EFFECT OF SIZE OF COATING DEFECT ON FATIGUE PROPERTIES OF STEEL THERMALLY SPRAYED WITH NI-BASED SELF-FLUXING ALLOY

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ABSTRACT

To clarify the effects of fusing on fatigue properties of thermally sprayed steel, four types of sprayed specimen with different heating length in the fusing process and with different coating thickness were prepared. After polishing the specimen surface, fatigue tests were carried out with a rotational bending machine at room temperature. Results showed that the size and amount of the coating defects were determined by fusing length; the longer the heating time, the larger the defect size and amount. Defect size and amount were also affected by the thickness of coatings. A thinner coating included smaller and less defects as compared to thicker coating. Since fatigue cracks originate from coating defects and propagate through them, the larger the size and amount of defects, the lower the fatigue strength. Therefore, the fatigue strength of the longer heating-length specimen was lower than that of the specimen treated with shorter length fusing. The fatigue strength of the specimen with thin coating was greater than that of the thick coating specimen. This was due to the difference of size and amount of defects in the coating. Consequently, the fatigue strength of a coated specimen is determined by the size and amount of defects in the coating. This means that it is very important to limit the size and amount of coating defects to achieve high quality sprayed coating.

1 INTRODUCTION

Thermal spraying is one of the many surface treatment methods. With an increasing demand for the application of this process in several industries, it has become important to clarify the fatigue resistance of steel with thermally sprayed coatings. In our previous study, it became clear that heating time in a fusing process strongly affects the fatigue properties of the thermally sprayed specimen; a longer heating time decreased the fatigue strength of the specimen. However, the basic mechanism of this has not been clarified. The aim of the present study is to clarify how defects in sprayed coating affect the fatigue properties of steel thermally sprayed with a Ni-based self-fluxing alloy.

2 EXPERIMENTAL METHOD

The material (substrate) used in this study was a medium carbon steel with a carbon content of 0.35%. After machining it into hourglass shaped specimens, the surfaces were polished by SiC paper (#400-#2000) and alumina powder. Then, all specimens were sprayed with a Ni-based self-fluxing alloy by a gas flame spraying method. Two types of post heat treatments (fusing) were performed at 1000℃ in a vacuum furnace for 0.5 hours (0.5h series) and 10 hours (10h series). After fusing, the coating was machined into a 1.0mm thickness and then polished by SiC papers and alumina powder.

The rotational bending fatigue tests were carried out at room temperature with a rotating speed of 3000rpm. Successive observations of fatigue crack initiation and its propagation behavior were also performed. The defect sizes on the coating surfaces were measured by using video microscope (×1000). In the 10h series specimens, additional fatigue tests and measurements of the defect size were carried out on specimens with different coating thickness of 0.5mm (10h-0.5mm series) and 0.2mm (10h-0.2mm series).

3 RESULTS AND DISCUSSION

Fig.1 shows the results of the fatigue tests. The fatigue strength of the 10h series with longer heating time was lower than that of the 0.5h series. To investigate the reason for this, we studied the coating. Fig.2 shows fatigue cracks in the specimen from the 10h series; fatigue cracks spread connecting many defects on the coating surface. This implies that defects in the coating affect the fatigue properties of sprayed specimens. Fig.3 shows the results of measurement of the defect size. The defect size of each series was well fitted by a double-exponential distribution. This means that the maximum defect size to be expected in the coating can be estimated by using extreme-value statistics. Fig.3 also shows that the estimated defect size in the 10h series was much larger than that of the 0.5h series.

In the fusing process, defects in the coating generate toward the coating surface resulting in larger and more defects near the surface. To confirm this, coating was machined into a 0.5mm and 0.2mm thickness and then the defect size and amount were measured. Fig.4 and Table 1 show the results. The defect size of each coating thickness was also well fitted by a double-exponential distribution. The estimated defect size of the 10h-0.2mm series was much smaller than that of the 10h-1.0mm series. In addition, the number of defects per unit area changed depending on the coating thickness; the thinner the coating, the smaller the defect size and the less the number of defects on the coating surface. Rotational bending fatigue tests were carried out on these specimens. Fig.5 shows the results. These results show that the thinner the coating, the higher the fatigue strength. This implies the defect size is one of the important factors which determine the fatigue properties.

4. CONCLUSION

In this study, we studied the effect of the coating defects on the fatigue strength of steel thermally sprayed with a Ni-based self-fluxing alloy. Results showed that the fatigue strength of a coated specimen is determined by the size and amount of defects in the coating. Therefore, it is very important to limit the coating defects to achieve high quality sprayed coating.

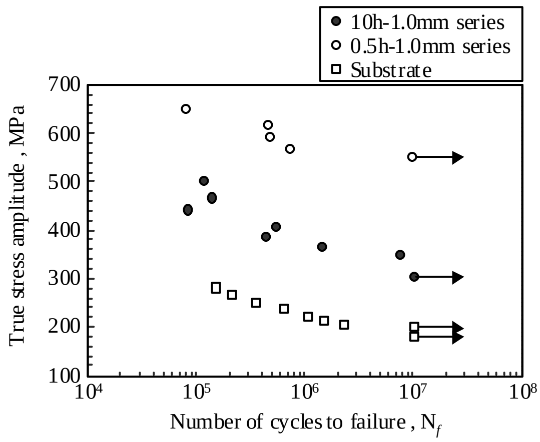

Fig.1 Results of fatigue tests
(Vacuum furnace fusing)

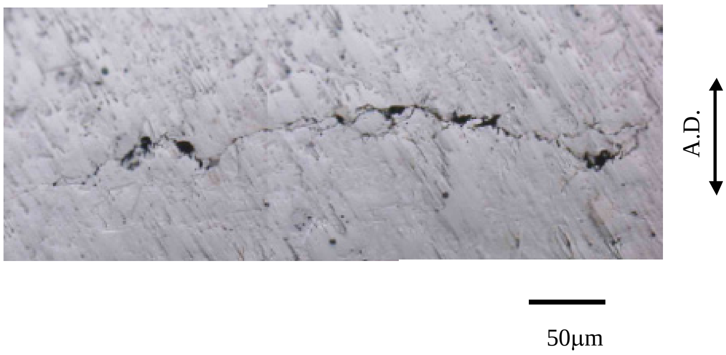

Fig.2 the observation of fatigue crack propagation on the coating surface
(Vacuum furnace for 10 hours, σ=350MPa. N_f =3.3×10^4)

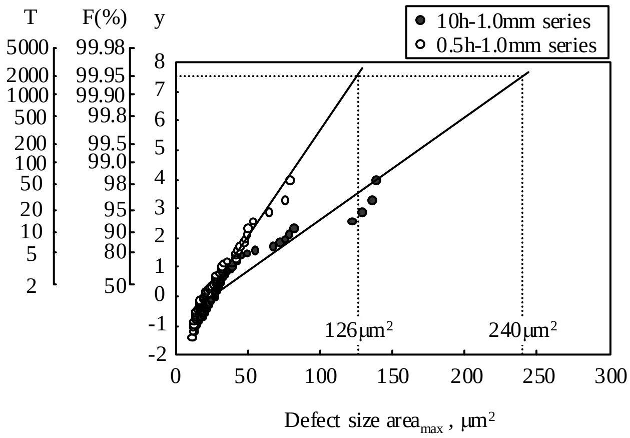

Fig.3 Distribution of the defect size
(Vacuum furnace for 10 hours and 0.5 hours)

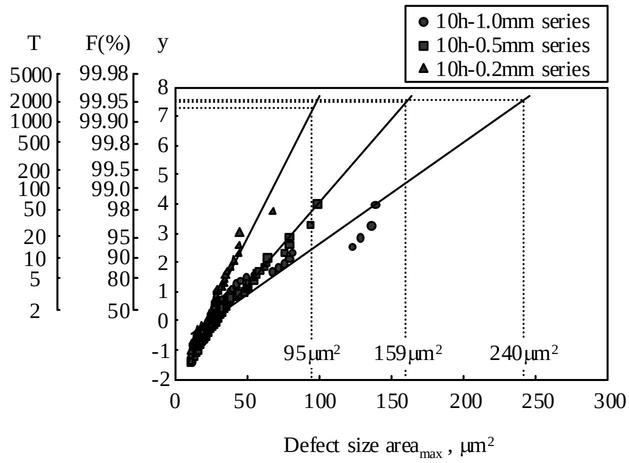

Fig.4 Distribution of the defect size
(Vacuum furnace for 10 hours)

Table 1 Number of defects on the coating surface per unit area

	10h-1.0mm series	10h-0.5mm series	10h-0.2mm series
Number of defects per unit area (N_d/mm^2)	44	33	15

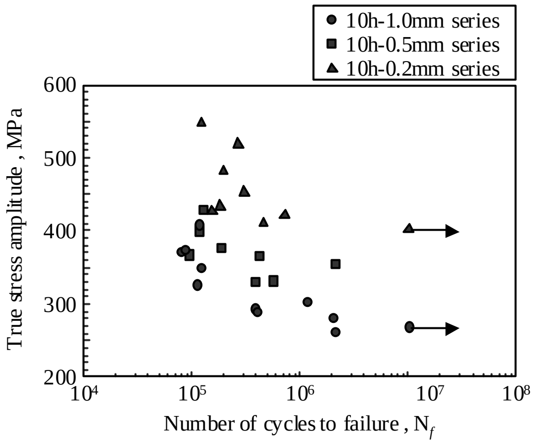

Fig.5 Results of fatigue tests
(Vacuum furnace for 10 hours)