

# Analysis on Fracture Reason of 20CrMo Driving Shaft

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**Abstract**—The fracture reason of a driving shaft used motorcycle engine was analyzed by means of macroscopic examination, chemical analysis, fracture analysis, hardness testing. The results showed that the fatigue fracture mode was determined and incomplete hardening of the axis and increasingly growing load were the main reasons which accelerated the fatigue fracture of the driving shaft.

**Keywords**-fracture; martensite; carburizing; quenching; driving shaft

## I. INTRODUCTION

A motorcycle engine driving shaft whose material is 20CrMo. The driving axle matched with original 10-inch wheels; now we need to use the driving axle to match the new engine with 12-inch wheels. Compared with the original engine, the engine power increased 8% than the original engine power. At first, the calculation was conducted on the static strength, fatigue strength and its stability. The result of calculation showed that the driving shaft was safe to match the new machine. But in

actual operation, during the 600 hours motorcycle chassis durability test, the driving shaft fracture occurred twice. In this paper, the fracture reason was analyzed from the material aspects in the case of existing equipment.

While failure analysis was carried on from the material aspects, because the chemical composition and microstructure decided the using performance, so failure analysis should be carried in the order: ingredient → Organization → performance[1-7].

## II. CHEMICAL ANALYSIS

### A. Macroscopic fracture analysis

The macro-morphology of the broken pieces is shown in Figure 1. From the fig.1 we can know there is obvious plastic deformation in the fracture and the fracture surface include fatigue source region, fatigue crack growth area and instantaneous fracture zone[7]. So, we judged that the fracture was fatigue fracture.



Figure 1 Appearance of fractured driving shaft

### B. Analysis of the chemical composition

Spectroscopic chemical analysis on sampling near the fracture driving shaft was carried on as shown in Figure 2. The spectrometer is model of OBLF-750 and made in Germany. The result of analysis is shown in Table 1. Compared with the standard material

composition, the chemical composition of the driving shaft is in line with the provisions of GB3077-88 of 20CrMo steel. So the chemical elements of raw materials are qualified.



Figure 2 Spectroscopic chemical analysis

TABLE.I CHEMICAL COMPOSITION OF THE CORE OF FRACTURED DRIVING SHAFT (%)

Composition	C	Si	Mn	P	S	Cr	Mo
Driving shaft	0.22	0.26	0.50	0.012	0.016	0.86	0.17
GB3077-88	0.17~0.2	0.17~0.37	0.40~0.70	≤	≤	0.80~1.10	0.15~0.25
	4			0.035	0.035		

### C. Metallographic examination

The heat-treatment of the driving shaft includes carbonitriding, quenching and tempering. The sample was gotten near the fracture source region. The cross section of the sample was used to prepare the observed surface and the inlaid sample was milled in the 200-1200 number of sandpaper. After finished sample grinding, the sample was rough polished fine polished until the sample was looked bright as a mirror without any minor scratches, as shown in fig.3. Using alcohol with 4% nitric acid solution eroded the surface of the sample, then the erosion good sample was observed using Carl Zeiss

inverted microscope which model was Axiovert 40 MAT. The sample of fracture shaft was observed microstructure of the surface layer and the core section, as shown in Figure4 and Fig .5. The surface structure of specimen was shown in Figure4 and core tissue sample was shown in Figure5. From the fig.4 we can learn that the surface microstructure was tempered martensite (tempering M) and a small amount of residual austenite (A ') and the structure was normal; from the fig.5 we can learn that the core part was ferrite microstructure (F) and pearlite (P), and the structure of core is the balance organization[8-10].

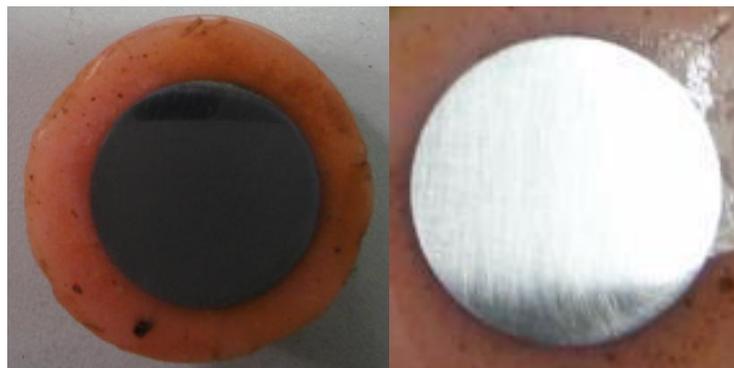


Figure 3 Sample of Metallographic examination

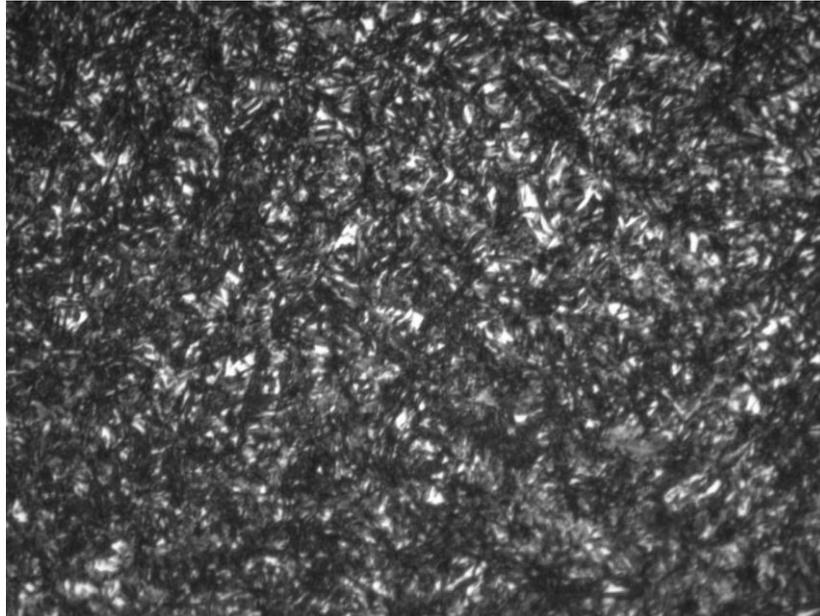


Figure 4 Surface texture of fracture driving shaft: tempering M+A' ~540X

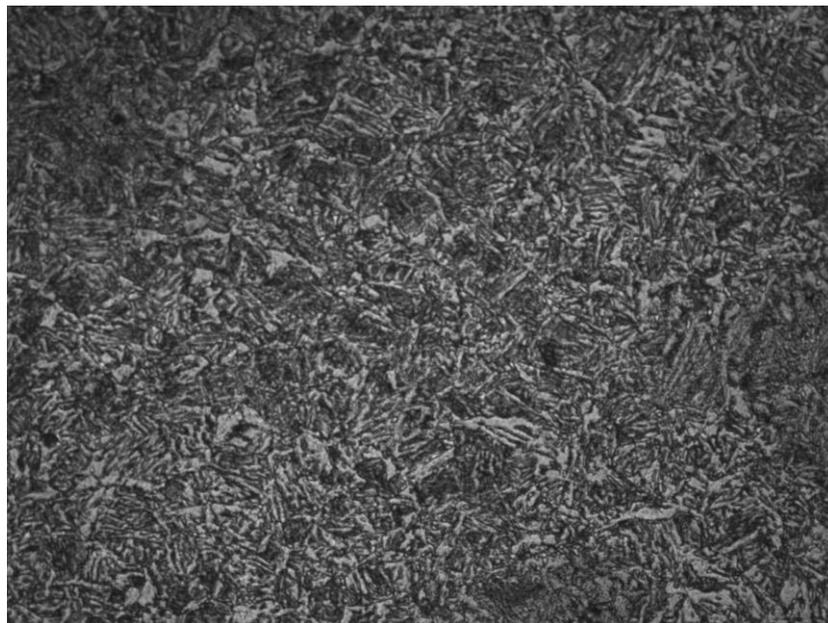


Figure 5 Core texture of fracture driving shaft: F+P ~540X

#### *D. Hardness Testing*

Using the HVRV-187.5-type Brinell hardness gauge, the surface and the core part was measured as shown in fig.6; and the demand of measurement includes two hands: Load of 1471N and hold time for 8-10s. The result of measurement is shown in the Table2.

As we can learn from the Table 2, the surface hardness values meet the design requirements and the core hardness values are significantly lower than the design requirements.



Figure 6 Sample of hardness

TABLE II SURFACE AND CORE HARDNESS OF FRACTURED DRIVING SHAFT

part of hardness test	Measure value	Mean value	Desired value
External round surface(HRA)	81、 83.5、 80.5	81.67	78~83
Core of cross section (HRC)	20.5、 20、 21	20.5	28~43

### III. ANALYSIS AND DISCUSSION

Based on the above physical and chemical test results, the chemical composition of the driving shaft is of qualified. Viewed from the microstructure, hardness of sample core matched with the microstructure match. The heat-treatment process includes carburizing quenching and tempering. We can know from the design drawings that the heat-treatment process of the fracture shaft was carried on carbonitriding, quenching and tempering. But the hardness of core part is lower than the demanded value. In cording to the demanded hardness value, the core texture should include higher hardness tempered martensite and tempered troostite texture.

### IV. CONCLUSION

Through analysis and testing, the results showed that the hardenability of driving shaft was not qualified and the strength in core part was low. In a word, the fatigue reason of the driving shaft is because of the bad hardenability and the growing load.

### ACKNOWLEDGEMENT

Langfang City Science and Technology Support Program, Project number: 2014011054

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