Sintering of the Crankshaft Position Sensor Wheel

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Abstract

All-surface, all-tooth machining and roll forming of cast iron have been used to manufacture the crankshaft position sensor wheel (CPSW). However, these methods pose many problems such as difficult processing, high material cost, and low tooth precision. Thus, we developed a sintered CPSW with an improved detection ability in order to resolve the problems related with the previous methods of manufacturing CPSW by simplifying the process flow and improving tooth precision. The sintering process is introduced in this study. We conducted an experiment to compare the sintered and roll formed products and analyzed the results to evaluate the reliability of the sintering process. Furthermore, we compared and analyzed stress and displacement in the sintered and roll formed products through the "Finite Element Method(FEM)". According to the experimental and FEM results, the sintered product showed satisfactory mechanical properties. It was less expensive to process and lighter and showed better quality than the roll formed product. The results of this study could be applied to design an optimum CPSW using the sintering process

Keywords : Sintering, Crankshaft Position Sensor Wheel(CPSW), FEM(Finite Element Method)

1. Introduction

The crankshaft position sensor wheel (CPSW) is an automobile part that controls spark and fuel injection timing by monitoring piston stroke. It is manufactured by either roll forming or all-surface, all-tooth machining of cast iron. Roll forming of CPSW requires a complex process. This process is not only costly but also results in high failure rates due to uneven teeth formed by pressing. CPSW manufactured by roll forming affects engine performance as well since low tooth precision interferes with piston stroke detection and spark and fuel injection timing control. [1]

This study was done to resolve the problems related with the previous methods of manufacturing CPSW and shorten the process flow, decrease failure rates by improving tooth precision, and enhance detection capability. In this study, the sintering process is introduced, and sintered products are compared with a roll formed product through an experiment in order to evaluate the reliability of sintering process. In addition, the finite element analysis (FEA) was used to compare stress and displacement in the sintered and roll formed products. For FEA, Pro/Engineer 2001 was used to come up with a 3-D model. Pro/MECHANICA 2001 was used to analyze the pre- and post-processes.

2. Experimental and Results

As shown in Fig. 1., the sintered CPSW was prepared in 5 steps. Table 1. shows the materials used for the preparation of sintered CPSWs.

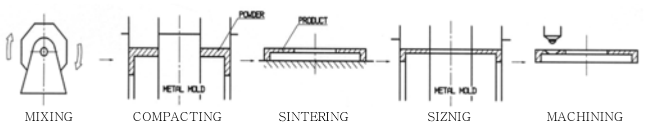

Fig. 1. Illustration for the Preparation of Sintered CPSW

Table 1. Materials used for the Preparation of Sintered CPSW

	Powder
Material A	Iron + wax 0.8wt%
Material B	Iron + P 0.45wt%+wax 0.8wt%

To evaluate the failure mode of CPSW in an engine running at high speed, the burst test (high-speed simulation test) was done using the jig shown in Figure 2.

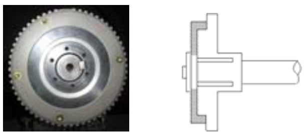

Fig. 2. Burst Test Jig and Test Model

Fig. 3. Test Jig for Repeated Load Test

To evaluate failure mode due to CPSW vibration in a slightly bent condition coming from centripetal force during engine runing, the jig was prepared at our lab as shown in Fig. 3.

As shown in Table 2, the roll formed product and sintered products A and B showed no failure after 3 cycles of burst test. The results of repeated load test are shown in Fig. 4. The fatigue limit was slightly lower in the sintered products

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A and B compared with that in the roll formed product.

Table 2. Results of Burst Test

Materials		1 Cycle	2 Cycle	3 Cycle
Roll Formed Product		OK	OK	OK
Sintered Product	A-Type	OK	OK	OK
	B-Type	OK	OK	OK

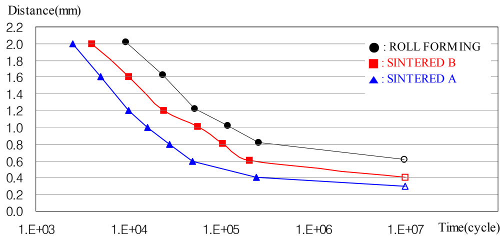


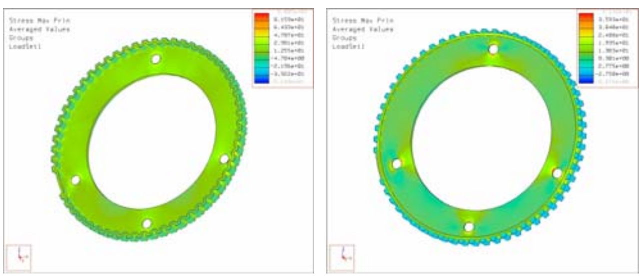
Fig. 4. Results of Repeated Load Test

3-D finite element analysis (FEA) was done in the roll formed and sintered CPSWs to evaluate stress, displacement and movement observed with the burst test and repeated load test. The Pro/ENGINEER(2001 version) was used to create a 3-D model, and the Pro/MECHANICA(2001 version) was used to analyze the solver and pre- and post-processes. Table 3 shows the material properties.

Table 3. Material Properties

Materials	Density(ρ)	Young's Modulus(E)	Poison's Ratio(υ)
Roll Formed (D 3512)	8.03E-10(kg·s/mm^4)	21345(kg/mm^2)	0.291
Sintered (SMF-1015)	7.14E-10(kg·s/mm^4)	14500(kg/mm^2)	0.241
Crank Shaft (SCM-445) Bolt(SCM-435)	7.96E-10(kg·s/mm^4)	21000(kg/mm^2)	0.300

The results of centripetal force analysis in Fig. 5. showed that maximum stress occurred at the medial side of the bolt hole in the roll formed product, whereas it occurred at the bolt hole in the sintered product. Table 4. shows the results of stress and displacement in the two products.



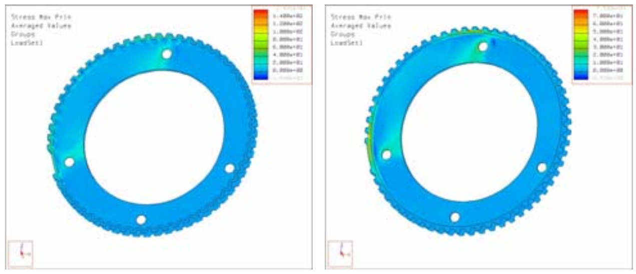
a. Stress in Roll Formed b. Stress in Sintered

Fig. 5. Stress at the 15,000rpm

Table 4. Result of Centripetal Force Analysis

	Max. Prin. Stress	Max. Disp.
Roll Formed	98.9kg/mm^2	0.448mm
Sintered	41.5kg/mm^2	0.224mm

As shown in Fig. 6, maximum stress is observed at the center of the major tooth in the roll formed product and at the corner "R" of minor tooth profile in the sintered product.



a. Stress in Roll Formed b. Stress in Sintered

Fig. 6. Stress at 1mm Displacement

3. Summary

The following results were obtained when the roll formed and sintered products were compared.

1. The sintered product was about 10% lighter than the roll formed product due to the presence of pores.
2. Although the mechanical properties of sintered product were inferior compared with the roll formed product, the results of FEA were satisfactory.

According to the results of this study, the sintered product was better in quality, less expensive and lighter than the rolled formed product. Based on the results obtained with FEA on stress and displacement in each product, we are planning to apply different conditions and variables to observe CPSW movement and design an optimum sintered product.

4. References

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