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Fatal Accident Cause and Conclusion

ABSTRACT: The Toolmarks Laboratory prepared a report concerning a traffic accident involving the death of a road workman. The driver of the vehicle that hit the workman claimed that the wheels had failed to respond when turning left at a roundabout. A traffic investigator photographed the rack and pinion assembly of the steering system, which was subsequently removed and brought to the Toolmarks Laboratory. The rack and pinion assembly of the steering system was rebuilt, and examination showed that the system functioned properly. Specifically, the front wheels responded correctly to the steering input. Laboratory photographs of the steering system were taken in two different positions, from the same angles as the investigator's photographs at the scene of the accident. It was clear that the steering system had not been assembled properly in the garage.

KEYWORDS: forensic science, toolmarks, comparison, steering system, rack and pinion

Generally, when an expert notices wear on parts, his conclusion is that the "worn zone" might have been the basic cause of the accident. In this case, however, the parts were rebuilt as properly as can be expected in a garage; the steering system worked in the "worn zone," and there was no interference with the various parts.

In some criminal investigations law enforcement agencies rely on expert analysis of forensic engineers to determine whether the cause of an accident is the result of a technical malfunction, human error, or a combination of several causes (1). Forensic analysis involves several applications from a number of disciplines to determine liability for an accident. A forensic engineer relies on all evidence to understand what happened (2,3). His conclusion takes into account all factors that might influence the case, including the affidavit of the police investigator who was at the scene of the accident. In this case, forensic examination confirmed and elaborated on the police investigator's report at an accident scene.

Case Description

While turning left at a roundabout (traffic circle), the driver lost control of his car and crashed onto the sidewalk, causing the death of a workman. The driver claimed lack of response of the steering mechanism as the cause of the accident.

The traffic investigator who examined the car at the scene came to the same conclusion as the driver—faulty response of the steering system. The traffic investigator checked the steering wheel system as he found it. He was not able to see the position of the pinion shaft.

The investigator did load the car onto a lift and photographed the exterior of the car and its parts, including the outer surface of the rack and pinion system in the steering mechanism. After he disassembled the steering system, he did not rebuild it to check functionality.

The mechanism was then removed and transported to the Toolmarks Laboratory to determine whether a faulty steering system was the cause of the accident, or whether the observed damage to that sys-

tem was caused by the impact, in which case the accident could be attributed to human error. The conclusions of police investigators are very important, but in this case forensic verification was sought.

Examination of the Evidence

In the Toolmarks Laboratory the disassembled steering system was rebuilt (Fig. 1), and its functionality was checked. It was found that the system worked properly with the steering wheel responding correctly. This seemed to indicate that the accident was caused by a human error. Taking into account, however, the police traffic investigator's report that the steering wheel did not respond when he checked the car after the accident, the difference between the laboratory examination and the investigator's report had to be explained.

During laboratory examination of all unassembled parts of the wheel system, the forensic expert noticed that the tip of the shift teeth in the rack and pinion (Fig. 2a) and the edge of the clamp (Fig. 2b) were worn. This, however, did not interfere with the functioning of the steering system.

The traffic investigator was contacted, but he was unable to recall details of the wheel position at the scene of accident, and which part of the steering system he considered had not functioned properly. The forensic expert received photographs of the car, including the overall view and one picture in which the rack and pinion position is shown. The photograph did not include a scale, and the worn place was not visible (Fig. 3).

The photographs taken at the scene of the accident were taken from a low angle, hence the bolt tightening the clamp fastening the rack and pinion assembly was not shown clearly. It was, therefore, impossible to determine from the photographs, whether the rack and pinion had been improperly assembled by the garage, thus causing a mechanical malfunction, or whether the accident was caused by human error.

Correct operation of the steering system requires that during assembly the distance between the pinion and the teeth in the rack be minimized. If this is not done, the teeth will wear out quickly, causing them to fail to engage the pinion correctly, which leads to a failure in the steering response.

When the pinion teeth are worn out, they will not interact correctly. Turning the steering wheel will have no effect on the wheels.

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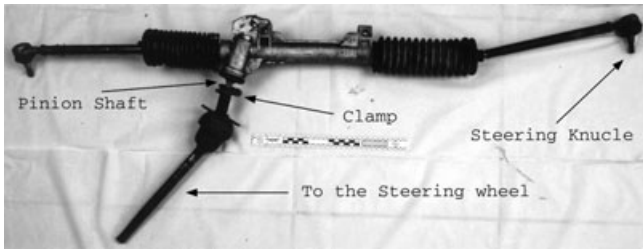


FIG. 1—The steering system assembly. The edges knuckle of the steering rack that connect it to the front wheels. In the middle bar housing contains the pinion shaft that connected to the steering wheel.

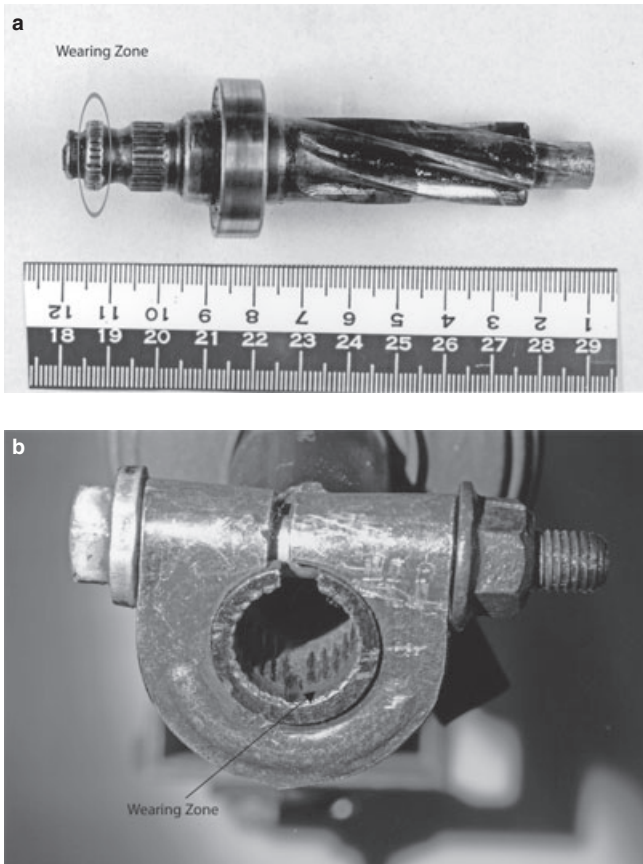


FIG. 2—The worn parts: (a) Pinion shaft—transfers movement from the steering wheel to the steering rack. Also, it shows the worn teeth on the left edge. (b) Clamp—links the steering wheel with the pinion.

As noted previously, wearing of the small teeth of the rack and pinion was observed while examining the assembly in the laboratory.

The hypothesis of this case was that the steering system had not been assembled properly and that therefore the small teeth on the rack were wearing. The worn teeth caused the fatal accident.

To verify this hypothesis the experts had to duplicate the investigator's photograph in the laboratory by locating the same direction of the system with the poor camera position. The rack and pinion assembly was put together twice:

1. Correctly—by screwing the pinion bolt tightening the clamp (see Fig. 2b) all the teeth length way.
2. Incorrectly—by tightening the pinion bolt only at the tips, so that it did not immobilize the pinion. (Incorrect assembly

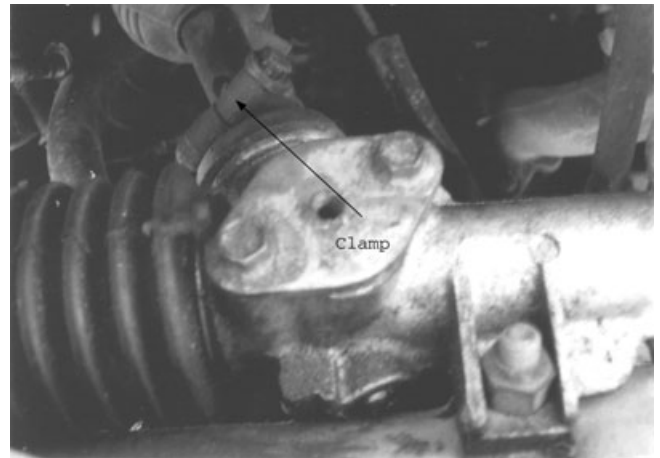


FIG. 3—Photograph taken at the scene of the accident.



FIG. 4—Photograph of the steering system assembly (upper view). The wheel system is assembled properly, with the bolt screwed all the way.

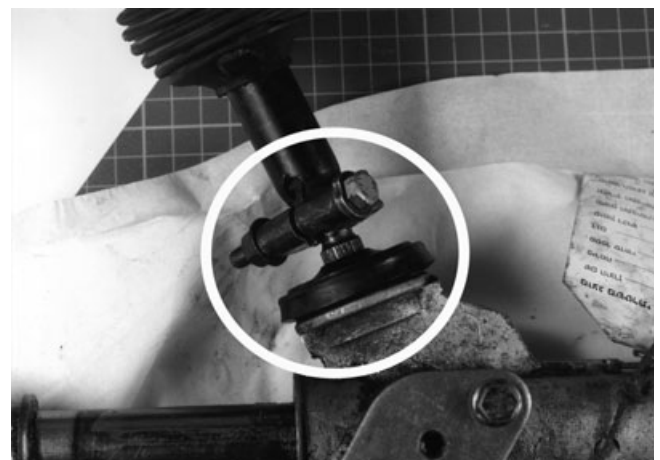


FIG. 5—Photograph of wheel system (upper view). The steering system is assembled incorrectly with the bolt screwed only at the tip of the rack and pinion.

places the teeth of the rack and pinion at the tip, so that they are pressed hard on the edges, which causes the teeth to wear out.)

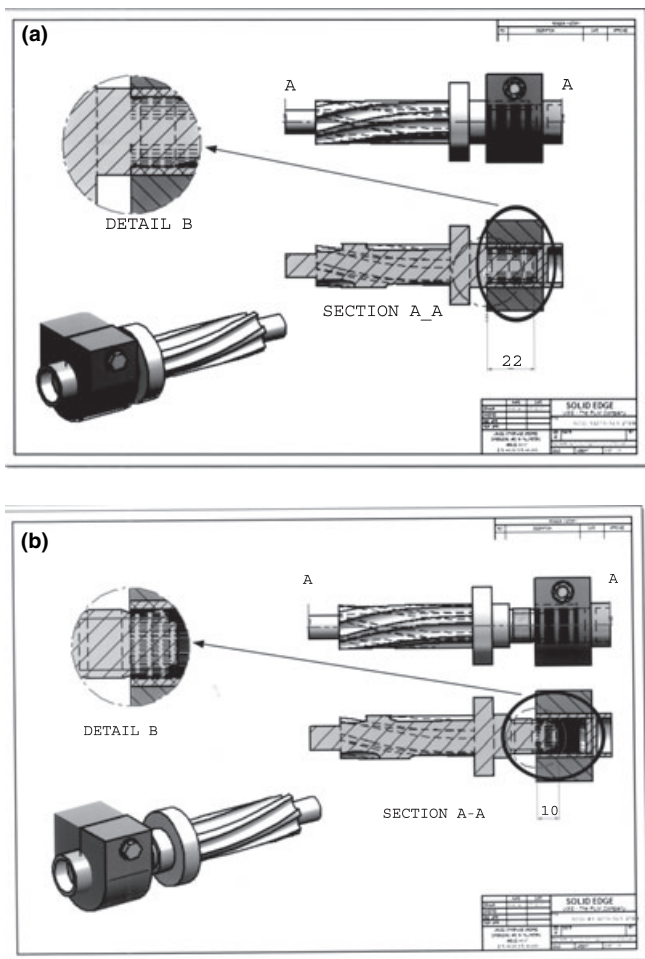


FIG. 6—The cross-section of rack and pinion in which both are assembled: (a) Correctly, (b) Incorrectly.

After each assembly, the rack and pinion were photographed in several positions, resulting in laboratory photographs identical to

those taken at the scene of the accident by the traffic investigator. The incorrect assembly is shown in Fig. 4 and the correct assembly in Fig. 5. The cross-section of rack and pinion in both assembled positions is shown in Fig. 6. It was demonstrated that in the incorrect assembly (Fig. 6b), the clamp bolt was screwed only at the tip of the rack and pinion, with narrow teeth only 10 mm in width. This wears faster than correct assembly (Fig. 6a) with a width of 22 mm (scales taken from the duplicate photographs that were taken in the laboratory).

Conclusion

The evidence from the laboratory photographs showed that the rack and pinion assembly was not put together properly in the garage. As a result the small teeth wore out slowly until the steering system did not respond, in accordance with the claims of both the driver and the police traffic investigator.

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