THE INFLUENCE OF A REAR TIRE TREAD SEPARATION ON A VEHICLE'S STABILITY AND CONTROL

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ABSTRACT

A series of open loop tests was conducted on three vehicles instrumented per SAE J266 to determine the effect of a rear tire tread separation on the vehicles' behavior. The vehicles tested were a 1989 Ford Bronco II, a 1996 Ford Explorer, and a 1993 Ford Taurus. The tests were categorized as tread separation event tests and tread-separated tests. The tread separation event tests were designed to determine how the vehicle responds as the tread is separating from the tire carcass at speeds ranging from 58-119 km/h (36-74 mph). Tires were prepared in a manner that would initiate either a complete or partial separation of the tread. The vehicle was driven on a straight path with the steering wheel held fixed as the tread came off. The tread-separated tests were run on vehicles where the tread was removed from one of the rear tires. The maneuvers conducted were circle turns per SAE J266 (constant radius and constant steer) and step steer turns. These tests were run to evaluate the steady state and dynamic oversteer/understeer characteristics of the vehicles.

The results of the tread separation event tests demonstrate that the vehicle's response is dependent on speed, duration, and the nature of the separation event. The vehicle responds by pulling to the side of the tread-separating tire. The longer the tread takes to come off, the greater the vehicle response. Once the tread had separated, the vehicle's response to the event ceased. Partial tread separations result in a significant vehicle response due to the continuous duration of the event. Higher speeds result in a greater vehicle response. The tread-separated tests show that the vehicles oversteer when the tread-separated tire is on the outside of the steering maneuver resulting in vehicle spinout. The vehicles transition to a steady state oversteer behavior at lateral acceleration levels of approximately 0.2 g.

INTRODUCTION

The reporting in the news media of consumer problems, including crashes, caused by catastrophic tire failures [tread separation events] has been increasing. The reports indicate that the vehicles are extremely difficult to control and that crashes are occurring in increasing numbers. Investigations of crashes and experimental testing have shown that the control problems clearly appear to be related to the response of the vehicle as a result of the catastrophic tire failure.

STATEMENT OF THE PROBLEM

Tire tread separation is a class of tire disablement that has not received attention over the years. This class of tire disablement typically has been lumped into the larger group of tire disablements labeled as flat tires and blowouts even though loss of air may not occur during a tire tread separation event. There is very little statistical data specifically about tire tread separations. Consequently, minimal testing has occurred to evaluate the effects of a tire tread separation on a vehicle's response, stability, and handling characteristics.

Some data that has been published recently represents "Closed Loop" tests evaluating whether a driver who has knowledge of the impending tread separation can control the vehicle. [1,2] This type of data is subjective in nature. "Open Loop" tests (such as those presented in this paper) remove the driver's influence from the outcome allowing an objective analysis of the result. Data from a series of open loop tests conducted on a Bronco II has recently been published providing an objective view of a vehicle's behavior during and after a tread separation event. [3]

Additional data, like that developed for the Bronco II, which spans across classes of vehicles is necessary to better understand the potential hazards associated with a tire tread separation event on all vehicles.

HYPOTHESIS

It had been shown through previously published work that a Bronco II (small Sport Utility Vehicle) would respond to a tread separation event by deviating from its original heading toward the side of the tread-separated tire. It was hypothesized that the heading change was a result of the tire tread interaction with the wheel well and surrounding structure. This was thought to create drag at this wheel position which in turn would generate a yaw moment that produced the heading change. The duration or time that it takes the tread to completely separate from the carcass of the tire was also believed to influence the heading angle change due to the magnitude of the impulse resulting from the drag. It was further hypothesized that these basic physics were present on all vehicles that experienced a tire tread separation.