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The development of a wear resistant hard-metal tappet in diesel engines

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Diesel engines have many sliding parts with solid body contact. For example, a piston-ring and a cylinder bore, a valve and a valve-seat, a cam and a valve tappet. These parts have a severe wear problem, during engine life times. During these times, the valve tappet has abnormal wear such as scuffing and pitting due to a hig. hertzian contact stress between the cam and the tappet. Excessive wear problems frequently occur to both the cam and the tappet.

To solve these problems, we developed an advanced wear resistant tappet. The developed tappet consisted of a hard-metal wear part and a steel body. To increase a bonding strength, those two parts were directly bonded to each other. Also to decrease a bonding temperature, we developed the composition of Ni-binder materials in the hard metal. To estimate the wear characteristics of the newly developed tappet, we performed wear tests and engine dynamo tests in order to compare them with a conventional Fe-base tappet. As a result, the newly developed tappet has better wear characteristics than those of the conventional tappet. In addition, we performed a 100,000km field-test, and the newly developed tappet showed much improved wear resistance.

Keywords : Diesel engines, Tappet, Wear resistance, Hard metal, Direct bonding

1. INTRODUCTION

At the valve-train system in the OHV(Over Head Valve) type Diesel Engine, cam and tappet have a relative movement with high contact pressure and high speed. So cam and tappet have wear problems like scuffing, pitting and severe wear.[1] To overco..e the problems, Many surface treatments and materials, such as a PVD/CVD coating, a ceramic material and a hard metals [2], were proposed as a cam contact part of tappet.

In order to use a hard metal or a ceramic material as a cam contact part of tappet, the hard metal or ceramics must be brazed or bonded with steel, due to the saving of weight and money. In the case of brazing method, we must use a silver alloy as a filler metal. Since the silver alloy has a high cost and a low shear strength, it's not proper method to tappet. Thus, we developed hard metal tappet, which was directly bonded to between steel and hard metal. But sintering or bonding temperature of conventional hard metal is 1400~1500℃, which is near steel's melting temperature. Therefore, we developed a new hard metal of low melting temperature. The bonding temperature of new hard metal with steel is below 1100℃. [3]

To compare the wear characteristics between a newly developed hard metal tappet and conventionally chilled iron tappet, we performed wear test, engine dynamo test, and field test. The te results show better wear characteristics in newly developed hard metal tappet than in conventionally chilled iron tappet.

2. EXPERIMENTS

First of all, we prepare a newly developed hard metal tappet and a conventionally chilled iron tappet. To compare the wear characteristics of them, wear tests were performed. In addition, engine dynamo test and field test in real truck driving situation were carried out.

Belows are detail experiment conditions.

2.1 Wear test

Cam and tappet have a line contact with rolling and sliding movement. Using the rolling and sliding adapter as shown in Fig. 1, we get the friction coefficient and scuffing time of each cam and tappet material combination.

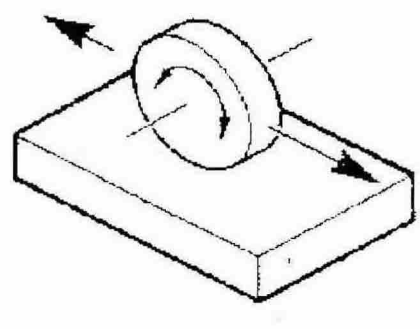

Fig. 1 Rolling and sliding movement in wear test.

Tests were performed at room temperature, reciprocal movements with 5Hz, 300N Load, and in a bath of solvent mixed with oil. Two materials of plates were used for the purpose of comparison; a newly developed hard metal and a conventionally chilled iron tappet. On the other hand, for the both case, the same material of roller, induction hardened steel, was used.

2.2 Engine dynamo test and field test

For the reliability of the tappet, dynamo test and field test were performed. Dynamo test conditions are as follows shown in table. 1. In addition, field test was performed until 100,000km, used the same kinds of engine.

Engine Type	6 cylinder in line(OHV)
Output	340 hp
Test time	250 hour
Test RPM(Crankshaft Speed)	2,000

Table. 1 Engine Dynamo test conditions

3. RESULTS

3.1 Wear tests

Scuffing times and friction coefficients of each tappet material are shown in Fig. 2 and Fig. 3.

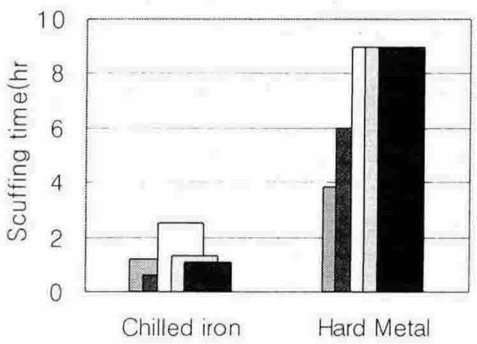

Fig.2 Scuffing times of each tappet material in wear tests. (Cam material : Induction hardened steel)

Scuffing time is defined as a time, at which friction coefficient is rapidly increased. To examine worn surface, Scanning Electronic Microscope (SEM) and Energy Dispersive Spectroscopy(EDS) were used. Microscopic observations show that cam material was founded on the surface of scuffing occurred tappet material. Therefore, we can conclude that the phenomena of rapid increase of friction coefficient may have a relation with adhesion between cam and tappet material. Wear test results show that the hard metal have a longer life time compared with the chilled iron as shown in Fig. 2. In addition, the friction coefficient of hard metal is lower than that of chilled iron. In these tests, the surface roughness of hard metal and chilled iron was at the same lavel.

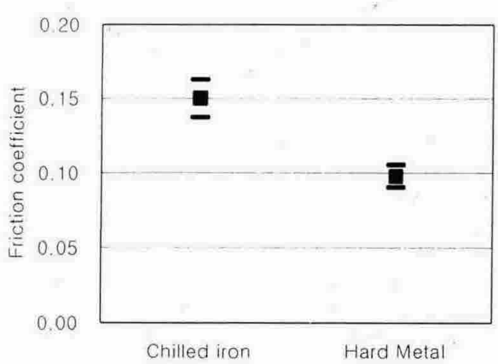

Fig.3 Friction coefficient of each tappet material in wear test (Cam material : Induction hardened steel)

3.2 Engine dynamo test and field test

To test a reliability of hard metal tappet, dynamo-test and field test were performed. Test engine is newly designed in-line type, 6-cylinder diesel engine. Output is nearly 340 hp. therefore it has much stronger valve spring force than before. And it means, the newly designed engine has lower opportunity of unusual wear of cam and tappet such as pitting and scuffing. To compare with chilled iron tappet, we used 6 chilled iron tappets and 6 newly developed hard metal tappets.

After the dynamo tests, 3 chilled iron tappet have pittings like Fig. 4, and other 3 chilled iron tappets and all hard metal tappets have no unusual wear. Pittings were initiated from subsurface crack, which were formed due to excessive contact pressure of cam and tappet. They accelerate the wear of a tappet and a cam.

Also the results show that the tappet with a pitting had a excessive wear of cam, but other normal tappets did not.

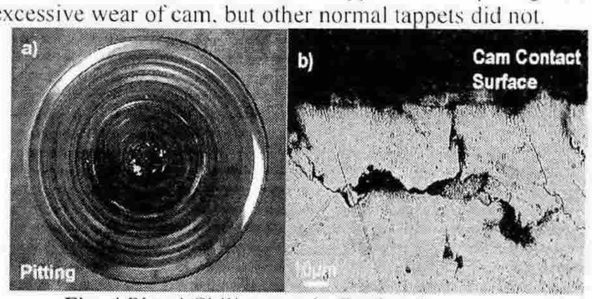

Fig. 4 Pitted Chill tappet in Engine dynamo test
a) Tappet surface, b) Cross section of pitted surface

In the case of 100,000km field test, all the applied tappets were the newly developed hard metal tappet. After the field test, all tappets of hard metal did not form unusual wear, such as pitting and scuffing. In addition, all of the tappets had a good cam-contact surface of fine polished. Its means, the re-use of the newly developed tappet is possible, after the life time of diesel engine.

4. CONCOLUSION

To test the performance of a newly developed hard metal tappet compared with conventionally chilled iron tappet, wear test, engine dynamo test, and field test were performed. The test results show that the wear characteristics of hard metal tappet, such as scuffing, pitting and friction coefficient, are much better than those of conventionally chilled iron tappet. Therefore, the commercial use of the newly developed hard metal tappet is possible. Furthermore, the re-use of the newly developed hard metal tappet will be also possible.

5. REFERENCES

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