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Engine Failure in Road Traffic as the Cause of a Traffic Accident

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Abstract: ***The article deals with technical analysis of the cause of a technical failure of the Mercesed vehicle, which led to a traffic accident due to the loss of the vehicle´s controllability. The methodology and procedures during the inspection of a vehicle as well as the methods applied to process documentation are systematically clarified. Subsequently, the individual findings are presented and evaluated and their technical interpretation is made. The strength calculation of the component (the timing chain) and the calculation of forces exerted on the chain are introduced. In the conclusion, the findings are evaluated with regard to the calculations and technical evaluation of the case is presented.***

Keywords: Traffic accident, vehicle, engine, timing mechanism, timing chain, construction, forces, ABS

1. Introduction

We can divide road traffic accidents from the viewpoint of the causes of their origin into subjective, i.e. caused directly by the drivers conduct or as a consequence of drivers conduct, and objective, i.e. those, arising independently of the drivers conduct, among which, technical failures of vehicles or other technical equipment as traffic lights, ramps or semaphore lights may be included. The causes of objective traffic accidents include road conditions that can be labelled as road defects.

Determining whether the cause of a particular traffic accident is subjective or objective is the task for technical analysts – experts on traffic accidents, and the results of their analyses performed for the needs of the police or court have significant impact on the final legal opinion on a traffic accident.

For the above reasons, it is necessary the experts to familiarise themselves with already solved case studies and obtain new information to apply within the scope of their activities.

2. Case Study

The case presented in this article relates to a traffic accident when a vehicle hit a pedestrian because the movement of the vehicle did not correspond with the required direction of movement. The track curve the vehicle followed in the intersection up to the point of collision was different.

The driver said that the vehicle had become uncontrollable just before the collision because of the front axle wheels blocked for a short time when the driver started turning a steering wheel; saying the vehicle only became manoeuvrable by exerting a great force on a steering wheel. After the accident, the vehicle engine was recognised to be dysfunctional, i. e. impossible to start.

In this case, it was a MERCEDES BENZ S 350 L, the year of production: 2006, mileage 271,465 km.

The vehicle´s timing mechanism had been repaired earlier, timing chain had also been replaced, and as it has been found out, the sprocket gears, have not been replaced.
The task of the technical expert was to assess whether the engine failure occurred:

- As a result of the destruction of a new timing chain material or
- As a result of the mode of the operation of a vehicle
- Or for other reasons, with the requirement that the cause be mentioned

3. Vehicle Inspection - Findings

- The entire vehicle has been inspected
- The engine has been removed and dismantled

The inspection of the vehicle has been documented in detail and the photos have been taken.

See a photograph and description of the most important findings.

A vehicle: No issues that could affect operability and manoeuvrability of a vehicle were found in the course of inspection.

Figure 1: View of a vehicle

Engine: The broken timing chain and the resulting damage to the piston group as well as valves were detected during the inspection of the engine – Figures 2, 3.

Figure 2: View of the damaged (broken) timing chain

Figure 3: View of the damaged valves in a cylinder head

While inspecting the timing mechanism, it was detected that a steel splinter had been firmly pressed in the teeth of the counter running gear wheel of the 2nd exhaust valves camshaft and the 1st suction valves camshaft gear wheel connected to the control toothed ring, and that the teeth of chain sprocket of the 1st suction valves camshaft to drive a timing chain is damaged -see Fig. 4.

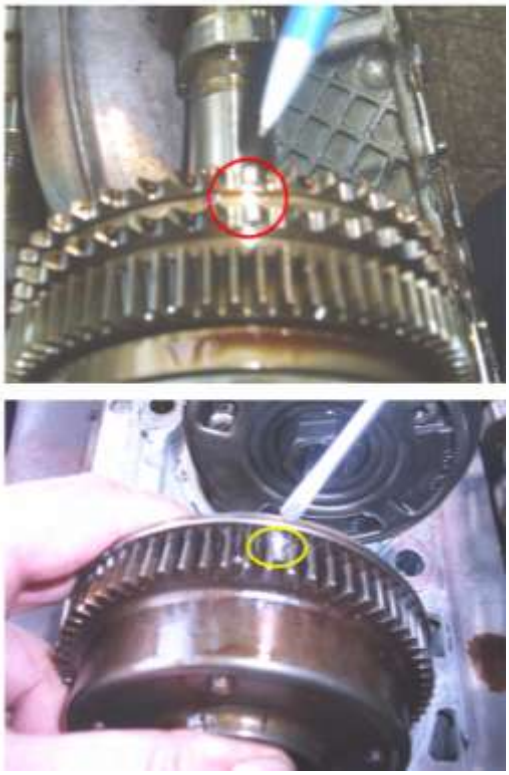

Figure 4: View of the sprocket gear

4. Layout of the engine timing mechanism for MB S 350 L and the design of a timing chain

Spatial layout of the engine timing mechanism

Fig.5 shows the representation of the sprocket gears driving the camshafts of the engine timing mechanism, and Fig. 6 illustrates the mutual engagement of the sprocket gears in a cylinder head.

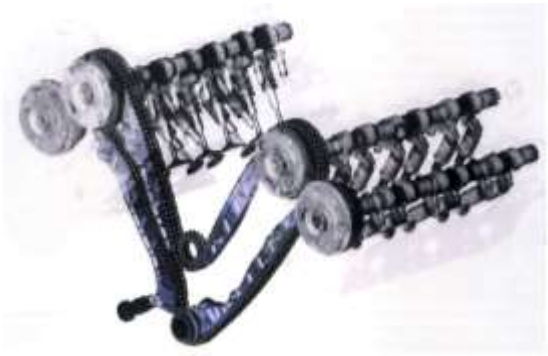

Figure 5: Engine timing mechanism of MB S 350L

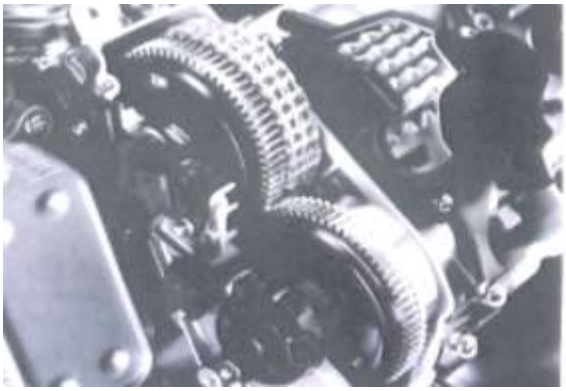

Figure 6: View of the fitting and engaging of the sprocket gears in a cylinder head.

Chains used to drive the valve timing mechanism

In this case, this is a two-sided roller chain (Duplex), whose outer (1) and inner members (2) consist of:

- outer plates (3)
- inner plates (4)
- pins (5)
- bushings (6)
- rollers (7)

The manufacturer indicates the guaranteed tensile strength: 25 – 30 kN

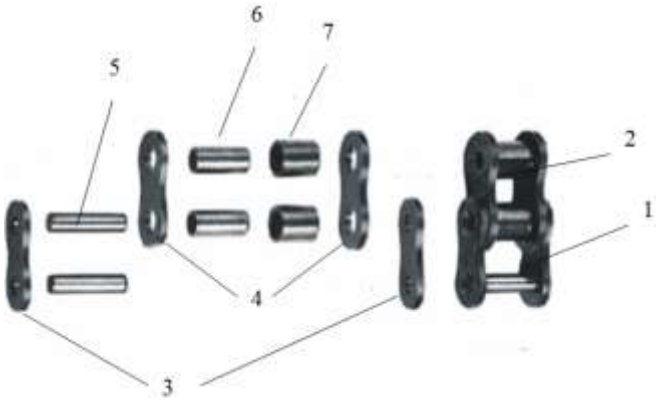

Figure 7: View of a timing chain member

wherein the assembly of said chain members is folded as follows:

Figure 8: View of the assembly of a timing chain member

5. The analysis of chain damage characteristics according to a finding

Upon a closer look at the timing chain illustrated in Fig. 9,

Figure 9: View of a timing chain

damage to two chain plates was detected (no.1 – inner and no. 2 - outer) – see Fig. 10

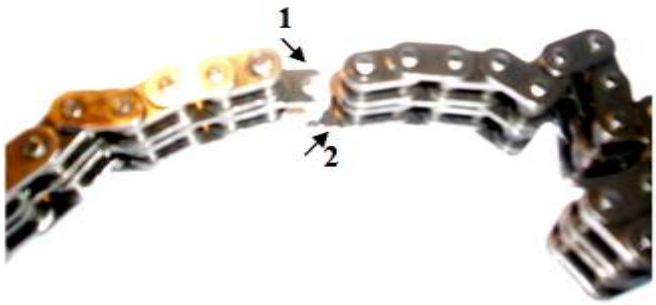

Figure 10: View of the damaged chain members

Upon closer examination of fracture areas of damaged chain members and after their enlargement, the details of damage zones were detected:

On a damaged chain plate no.1:

Figure 11: Display of the position of plate no.1 of a chain member

The detail of fracture is illustrated in Fig.12

Figure 12: View of the detail of plate no.1 fracture of the chain member

Opinion on the fractures at chain plate no.1:

It is clear that:

- The part (inside the pin), on which the chain plate no.1 had been placed, had been hitting the gear casing and timing gears, and subsequently got loose
- In this case, it is a brittle fracture without a crack (i. E. Fatigue characteristic) without a plastic change of the fracture surfaces (these are crystalline except for the area where addition damage occurred due to hitting) at a damaged chain plate no.2:

Figure 13: Display of the position of plate no.2 of a chain member

The enlarged detail of the plate no. 2 fracture is shown in Fig.14

Figure 14: View of the detail of plate no. 2 fracture of the member chain

Opinion on the fracture zones at chain plate no. 2:

It is clear that:

- The part (inside the pin) on which the chain plate no. 2 had been placed had been hitting the gear casing and timing gears, and subsequently got loose
- In this case, it is a brittle fracture without a crack (i.e. Fatigue characteristic) without a plastic change of the fracture surfaces (these are crystalline except for the area where addition damage occurred due to hitting)

6. Analysis of the possible damage to a timing chain in normal operation condition of the engine unit

In the normal operation, the engine unit is able to affect a timing chain (if the chain is tensioned due to the timing wheel „jam“) by the force derived from the engine torque of the vehicle MB S 350 L – see Fig.15:

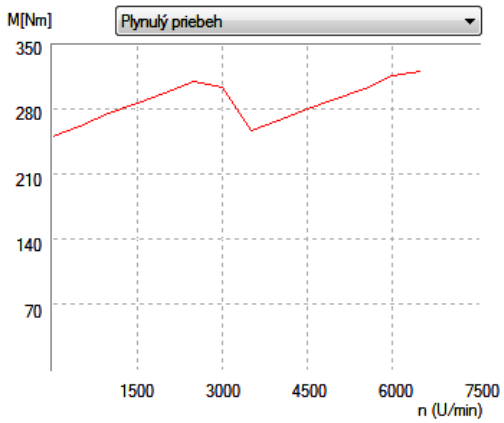

Figure 15: Engine torque flow

For the indicative calculation based on theoretical increased maximum engine torque M_{max} = 350 Nm

$$F = \frac{M}{r}$$

$$F = \frac{350}{0,05}$$

$$F = 7000N$$

If the fracture value declared for a single timing chain – 2 plates is about 25 to 30 kN – the source- a manufacturer´s catalogue), it is obvious, that under normal circumstances, the chain cannot get broken during the engine roll due to force common effects.

Therefore, it is necessary to raise the possibility of breaking a timing chain due to the force induced by the change in the kinetic energy of a moving vehicle.

Assuming a vehicle, after “an engine jam”, starts to slow down, when deceleration a = 10 m/s^2 and its weight is 2000 kg, the force on a wheel would be exerted as follows:

$$F = m.a$$

$$F = 2000.10$$

$$F = 20000N$$

which would cause a momentum

$$M = F.r$$

$$M = 20000.0,5$$

$$M = 10000Nm$$

and this, after the transmission through the traction device would exert the force on a timing chain as follows:

$$F = \frac{M}{r_1}$$

$$F = \frac{10000}{0,1}$$

$$F = 100000 Nt.j. 100 kN$$

This value exceeds the limit value for the maximum force needed to break a chain member. On the other hand, technically, it is possible to exclude the force destruction of two chain plates due to material defect in the chain.

7. The analysis of possible occurrence of the damage to a timing chain based on findings

Based on the findings stated above, in this case we can assume that during the operation of the engine of vehicle mark MB S 350L, vehicle registration number XXXXX the phenomena occurred as follows:

1) Two teeth of a chain wheel of the 1st suction valves camshaft were destructed and were broken because of excessive wear- see Fig.16
   Note. The breakage did not have a direct effect on the engine´s performance, as the chain has a multi-tooth engagement on the sprocket. It was impossible to detect breakage during operation without disassembly.

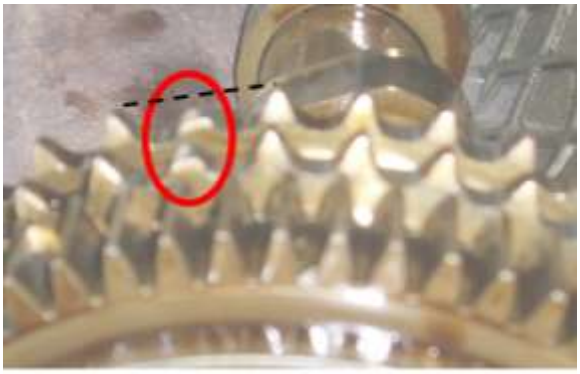

Figure 16: Broken teeth of the chain sprocket of the 1st suction valves camshaft

2) The broken parts started to move within the area of the timing mechanism but we cannot define time limits exactly. However, based on the degree of wear of the teeth remains we can say it was a longer time.
3) In the course of the engine operation, one fragment moved upwards and got jammed in the counter running sprocket wheel of the 2nd exhaust valves camshaft (and to the control sprocket wheel), where this fragment was later forced in by sprocket wheel of the 2nd suction valves camshaft when engaging its teeth – see Fig. 17

Figure 17: View of the fragment jammed in the sprocket gear II of the exhaust valves camshaft.

4) Because the fragment have got jammed in the gear, the wheels stopped running and thus the movement of the timing chain, on which the force caused by the movement of a vehicle- acting against the movement of the timing chain – was exerted (transmitted from the wheels through the gearbox, clutch, crankshaft to the timing wheel and chain), and because of such force the timing chain got strained and then broken.
5) Since this timing chain breakdown produced a change in valve timing, the valves contacted the piston top and then they bent down.
6) Due to the tightness loss of the combustion zone of cylinders (and combustion loss), the fuel flowed around pistons and consequently at least one piston (1st cylinder) was caught up due to lubrication loss along its walls – Fig. 3

8. Conclusion

We consider two broken teeth of the sprocket wheel of the 1st suction valves camshaft a direct cause of the malfunction of the MB S350 L (breakage of a timing chain). The fragments of these teeth were during the engine run subsequently transferred onto (while driving) the counter running sprocket wheel of the 2nd the exhaust valves camshaft, where they were forced in by the sprocket wheel of the 2nd suction valves camshaft, as a result of which, timing wheels got blocked and the timing chain burst. As a result of the mentioned failure, the manoeuvrability was inevitably reduced both directionally (a sharp increase in steering effort) and with regard to the acceleration profile, too, resulting in the abrupt deceleration of a vehicle at the moment of the timing chain destruction and a short-term loss of steering control - directional manoeuvrability- occurred due to blocked front axle wheels.

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