

The Development of High Contact Fatigue Strength P/M Sprocket for the Silent Chain System

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Abstract

Recently, automotive engines have changed to the silent chain system in order to reduce noise and to improve reliability. High contact fatigue strength is needed for the sprockets of silent chain system. As a result, a high-contact-fatigue-strength P/M material was developed using the technology of surface rolling, which densifies the surface layer of sintered parts. It was established that the contact fatigue strength of the developed material was a great improvement over that of the conventionally used sintered material.

Keywords : sprocket, contact fatigue strength, surface rolling, carbide dispersion carburizing

1. Introduction

High contact fatigue strength is needed for the sprockets of silent chain systems in order to achieve high contact pressure in the sprocket tooth flanks. Because pores are a point of origin for stress concentrations, reducing porosity, in other words, densification, is an effective method of improving the contact fatigue strength of sintered parts. Surface rolling of sintered parts is a method in which a densified layer, like that obtained by the powder forging method, is formed only in the surface layer. Densification of the surface layer was therefore studied by rolling, with the aim of improving the contact fatigue strength of sintered parts for silent chain sprockets. In addition, this report also describes the results of an investigation of combined technologies using surface rolling and carbide dispersion carburized quenching and tempering, which was carried out to obtain a higher level of contact fatigue strength.

2. Experiments and Results

The raw materials used in this research were a pre-alloyed powder (Fe-0.5Ni-0.5Mo), natural graphite, and a compaction lubricant. Table 1 shows the mixed ratios of these materials.

Table 1. Mixing ratio (mass %)

Pre-alloyed Powder	Graphite	Lubricant
99.7	0.3	0.8

In order to investigate the effects of densification and heat treatment on contact fatigue strength, specimens were prepared by the four methods shown in Table 2. As a

comparative material, specimens of the same shape were also prepared and evaluated using wrought steel (AISI4120), which was carburized heat treatment.

Table 2. Manufacturing and heat treatment conditions of test specimens.

No	Densification method	Sintering	Heat treatment
1	Double pressing and Double sintering (7.3Mg/m ³)	1473K	CQT
2	Double pressing and Double sintering (7.5Mg/m ³)	1473K	CQT
3	Surface rolling	1473K	CQT
4	Surface rolling	1473K	CD
-	AISI 4120	-	CQT

CQT: Carburized quenching and tempering
CD: Carbide dispersion carburizing treatment.

Figures 1 and 2 show the pore distribution and density distribution of specimen 3 in Table 2. Surface rolling, in which a forming force is provided by the action of a roller, is an effective method of obtaining a densified layer in the near-surface layer of sintered materials^[1,2]. Therefore, in the rolled specimen 3, porosity decreased from the interior toward the surface, and the specimen showed a high density exceeding 7.7Mg/m³ in the region of 600 μm from the surface.

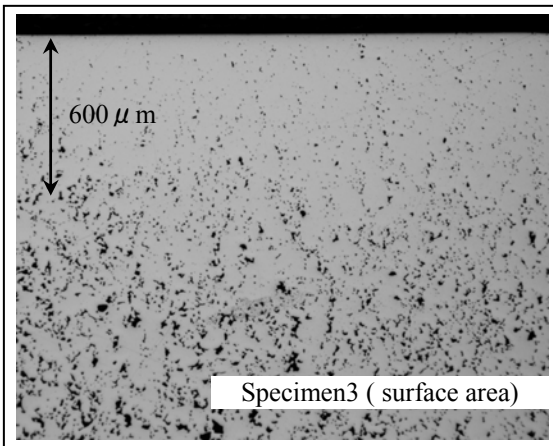


Fig. 1. Pore distribution of rolled specimen.

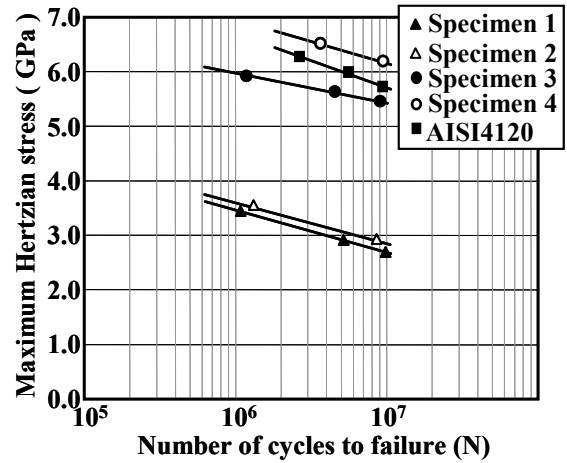


Fig. 3. Results of contact fatigue test.

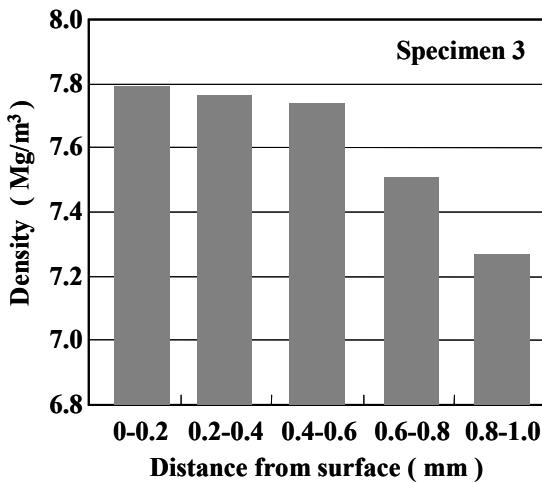


Fig. 2. Density distribution of rolled specimen.

Figure 3 shows the results of pitting tests of the sintered specimens and AISI4120. As can be seen the contact fatigue strength increases, as density increases.

This means that by reducing the quantity of pores, which are an origin of stress concentrations, the contact fatigue strength of sintered steels is effectively improved.

The carbide dispersion carburizing treatment is one method of improving the contact fatigue strength of wrought steels. Specifically, because it is necessary to increase the softening resistance of the steel, a method of utilizing precipitated carbides by carbide dispersion carburizing was proposed [3].

Specimen 4, which was rolled and carbide dispersed carburized treated, shows that the high contact fatigue strength was greater than that of specimen 3. This was because the residual compressive stress and softening resistance of specimen 4 was higher than that of specimen 3.

3. Conclusion

A high contact fatigue strength sintered material has been developed by applying a combination of surface rolling and a carbide dispersion carburizing treatment, and has been applied to the crank sprocket of automotive silent chain systems. The crank sprocket made of the newly developed material is shown in Figure 4.

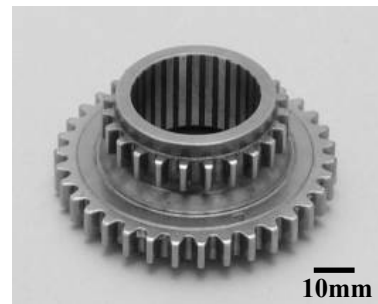


Fig. 4. Crank sprocket for an automobile engine.

4. References

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