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EXAMINATION OF A FAILED BOLT FROM THE CONNECTING ROD OF A DIESEL ENGINE USED FOR POWER GENERATION

by

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PHYSICAL METALLURGY DIVISION

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C.M. Webster* and R.D. McDonald**

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SUMMARY OF RESULTS

A failed and a good bolt were compared to determine whether differences existed which might account for the sudden failure.

It was found that the failed bolt, although similar in composition, to the good bolt, had received only a normalizing treatment. The good bolt had been quenched and tempered and, therefore, had developed mechanical properties superior to that of the failed bolt. The inferior properties of the failed bolt were believed to be mainly responsible for its failure.

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INTRODUCTION

On March 20, 1964, damaged diesel engine components, which had failed in service in a power generation plant, were submitted to the Physical Metallurgy Division, Mines Branch, Department of Mines and Technical Surveys by Mr. D. Cleland, Air Services, Civil Aviation Branch, Department of Transport. The parts consisted of a piston, connecting rod, one half of a broken connecting rod bolt and two pieces of a failed connecting rod bolt. It was requested that a limited metallurgical examination be carried out to determine if the failed bolt was of the same material as the broken (good) bolt. Following the examination the components were to be returned, as intact as possible, for further examination by the manufacturer.

VISUAL EXAMINATION

Visual examination of the component parts showed that the connecting rod had been severely bent, with one side of the big end bearing section broken off. The opposite side was badly battered and had half of a broken connecting rod bolt still in place. The broken bolt in the connecting rod showed considerable necking down and appeared to have broken in a ductile manner due to overload. The failed bolt had fractured in a brittle manner at the shoulder of the head. The head had pulled off with only slight evidence of fatigue and little or no distortion.

X-RAY FLUORESCENCE ANALYSIS

Filings from both bolts were analyzed by the X-ray fluorescence method to determine if any alloying elements above the 1% level were present. The results of these tests were similar for both bolts and no alloying element was shown except manganese. There is some doubt of the ability to discern alloying quantities of less than one per cent by this method.

SPECTROGRAPHIC ANALYSIS

Spectrographic analyses of the filings from the bolts were carried out and these results are given in Table 1. They do not show any significant differences, and the alloying elements are present only in residual quantities.

TABLE 1

Mines Branch Semi-Quantitative
Spectrographic Analysis (%)

Sample No.	Fe	Si	Mn	Mo	Cr	Al	Ni	Co	V	Cu
Failed Bolt	P.C.	0.41	0.48	0.006	0.03	0.002	0.09	0.03	N.D.	0.06
Good Bolt	P.C.	0.38	0.53	0.01	0.03	0.003	0.09	0.03		0.06

Spectrographic Report No. SL 64-054
P.C. - Principal Constituent
N.D. - None Detected

CARBON ANALYSIS

Sufficient drillings were obtained from each bolt for carbon analysis, the results of which are as follows.

Failed bolt - C - 0.35%

Good bolt - C - 0.39%

The compositions of the bolts indicated by the above analyses are similar to an SAE 1034 steel.

HARDNESS DETERMINATION

Hardness determinations on the bolts showed the good bolt to have a slightly higher hardness than the failed bolt. The results were as follows.

Failed bolt - R_b 95-96 (R_c- 18)

Good bolt - R_b 99 (R_c- 22)

The estimated tensile strength for these hardness levels are 101,000 psi and 112,000 psi respectively.

METALLOGRAPHIC EXAMINATION

Microscopic examination of the bolts showed that the good bolt had been quenched and tempered, whereas the failed bolt had a normalized microstructure, consisting of ferrite and pearlite. Figure 1 shows the microstructures of the two bolts.

DISCUSSION

The metallurgical examination indicated that both bolts were made from the same grade of steel. They differ, however, in the final heat treatment they had received. The normalized microstructure of the failed bolt would be expected to have a higher notch sensitivity and a lower ultimate tensile strength than the quenched and tempered microstructure of the good bolt.

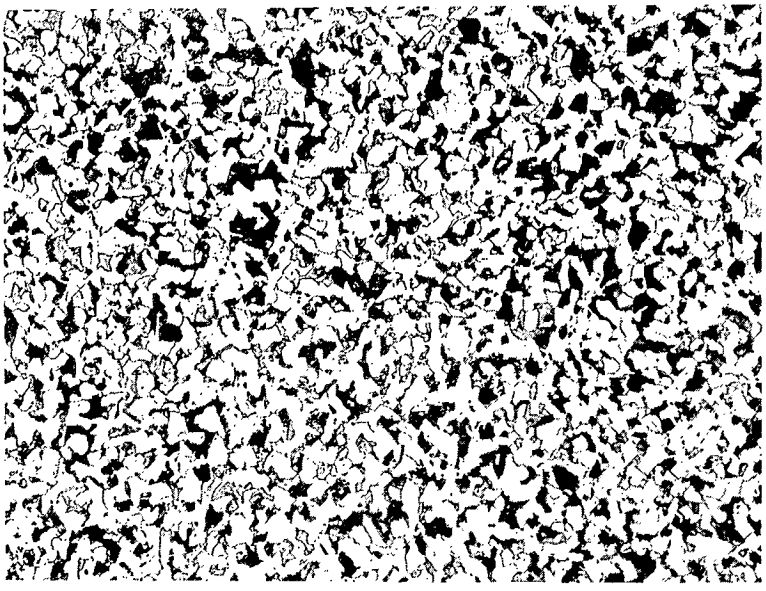
CONCLUSIONS

1. The carbon content of the good and failed bolts were not significantly different.

2. The properties and microstructure of the "good" bolt were developed by a quenching and tempering treatment and this is believed to be the correct treatment for this material and service.

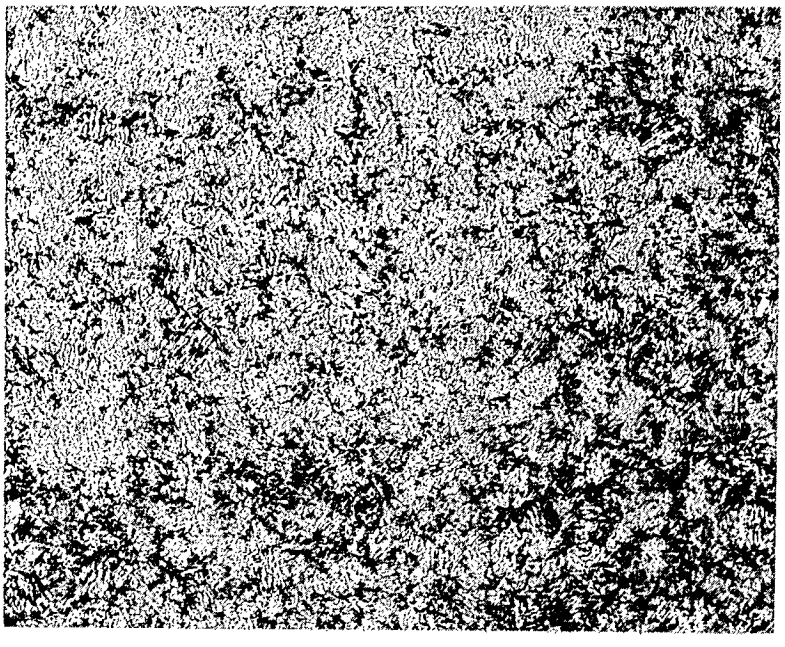
3. Based on the second conclusion, the failed bolt did not receive the proper heat treatment; consequently, the required properties for the service were not developed.

4. The failure was associated with the inadequate heat treatment of the bolt. However, this examination did not indicate positively whether or not any other factors, such as design or machining of the bolt, were involved.



(a)

200X Etched 2% Nital



(b)

200X Etched 2% Nital

Figure 1.

(a) Microstructure of failed bolt

(b) Microstructure of good bolt