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The prediction methodology for tire's high speed durability regulation test using a finite element method

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ABSTRACT

In the tire industry, indoor accelerated life tests as regulations have been performed to ensure tire durability performances instead of outdoor field test. The finite element method has been widely used to minimize real test time and cost, but prediction method for accelerated life test had hardly been made in the past. This study presents a rational methodology to predict the tire's failure life at the steel belt edge region due to high speed regulation test. Based on the finite element analysis and fatigue characteristic of rubber material, a method to determine exact failure time is proposed. The steady-state rolling analysis by FEM to get strain energy density range(ΔSED) at the steel belt edge region and fatigue test of rubber compound to obtain ΔSED- number of cycle(N_f) curve were used. The reliability of proposed prediction method was verified by real indoor test.

1. INTRODUCTION

After the invention of a tire, the initial purpose of the development has focused on safety and long mileage, but in order to improve the vehicle's performance due to various performance requirements for use, the tire has been developed with a very complicated structure. The durability of the tire performance is one of the most important performances metric in terms of the vehicle's protection and passenger's safety, so it should be a top priority during tire development. Fig. 1 shows the typical structure of the radial tire.

Recently, as energy and environment problems are emerging as global issues, studies on vehicle's energy source and fuel efficiency have been performed actively. In the view point of the vehicle, the development of hybrid and electric vehicle has been expanded, and in the viewpoint of the tire, the design to minimize rolling resistance related to vehicle's fuel efficiency has been required. However, electric and hybrid vehicles have relatively high weight due to battery and an additional source of power comparing to the general passenger car, while tires decrease weight to minimize rolling resistance. Because of these trends on the durability of a tire work as conflicting conditions, in recent years, tire durability issues has been magnified in the tire industry.

The durability test in normal driving condition is very difficult and time-consuming task. Generally, tires have longer lifetime by failure than that of tread wear, and field test cannot ensure driver's safety, so failure test under normal vehicle driving condition is almost impossible. Thus, to simulate tire's failure mode by the indoor test, each group and country such as Economic Commission for Europe(ECE) in the European countries and the Federal Motor Vehicle Safety Standards(FMVSS) in North America have regulations for accelerated life test, and it has been used as a essential test in order to export tires.[1-2] This indoor accelerated life test has been used as a substitute for durability test in the field. Among regulation accelerated life tests, high speed durability test is performed to simulate fatigue failure at the steel belt edge region as shown in Fig. 2 by increasing driving speed under constant load until tire's failure.

The prediction of tire's performances using a finite element analysis has been widely used to

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