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The role of tire size over the fatigue damage accumulation in vehicle bodies

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Abstract

One of the most important components related to vehicle dynamics is the tire and wheel set. According to their dimensions (diameter, height, width, design) the vehicle dynamic behavior and driving comfort are seriously affected. Besides these aspects, the wheel/tire configuration has a main role over vehicle design and style. Nowadays, there is a design strategy which main feature is the increase of wheel diameter, causing the reduction of the tire side profile (tire height). After the increase of the wheel size, the total dynamic and static diameter of the whole set must be the same, causing the previous mentioned tire height reduction.

In this work we investigate concerning the fatigue damage accumulation over light passenger vehicle body, related to the changes in the wheel/tire sizes. The vehicles were instrumented with strain gages in order to collect the stress levels acting at several areas of the vehicle body. These measurements were performed with a wide range of wheel/tire sizes in order to verify the importance of this component over structural integrity. The increase of the wheel size (and therefore decrease in tire height) has a significant role in the stress levels acting over the vehicle body, causing a higher fatigue damage accumulation. These new stress levels must be considered during the dimensioning of the vehicle components with higher wheel dimensions.

Keywords: fatigue; damage accumulation; fatigue life.

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1. Introduction

One of the most important components of the vehicle suspension is the tire/wheel set. The tire is in charge of the contact between the vehicle and its working surface: the ground, which can be either an excellent smoothed high speed road, or a mud and treacherous combat field. Moreover, the tire set has a bold role over the definition of the traction limit, acceleration and braking performances and vehicle steering control. The main objectives for the tire design, according to Gillespie (1992), are:

- Support the vertical load, while cushioning against road shocks;
- Develop longitudinal forces for acceleration and braking;
- Develop longitudinal forces for cornering;

Besides these above mentioned technical requirements, the tire/wheel set design must undergo a relatively new aesthetic rule - its size. In the last few years, the diameter of the wheel in the vehicles has showed a real increase, thanks to some style tendencies which reign over the new vehicles designs. Before, big wheels were restricted only to sport or high performance cars, but nowadays even low-budget vehicles are equipped with this kind of device (de Paula, 2011). And as bigger the wheel size is, smaller is the tire profile, due to geometric restrictions.

Whereby these big wheels are spreading over almost every vehicle type, it seems reasonable to verify its influence over the first objective of the tire design. The aim of this paper is to measure the several levels of loads that are applied in one light passenger vehicle body, due to the increase of the tire/wheel size. These load levels are important for the calculation of the fatigue damage accumulation on the body areas (Stephens and Fatemi, 2001; Schijve, 2009).

2. The tire

2.1. History and definitions

The modern tires are visco-elastic toroids that evolve the wheel rims. The torus is composed of a flexible carcass of high-tensile-strength cords fastened to steel-cable beams that anchor the assembly to the rim. The internal pressure stresses the structure and any external force causing carcass deformation will result in a tire reaction force (Gillespie, 1992).

The first tires were simple iron or steel bands place in the wheel of carriages or wagons. The first pneumatic tire was introduced by John Boyd Dunlop in 1888 (Esteves, 2012) and his concept is being refined during the years. Tire constructions can be represented by two basic types: radial and bias tires (Gillespie, 1992; Esteves, 2012).

In bias tires (Fig. 1) the parallel plies or carcass are made up of two or more plies extending from each bead with cords with angles between 35° and 40°. Due to the stiffness of the tire, it has a low capacity in absorb bumps on the ground. Impact and shaking are strongly felt by the driver and machine. Bias tires were common in the North-American vehicles before 1960 and today are relegated to trucks.

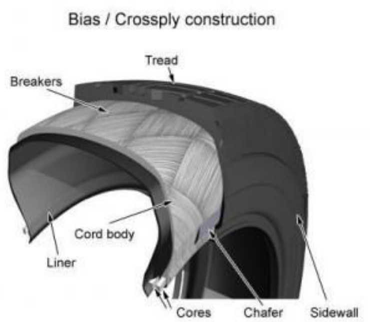

Fig. 1. Bias tire construction. Source: Recstuff website.