Assessing the Possibility of Engine Failure of a MAN 18.284 Truck as a Result of Water Intake when Driving through Water Surface

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Abstract: ***The article deals with a performed experimental investigation of the behaviour of a water wedge and the way forced water splashes while a truck with the weight of more than 8 tons drives through the water surface in relation to the construction and location of its water filter. A course of individual experiments carried out using a comparable vehicle and comparable tires is demonstrated as well as the found parameters and a visual assessment of the shape and manner of the forced-out water movement. In the conclusion there is a summary of the acquired knowledge and its generalisation for the needs of a further use in a technical assessment of the stated issue.***

Keywords: Truck, air filter, water surface, water depth in passage area, wedge of water, water splash, aquaplaning

1. Introduction

In the practice of technical experts and consequently during the investigation of insurance events an issue of an engine destruction often occurs, or a destruction of its pistons caused by the water sucked into the engine during a drive or while passing through a road flooded by water of a certain depth. This issue is not entirely new, but perhaps it will be interesting to learn about the knowledge acquired in solving a similar problem, during which a MAN 18.284 truck was used.

In the current case it was an assessment of a statement that:

When driving on a state road, due to heavy rain, a vehicle entered a part of the road flooded by water, the water level of approximately 30 cm and when passing the stated part of the road some water was sucked into the engine of the MAN 18.284 truck through an intake throat of the air filter, which resulted in an engine failure.

An examination was carried out, the part of which were the findings associated with the construction and location of the air filter throat and the consequences of the truck passing through the water of the stated depth under comparable circumstances. The article will deal with these issues, whereas one of the fundamental questions is to determine such driving speed of the truck that would result in water entering the intake throat of the air filter with regard to its location and construction, either by splashing (aquaplaning) or flooding by a water wedge (wading).

2. Assessment of Air Filter Location and Its Design Solutions

Location of air filter in MAN 18.284 truck

The air filter is located on the right side of the vehicle in its front part, in front of the fore axle in the area beneath the cab. It is located on the vehicle frame from the outside. The inlet opening covered with a coarse cleaner fitted with a front cover to prevent any impurities from entering due to the influence of air streams is situated at the height of 740 mm (lower edge) to 960 mm (upper edge) – Fig.1.

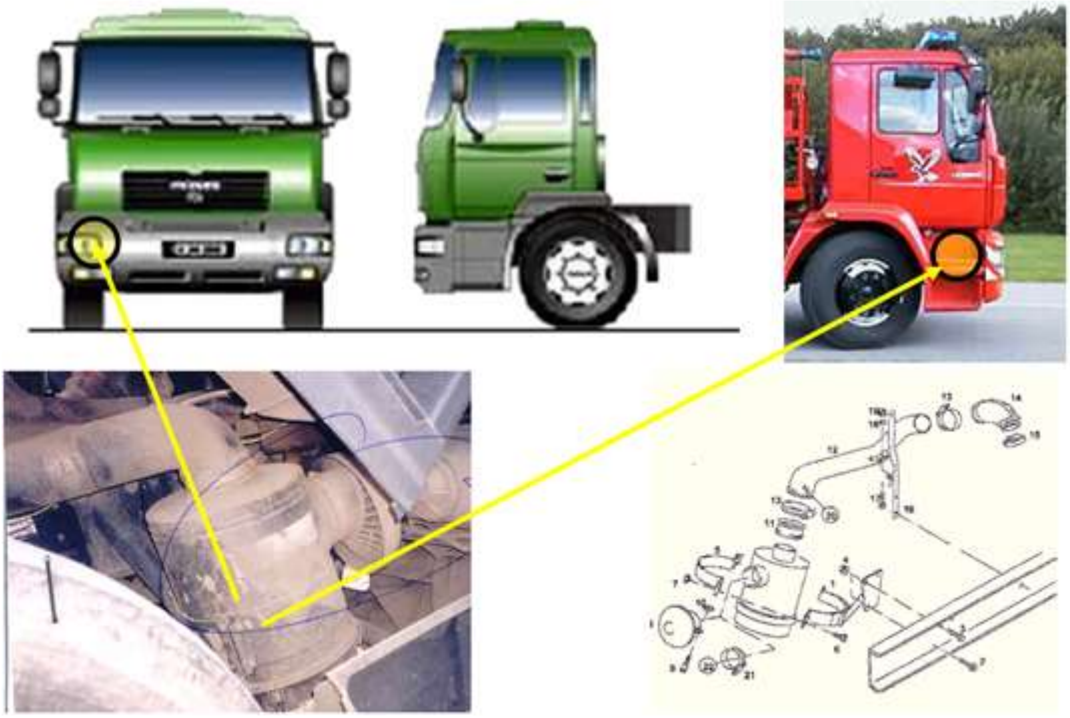


Figure 1: View of air filter location in MAN 18.284 vehicle and components of air intake system to engine

Design and technical solution of MAN 18.284 air filter:
In this case, it is a dry filter with a replaceable filtration element, where the air entering through the rain cover is fed into the part between the filtration element circumference and the housing, then it enters its inner part through the filter element and it is exhausted into the intake piping of the engine. The air filter body consists of two parts – the upper one with inlet and outlet openings and the lower one, which is removable (when replacing the filtration element) and has a sealing and a dust valve. The filtration element is firmly mounted.

Evaluation of air filter technical solution considering possible water penetration
In order to suck water into the engine it would be necessary to flood the air filter up to its upper part after an apparent destruction of the filtration element by water that penetrated the air filter body, whereas flooding of the air filter is out of question considering its construction and the construction of an intake end piece, which ensures the discharge of any possible water penetrating via a siphon principle – view of design and function scheme in Fig. 2, 3 and 4:

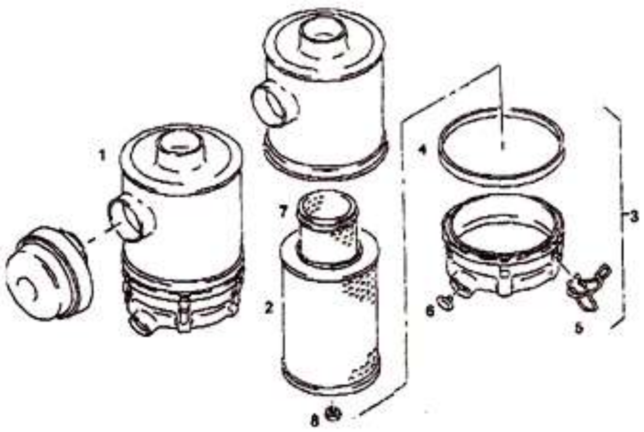


Figure 2: Design of air filter body and element

Figure 3: Detail of design of air filter inlet intake throat

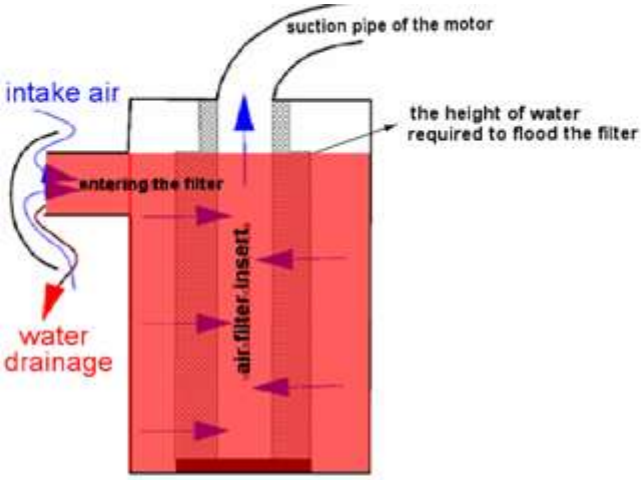


Figure 4: Schematic view of possible short-term flooding required to suck water in siphon system design of air filter intake throat

3. Theoretical conditions of passage through water in regard to area of tire contact with road and passage speed

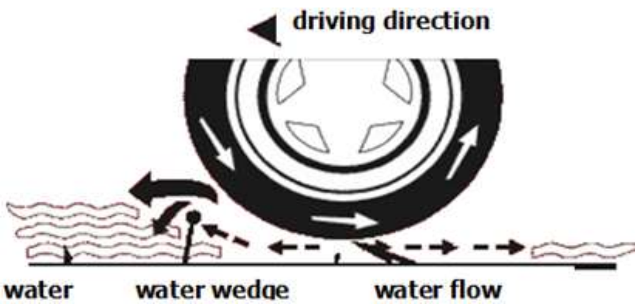


Figure 5: Scheme of directional instability when exceeding limit speed of wheel movement while passing water

Wading, water wedge depth, occurrence of aquaplaning effect when a truck drives through water as a limiting factor of vehicle movement speed

- When passing through water, an aquaplaning effect occurs depending on a tire profile height and type, water film height (or water depth), tire front shape after exceeding certain speed, the limit speed being dependent especially on the depth of tire immersion and the tire profile quality relative to this depth, in case it is not a thin layer of water. The limit speed is the speed
- At which a vehicle is still directionally stable and operable. At the water level of 100 to 500 mm, based on the performed confirmation tests, the speed of up to 30 km/hour is considered the speed limit of a vehicle movement, due to a hindered drainage of the water forced out by the tire profile (the surrounding environment changes from air to water, which has a higher density and viscosity). This is even more justifiable in case of a truck, as the waves generated by the front of the fore axle raise the level for the rear axles, which may cease to be directionally stable soon. It is also necessary to consider the influence and load of a vehicle – Fig. No. 5,6,7.

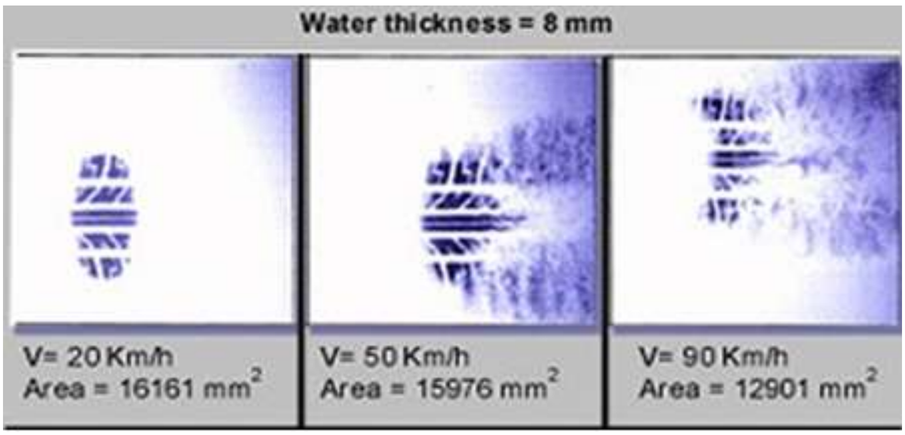


Fig. 6: Result of measuring size of contact area between tire and road while passing water of 8 mm

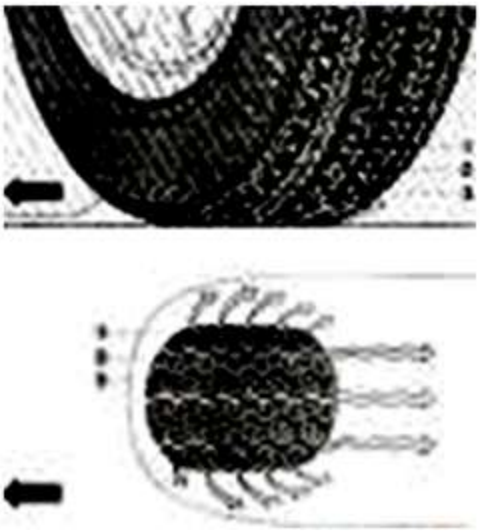


Figure 7: View of forced water movement in ground plan

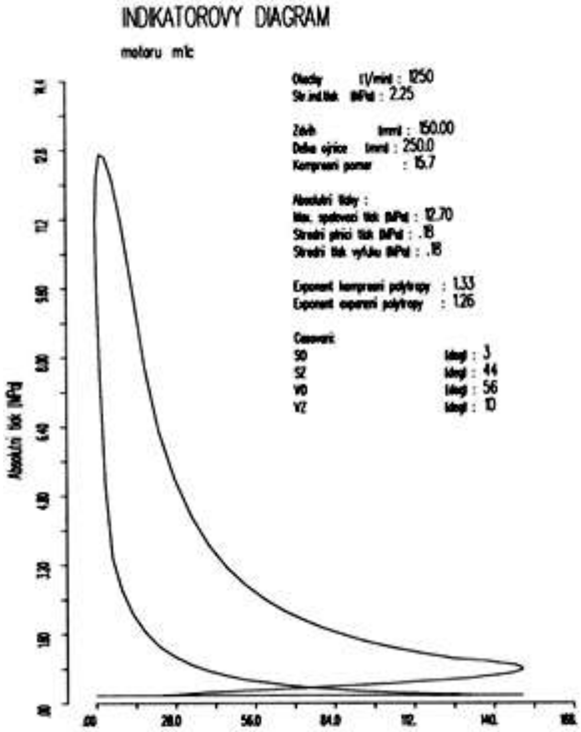


Figure 8: Indicator p-v diagram of a comparable CI engine

4. Air intake Vacuum Generated by Charged Engine

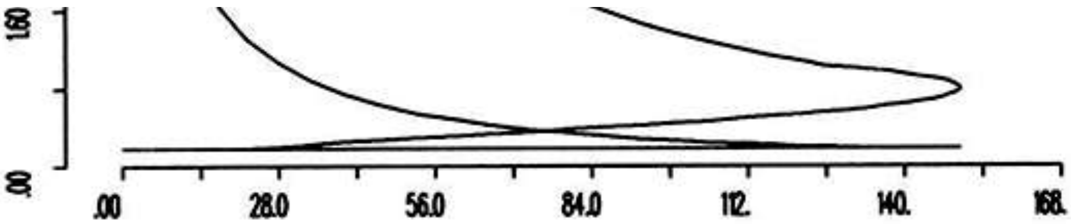


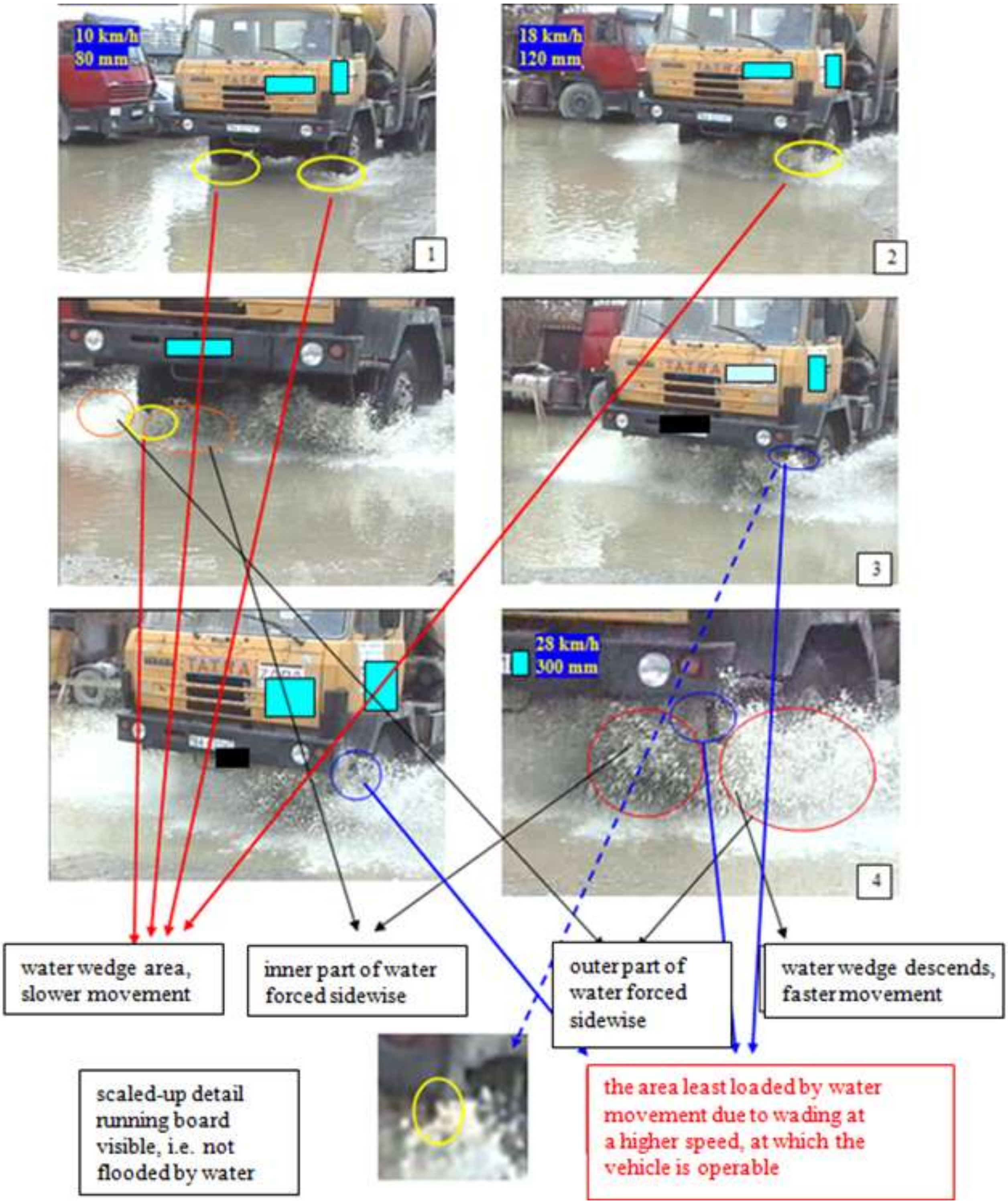
Figure 9: Detail of negative intake loop of indicator p-v diagram of a comparable CI engine

5. Experiment

Method

To examine the occurrence of a water edge test drives of a Tatra 815 truck (T) with a water depth corresponding to the tire diameter ratio were performed, the results of which are presented further. The passage of the vehicles was filmed with a video camera and then evaluated in detail in relation to the problem being solved. The T815 truck, minimum water depth of 80 mm, maximum water depth of 300 mm, speed of 10 - 28km/hour, during the passage the vehicle was accelerated to a low gear, the monitored orientational area of the water filter location: the right side of the cab´s running board.

Course of experiment with description



6. Result of Performed Test Drives in terms of Moving Water Range

- At the speed of up to approximately 10 km/hour and the height of water level of up to 100 mm a water wedge was formed in front of the tire, the height of which was approximately twice the water level height and it was of a homogenous nature without a significant side wave due to a uniform forcing of water sideways, without it being splashed.
- At higher speeds any potential water forcing phenomena could be characterized as an aquaplaning type since the front side of a moving tire generates a relatively small water wedge and a high side splashing of forced water is expected.
- at the speed of up to approximately 20 km/hour and the height of water level of up to 150 mm a water wedge was formed in front of the tire, the height of which can be estimated as twice the height of the water level and it was of a partly splashing nature with a side wave of approximately the same height as the water level height.
- at the speed of up to approximately 30 km/hour and the height of water level of up to 300 mm a splashing water wedge was formed in front of the tire with the maximum splashing water height of up to 600 mm and the side

splashing of forced water became dominant, while this water reached the area of the air filter inlet throat (in this case the area of the left front running board), but in every case this area was minimally affected by water and never flooded.

According to the behaviour of the vehicle the stated water level movement and height were at the limit of the vehicle´s steering control, i.e. the possibility of water being forced to the sides of the tires was considerably reduced due to their immersion, which have the features of aquaplaning, but in this case it is a part of wading of the vehicle in the contact area of the tires and road.

7. Conclusion

The design of an air filter inlet throat using the siphon system and its location in a MAN 18.284 truck largely prevents an accidental suction of water splashing due to a vehicle movement in water and this may occur under the conditions different from those according to the described passage through water. It is most likely that any possible flooding above the height of the air filter intake throat would result in an apparent destruction of its filtration element and filter housing as a result of the vacuum generated by the engine piston movement, as shown by an indicator p-v diagram of a comparable CI engine. Also, the finding that with an increasing speed of a vehicle movement a homogenous water wedge generated in front of the tires as a result of their movement decreases may have a significant impact on the assessment of a particular case in relation to the stated or detected water depth and the stated vehicle movement speed during its passage.

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