Ductile iron is used in many automotive components, where strength must surpass that of aluminium but do not necessarily require steel

Formation of spheroidal graphite iron without magnesium treatment

TECHNOLOGY

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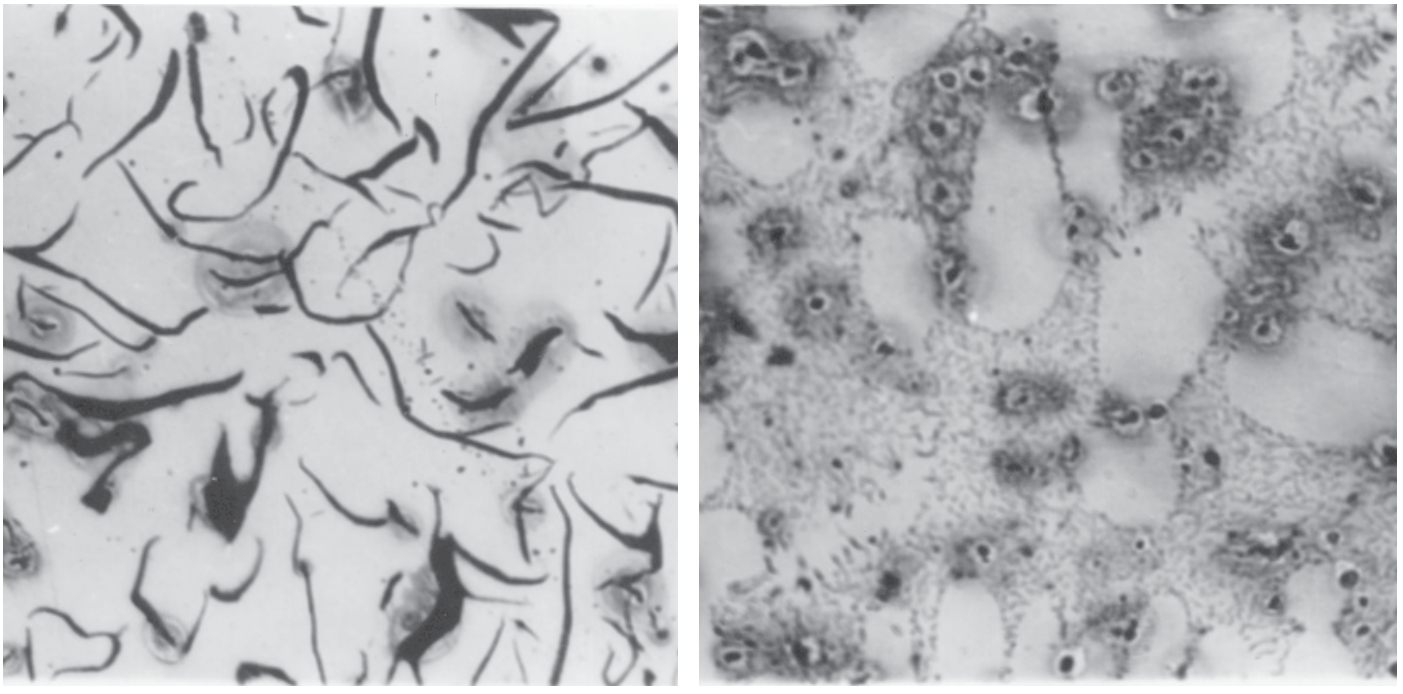
This study reports the effect of Electric Current Treatment (ECT) on cast iron melt during freezing in a sand mould. It is observed that the ECT modifies the shape of flake graphite to nodular graphite due the removal of dissolved gases from molten iron. This process changes cast microstructure from pearlitic to ferrite-pearlitic, which indicates that ECT modifies the equilibrium diagram of Fe–C/G system

CAST irons as construction material are still maintaining the standard of usability, because they provide a wide range of usable properties and also be-

Figure1: Effect of ECT during freezing of molten cast iron in sand mould

(a) Without any treatment

(b) With electric current treatment (ECT)



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cause they require less expensive metallurgy (technology) and in many cases they provide a more economically convenient solution. Ductile or spheroidal graphite (SG) cast iron was discovered in 1943 by Keith Millis. While, most varieties of cast iron are low tensile strength and brittle, ductile iron has much more impact and fatigue resistance, due to its nodular graphite inclusions. Ductile iron is used in the form of ductile iron pipe for water and sewer lines. Ductile iron is also used in many automotive components, where strength must surpass that of aluminium but do not necessarily require steel. Other major industrial applications include off-highway diesel trucks, agricultural tractors, and oil well pumps. In wind power industry nodular cast iron is used for hubs and structural parts like machine frames. Nodular cast iron is suitable for large and complex shapes and high (fatigue) loads.

Literature

Vondrak et al (1) showed that cupola melt contents dissolved gases like N (101-103 ppm), O (64-104 ppm) and H (1.0-1.1 ppm). According to Goodrich (2), nitrogen level in gray cast iron normally has equilibrium of 70 ppm. When the dissolved N increases to 150 ppm, fat flake graphite is produced. Nitrogen is generally controlled by Ti. At high N content, if Ti is present, the graphite structure will be normal flake graphite.

Ten (3) established that oxygen influences the structure and properties of cast iron. Oxygen, initially present in molten melt in chemically combined state (as non-metallic inclusion), does not have a significant effect on the cast iron crystallisation. It acts as a graphite crystallisation substrate and also increases the graphitisation degree of the cast iron. Dissolved oxygen deactivates the potential graphitisation centres that increases chilling tendency of cast iron. At the same time, the more cast iron is saturated by oxygen, the higher its tendency for graphitisation modification.

Yamamoto et al (4) conducted extensive trials to verify the hypothesis of the formation of nodular graphite inside gas bubbles to establish it as a gas bubble theory of nodularisation of graphite. It was found that graphite nodules can be obtained by four methods:

(a) addition of deleterious elements such as S, Se, Te, Pb, and Bi

(b) addition of Ce, La, Y, Ti, and Zr which have absorbed a large amount of hydrogen

(c) direct injection of gases into the melts

(d) precipitation of nitrogen from super-saturated molten cast iron.

The formation of gas cavities and hollow graphite nodules was observed and attrib-

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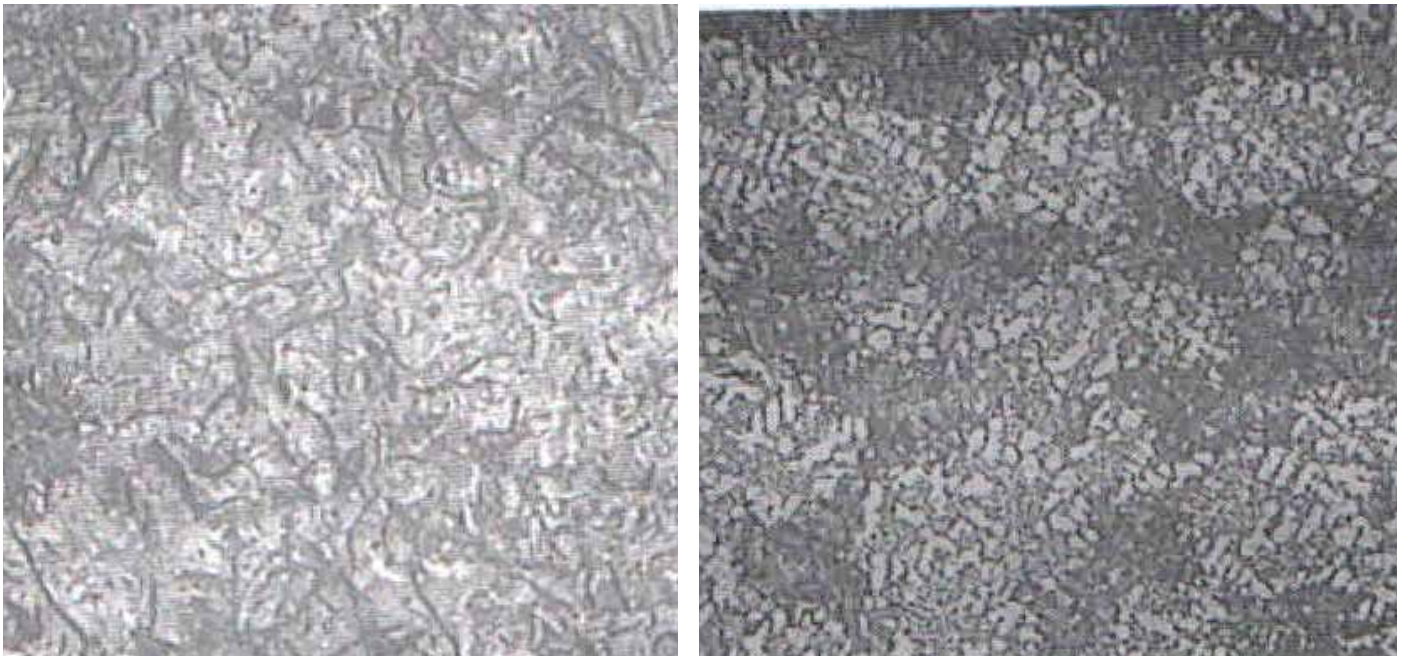
Figure2: Modification of matrix phase with ECT

(a) Without any treatment

(b) With electric current treatment (ECT)



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uted to the dearth of graphite in bubbles or to its absence. Some characteristics of graphite nodules could be best explained by the proposed gas-bubble theory.

Prodhan (5&6) has established that dissolved gases in molten metal/alloys can be removed by electric current (DC) treatment (ECT). This process has been successfully implemented at RAPSRI Industry (a copper die casting foundry) in Bangalore, India.

Present work

This report describes the effect of ECT during freezing of molten cast iron in a sand mould. **Figure1** shows that the flake graphite (**Figure1a**) has been modified to nodular graphite (Figure1b) by ECT. The author feels that the dissolved gases like nitrogen and oxygen are been removed by ECT (5&6). In the absence of these elements, graphite in excess of the solubility limit (of molten iron) will be separated and form its own crystals which would be spherical due to lowest surface area to volume ratio.

In Figure1, (a) untreated sample shows flake graphite, but (b) ECT treatment shows nodular graphite.

Melting was done in Induction Furnace at CSIR – National Metallurgical Laboratory.

However, the etched microstructure (**Figure2**) showed the modification of matrix phase with ECT. The untreated sample (**Figure2a**) shows fully pearlitic structure which can be modified to ferrito-pearlitic structure by ECT. It may be concluded that ECT modifies iron-carbon equilibrium phase diagram.

In **Figure2**, (a) untreated sample shows pearlitic matrix with flake graphite, but (b) ECT treatment shows ferrito-pearlitic matrix and nodular graphite.

Melt was taken from Cupola Furnace at Sett Iron Works, Howrah

Conclusion

This study reveals that flake graphite in cast iron can be converted to nodular iron by electric current treatment (ECT) during sand casting. This study was conducted both in laboratory (induction furnace melt), as well as in a foundry (cupola furnace melt). This process does not require any magnesium treatment. It is a low cost and pollution-free process. Post inoculation is not required for this process.

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