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Effect of Austenitizing Treatment on Structure and Hardness of Bainite Ductile Cast Iron

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Abstract: By continuous quenching process, the effect of austenitizing temperature and time on the structure and hardness of bainite ductile cast iron was studied. It was found that (1) low austenitizing temperature would result in scrap ferrite existing in matrix, which reduces the macro-hardness of bainite ductile cast iron; (2) high austenitizing temperature would make carbide decomposed, which also induces the macro-hardness of bainite cast iron, and (3) austenitizing time has little effect on the structure of bainite ductile cast iron, but as it increases, the macro-hardness of bainite ductile cast iron and micro-hardness of bainite increases. To the ductile cast iron, as a result, the suitable austenitizing temperature and time are recommended as 880℃ and 120 min respectively.

Key words: austenitizing treatment; bainite ductile cast iron; structure; hardness

In 1949, Braidwood predicted that the cast iron with needle structure (bainite ductile cast iron) might be the best one in mechanic properties [1]. Because of the difficulty in production control, this kind of cast iron was not widely applied in industry [2]. As the predigesting of production process in recent years, bainite ductile cast iron is now getting widely used in industry [3–6]. The transformation mechanism of bainite in ductile cast iron is different from that in steel, so it is important to study the factors that affect the bainite transformation process of ductile cast iron. To the bainite ductile cast irons in which bainite formed by continuous quenching, austenitizing treatment plays important role in bainite transformation by which the structure and properties of bainite ductile cast iron are determined.

1 Experimental

The cast iron melt with composition (mass fraction in %) of 3.4–3.6C, 2.5–3.0Si, 2.5–3.0Mn, 0.3–0.5Mo was prepared in an induction furnace with commercial pig iron, scraps, ferromanganese, ferrosilicon and ferromolybdenum. After being treated with RE-Mg alloy, the melt was poured into a sand mould to make samples of ϕ30 mm × 400 mm in size.

The austenitizing treatment was performed in a chamber furnace. Some samples were put into the chamber furnace, heated to 860, 880 and 900℃ respectively and hold for 2 h to study the effect of austenitizing temperature. The other samples were put into the box furnace, heated to 880℃ and hold for 90, 120 and 150 min respectively to investigate the effect of austenitizing time. Then all the samples were quenched into water that was specially designed to control cooling rate and analyzed by microstructure, hardness and micro-hardness.

2 Results

When the austenitizing temperature is low, there are some scrap ferrites in matrix. As it increases, the scrap ferrite disappears and bainite increases; when it reaches to 900℃, carbide which formed during solidification decreases. **Figure 1** shows the structure of the samples with different austenitizing temperature. In addition, both the macro-hardness and micro-hardness increases when the austenitizing temperature increases from 860 to 880℃ and decreases slightly when it increases from 880 to 900℃ (**figure 2**).

The austenitizing time has little effect on the structure of bainite ductile cast iron (**figure 3**). However, the macro-hardness increase when it increases from 90 to 120 min and decreases slightly when it varys from 120 to 150 min, but the micro-hardness of bainite increases linearly as it increases from 90 to 150 min (**figure 4**).

3 Discussion

According to reference [7], the eutectoid transformation temperature of cast iron is related to silicon content. When the silicon content increases 1% in mass fraction, the eutectoid transformation temperature increases about 0–30℃. Because the silicon content of the present cast iron is higher than the common one, the eutectoid transformation temperature is higher than the

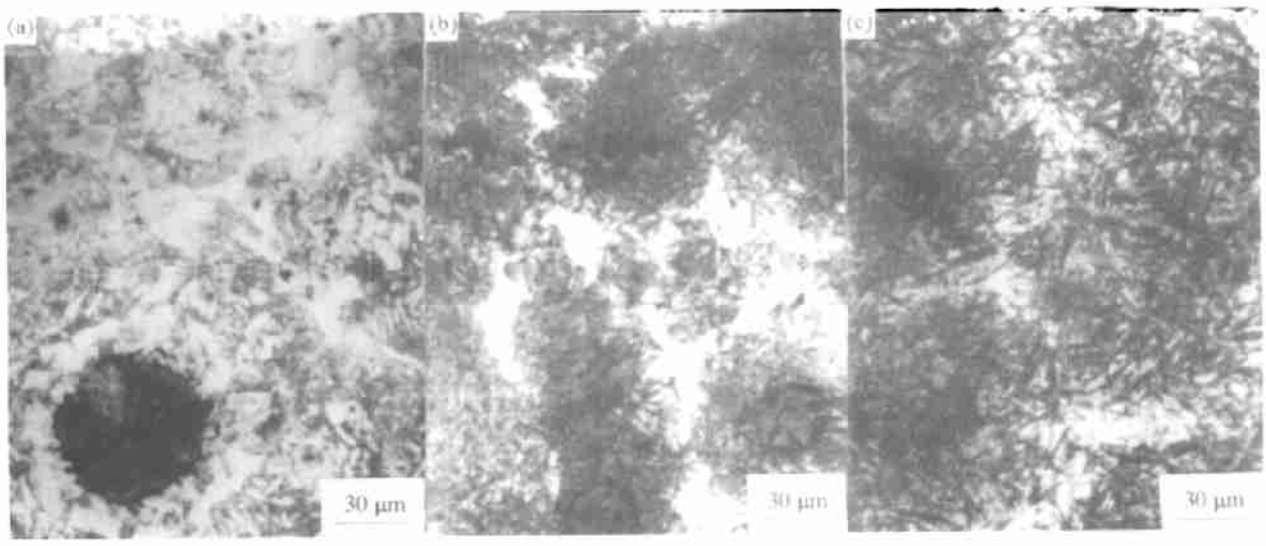

Figure 1 Structure of bainite ductile cast irons with the austenitizing temperature (a) 860, (b) 880 and (c) 900℃.

usual. It is the reason that there is still some ferrite structure existing after being austnitized at 860℃ (figure 1 (a)). The existence of scrap ferrite reduces the macro-hardness of cast iron [8], so the macro-hardness of cast iron which is austenitized at 860℃ is much lower than others. As the austenitizing temperature increases, ferrite disappears, and the macro-hardness increases. When the austenitizing temperature is higher than 900℃, carbide which formed during solidification is decomposed, and the macro-hardness gets a little lower.

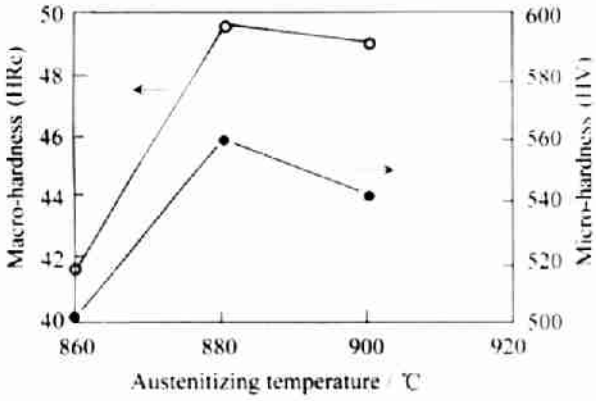

Figure 2 Hardness of bainite ductile cast iron and micro-hardness of bainite with different austenitizing temperature.

The austenitizing time has little effect on the structure of bainite ductile cast iron, therefore, the macro-hardness of the samples are directly related to the micro-hardness of bainite.

The micro-hardness of bainite is related to the content of carbon that dissolved in austenite during austenization treatment.As the austenitizing temperature and time increases, the carbon content of austenite increases, this results the micro-hardness of bainite increasing.

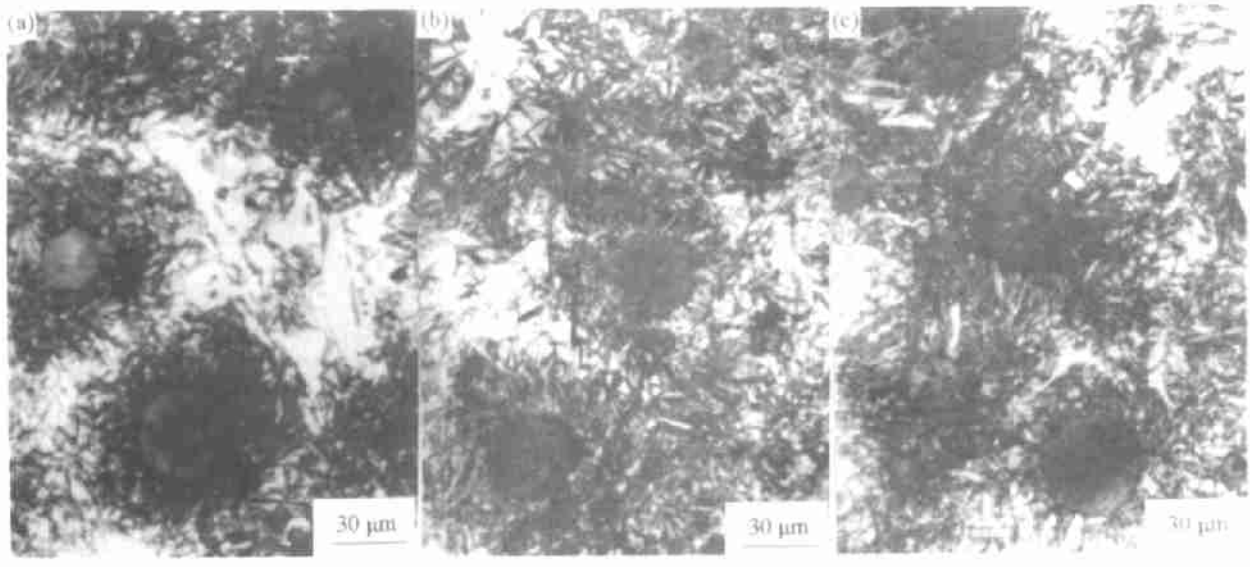

Figure 3 Structure of bainite ductile cast irons with the austenitizing time (a) 90, (b) 120 and (c) 150min. The austenitizing temperature is 880℃.

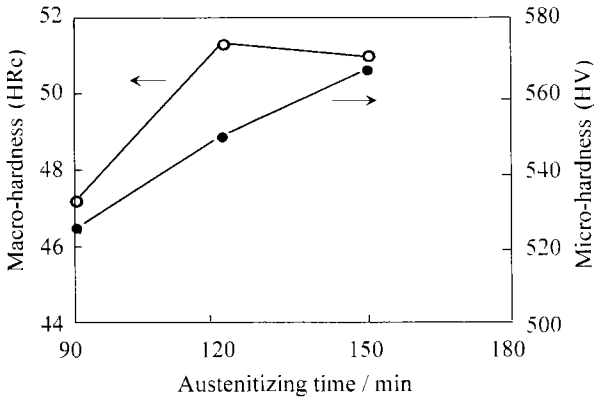

Figure 4 Hardness of bainite ductile cast iron and micro-hardness of bainite with different austenitizing time.

The size of bainite needles also affects the micro-hardness of bainite. When the austenitizing temperature is as high as 900℃, the distribution of carbon in austenite is more equal, which results in bainite needles getting thicker (figure 2(c)), so the micro-hardness of bainite is a little lower.

4 Conclusions

(1) Austenitizing temperature has a great effect on the structure and properties of bainite ductile cast iron. Low austenitizing temperature would result in scrap ferrite remaining in matrix, which reduces the macro-hardness of bainite ductile cast iron. High austenitizing temperature would make carbide decomposed, which also induces macro-hardness of bainite cast iron. The effect of Austenitizing temperature on micro-hardness of bainite ductile cast iron is similar with that on macro-hardness.

(2) Austenitizing time has little effect on the structure of bainite ductile cast iron, but it has great effect on the macro-hardness of bainite ductile cast iron and micro-hardness of bainite.

(3) To the ductile cast iron in present research, the suitable austenitizing temperature and time are recommended as 880℃ and 120 min.

Acknowledgements

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