

High-performance Shell Bearing from New Material

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ABSTRACT

A material that combines high thermal conductivity, seizure toughness, and high strength was developed by enhancing hardening methods and fine homogenization in the deposit phase of a Corson alloy. This material was used as the back metal for shell bearings, it was used in parts as a “high strength high thermal conductivity shell bearing,” and it achieved consecutive use in events under one-engine, two-race rules.

1. Introduction

Shell bearings for use in Formula One racing engines require sliding durability to a high PV value (surface pressure $P \times$ peripheral velocity V : 2000 MPa m/s or above) in order to sustain the inertial force and explosion force experienced under high speed conditions. When concerns about insufficient durability existed, there were sometimes cases when engine power performance would be suppressed in order to assure durability.

Figure 1 shows the cross-sectional structure of shell bearings. Conventional shell bearings have a three-layered structure. On the other hand, shell bearings for use in Formula One racing require sliding durability that is enhanced to an ultimate degree, and therefore Cu alloy back metal with a two-layered structure that emphasizes heat drawing performance was adopted. With this structure, the material properties of back metal Cu alloy have a substantial influence on shell bearing durability, and it was therefore decided to aim for development of a new Cu alloy.

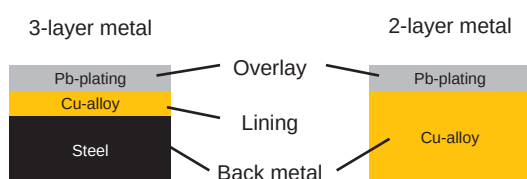


Fig. 1 Cross-sections of each metal

Table 1 Main properties of several Cu-alloys

Material	Electric conductivity IACS (%)	UTS MPa	0.2%YS MPa
BeCu50	45-50	690 - 800	—
BeCu25	25	>1000	—
CF-2 (Cr-Cu alloy)	65	490	—
NC50 (Corson alloy)	40-45	690	590

2. Development of New Cu Alloy for Use in Shell Bearings

A Cu alloy for use in shell bearing back metal should have the following three properties in combination:

- (1) Thermal conductivity: Efficient cooling of heat generated by sliding
- (2) Sliding performance: Inhibit seizing against nitriding crank shaft
- (3) High strength: Assure contact pressure with connecting rod big end

2.1. Selection of Alloy

Table 1⁽¹⁾ shows the main properties of typical Cu alloys. Cu alloys with high thermal conductivity as represented by electric conductivity (IACS%) are Be-Cu alloys (hereafter BeCu), Cr-Cu alloy (hereafter CF-2), and Corson alloy (hereafter NC50)⁽²⁾.

These Cu alloys were subjected to a test of toughness against seizure with nitriding steel using the sliding rig test of Daido Metal Co., Ltd. The

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results are shown in Fig. 2. NC50 has greater seizure toughness than BeCu alloy, which makes an excellent sliding material for use in a bush and is commonly found in that application. NC50 is a Cu alloy of the deposit strengthening type that has Ni, Si, and Cr as main additive constituents. The deposit phases (Ni_2Si , Cr_3Si) are thought to suppress its seizure against steel. Material development was carried out using NC50, a material that achieves a balance of high thermal conductivity and seizure toughness, as the base.

2.2. Balance of Thermal Conductivity and Strength

The use of NC50 material as shell bearing back metal to assure contact pressure against the connecting rod big end under high PV conditions necessitates strength.

Greater strength can be achieved by increasing the deposit phase, but increasing the quantity of additive elements results in a reduction in thermal conductivity. Instead of changing the quantity of additive elements, therefore, it was decided to seek higher strength by adding hardening methods (extrusion method, multi drawing method) to the process. In addition, the heat treatment was optimized (by multi heat treatment) in order to achieve a finer, homogenized deposit organization, and thermal conductivity was increased. Relative to NC50 (the base material), the developed material NC50ES achieved a 30% increase in strength and a 12% increase in electric conductivity (Fig. 3).

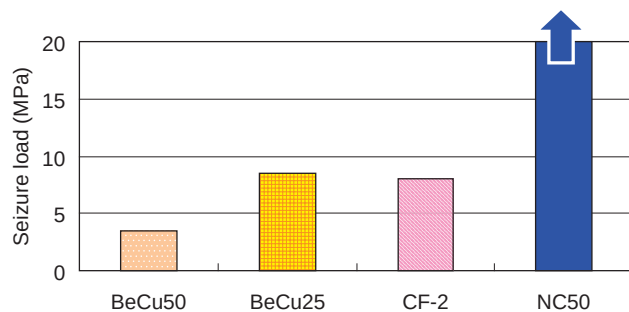


Fig. 2 Seizure toughness of Cu alloys

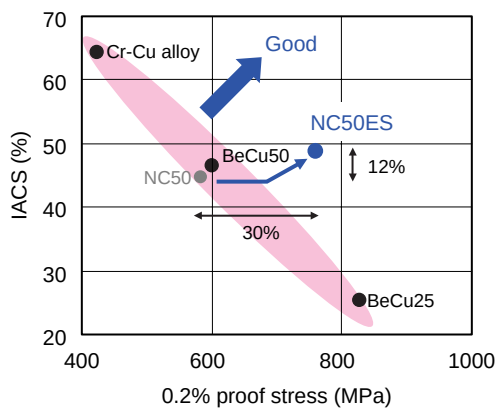


Fig. 3 Position of NC50ES material

3. Confirming the Effectiveness of Shell Bearing Parts

3.1. Shell Bearing Rig Test

Prototype shell bearings were fabricated with NC50ES material as the back metal. These were subjected to performance evaluation using a shell bearing tester⁽³⁾. Figure 4 shows the results.

The horizontal axis shows the flow rate of the oil supply from the shaft to the shell bearing, while the vertical axis shows the shell bearing temperature (measured by a thermocouple embedded inside the shell bearing). It was confirmed that NC50ES has a shell bearing temperature 3-5°C lower than that of conventional materials. This is conjectured to be the effect of increased thermal conductivity in the back metal material.

3.2. Engine Tests

Figure 5 shows the state of damage to the shell bearing sliding surface after conducting engine endurance testing. The condition of the remaining overlay on the shell bearing surface (No. 1 cylinder on the connecting rod beam side) is shown three-dimensionally. There is more remaining overlay (area) on the NC50ES shell bearing. It is speculated that when the temperature of the shell bearing as a whole is reduced, this also causes the temperature of the overlay to decrease, resulting in an increase in wearing toughness. This material also made it through durability testing in modes matching the most

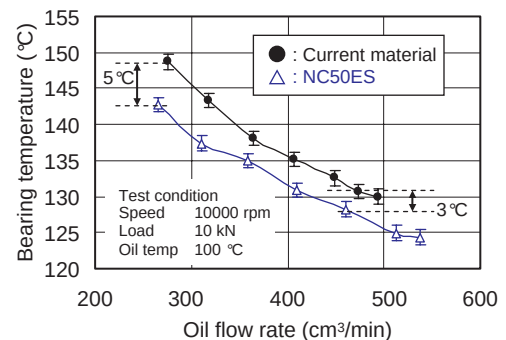


Fig. 4 Result of test on bearing tester

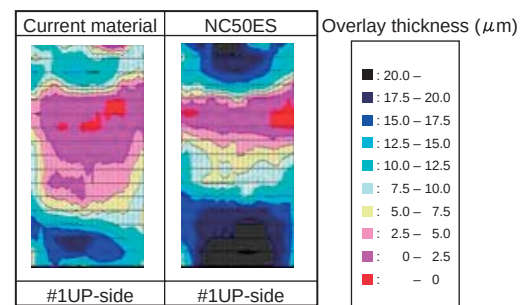


Fig. 5 Overlay thickness after engine endurance test

demanding high-load conditions on the circuit, and produced satisfactory results without adhering, seizing, or cracking.

4. Conclusion

The new Cu alloy NC50ES was developed for use as shell bearing back metal. Shell bearing parts were fabricated from the material.

The reliability of the shell bearings was enhanced with respect to the high-speed, long-distance assurance of Formula One engine regulations. The shell bearings achieved continuous use in events under one-engine, two-race rules as well as straight-end 19000 rpm performance enhancement.

References

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- (2) JP, 3563315, B (2004)
- (3) Machida, K., Takahashi, S., Ueshima, H., Fujiki, K., Proposal of New Bearing Simulation Rig Tester for High Efficiency Engine Bearing Development, Honda R&D Technical Review, Vol. 18, No. 2, p. 131-139

Acknowledgement

This occasion is taken to express the warmest gratitude to Miyoshi Gokin Kogyo Co., Ltd., and Yamato Gokin Co., Ltd., which cooperated generously in the development of this material.

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