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CRACK ANALYSIS OF CRANKSHAFT FOR DIESEL ENGINE

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Preliminary Note – Prethodno priopćenje

The cause of crankshaft fracture crack of a certain vehicle has been analyzed through macroscopic inspection, chemical composition analysis, microstructure analysis, hardness test, mechanical properties test and dimension inspection. The analysis results show that: All of its chemical composition, microstructure, hardness, mechanical properties and dimensions accord with the technical specifications. However, due to the bearing score of the seventh main journal and the wear of fillet, the crankshaft cracked at multi-points from the fillet. The reason is that the fracture of crankshaft is finally caused by large cyclic external force.

Keywords: crankshaft, crack, chemical composition, microstructure, mechanical properties

INTRODUCTION

This paper mainly identifies the cause of the crankshaft fracture crack through a series of analysis and inspection for a certain vehicle, such as macroscopic inspection, chemical composition analysis, microstructure analysis, hardness test, mechanical property test and dimension inspection.

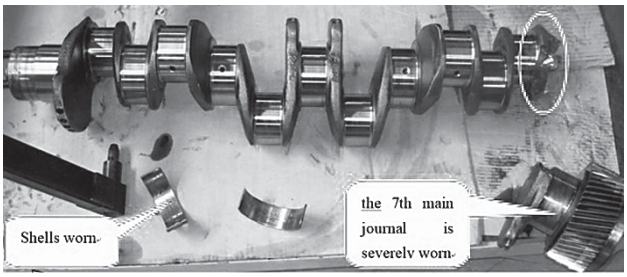

Figure 1 Broken shaft morphology

EXPERIMENT ANALYSIS

Macroscopic fracture inspection

From the broken crankshaft and its accessories, it occurs for the bearing score of the seventh main journal, a little serious wear of the journal and bearing shells (Figure 1), serious wear of the boss on the broken side of the seventh main journal (Figure 2). However, the journals are in good condition, and there is no bearing score.

From the macro fracture, there are two crack sources that both are in fillet on the side of the main journal at the fracture of the crankshaft. And the boss and fillet are worn seriously. It will easily cause the crank of the crankshaft from here and ultimately led to fracture. There is a larger area of crack break, which accounts for more than a half of the whole fracture. It can be determined that the crankshaft is subjected to large external force during use.

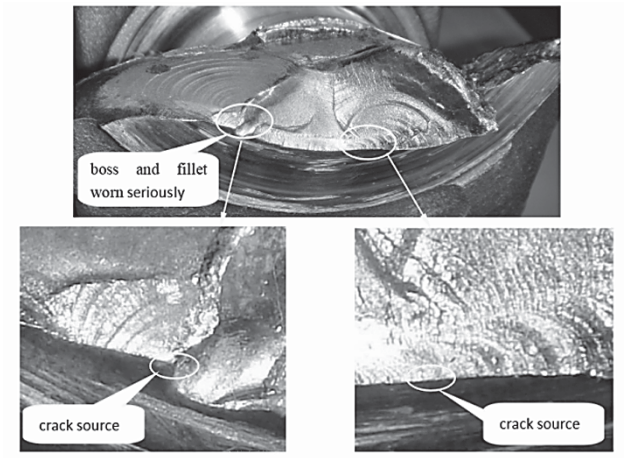

Figure 2 Macroscopic fracture morphology

Chemical analysis of crankshaft

The crankshaft is made of alloy steel, grade C38N-2BY. The chemical composition of crankshaft that is sampled in its internal was analyzed by the method of reading spectrum directly. The results shown in Table 1, the chemical composition of crankshaft is qualified and within the range of the technical requirement.

Microstructure analysis of fracture

From the microstructure (Figure 3), Observation of the microstructure near the crack revealed that there is a slight amount of sulfide in it. According to the test results of microstructure, as shown in Table 2, they are all within

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Table 1 **Chemical composition of crankshaft / wt. %**

Element	C	Si	Mn	P	S	Cr	Mo	Ni	Cu	Al
Technical Specifications	0,35 ~0,41	0,20 ~0,65	1,3 ~1,65	≤0,025	≤0,025	0,1 ~0,2	≤0,10	≤0,20	≤0,25	≤0,01
Detection Value	0,39	0,54	1,52	0,019	0,017	0,145	0,04	0,099	0,01	/

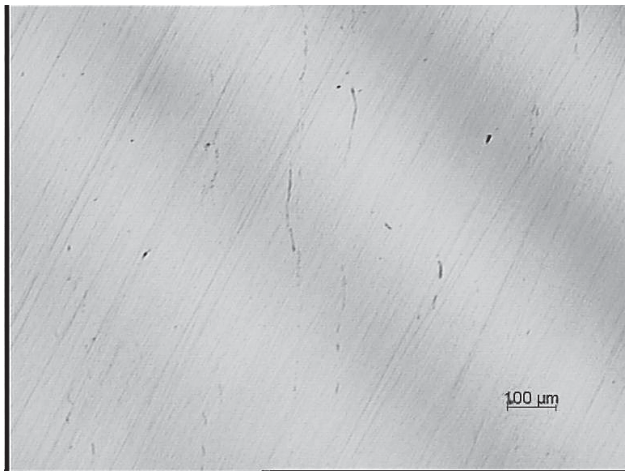

Figure 3 Matrix at the fracture

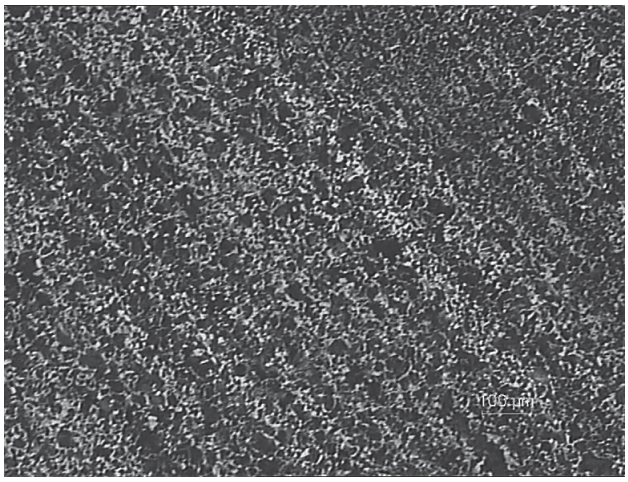

Figure 4 Matrix after fracture corrosion

the range of technical requirements. After pickling and electrolytic etching, the morphology as shown in Figure 4, that the grain size of the matrix whose grade is Grade 7 is relatively uniform, is finally formed. The grain size of the matrix is relatively uniform, and the grade is Grade 7. After eroding the sample of the crack source of crankshaft, the metallographic structure obtained under microscope by 500 times of the material is quenched martensite (Figure 5). Its grade is Grade 5 (As shown in Table 2).

Table 2 **Detection results of microstructure**

Item	Grain size (grade)	Sulfide	Quenched martensite
Technical Specifications	5-8	K4≤30	/
Detection Value	7	<30	5

Hardness test

It was found that after cutting the quenching hardness sample on the fractured journal, wherever journal

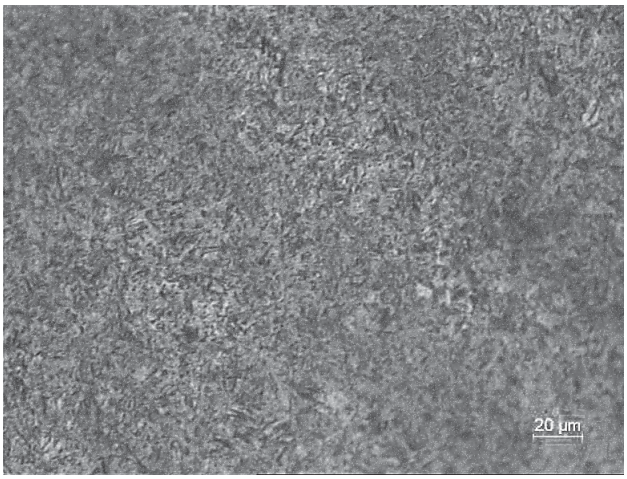

Figure 5 Quenched martensite at fracture (500 ×)

or fillet, the depth of hardening layer meets the technical requirements, and the surface hardness is above it. It is clear that the quenching of the crankshaft is good.

Table 3 **Detection results of surface quenching**

Item	Depth of hardening layer (mm)			Surface hardness (HRC)
	Journal	Fillet 1	Fillet 2	
Technical Specifications	>2,5	>1,8	>1,8	≥50
Detection Value	2,74	3,15	2,81	52,5

Mechanical property test

The tensile and impact tests were carried out on the crankshaft of a certain vehicle. According to the test values of mechanical properties in Table 4, the strength, toughness and hardness of the crankshaft are all within the technical requirements, and the performance is good.

Table 4 **Detection results of mechanical property**

Item	Tensile strength Rm/MPa	Yield strength Re/MPa	Elongation /%	Fracture shrinkage /%	Hardness / HBW
Technical Specifications	750 -900	≥450	≥12	/	226 -269
Detection Value	797	558	22,4	53,4	257

Dimensional inspection

Due to the bearing score of the seventh main journal which isn`t returned yet and the wear of fillet, the size of the journal cannot be detected. According to the factory inspection data, the dimensions of the crankshaft journal all satisfied with the technical requirement.

CONCLUSIONS

In conclusion, the chemical element composition, microstructure, hardness, mechanical properties and dimensions of the crankshaft are all qualified. However, from the macroscopic observation of the fracture, the fillet on the side of the 7th main journal is severely worn, and there are two original cracks here, which crack and eventually cause the crankshaft to fracture.

After the engine was disassembled, it was found that the 6th cylinder of the engine next to the seventh main shaft diameter had more carbon deposits than other cylinders, indicating that the cylinder is prone to rough work during operation, which brings additional load to the crankshaft, which causes the seventh main shaft diameter. The fillet is excessively worn, and the two crack sources at the crankshaft's fillet wear will accelerate the propagation of cracks under the action of a large cyclic external force. This further verifies that the long-term rough work of the sixth cylinder of the engine is the main reason for the fracture and failure of the crankshaft.

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Note: The responsible translator for English language is Defa Liu, Harbin, China