Ductile Iron Society

RESEARCH PROJECT No. 32

IMPROVING THE PROPERTIES OF AUSTEMPERED DUCTILE IRON
DIS Research Project No. 32

by
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Climax Research Services

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DUCTILE IRON
SOCIETY

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SUMMARY

An investigation of the influence of austenite content on the properties of austempered ductile iron was undertaken. The "reacted" austenite content in the austempered structure was controlled by varying austenitizing temperature and, thus, the carbon content of the austenite during austenitizing. Ductile iron plates measuring 1.25 by 8 by 10 inches and containing 3.4C-2.7Si-0.26Mn-1.1Ni-0.16Mo were austempered at 725F (385C). The properties evaluated included tensile properties, machinability and thermal expansion coefficient.

Studies in a laboratory dilatometer were conducted to determine the transformation behavior of the ductile iron alloy with the intent to vary the carbon content during austenitizing. The investigation included "step-austenitizing" in which the material was first heated above the upper critical temperature and subsequently cooled and held below the critical temperature. The experiments demonstrated that the carbon content of the austenite could be controlled by varying austenitizing temperature, even at temperatures below the upper critical temperature (α-transus). The stability of austenite, when cooled down into the intercritical region was found to be high, with no proeutectoid ferrite formation occurring; and specimens were successfully austempered from temperatures (1440F/782C) well below the α-transus without pearlite or ferrite formation preceding the bainite reaction.

Intercritical heat treatments were also performed with the intent to produce a mixed ferrite + ausferrite microstructure. Heat treatment in the intercritical (three-phase) region showed that an austempered structure of 50% proeutectoid ferrite + 50% ausferrite could be achieved when austempering from 1450F (788C).

Austempering of the plate castings was performed at 725F (385C) from austenitizing temperatures above the critical temperature and by step-austenitizing to temperatures below the upper critical temperature. Austenite content in the austempered structure was found to decrease with decreasing austenitizing temperature. Tensile properties were found to generally increase with decreasing austenitizing temperature. Machinability in drilling was found to improve significantly as austenite content was reduced. The thermal expansion coefficient also decreased with decreasing austenite content.

Austempering of the plate castings was also performed at 725F (385C) from an intercritical temperature [1450F (788C)] below the upper critical temperature. Tensile strength was reduced but tensile elongation was quite high. Machinability in drilling was found to improve significantly, comparing quite favorably with pearlitic (grade D5506) ductile iron.

The benefits of lower final or **reacted** austenite content in ADI structures were clearly demonstrated in this investigation. The results of austenitizing at temperatures near, and below, the α-transus produced lower **reacted** austenite contents and showed significant improvements in properties. The problem with formation of free ferrite when austempering from lower austenitizing temperatures should be addressed to better define the potential for step-austenitizing prior to austempering.

The properties obtained by austempering directly from the intercritical temperature range were also quite interesting. While the properties of this material did not meet the specifications of any of the ADI grades, the good strength, high ductility and excellent machinability observed in this material are very encouraging and suggest that further investigations are warranted. The particular combination of properties observed for this material suggests that the material should be considered for high toughness applications. The material should be evaluated more thoroughly with a range of heat treatments (and ferrite/ausferrite ratios) to further develop the structure-property relationships. Fracture toughness and fatigue properties should also be evaluated to better define capabilities.