The Concept of Hydroplaning of Commercial Vehicle on Wet Road

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Abstract— Aquaplaning or hydroplaning by the tires of a road vehicle occurs when a layer of water generates between the tires of the vehicle and the road, foremost to a damage of traction that avoids the vehicle from returning to control. If it happens to all wheels concurrently, the vehicle becomes, in consequence, an uncontrolled sled. The grooves of a tire are designed to separate water from underneath the tire, as long as high friction even in wet conditions. Aquaplaning or hydroplaning occurs when a tire come across more water than it can disperse. In this work we are going to do a CFD simulation of tire on a wet road conditions by using some technical parameter.

Key words: Hydroplaning, Aquaplaning, Tire, Groove, Water, Commercial Vehicle, Trucks, Simulation, CFD, Lift Force

I. INTRODUCTION

Hydroplaning is a exclusive phenomenon in which the water on a wet road surface or highway is not evacuated from the insignificant tire-ground contact area by a rolling tire or by a affecting but non-rotating tire at a rate firm enough to allow the tire to make contact with the road surface over its complete insignificant footmark area, as would the case of action on a dry surface. When hydroplaning happens, the tire cycles on a section or film of water over a part or all of its footmark area, depending on the conditions. This creates a condition where the vehicle experiences low coefficient of friction and uplift forces in the fluid film adept to cause a loss of contact between the tire and the road surface. This causes a loss in braking ability and could lead to accidents. In this work we were doing analysis on commercial vehicle tire.

Fig. 1: Aquaplaning or hydroplaning by the tires

A. *Concept of Hydroplaning*

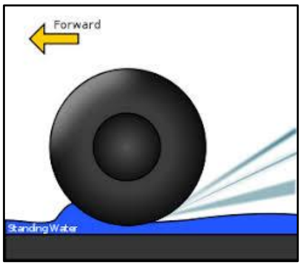

Fig. 2: Hydroplaning demonstration by the tire

The hydroplaning difficulties can be exhibited as a level of water and a road surface affecting at a speed near the wheel. A locked wheel is exhibited as sliding on a flooded road surface. In this study, water is used as a contaminant and the temperature is assumed to be 22ºC. Hydroplaning is expected to happen when the normal ground hydrodynamic pressure is corresponding to the tire pressure of the wheel, i.e. the vehicle’s load is equal to the hydrodynamic lift force.

1) Fluid Flow Model

The flow in hydroplaning is mostly turbulent in environment and this has to be accounted for in the exhibiting of hydroplaning. It is therefore essential to apply the semi-empirical standard k-ε model for the turbulence modelling. The problem is solved by computational fluid dynamics (CFD) software, using ANSYS.

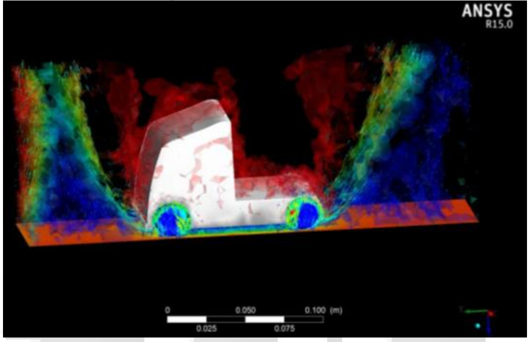

Fig. 3: Effect on vehicle in rainy season

II. CFD ANALYSIS

1) Boundary Conditions Used

The upstream boundary conditions involve of a couple of inlets, namely a velocity inlet of 5.08 m/s thick for water and a velocity inlet of 54.8 m/s thick of air. The road surface is exhibited as an affecting smooth plane wall with no micro-texture. The speed of air, water and the road surface are kept as 55.3 km/h). The inlet is placed at a distance of 75 mm away from the leading edge of the tire. The behind edge is exhibited as a pressure outlet with the pressure set as 0 kPa. The top boundary is set as a pressure outlet at the atmospheric pressure and the top boundary is located at a distance of 25.4 mm. The side edges are exhibited as pressure outlets with the pressure set as 0 kPa. It is noted that the centreline of the tire can be preserved as a plane of symmetry. The positions of the boundaries have been selected such that they would not have any important effect on the road hydrodynamic pressure under the tire.

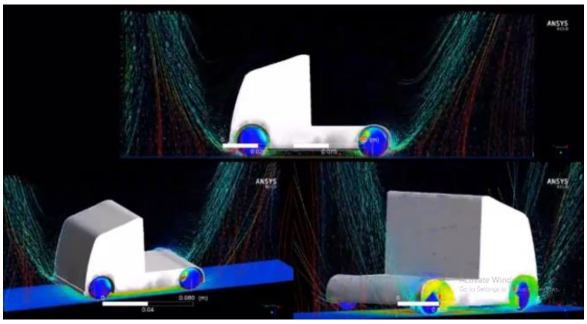

Fig. 4: Effect on vehicle in rainy season

2) Material Properties

The properties of water and air at 22^{o}C are used in this work. The density, dynamic viscosity and kinematic viscosity of water at 22^{o}C are 998.2 kg/m^3, 1.002 x 10^{-3} Ns/m^3 and 1.004 x 10^{-6} m^2/s individually. The density, dynamic viscosity and kinematic viscosity of air at standard atmospheric pressure and 26^{o}C are 1.204 kg/m^3, 1.82 x 10^{-5} Ns/m^3 and 1.51 x 10-5 m^2/s individually.

III. STUDY PARAMETERS

To offer a mutual source for the analysis, with a cross sectional radius of 394.2 mm and a tread width of 149.4 mm is assumed for this work.

The following common dimensions of grooves in tire tread and pavement surface are used:

- Groove width – 6.02 mm
- Centre-to-centre groove spacing – 22.3 mm
- Groove depths considered – 0 mm, 2.2 mm, 5.3 mm and 9.8 mm
- Water film thickness – 8.52 mm
- The top limit of 9.8 mm groove depth is used as it is the maximum groove depth.

A. Model Parameters

This segment signifies the salient features of the 3-D model of dynamic hydroplaning is shown in Figure 5.

In the modelling of a tire, three structural components are considered namely sidewalls and tread. The tire construction is modelled by an outer rubber tread. The tire rubber is considered as a nearly incompressible material.

Fig. 5: 3D modelling of tire

IV. SCOPE OF ANALYSIS

The aim of this work is to estimate the relative efficiency of grooving measures, namely grooving of road surface and keeping sufficient groove depth in tire tread, in decreasing the hydroplaning risk for commercial vehicle. The comparative vehicular hydroplaning risks of two road surface segments can be measured by computing their particular hydroplaning speeds. The road surface section that has a lower vehicular hydroplaning risk is the one with the higher hydroplaning speed. The comparative effectiveness of the two measures in reducing hydroplaning risk can thus be measured by comparing their particular hydroplaning speeds.

For easy clarification in the current relative work, matching groove patterns are considered for both road surface and tire tread. The case of smooth tire sliding on a smooth road surface is occupied as the basis of reference to evaluate the benefits of introducing tire or pavement grooves. Overall, the following seven cases are examined in this study:

- Smooth tire sliding on smooth road surface.
- Smooth tire sliding on longitudinally or transversely grooved road surface.
- Longitudinally or transversely grooved rib tire sliding on smooth road surface.
- Longitudinally grooved rib tire sliding on longitudinally grooved road surface.
- Transversely grooved rib tire sliding on transversely grooved road surface.
- Longitudinally grooved rib tire sliding on transversely grooved road surface.
- Transversely grooved rib tire sliding on longitudinally grooved road surface.

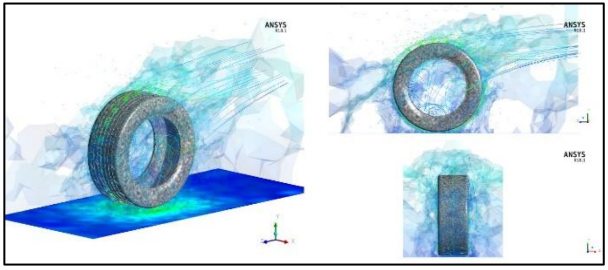

Fig. 6: Water effected by tire

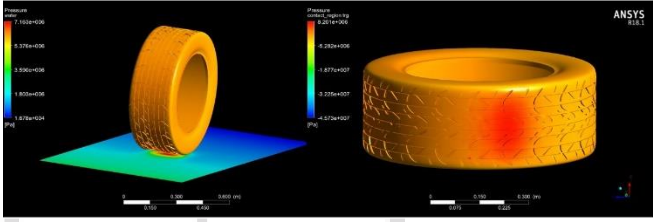

Fig. 7: Pressure Water & Contact region tire

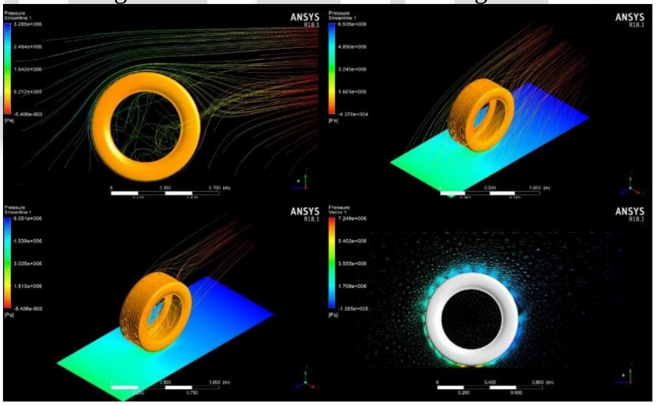

Fig. 8: Streamline Inlet, water, Tire & Vector

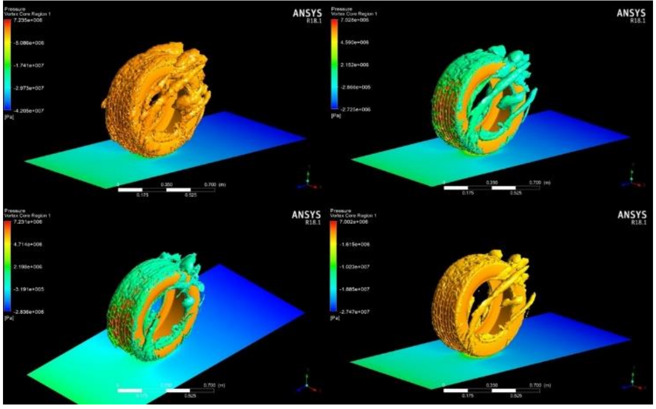

Fig. 9: Vortex core region

Pressure	Maximum	Minimum
Water	7.163e+006 Pa	1.678e+004 Pa
Contact region tire	8.201e+006 Pa	-4.573e+001 Pa
Streamline Inlet	30285e+006 Pa	-5.408e-003 Pa

Streamline water	6.535e+006 Pa	-4.376e+004 Pa
Streamline Tire	6.051e+006 Pa	-5.408e-003 Pa
Vector	7.249e+006 Pa	-1.385e+005 Pa
Vortex core region	7.235e+006 Pa	-4.205r+007 Pa

Table 1: Results

Fig 1 and 2 show the Aquaplaning or hydroplaning by the tires & hydroplaning demonstration by the tire. Figure 3 & 4 Show the effect of water in rainy season on commercial vehicle. Figure 5 show the 3-D modelling of Tire whereas Figure 6 to 9 show the analysis of tire by using Ansys 18.1

V. CONCLUSIONS

This work presents the improvement of a 3-D hydroplaning simulation model using ANSYS. In this work, smooth tire was measured to roll and slide over plane road surface.

Hydroplaning speed designed using the developed simulation model was accordingly confirmed against the past experimental studies and the results.

The developed model was simulated for tire and water depth conditions. It was detected in over-all that the hydroplaning speed increases with the increase in tire pressure for both rolling and sliding tires, it was also detected that underinflated tires and pavement with yawning water depths are more disposed to the risk of hydroplaning.

A. Future Developments and Recommendations

This research focuses mainly on modelling hydroplaning for rolling tires. The established model can be professionally extended for the purpose of hydroplaning speed and skid resistance for tires rolling over real road surface. These applications will help highway safety establishments to measure the skid resistance and the tendency of hydroplaning associated with road surface with different asphalt mix designs under different working conditions of vehicles.

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