Development of Wear-Resistant Sliding Parts Material

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Abstract

Conventional high-speed steels, which are carbide decentralized materials, are used for sliding parts, but they lack sufficient hardness for some applications. Improvement of surface hardness is possible for high-Cr steels through nitriding. However, nitriding P/M parts is not advisable without sealing the porosity before treatment, as they will become brittle. However, it is difficult to seal the pores with steam treatment, because high-Cr steel has a passive film on the surface. Controlling nitriding by decreasing the amount of oxygen on the surface to be nitrided, and grinding to decrease the porosity of the surface, makes it possible to produce a material that has reasonable and sufficient hardness in the required areas.

Keywords : sliding parts, stainless steel, nitriding

1. Introduction

We have harnessed the features of powder metallurgy and offered solid-phase sintered high-speed materials for sliding applications previously. Since there are no large carbides compared with wrought high-speed steel and also no anisotropy, wear on mating components is minimized. Furthermore, solid-phase sintered parts have a pore structure that permits oil retention, which is beneficial for sliding parts[1)]. However, in severe applications, a more wear-resistant material is required, and has been developed. Nitriding wrought SUS440C[2)] for sliding applications is typical.In our company,an investigation into a process design to nitride sintered SUS440C was performed. Stainless steel is noted for having a passive film on the surface[3)], and in P/M this film exists on the surfaces of the continuous porosity of the material.This passive film on the inside surfaces was increased through processing, and the film on the surface requiring higher hardness was removed. Thus, nitriding can be done in a controlled manner only on the necessary surfaces.

2. Experimental and Results

The experiment was performed using atomized stainless steel powder. The chemical composition of the material is shown in Table 1.

Table 1. Chemical composition (mass%)

	Fe	Cr	Si	C
SUS440C	80	17	2	1

The powder was mixed with 0.8% lubricant, compacted at 1100MPa and sintered under vacuum at 1250℃ for 60 minutes. Heat treatment was done in a vacuum furnace at 1050℃ and tempering was done at various conditions in a batch furnace. Nitriding processing conditions are shown in Figure 1.

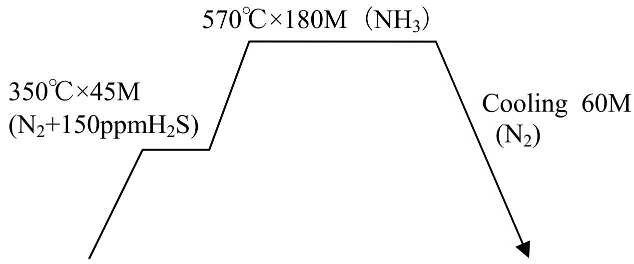

Fig. 1. Nitriding processing condition.

For surface sealing, various processes, such as barrel tumbling, shot peening, shot blasting and grinding were performed on the parts, and the surface pore fraction and depth of nitride layer were measured.

For nitride prevention, different tempering conditions were tested and parts were nitrided after grinding. The relationship between nitride penetration beyond the main layer and oxygen content was examined.

The results for sealing, effectiveness are shown in Table 2. They show that a surface pore fraction of 5% or less produces the most controlled diffusion. Although grinding did not completely close the surface porosity (see Figure 2), the surface was adequately prepared for controlled nitriding.

Table 2. The relation of processing conditions, surface area, and internal diffusion

Work conditions	Surface pore fraction (%)	Nitriding layer ($\times 10^{-6}$m)
High-speed barrel	4	50-120
Shot peening	1	30-100
Grinding	0.5	20-90
Shot blast 5M	2	40-120
Shot blast 1M	5.5	600-900
Barrel	6	800-1000
No	12	all

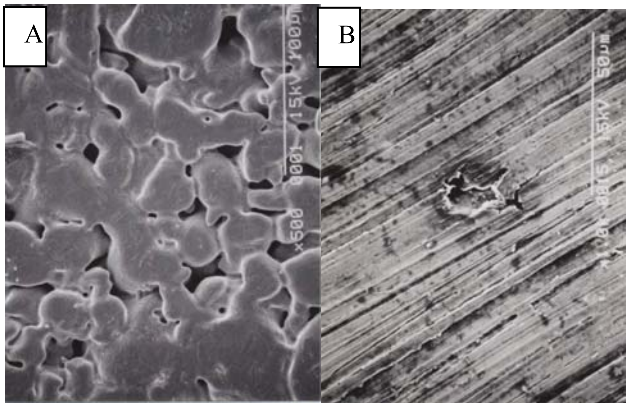

Fig. 2. SEM micrographs of surfaces A) no Machining, and (B) as graund.

The results for nitride prevention are shown in Table 3. It was noted that a higher oxygen content was formed at 6 00℃ in air. Although the highest oxygen content wasf ound in steam treated parts,nitride penetration was the most severe and resulted in part distortion.

Table 3. The relation of tempering conditions, the a mount of oxygen, and internal nitriding

Tempering	oxygen (%)	nitride presence below main layer
As quenching	0.020	partial
200℃ (air)	0.026	partial
600℃ (N2)	0.050	prevalent
600℃ (air)	0.090	none
600℃ (ST)	0.300	throughout

3. Summary

From the above results, the following model can be considered and nitriding can be performed on sintered stainless steel parts in a controlled manner.

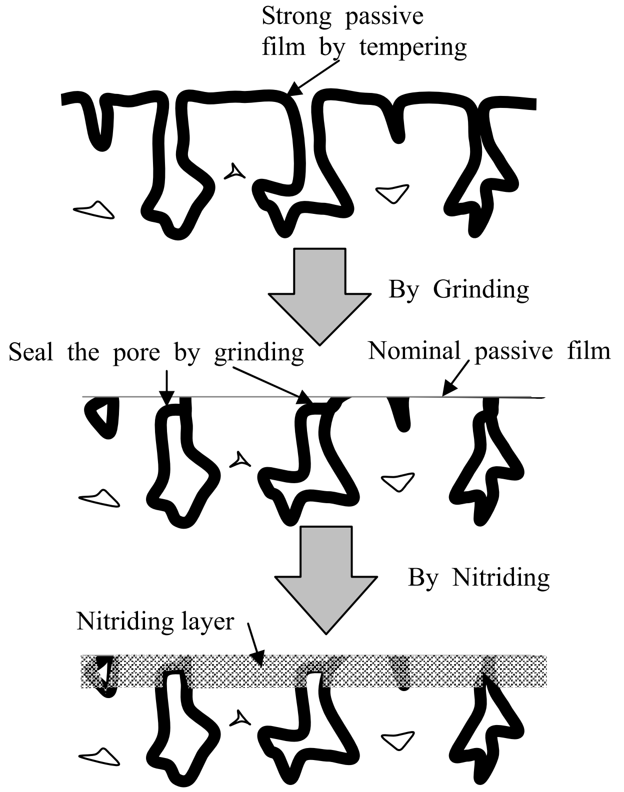

Fig. 3

4. References

1) JP1993214 Patent, Sumitomo Electric Industries, Ltd.
2) JP1668288 Patent, Toshiba Corporation.
3) Japan Stainless steel association、Stainless steel manual(1995)