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Experimental Analysis of a Run-flat Tires for Automobiles

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***Abstract* - The idea of a runflat tire was initially put forth in few decades back; the substantial research has been put toward developing high-performance runflat tires. The internal air filled with preset pressure level quickly escapes when a standard pneumatic tire is punctured, causing the sidewall to become flat [1]. This forces the sidewall to be squeezed between the aluminum wheel and the ground, lowering the tire axis. The basic goal of a runflat tire is to keep the sidewall from flattening even when the internal pressure is zero [3]. Run flat tires have additional internal structure that allows support in case of deflation. When evaluating the performance of a runflat tire, the primary aspects to take into account are the maximum driving speed and distance, the comfort of the ride, and the durability [2]. Due to the runflat system's surface deformation, causes chipping and micro-fractures on the surface outer diameter (OD) of the runflat system that is supporting the outer tire when it hits a hard surface, the risk of tire disintegration after a few kilometers increases [5]. The design of runflat system is analyzed for its structural integrity with respect to speed and load. The analysis showed that when the temperature rises, the tensile strength and modulus of the insert compound dropped. The loss factor and distortion both have an impact on the insert rubber's ability to generate heat [6, 7]. The deformation of the support rubber and the heat storage of the support could be minimized, which could considerably enhance the sinking rate of the tire under zero pressure. This could be accomplished by utilizing insert rubber with a higher hardness or increasing the structural stiffness of the tire.**

***Index Terms* - Runflat, Runflat insert, deburring, self-supporting, auxiliary supporting.**

1.INTRODUCTION

A flat tire tube or tubeless is a pneumatic tire that has chances to drop air pressure. This can cause the wheel rim to rub against the tire tread, harm the car's rim, causing the rims to suddenly crash to the ground, and possibly cause the vehicle to lose control or suffer irreversible rim damage. To prevent the damage of tire a method that would enable the tire to continue to run after being punctured while giving the motorist adequate time to reach the local repair facility. When a tire is punctured, design a flat tire running system to prevent a permanently deformed tire. In addition, when a tire flattens because of the state of the road, the suspension tension will rise. A support ring is placed inside the tire to build a system for running flat tires that will sustain the vehicle weight and can be adjusted to match any type of tire and wheel size.

There are two types of runflat systems are used. They are self-supporting runflat systems and auxiliary-supporting runflat systems. In self-supporting runflat system a special designed reinforced side walls are used to support the four wheel vehicle to keep them rolling even after puncture. The other runflat system is auxiliary-support runflat system are designed especially for military vehicles. The thread of a flat tire rest on a ring attached to the wheel rim when it punctured. This auxiliary support system having stiffness in their sidewalls gives better ride quality. The sidewall of the tire is fortified by making it thicker bead on the corner in order to safely sustain the weight of vehicle.

2. DESIN OF RUNFLAT SYSTEM

2.1 Design of a Runflat System:

To demonstrate a complex mechanical system with drawings use mechanical modeling. Each component in the system is represented quantitatively. Run-flat tire design mainly includes three aspects: structure, dimension and material. To achieve the greatest level of visualization creating several components with varying stiffness, heat generation, and shapes to change the sidewall's stiffness, the effects of heat and stress concentration on the zero-pressure durability of tires were explored.

2.2 Finite Element Analysis (FEA) of Runflat System:
The Finite Element Analysis is the numerical method used to simulate any given physical occurrence. The static analysis gives the effect of loading conditions on a structure. Ignore the inertia and damping effects caused by varying loads with time. A static analysis includes the steady inertia loads such as rotational velocity, gravity and time. The change in loads can be approximated as static equivalent loads.

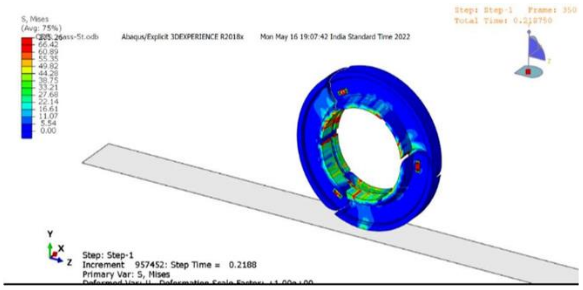

Fig.1 Static analysis of Runflat system

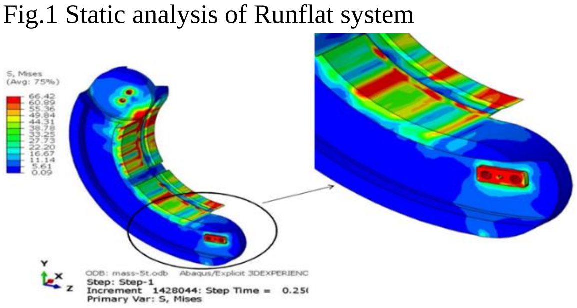

Fig.2 Stress analysis of the runflat system

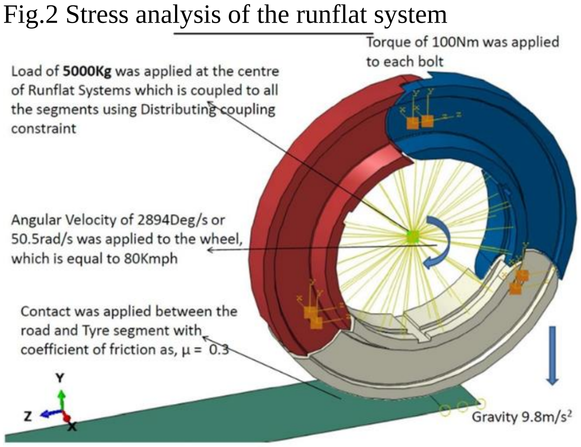

Fig.3 Boundary conditions of the runflat system

1. The design of runflat system is analyzed for its structural integrity at a speed of 80 Kmph with a load of 5000 Kilos.
2. Each bolt is applied with a pre-axial torque of 100 Nm
3. Runflat system segments are made of ballistic composite
4. M14 bolts made of high tensile steel
5. All the stresses on each runflat segment are checked whether the stress is in permissible limits of our design.

3. MATHEMATICAL CALCULATIONS:

Speed = 80kmph,
Radius of Runflat Systems r = 440mm
V = 80kmph = 22.22m/s
$V = r \times \dot{\omega}$
$22.22 = 0.44 \times \dot{\omega}$
$\dot{\omega} = 50.5$rad/s
Which is approximately equal to 8.038 revolutions/sec or 2894 Deg/sec
80kmph = 2894 Deg/sec

Runflat Systems width = 95mm
Let us consider contact line width as 2mm approx.
Area = 95 x 2 = 190mm2,
Force = 5040Kg = 49442.4N,
Pressure = Force / Area Pressure= 49442.4/190 = 260.2N/mm2
Pressure = 260.2N/mm2

The pressure is almost equal to FEA analysis value of 259.25N/mm2.The ultimate tensile stress is 82.7MPa; however the stresses on the Runflat systems are closer to 66.42MPa. Therefore, the Runflat design has a 20 percent safety factor.
From the analysis and mathematical calculations it is observed that the 5000 kilograms applied load with self weight of a person was appropriately taken into account while assessing the stresses in the analysis. The strains at the rim and segment interface will increase as the Runflat Systems are mounted to the rim. Line contact will be present at the segment bottom (the zone of contact between the segment arc and the road), making it possible to see the contact pressure or stress at the interface.

4. MANUFACTURING OF RUNFLAT SYSTEM

The runflat is produced in accordance with inable requirements, which serve as a universal benchmark for all runflat produced. One of the most time-consuming steps in the entire production process is casting the runflat using vacuum injection casting. Casting is the first step of runflat manufacturing process. After casting processing, the cast runflat is made with counters and other PCD (Pitch Circle Diameter) holes are drilled into it. The work placed on the lathe for facing and turning operations. Reduce the diameter of the runflat as per the required size of the tire. The runflat system’s locking and bolting components, nut insert and taper locks are made to fit through milling operations. Machined corners are present in order to prevent problems like wobbling or vibration when driving the vehicle. Advanced CNC (Computer Numerical Control) machines are utilized to precisely contour the runflat surface to match the profile of the wheel rim. Deburring the bolting holes and mounting the runflat on the wheel rim allow for proper testing of factors such bolt torque, slippage, butting, etc. To guarantee that the required level of material quality is obtained, quality control techniques like random sample collection procedure are adopted.

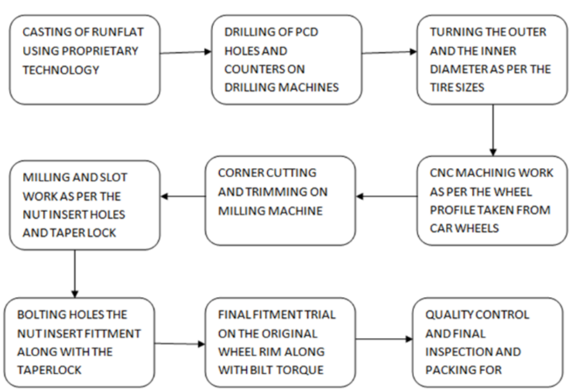

Fig.4 Runflat Manufacturing Process

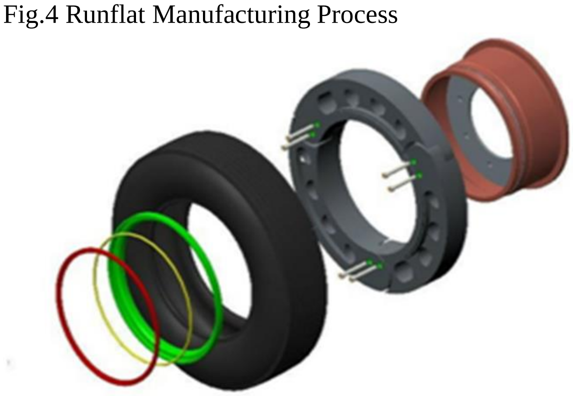

Fig.5 Assembly of Runflat system

5. TESTING

Two unique sets of perforated tires will be used during the road and off-road trials. The weight and moment of inertia differences between the regular wheel/tire assembly and those equipped with the runflat system must be established prior to the trial in order to estimate the anticipated long-term mechanical impact on the vehicle equipped with the runflat systems. Proof marks will be applied to the tire and wheel prior to the trial to determine the amount of tire rotation that will occur on the wheel. Rotation of the tire on the wheel during the trial is permitted but the degree of rotation should be established and such rotation should not prevent completion of the trial.

5.1 On Road Trial

The trial route will be a figure-of-eight circuit with curves that have radii between 25 and 100 meters, similar to a typical made-up concrete or tarred road. The requirements must be met for the vehicle to complete the circuit with 3 Km at a speed limit to 90 Km/hr, 22 Km @ 50 Km/hr and 75 Km @ 25Km/hr

5.2 Off Road Trial

The off-road trial will be conducted on a twisting off-road course including open-land obstacles like hills, ditches, and tree trucks. The car must move at a pace of roughly 30 km/h over the trial route for two hours.

5.3 Acceptance

A trial shall be deemed successful if the test vehicle successfully completes the aforementioned trial without the tire detaching from the wheel or igniting. The tires that will be useless after the trial are those that were penetrated.

5.4 Penetration of Trial Tire

The penetrations will be made by standard 7.62 mm ball rounds fired from a distance of 50 meters. 5 rounds will be fired into the side wall and 2 into the tire tread according to the pattern set out above. Aiming marks should be attached to the tire

5.5 Conditions of Trial

1. The shooting trial will be carried out on the runflat equipped wheels when fitted to the vehicle to which they are normally fitted. All the trial tires must be new approved or approved retreaded tires.

2 For 4 x 4 vehicles, one of the penetrated tires will be mounted on one of the steering wheels and one on the rear position.
3 With power assisted vehicles, the trial wheels will be positioned in the worst-case positions.

6. CONCLUSION

Tire temperatures maintained within acceptable range throughout all phases of the trial but it is observed that during the testing temperature rises, due to that the tensile strength and modulus of the insert compound decreased. The loss factor and distortion both have an impact on the insert rubber's ability to generate heat. The deformation of the support rubber and the heat storage of the support could be minimized, which could considerably enhance the sinking rate of the tire under zero pressure. This could be accomplished by utilizing insert rubber with a higher hardness or increasing the structural stiffness of the tire. The endurance of the zero-pressure run flat tire and the early failure point of the insert rubber substantially correlated with the maximum strain energy. The maximum strain energy density should be at the top of the bead and cross-section insert rubber. There was no evidence of circumferential movement between the wheels and tires.

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