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Effect of Casting Skin Condition on Fatigue Strength of Gray Cast Iron

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The microstructure around casting skin of cast iron changes according to conditions such as the mold and cooling speed. When self-hardened mold is used, the all pearlite is obtained. When green sand mold is used, the microstructure of the pearlite and the ferrite is obtained. In this study, we conducted fatigue tests on two kinds of gray cast iron: one is the sample taken from casting skin consisting of fully pearlite and another one is the sample consisting of pearlite-ferrite mixture, and investigated the effects of fatigue strength. For comparison, tests were also conducted on the sample of perlite matrix whose surfaces have been machined, sampled from inside the material.

The fatigue strength of the casting skin compared with the thoroughly machined sample (from the internal part), in case of pearlite casting skin increased 20% and in case of pearlite-ferrite mixed decreased 12%. Because the tensile strength of ferrite is supposed to be lower than one of pearlite, fatigue strength became lower. Comparing thoroughly machined with casting skin both in pearlite matrix, the fatigue strength of casting skin was higher because the cooling rate was faster in the casting surface, graphite size became refiner and the number of eutectic cell was larger than the inside.

Keywords: *Cast Iron, Casting skin condition, Fatigue strength, matrix.*

1. Introduction

In some cases cast iron products are used with casting skin, there are need to investigate the effect of the casting skin on the mechanical properties. When the casting skin microstructure of each part of the gray cast iron cylinder head was investigated, most parts were found to be pearlite, and pearlite/ferrite mixtures and ferrite due to decarburization were observed in some parts. Otherwise, the actual tensile strength was measured inside the part which was wholly treated. The microstructure was found to be pearlite, and the strength near the casting skin is thought to be different from inside due to the influence of ferrite and the surface roughness. In this study, the fatigue tests were carried out using test pieces with two kinds of casting skin: pearlite and pearlite-ferrite mixed. For comparisons, fatigue tests were also conducted on pearlite samples wholly treated from the inside.

2. Experimental procedure

2-1. Sample preparation

The samples were prepared using 100kg high frequency induction furnace from 50% retuned scrap and 50% steel scrap. After melt, Fe-Si alloy which is equivalent to 0.35% of the molten metal was inoculated by the ladle inoculation, and the casting into the self-hardening mold and green sand mold. The self-hardened molds applied to get pearlite matrix, on the other hand green sand mold for pearlite and ferrite mixed matrix. The reasons why pearlite-ferrite mixed matrix structure appeared in the casting skin were caused by the chemical reactions between oxygen from the moisture in the green sand and carbon in cast iron melt to become CO or CO_2 gas and to be evaporated so that the carbon concentration of the casting skin became lower partly. Changes occur only near the casting skin and the inside is pearlite. Their target chemical compositions were 3.3%C -2.0%Si-0.7%Mn-0.2%Cr-0.25%Mo and 0.65%Cu.

2-2. Fatigue test

The fatigue test sample measured 4mm in thickness and 90 mm in length. It had flat plate with rounded notches in the center. Specimens had only one side casting skin and another side is machined. Figure 1 shows the test piece shape.

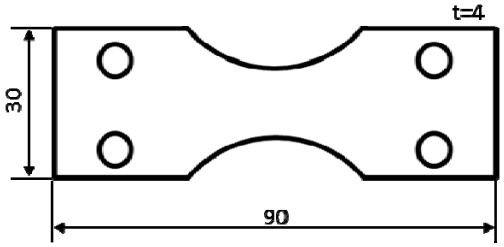

Fig.1 Test piece shape and dimention.

Plane bending fatigue tests were conducted at the following conditions : test temperature was set to room temperature, repeated rate is 1100cpm, complete pulsating condition of stress ratio R = 0. When the bending moment dropped 30% from the initial setting level, it was considered as crack. When there was no drop in stress, tests were conducted up to 1E+7 times. Figure 2 shows the state of the casting skin of the sample used in this test.

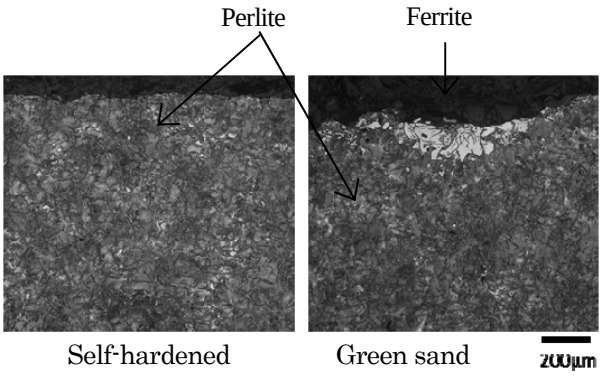

Fig.2 Microstructure of casting skin.

3. Experimental result

Figure 3 shows the tensile strength of each material. Tensile strength of pearlite casting skin (hereafter called S-P) was the highest and pearlite-ferrite mixed (hereafter called S-P/F) was the lowest. In addition, the inconsistency of the tensile strength of S-P/F was greater than other samples. It is considered that the reason for due to the difference in the ferrite formed on the casting skin according to the material. The machined sample (hereafter M-P) whose total surface had been machined and extracted from inside mold, had a consistent microstructure and stable tensile strength.

Figure 4 shows S-N curve of plane bending fatigue test. Compared with the fatigue strength of the M-P, in case of S-P increased 20% and in case of S-P/F decreased 12%. This trend was the same as the tensile strength.

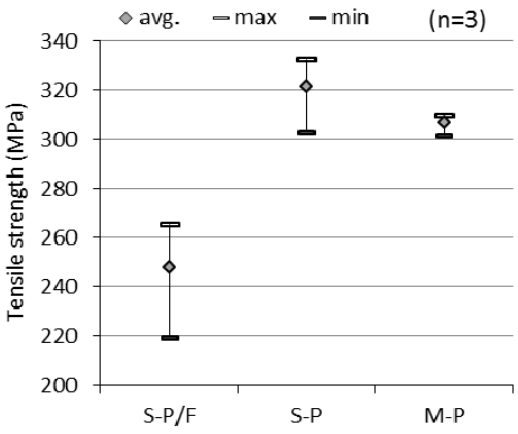

Fig.3 Tensile strength of each material.

Comparing thoroughly machined with casting skin both in pearlite matrix, the fatigue strength of casting skin was higher because the cooling rate was faster in the casting surface, graphite became finer and the number of eutectic cell was larger than the inside. In the case of gray cast iron, the cracks are thought to pass through the graphite/graphite material or graphite/matrix. It is considered that the number of eutectic cells was larger, the resistance to crack propagation increased. Figure 5 shows compared eutectic cell of the casting skin and the inside.

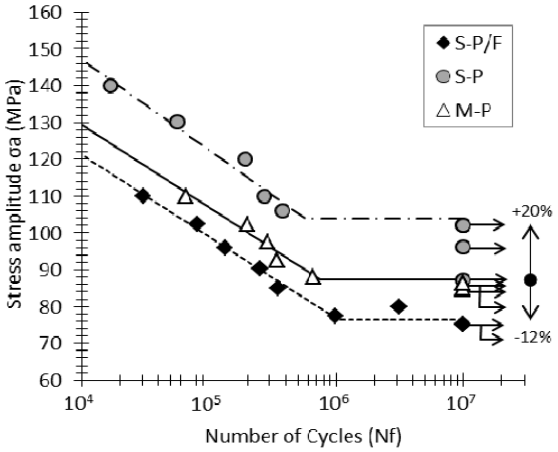

Fig.4 S-N curve of plane bending fatigue test.

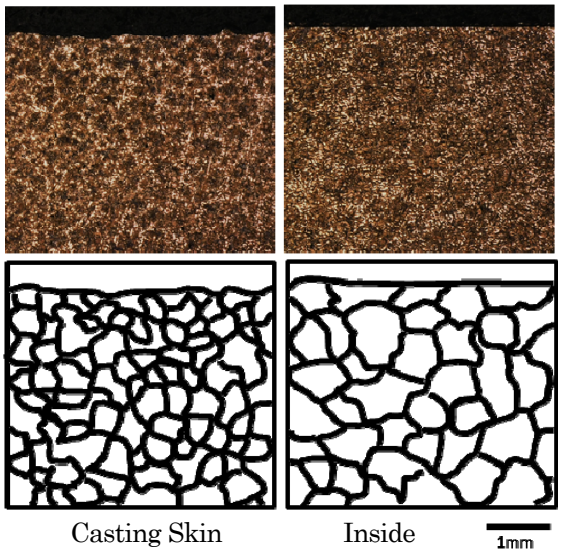

Fig.5 Eutectic cell of surface.

4. Conclusion

Casting skin microstructure becomes finer because cooling rate is faster than that of inside. It indicated the tendency of the fatigue strength was higher. However, the fatigue strength was reduced when the matrix is the perlite and the ferrite mixed.