VEHICLE SOILING: AN EXPERIMENTAL AND THEORETICAL APPROACH

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1 Introduction

For a long period, the aerodynamic design was basically based on criteria like maximum velocity, fuel consumption and driving dynamics and therefore concentrating on the minimization of drag and lift. In the years 1969/70, vehicle soiling was beginning to be accepted as additional development criteria, especially since first positive results where presented by Mercedes-Benz [1].

The extent of soiling appearing on vehicles operated in wet and dirty surroundings is important for both, active and passive safety as well as the passenger comfort. For active safety it is important to preserve the visibility through the side window onto the exterior rear-view mirror as well as the view through the rear window. The reliability of the windshield wipers and especially the unfailingly function of the disk brakes under all wet conditions has to be ensured, particularly under heavy rain or when water is present on the road [2, 3]. The passive safety of a vehicle depends on the visibility of headlights and indicators, the tail- and braking lights and the license plate for other road users.

Last but not least, for passenger comfort it is required to keep all vehicle components as clean as possible, especially door handles and sills with which passengers can come into contact whilst boarding or disembarking.

2 Soiling Mechanisms

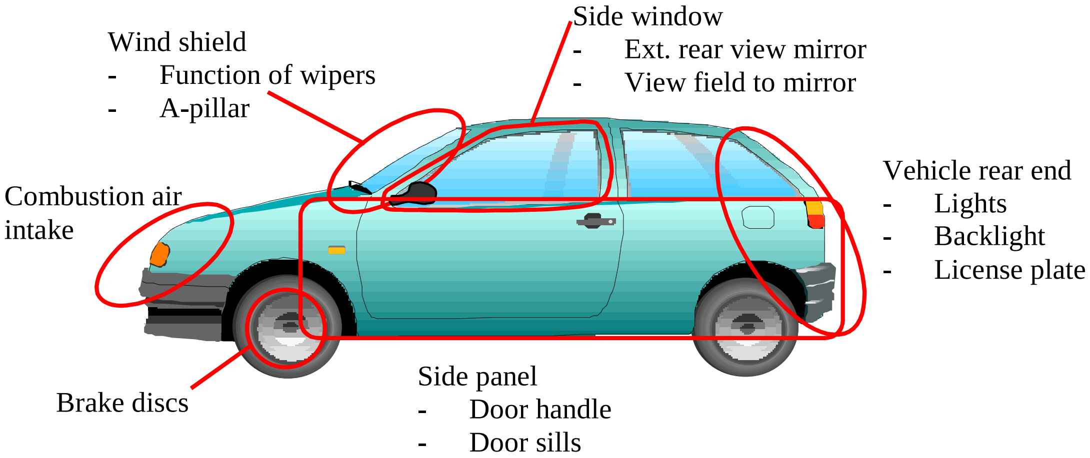

Fig. 1: Areas on a passenger vehicle critical to soiling.

Vehicle soiling can be defined as the resulting picture of the vehicle contamination which recognisably remains after a defined and reproducible situation in the case of a drive during rainy conditions or a drive over a wet or dirty road. Although the following chapters concentrate on soiling due to water and wet conditions, it should not be forgotten that vehicle soiling can also result from dust. Areas of soiling on a passenger vehicle, as displayed in Fig. 1 are the windshield and the function of the wipers, the a-pillar, side window and rear view mirror, the side panels including the door handles and sills and the vehicle rear end with back light, rear lamps and license plate. According to a definition established by FKFS in the early 70's, vehicle soiling can be subdivided depending on the origin of the soiling into vehicle self-soiling and vehicle foreign soiling [4].

2.1 Vehicle Self-Soiling

Vehicle self-soiling is the resulting dirt deposit on a vehicle moving on a wet road without any influence of other road users. In this situation the vehicle will be exclusively bedewed by droplets full of dirt which it whirls up by its own movement over the road.

The rolling motion of a wheel displaces and picks up water in the tire contact area. The displaced water splashes to the side of the wheel and also generates a "bow wave". On the other side, the tire transports the picked up water upwards and sprays it off in radial direction due to the acting centrifugal force.

Splash and spray is a term commonly used in the field of vehicle soiling and describes together the adverse effects on visibility caused by vehicles travelling on wet roads. "Splash" consists of very large liquid droplets that fall ballistically to the ground. The splash induced by trucks does not contribute greatly to the reduced visibility because the splashed droplets typically remain close to the ground, out of the line of other driver's vision.

"Spray" consists of smaller droplets that remain airborne for a long time. Very small droplets also produce of a fog cloud. This is the result of the presence of three elements:

1. water,
2. a hard or smooth surface struck by the water,
3. and a turbulent air flow to pick up and carry the water [5].

Kössler [6, 7] concentrated in his research on the basics of spray fog of free and covered wheels. As displayed in Fig. 2, the spray off from a free rolling wheel can be separated in two zones. The zone in proximity to the ground is dominated by splash. The water film on the ground is displaced by the tire and splashes to both sides of the wheel up to an angle of 45°. The tire picks up water and accelerates it. At the end of the tire contact area, most of the picked up water detaches from the tire in large droplets and creates a splash of an angle between 20° to 30°. The remaining water needs some time to accumulate and sprays of as smaller droplets in the upper rear zone of the tire. Further essential findings of Kössler are:

- The biggest amount of water is thrown off in an angle < 30° to the ground. Due to the wake of the wheel, the influence of the wind is negligible.
- The amount of spray is reduced with increasing angle of rotation.