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Stability Control of Vehicles during Tyre Burst with Auto Expanding Rims

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Abstract

This paper focuses on a new idea to prevent vehicle accidents due to skidding while tyre bursts. Tyre bursts are common in highways where vehicles ply at very high speeds which lead to fatal crashes when the vehicle loses stability. The new design prevents this stability loss which occurs when one of the tyre losses air within a fraction of second. The wheels are provided with pads which will be ejected to occupy the required diameter of the wheel once the tyre bursts. The response to tyre burst can be provided with a lock releasing arrangement and electronic system that will enable the tyre to regain its original diameter. Hence there is no need for the driver or occupants to get panic as the vehicle will be completely stable. This will completely prevent crashes and safeguard passengers. The expanded rims can be restored to their original size by compressing the pads again and hence reused.

Keywords: stability, expansion, tyre.

INTRODUCTION

Tyre bursting is one of the major problems faced by vehicles especially at highways. Almost 70% of the accidents taking place in highways are due to tyre burst all over the world.Several companies have come forward to put their efforts best to prevent accidents by various means. But there is nowhere a complete solution for this problem except the Run Flat Tyres used in VR security vehicles which are operable only for a certain speed limit. Once the vehicle loses stability after blown out tyres, it will no longer be under the control of driver as the speed in very high. Thus some changes must be needed in the wheels for the safety of the passengers in order to reduce such accidents. Highways are places where vehicles move at more than 100 kmph continuously. Due to the increased heat, lack of maintenance and sharp objects pricking the tyre, the probability for occurrence of tyre burst is very high. Even if there is a mild imbalance, it will be difficult for the driver to put the vehicle under his control due to high speed on highways, ultimately leading to accidents and loss of lives. In

India, Yamuna Expressway, the six lane road connecting Noida with Agra ranks first in accidents due to tyre bursts and several people die each year.When a vehicle travels at very high speed in highways for very long distances, the tyre becomes overheated due to friction between the road and tyres. Due to this high temperature, the air in the tyre expands thereby increasing the tyre pressure. If this is not noticed by driver it may lead to bursting of the tyre leading to instability of the vehicle due to sudden change in diameter of the wheel [1].

Fig. 1. *Burst tyre*
Courtesy: www.cartrade.com

LITERATURE REVIEW

SadokSassi et al[2015] have studied the effect of tyre burst on vehicles which leads to loss of stability by making the vehicle swirl in the direction of burst tyre. **E O Bolarinwa et al[2004]** have done finite element test on how tyre burst affects the tyre material. **Kyoung Moon Jeong[2016]** has carried out analysis on the breaking of beads from which the bead design can be properly carried out.

EXISTING DESIGN AND PROPOSED DESIGN

In order to prevent tyre bursts, several vehicles are now equipped with tubeless tyres. This is because the air leakage rate is low in these tyres compared to ordinary design [2]; thereby tyre bursting can be avoided. However it does not prevent bursting always. Bursting may happen if the tyre is old or when tyre gets damaged by sharp objects. Hence it is not believable in all emergency situations [3].BMW Motors has come forward with a new technology to prevent skidding of vehicle during tyre bursts. It uses run flat tyres similar to one shown in Figure 2 which are provided with polymer lining at the inner side to keep the vehicle stable. However it does not reduce the chance of skidding completely. This technology is also used in high security vehicles.

Fig. 2. *BMW Run Flat Tyre*

Courtesy: nl.wikipedia.org

The objective of this design paper is to overcome even the skidding which takes place in the Run Flat Technology by BMW. The main problem of vehicle skidding during tyre bursts is due to the change in diameter of the wheel. If this problem is rectified, the vehicle will be completely stable. Thus the proposed deign is that the wheel rim in Figure 3 must be modified with paddings as in the construction given below which will retract to the required position of the tyre. The design of rim in Figure 3 is made using Solid works 2015.

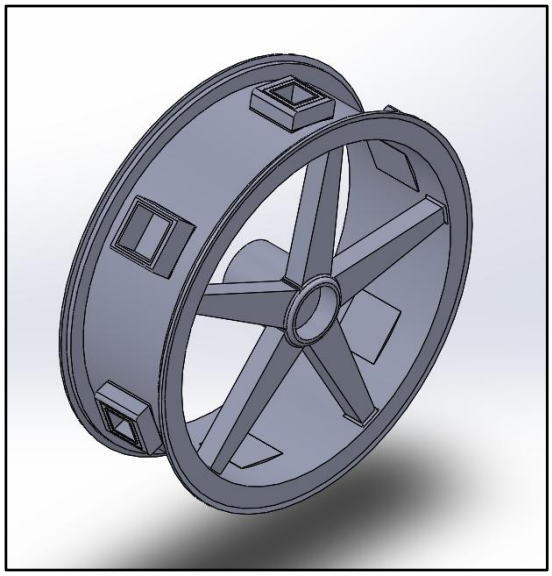

Fig. 3. *Modified wheel rim.*

The following parts play a vital role in maintaining stability of vehicle. The Wheel pads shown in Figure 4are made of honeycomb structured aluminium alloy base lined with hardened rubber which serves as support to the vehicle when touched with the bottom. Springs are provided to make the pads move outwards. The system is equipped with locks to keep the pads compressed. The releasing of locks is carried out by actuators.

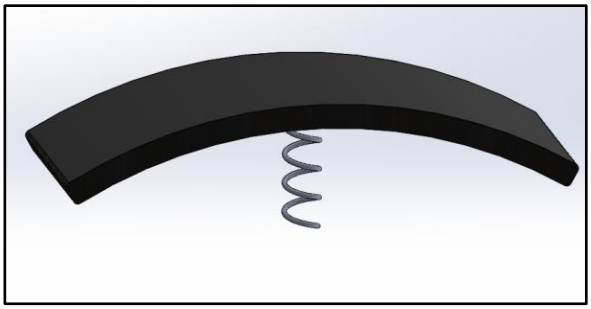

Fig. 4. *Wheel pad.*

The pads used to correct the diameter of the wheel must withstand the downward force of the vehicle which consists of the weight of vehicle and also the force due to high speed. The design must also withstand the bursting pressure. Hence, hardened rubber must be used for covering the pads. The time taken for expansion must be as much as possible (<50 milliseconds) for effective functioning of this system. The tyre stands on the rim with the help of metal bead [4].

CONCEPT PROOF

When the tyre bursts suddenly the air gap between the tyre and rim will be vanished. During this stage the locks provided to the pads will be opened. Eventually, the pads which are kept compressed with springs expand to occupy the space occupied initially by air. The expansion of pads takes place due to centrifugal force acting on them and also due to spring force. Once they expand, they are locked in the prede-

termined positions to get the required wheel diameter. Thus the loss in height of the wheel is brought back to original state so that the vehicle's stability will be maintained. The expansion process takes place within fraction of seconds similar to airbag so that the stability of vehicle will be controlled within very short period of time.

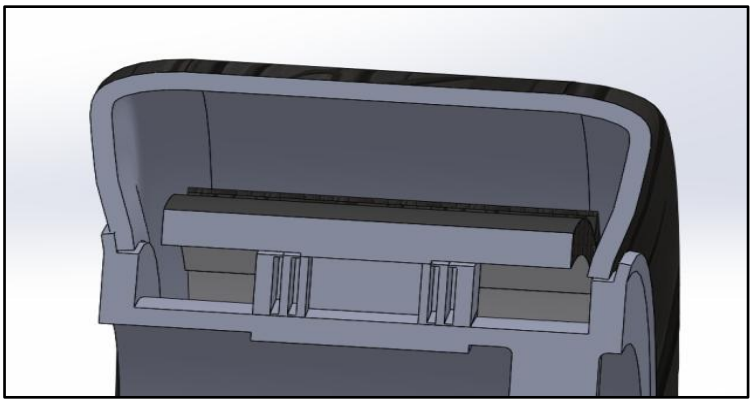

Fig. 5. *Pad position at normal condition.*

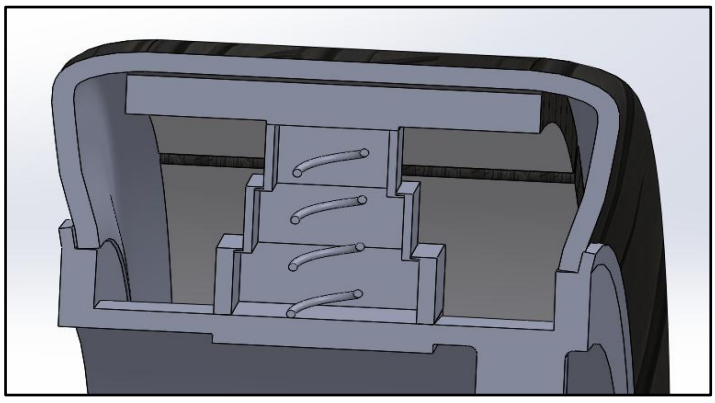

Fig. 6. *Pad position after tyre burst.*

In order to reuse the rims, the tyre must be replaced and the pads can be once again locked in predetermined positions. Hence there is no other expenditure apart from initial investment.

CALCULATIONS

(For vehicle with 15 inch wheel moving at a speed of 150 km/hr)

Angular velocity = v/r
= 41.67/0.18
= 231.5 rad/s

Centrifugal force = $m\omega^2 r$
= 0.1*231.5*231.5*0.18
= 965 N

Spring stiffness = 5 N/mm

Time taken for Expansion = (mass*speed)/Total force
= (0.1*41.67)/(965+125)
= 4 milliseconds

Theoretical Recovery distance = 41.67*4/1000
= 17centimetre

CONCLUSION

The implementation of this idea may bring a great reduction in the number of road accidents due to tyre bursts and helps to save lot of lives. It can be installed in any vehicle by just making slight modifications in the rim. The stability of the vehicle can be maintained to a great extent. It will also be helpful to drive the vehicle to the nearby service station for replacing the wheel during tyre burst and also when puncture occurs. It can also save people in aircrafts which crash due to tyre bursting. Thus passengers can enjoy a safe and happy journey.

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