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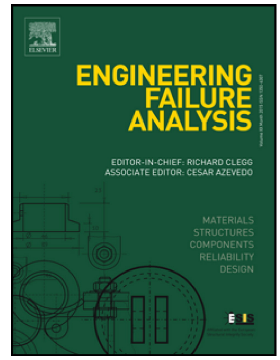

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Ductile cast irons: microstructure influence on the damaging micromechanisms in overloaded fatigue cracks.

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Abstract

Recently discovered, Ductile Cast Irons (DCIs) are able to combine the high toughness values of steels with the good castability of grey irons. These grades are also characterized by an interesting fatigue crack propagation resistance. Their fatigue crack propagation resistance depends on loading conditions, chemical composition, matrix microstructure and graphite elements morphology (e.g. graphite elements nodularity, volume fraction, density, distribution, dimension).

DCIs are widely used in critical automotive parts (e.g. wheels, gears, crankshafts in cars and trucks) and in many other applications, like pumps, pipes or turbine components. Considering these applications, the possibility of an overload is not negligible.

In this work, the microstructure influence on the damaging micromechanisms in overloaded fatigue cracks in a ferritic DCI was investigated considering fatigue precracked Compact Type (CT) specimens at room temperature. These specimens were metallographically prepared, chemical etched and, then, fatigue precracked and overloaded. According to a step by step procedure, lateral surfaces were observed by means of a Scanning Electron Microscope (SEM).

Nomenclature

DCI: Ductile Cast iron
R: Stress ratio ($R=P_{min}/P_{max}$)
K_I: stress intensity factor (mode I)
ΔK: stress intensity factor amplitude
a: crack length during the fatigue crack propagation
a_0: initial crack length (before the precracking procedure)
SEM: Scanning Electron Microscope
CT specimen: Compact Type specimen

Introduction

In the first half of the last century, the goals of a combination of good castability and high toughness values were fulfilled by malleable iron by means of an extended annealing treatment of white iron. During this heat treatment, cementite decomposes to graphite that precipitates as aggregates in a matrix whose microstructure (ferrite or pearlite) depends on the cooling cycle from the annealing temperature. The high costs related to the extended annealing treatment and the difficulty to cast sound white iron components limited the utilization of these grades. In 1943 [1], in the International Nickel Company Research Laboratory, a magnesium addition allowed to obtain a cast iron containing not flakes but nearly perfect graphite spheres. In 1948, a small amount of cerium allowed to obtain the same result.

Cast irons with nodular graphite elements (Ductile Cast Irons, DCIs) are characterized by a very good combination of overall properties: high ductility (up to more than 18%), high strength (up to 850 MPa and, considering austempered ductile iron, up to 1600 MPa) and good wear resistance. Matrix controls these good