Summary of the mechanical properties investigation

Condition	Tensile strength	hardness	Elongation	Impact energy	Note
	MPa	HB	%	J	
As cast	650	245	8	2,7	Impact energy sample with a „V“ notch
Heat treated	1100	345	8	65	Impact energy sample without notch
All values are average of three measurements					

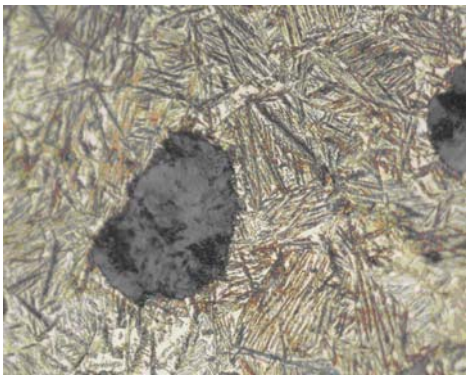


a) Mag. 500X (nital etched)

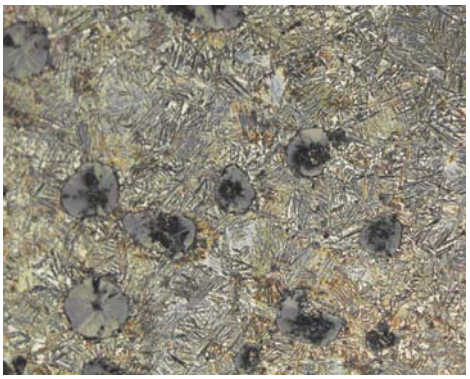


b) Mag. 200X (nital etched)

Picture 3. Microstructure of ADI



a) Mag. 500X (nital etched)



b) Mag. 200X (nital etched)

Picture 4. Microstructure of ADI

4. CONCLUSIONS

- After heat treatment tensile strength and hardness of nodular cast iron samples show significant increase in the tensile strength and hardness
- There was no decrease in ductility and fracture toughness after heat treatment
- Austempering temperature has influence on the shape and size of ausferite sheaves

5. REFERENCES

[1] Y. S. Lerner, Modern Casting of Ductile Iron, American Foundry Society, Schaumburg, Illinois, 2006
[2] M. Ostojić, A. Beroš, Nodularni liv, Univerzitet u Zenici, Zenica, 2008
[3] S. I. Karsay, Ductile Iron-production practicies, American Foundry Society, 1975
[4] J. E. Gruzlesky, Microstructure Development During Metalcasting, American Foundry Society, Des Plaines, Illinois, 2000
[5] P. Beeley, Foundry Technology, Butterworth-Heinemann, 2001