Cairo University

TWO-STEP AUSTEMPRING OF GGG50 FOR PRODUCTION OF DUCTILE IRON, LOW ALLOYED STEEL SUBSITISTION

By

Adel Mahmoud Mohamed Malik

A Thesis Submitted to the

Faculty of Engineering at Cairo University

in Partial Fulfillment of the

Requirements for the Degree of

MASTER OF SCIENCE

in

Metallurgical Engineering

FACULTY OF ENGINEERING, CAIRO UNIVERSITY

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Nomenclature

UTS	Ultimate tensile strength
EL%	Ductility %
HBN	Hardness brenil number
γ_R %	Retained austenite %
Im	Impact toughness
Aus.	Austempering
R.T	Room temperature
γ°	Matrix austemite
$\gamma^{h.c}$	High carbon austemite
a	Bainitic ferrite
CMRDI	Central metallurgical and research and development institute
ELm%	*Element %*
S.No.	Sample number
prop.	properties
Cond"	Condition
DCI	Ductile cast iron
ADI	Austemerd ductile iron

UAV	Untransformed austenite volme
HLAT	High - low austempering temperature
LHAT	Low - high austempering temperature
$Xy\,.Cy$	Austenite carbon
X y	The volume fraction of austenite
Cy	The austenite c-content.
d	The ferrite cell size.

Abstract

Castings made of Austempered ductile iron (ADI) have attracted practicing engineers and researchers, alike, mainly because of its excellent strength and wear properties and also at the same time cheaper to process and produce w.r.t comparative forged steel parts.

In this investigation, ductile iron samples from GGG50 were prepared and subjected to a two - step austempering heat treatment cycle following the austenitizing treatment. Six groups of samples were prepared for this heat treatment cycle.

All groups of samples were initially austenitized at 900°C for one hour, after that they were subjected to two - step austempering process at 400°C and 250°C respectively, in the 1st step, the samples were rapidly quenched into a salt bath maintained at 400°C for one hour (step of constant time and temperature) after that all the samples were taken to the 2nd step by rapid quenching again into a salt bath maintained at 250°C (step of variable time throughout six time intervals).

The six time intervals were as follow:

The first groups of samples were austempered for 0.5h, the second group for 1.5h, the third group for 2hr, the fourth group 2.5h, the fifth group for 3.5 and the group for 4.5h.

Effect of this two - step austempering heat treatment on the microstructure and tensile properties of the samples were examined and compared with the properties of a reference low alloy steel type (16 Mn Cr 5).

The results have shown that the new two - step austempering process has resulted in moderate improvement in the ultimate tensile strength and the ductility of the resultant ADI compared to one step ADI. The results are analyzed based on the microstructure features which greatly effect the mechanical properties of ADI castings produced.

CHAPTER 1: Introduction

Scraper Chain Conveyors are used in the industry for transporting things and parts to long distances for Example from silo to another. These working conditions require superior Mechanical properties as high tensile and yield strength, higher hardness and excellent wear characteristics. Also, weight of the chain conveyor is a very important factor in these conditions [1]. ADI is a candidate material recommended for this application substitution for forged steel in this industrial field. ADI has a matrix which consists of a combination of accicular ferrite and stabilized austenite [2]. This structure results in an exceptional combination of strength and ductility. The Structure and properties of ADI depend on composition and heat treatment parameters which lead to changes in the microstructure.

Conventional austempering process consists of austenitizing the castings in the temperature range of 871°C- 982°C for sufficient time to get a fully austenite (γ)matrix and then quenching to an intermediate temperature range of 250°C - 400°C. to form bainite. The Mechanical properties of ADI depend on the bainitic matrix which consists of ferrite and higher volume of retained austenite. The presence of appreciable amounts of retained austenite in ADI leads to better wear resistance and fatigue strength, due to high work hardening nature of austenite [3].

The two - step austempering process is better than the conventional one in the side of the resultant mechanical properties. Tianghuai yang and susilk putatunda [4]. have carried out investigation to examine the influence of two - step austempering process on yield, tensile strength and fracture toughness and the results have indicated significant improvement in the mechanical properties of ADI. By adopting two-step austempering process where GGG50 is first austentized and austempered in two – steps, ADI may be used as a substitute for some low alloyed steels.

The objective of this work is to (1) study the effect of two - step austempering of GGG50 on the resulting microstructure and mechanical properties of ADI at different time intervals for the2nd step of austempering. (2) Evaluate γR and its effect on the resulting mechanical properties of ADI. (3) Analyze the results to determine the optimum heat treatment process and its parameters which give the most favorable combination of mechanical properties compered to the alloy 16 Mn cr5 (Case hardening steel). (4) Evaluate the impact toughness of the resulting ADI and its relation with the 2nd step austempering time.