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Effect of Rare Earth Content on Fatigue Strength of Spheroidal Graphite Cast Iron with Different Thickness

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Spheroidal graphite cast iron is excellent in mechanical properties. The spheroidization ratio and nodule count of graphite is effect to mechanical properties. Therefore, rare earth used in order to improve the spheroidization rate and nodule count of graphite. However, the supply of rare earth is relies on imports from overseas in Japan. Need for spheroidal graphite cast iron with mechanical properties not inferior to conventional products without the use of rare earth is growing. Effect of rare earth is different by the thickness of the casting. Therefore, we investigated the effect on the fatigue strength by the rare earth content in the different thickness of spheroidal graphite cast iron.

Keywords: *Rare earth, Spheroidal graphite cast iron, Fatigue strength*

1. Introduction

Spheroidal graphite cast iron is widely used in various purposes due to its excellent in mechanical properties. In the case of spheroidal graphite cast iron, spheroidal graphite can be used to alleviate the stress concentration that may occur into the matrix. Consequently, spheroidal graphite cast iron exhibits an excellent mechanical so that it has been used as automobile parts. It has been reported that the fatigue other than tensile strength has bad effect on failure of machine component. So, consideration of fatigue strength is often required for the designing of machine component [1]. Moreover, it is clear from previous studies that the fatigue phenomenon has been confirmed for variety of materials under various conditions [2]. Additionally, previous studies have been reported that the starting point of failure is often at the variant part of shape.

Therefore, the purpose of this paper is to make clear the effect of RE contents on fatigue strength of spheroidal graphite cast iron by using the plane bending fatigue test.

2. Experimental condition

2.1 Materials

In order to investigate the influence of different RE content on its fatigue strength, spheroidal graphite cast iron are prepared by using different nodularizer which contain RE content 0% and 1.0%. The specimens were made from iron scraps, speroidizing in sandwich method. Table 1 shows the chemical composition of nodularizer. Shape of specimen is a plate sized with 120×40×50mm. The molten metal was poured into the mold at 1683K. Table 2 shows chemical composition of molten metal. Table 3 shows the spheroidization ratio is more than 80% in RE1.0% and RE0%. Fig. 1 shows microstructure of specimens. The microstructure is all ferrite in the specimens.

Table 1 Chemical composition of nodularizer.

mass%

	Si	Mg	Ca	Al	RE
RE1.0%	45.88	5.92	2.98	0.19	0.92
RE0%	45.90	5.80	2.90	0.20	-

Table 2 Chemical composition of molten metal.

mass%

RE	C	Si	Mn	P	S	Cu	Mg	Cr
1.0%	3.67	2.62	0.28	0.011	0.010	0.045	0.046	0.029
0%	3.68	2.66	0.28	0.012	0.010	0.045	0.039	0.029

Table 3 Spheroidization, nodule count and brinell hardness of each specimen.

	Spheroidization [%]	Nodule count [counts/mm^2]	Brinell hardness [HB]
RE1.0%	90	288	130
RE0%	90	281	128

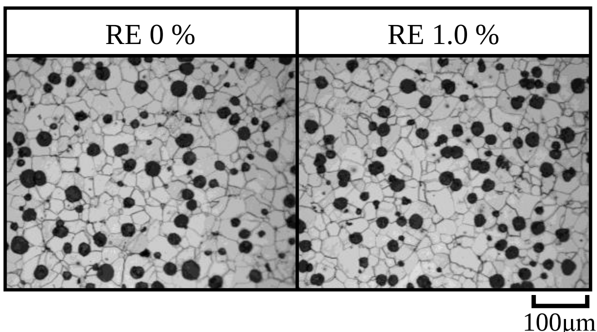

Fig. 1 Microstructure of specimens.

2.2 Experimental method

The fatigue tests were performed by using plane bending fatigue testing machine. The schematic diagram of the specimen is shown in fig. 2. The testing condition is shown in Table 4. The stop condition of fatigue test is the 10^7 time repetitions or fracture of specimen. Fatigue strength is the load stress if the specimens were not fractured. After fatigue test, the fracture surface was observed by using Scanning Electron Microscopy (SEM).

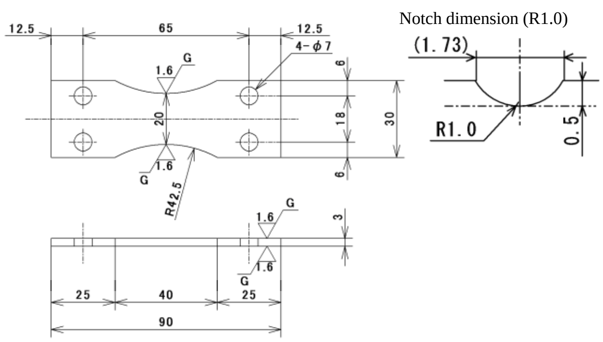

Fig. 2 Schematic diagram of test specimen.

Table 4 Condition of plane bending fatigue testing.

Loading cycle	1200 cycles per min
Stress ratio	-1
Maximum number of cycles	10^7
Test environment	Room temperature

3. Results and discussions

The S-N diagram and fatigue strength obtained from plate bending fatigue tests are shown in Fig. 3. RE1.0% became 234MPa in smooth specimens and 177MPa of notch specimens. RE0% became 190MPa of smooth specimens and 169MPa of notch specimens. The smooth specimens fatigue strength was reduced in RE0% but it became the same fatigue strength in the notch specimens.

And then, micro image of the fracture surface is observed by using SEM. Casting defect is confirmed in the specimens without RE content in Fig. 4. We evaluated each casting defect quantitatively by using $\sqrt{}$ area parameter [3], stress intensity factor (ΔK) and thresh hold stress intensity factor (ΔK_{th}), respectively.

$$\Delta K = \alpha \Delta\sigma \sqrt{\pi\sqrt{area}} \qquad (1)$$

Where α denote a constant of place of defect and $\Delta\sigma$ is stress range. In addition, we can express the ΔK_{th} as the following equation.

$$\Delta K_{th} = 3.3\times10^{-3}(HV+120)\left(\sqrt{area}\right)^{1/3} \qquad (2)$$

The values of ΔK / ΔK_{th} in the specimens without RE are about 1.1. Indicating that fatigue strength of specimens without RE is decreased to excluding RE.

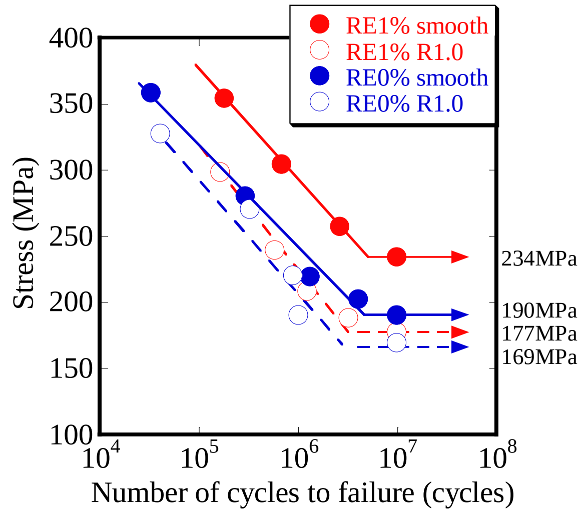

Fig. 3 S-N diagram

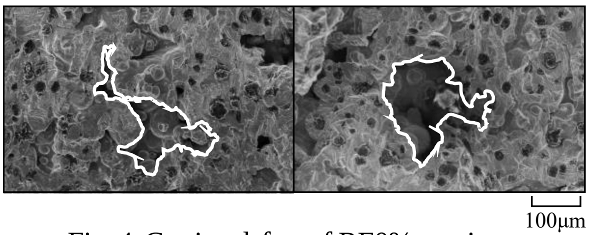

Fig. 4 Casting defect of RE0% specimens

4. Conclusions

The purpose of this paper was to make clear the influence of thickness and notch sensitive on the fatigue strength of spheroidal graphite cast iron. Results are shown below.

[1] As a result of fatigue test, the smooth specimens without RE have fatigue strength of 190MPa. In contrast, the specimens with RE have fatigue strength of 234MPa.

[2] The notch specimens without RE have fatigue strength of 169MPa. In contrast, the specimens with RE have fatigue strength of 177MPa.

[3] Values of $\Delta K/\Delta K_{th}$ in the specimens without RE are about 1.1, resulting in the fatigue strength decreasing of specimens without RE.

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