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Analysis Of Wheel Rim Cornering Fatigue Test

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***Abstract*—Wheels have vital importance for the safety of the vehicle and special care is needed in order to ensure their durability. The development of the vehicle industry has strongly influenced the design, material selection and manufacturing processes of wheels. The wheels loading manner is a complex one; further improvement and efficient wheel design will be possible only if the loading will be better understood. In this paper, the moped wheel rim is analyzed with finite element method by varying the no. of spots, in order like 24, 21, 18, 15, and 12. The static stresses are studied in order to find the zones with higher stress concentration and to suggest the better design solution. The results of Ansys have been compared with those obtained by using an experimental stand. The present paper deals with the failure pattern at the weld location of tubeless wheel rims.**

Keywords— Automotive Design, Fatigue Testing, Finite Element Analysis.

I. Introduction

As part of technological improvement, comfort and safety have become essential demands of human beings. This comes not only from market-oriented competition but also from legislation that may seek some certain standards. Cars, important favors of technological development, are widely used in daily life. It seems that mankind no longer lives without them. Therefore, these wonderful machines should be safe and economical so that people could use them safely and more people could purchase them. Since rims, on which cars move, are the most vital elements in a vehicle, they must be designed carefully. The rim type examined in this study has some trouble when touching any curb or entering a sharp curve. The rims manufactured by various methods are made of either steel or cast aluminum alloys [1-2].

Automotive wheels have evolved over the decades from early spoke designs of wood and steel, carryovers from wagon and bicycle technology, to flat steel discs and finally to the stamped metal configurations and modern cast and forged aluminum alloys rims of today's modern vehicles. Historically, successful designs arrived after years of experience and extensive field testing. Since the 1970's several innovative methods of testing well aided with experimental stress measurements have been initiated. In recent years, the procedures have been improved by a variety of experimental and analytical methods for structural analysis (strain gauge and finite element methods). Within the past 10 years, durability analysis (fatigue life predication) and reliability methods for dealing with the variations inherent in engineering structure have been applied to the automotive wheel [3-4].

Wheels are clearly safety related components and hence fatigue performance and the state of stress in the rim under various loading conditions are prime concerns. Further, wheels continue to receive a considerable amount of attention as part of industry efforts to reduce weight through material substitution and down gauging. Although 2 wheels are loaded in a complex manner and are highly stressed in the course of their rolling duty, light weight is one of the prime requirements, hence cast and forged aluminum alloys are essential in the design. Light aluminum alloy wheels enjoy a great popularity at present. For many consumers, a perceived exclusivity is a predominate factor, and these wheels are even considered as status symbols [5].

The necessity to improve fuel consumption has caused many motor car manufacturers to break new ground in their vehicle design. Rounded surfaces have also clearly demonstrated that a smooth outer wheel surface gives a further reduction in air resistance. In this work to save the manufacturing cost and ultimately reduce production cost, method of cornering fatigue test has been employed. To achieve this, implementation of 18 spots wielding over 24 spots has been proposed. Cornering fatigue test has been used to evaluate effect of axial force on wheel and suggests proper number of wield spots which joins rim and disc assembly of wheel arrangement.

II. Wheel Rim Material

As the volume of passenger cars increased the only material and method of manufacture that could provide an economic wheel was the disc wheel formed from hot sheet rolled. The rim was made by roll forming a flash butt-welded hoop. Mechanically caped SAE 1008 and 1010 grades were the typical rim materials. Mechanically caped steel provides higher usable metal yield from ingot and more uniform chemical through the thickness of the sheet which improved the butt weld ability. Rimmed steel in SAE grade 1012 and 1015 were used for the disc because on hot rolled sheet that was very low in alloy content

TABLE I. MATERIAL CHARACTERISTICS

SAE Grade	**Typical Chemistry (%)**				**Minimum Typical Properties**		
Rim	***C***	***Mn***	***P***	***s***	***TYS(KPa)***	***TS(KPa)***	***%E***
C1008/1010	0.1	0.35	0.04	0.05	206700	310050	30

III. Experimental Setup Of Cornring Fatigue Test And Results

The dynamic cornering fatigue test is a standard SAE test, which simulates cornering induced loads to the wheel. Fig 1 shows the test system in which the test wheel is mounted to the rotating table, the moment arm is fixed to the wheel outer mounting pad with the bolts and a constant force is applied at the tip of the moment arm by the loading actuator and bearing, thus imparting a constant rotating bending moment to the wheel. If the wheel passes the dynamic cornering fatigue test, it has a good chance of passing all other required durability tests [6-8].

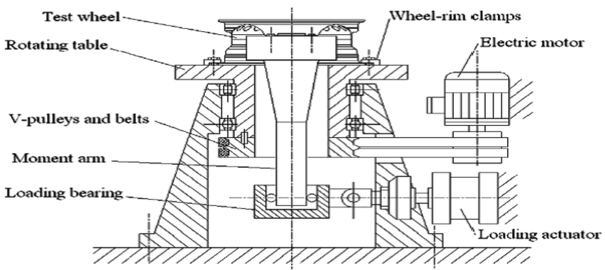


Fig 1.Sketch of the dynamic cornering fatigue test system.

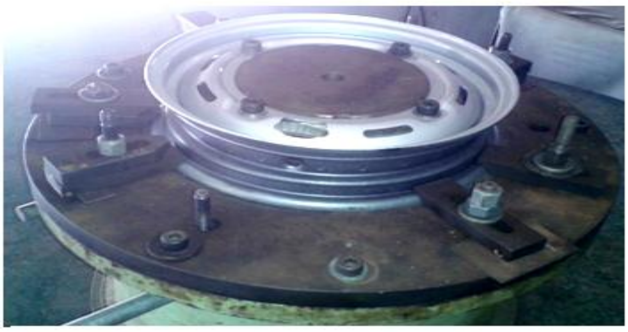


Fig 2. Dynamic cornering fatigue test set up.

TABLE II. EXPERIMENTAL TEST PARAMETRES

CORNERING FATIGUE TESTING			
REF.STD:IS 073			
part name: Wheel Rim	***Wheel Rim Identififcation:02***		
Assembly:(Honda)			
Part no:42701 kpl 9000 h1	***Wheel Rim Specification: 2.15 j x 10***		
Test Details			
Max. Static load on wheel	**Radius Of Tire Under Static Load**	***Coefficient Of Friction (μ)***	
206	0.203	0.7	
Test B.M. Specified	***Number Of Cycles Specified***	***Test Frequency***	***Torque Of Bolts***
54.0 kgm	100000	-	27 TO 31 Nm.

TABLE III. EXPERIMENTAL TEST RESULTS

Results			
No. Of samples	***No. of cycles performed***	***Bending Moment of test (kgm) applied***	***Result***
1	1000000	55 kgm	Positive
Conclusion : Result found satisfactory .No crack observed after die penetration test			

IV. Finite Elelment Analysis Of Automobile Wheels

Stress calculations in automobile rim have usually been restricted to the rim. The method described here has thus far been applied only to the rim; it could be logically applied to entire wheel. The wheel is modeled by a finite element technique enabling representation of complicated shapes by a set of interconnected simple bodies. The stresses calculated within each element describe the stress distribution of material may be determined. Formulation of the stiffness matrix of a constant strain triangular element for axisymmetric problem is given.

Fig 3. Shows typical element seen to have its position and dimensions defined by i, j and k (it's node numbers in the grid work) and their co-ordinates. In the reference plane, which is that of the cross-section, r is the radial distance from the center of the axle, and z an axial distance measured from any convenient reference.

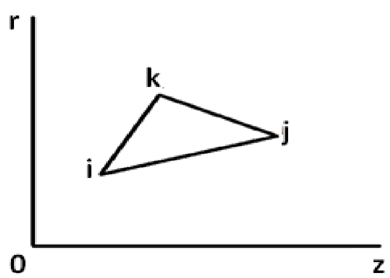


Fig 3. Triangular element model.

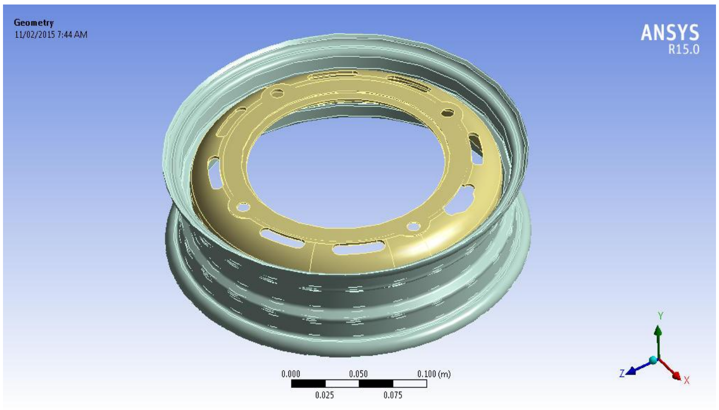


Fig. 4. 3D model of wheel rim.

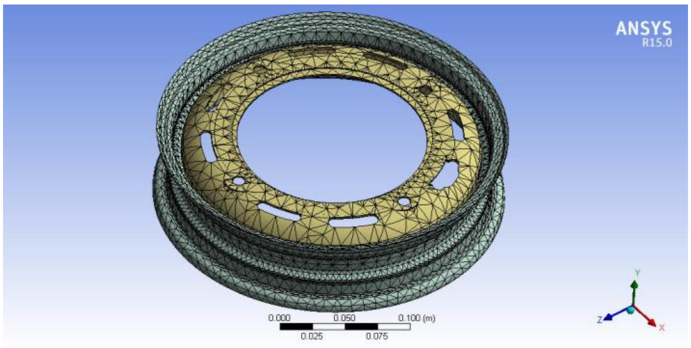


Fig. 5. 3D Mesh view of wheel rim.

V. Analysis Of Wheel Rim

A. Analysis of a wheel rim with 24 weld spots

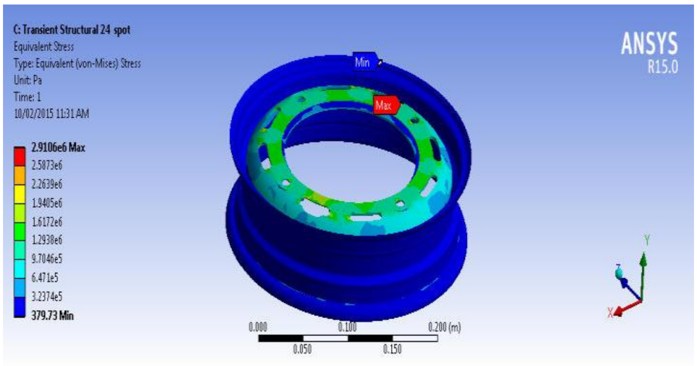


Fig. 6. Von-Misses stresses.

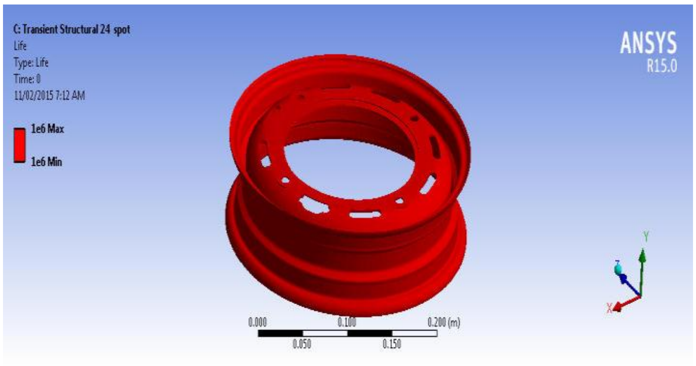
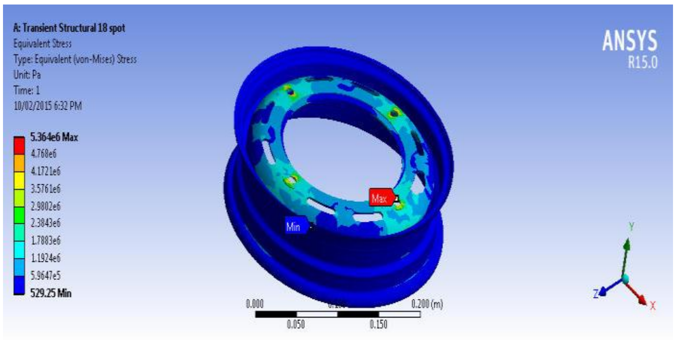


Fig. 7. Life of Rim.



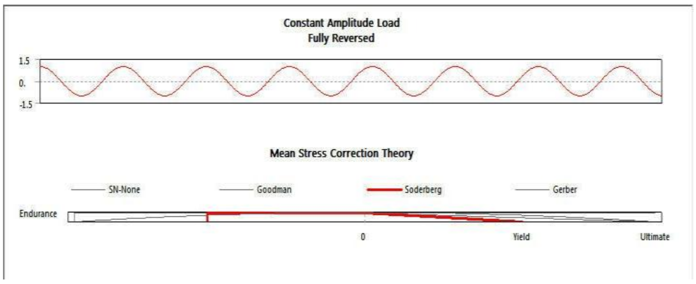


Fig. 8. Fatigue Life.

B. Analysis of a wheel rim with 18 weld spot:

Fig. 9. Von-Misses stresses.

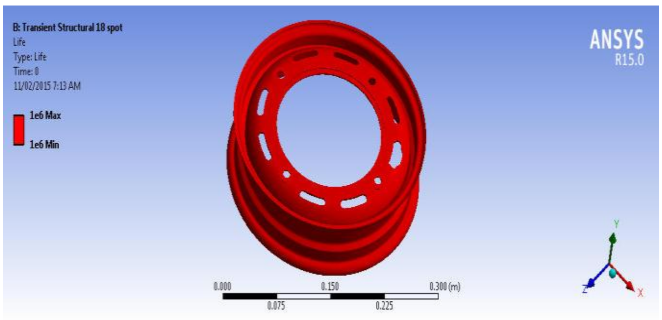


Fig. 10. Life of Rim.

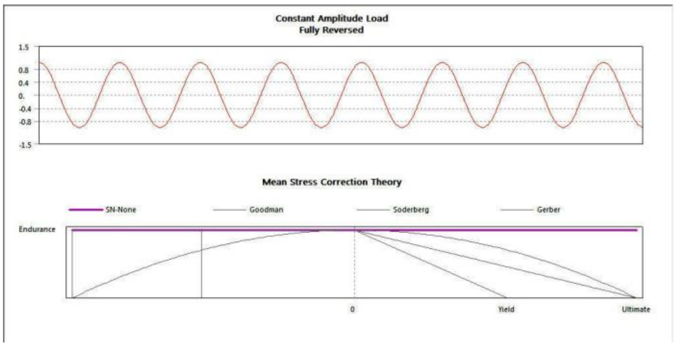


Fig. 11. Fatigue Life.

C. Analysis of wheel rim with 15 weld spot

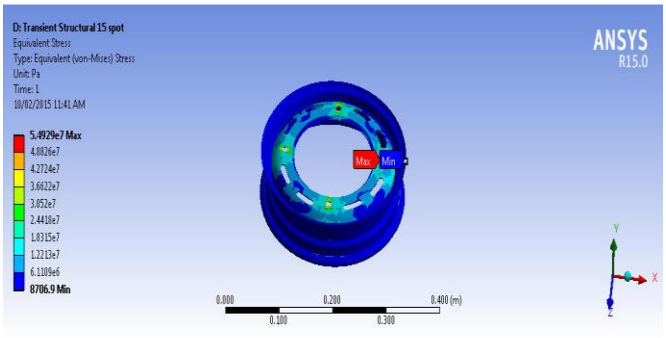


Fig. 12. Von-Misses stresses.

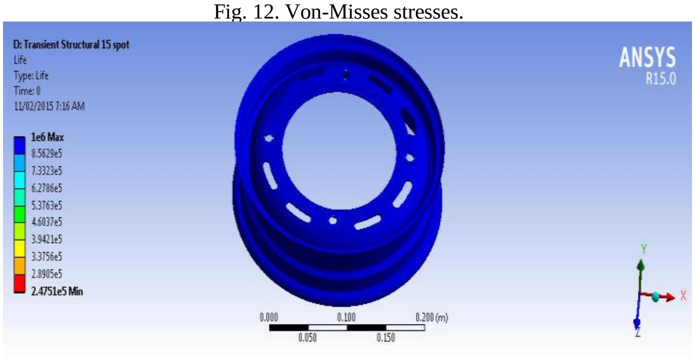


Fig. 13. Life of Rim.

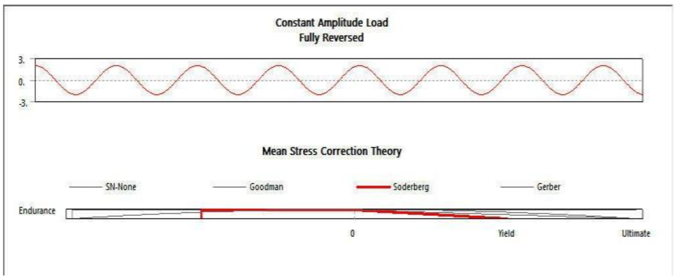


Fig. 14. Fatigue Life.

VI. Experimrntal Results

Following comparison in-between experimental and analytical results gives proper idea about stress over rim; elastic strain and life of wheel rim assembly comparative study easily evaluate optimization of no. of welding spots present in between wheel disc and rim assembly.

TABLE IV. Experimental Test Results

No of weld spots	Equivalent stress	Equivalent elastic strain	Total deformation	Life	Remark
24	$2.9413*10^{-6}$	$1.8914*10^{-6}$	$4.7434*10^{-6}$	$1*10^{-6}$	Pass

TABLE V. Analytical Results

No. Of Weld Spots		24	18	15
Equivalent Stress	***Max(pa)***	$2.9106*10^{6}$	$5.364*10^{6}$	$5.4929*10^{7}$
	Min(pa)	379.73	528.25	8706.9
Equivalent Elastic Strain	***Max(mm/mm)***	$1.9622*10^{-5}$	2.6742*10-5	2.7605*10^-4
	Min(mm/mm)	$5.1145*10^{-9}$	$2.3445*10^{-8}$	$1.8632*10^{-7}$
Total Deformation		$4.7024*10^{-6}$	$4.8762*10^{-6}$	$4.8739*10^{-5}$
Life		$1*10^{-6}$	$1*10^{-6}$	$2.47*10^{-5}$
Remark		Pass	Pass	Fail

VII. Conclusion

In this paper analysis of wheel rim cornering fatigue test have been proposed. From experimental & analytical data it's clear that a wheel rim of 18 weld spot can give same result as that of 24 weld spot for CFT test & optimization of wheel rim is achieved.

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