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CASE REPORT

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A Traffic Accident Caused by Fatigue Failure of Axle

ABSTRACT: An investigation of a traffic accident involving a tractor-trailer and a passenger car that were traveling at high speed is presented. The cause was the fracture of a trailer axle. The investigation showed that the fracture was because of the fatigue failure. In addition, cracks were found in the remaining three trailer wheels. Hardness measurements showed that, because of inadequate heat treatment of the metal, they were prone to failure.

KEYWORDS: forensic science, traffic accident, trailer axle, fatigue failure, hardness, heat treatment

Mechanical component failure of vehicles, especially heavy trucks or trailers that move fast on highways, may lead to serious traffic accidents. An unusual traffic accident occurred in the divided highway involving a trailer and a passenger car (1). A wheel axle of the moving trailer was fractured. The fractured wheel bounced along the road and moved to the opposite lane across the median strip and struck the windshield of a passenger car moving in the opposite lane. The driver of the passenger car died at the scene. It was observed that the other three axles of the nonfractured wheels had cracks at the lower part of the axle. The beach marks that are the most characteristic feature of fatigue fracture were clearly visible at the fractured surface of the axle. Generally, a trailer has nonrotating, tapered, and hollow axles that are mainly subjected to bending loads. One of the common mechanism by which axles may fail is fatigue. Such fatigue failures are usually the "weak link" phenomenon that initiates failure due to vulnerable points in a stressed system, often at mechanical or metallurgical stress raisers (2,3). This case report presents an unusual traffic accident at highway that was caused by fatigue fracture of a wheel axle of a trailer.

Case Report

A wheel axle of the trailer that ordinarily covers 353 km a day along the divided highway was fractured. The trailer was manufactured in 2001. The maximum capacity tonnage was 27. The measurement of gross weight of the trailer at the entrance of the toll gate shows that the trailer was fully loaded. The tachograph of the tractor shows the average speed of the trailer was approximately 90 km/h. The fractured wheel bounced along the road and moved to the opposite lane across the median strip and struck the windshield of a passenger car moving in the opposite lane. Figures 1–3 show that the trailer with a failed wheel axle and the passenger car that was struck by the failed wheel. Figure 4 shows the typical crack on the lower part of other three axles. Figure 5 shows the fractured surface of the failed axle of the trailer and the wheel. The beach marks were clearly visible at both the lower and upper parts. The Chevron mark is shown in the finally fractured mid section.

Results and Discussion

The fractured surface of the axle is given in Fig. 5. The fatigue cracks develop from both the lower and the upper part of the axle.

FIG. 1—*The trailer with failed axle. The left first axle is completely fractured.*

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FIG. 2—*The failed wheel. The wheel is completely separated from the trailer because of the fracture of axle. The fractured surface of the axle shown in the brake drum is magnified in Fig. 5(b).*

FIG. 3—*The passenger car struck by failed wheel (refer to Fig. 2). Windshield and roofs are struck by the failed wheel.*

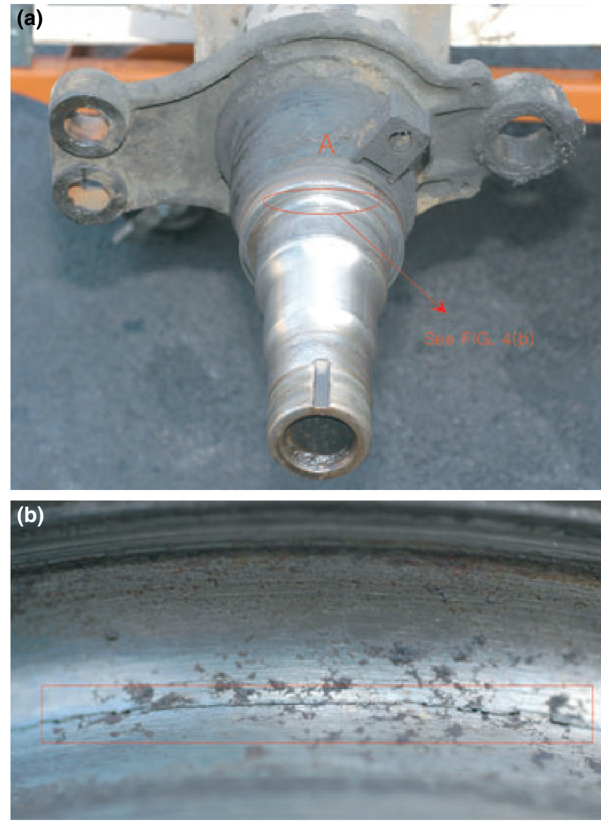

FIG. 4—*(a) Typical shape of the non-fractured axle which is disassembled from the trailer. Crack is formed on the lower (location A) part of the axle. (b) Magnification of location A of Fig. 4(a). Crack is clearly visible along the circumference of the lower part of the axle.*

TABLE 1—*The material composition of SM45C and the chemical composition of failed shaft (weight %).*

	C	Si	Mn	P	S
SM45C	0.42–0.48	0.15–0.35	0.6–0.9	<0.03	<0.035
Axle specimen	0.43	0.21	0.7	0.017	0.006

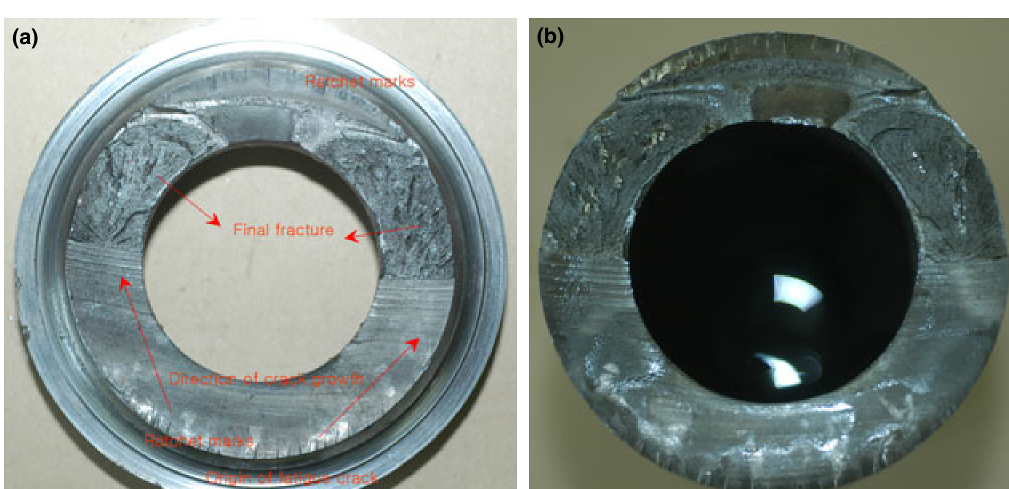

FIG. 5—*(a) The fractured surface of the axle (trailer part). (b) The fractured surface of the axle (wheel part). The beach marks are clearly visible both at the lower and upper parts.*

The pattern represents the typical reversed bending moments (2,3). The crack originates at the lower part of the axle and this corresponds to the crack location shown on other three axles that were not fractured. Multiple ratchet marks are shown on the origin of the fatigue cracks. It is reported that such multiple ratchet marks that merged to form beach mark are indicative of high nominal stress (2,3). Crack locations commonly shown on other three axles also indicate high nominal stress caused by bending. The manufacturing specification of the axles shows that the axles were made by SM45C with quenching and tempering. Chemical analysis was done on the specimen cut from the cross section of the axle by using an emission spectrometer. Table 1 shows the specified chemical composition of SM45C along with the results of chemical analysis, and there was no peculiarity in the mix.

Hardness measurements (Rockwell hardness Scale C [HRC]) were carried out on the three specimens along the cross section, and the results are commonly 12–13 HRC. From the specification, the hardness of SM45C with heat treatment is 15–28 HRC. The measured hardness shows that the axle was poorly heat-treated.

From the fractography of the failed axle, it can be concluded that high nominal stress was applied on the four axles of the trailer. The cause of high nominal stress is the material itself that is lower in strength than specification or the overload of the trailer. From the hardness measurement, we reached a conclusion that the poor heat treatment is the major cause of the failed axles.

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