Dynamic Contact Analysis of Wheel and Rail Mechanism for Obtaining Maximum Contact Pressure

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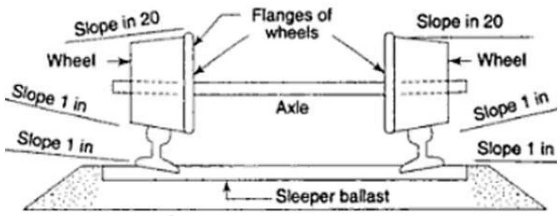
Abstract: **Railway transportation system, as one of the notable means of commuting systems serves for the human societies. The wheel–rail contact is a crucial component in the successful operation of railways. The stress distribution is an important factor at the Rail- Wheel contact interfaces, that is, two materials contacting at rolling interfaces which are extremely influenced by geometry of the contacting surfaces, material attributes and loading and boundary conditions. The rolling contact of a wheel on a rail is the basis of many Rail-Wheel related problems which include wear, plastic deformation, fatigue etc. Using CATIA, wheel and rail are modelled individually and assembled. The finite element analysis i.e ANSYS is used to perform the contact analysis by considering the loading and boundary conditions of the rail and wheel contact for a stress analysis. A 3-D finite element model of wheel and rail rolling contact is developed on the most critical section of rail track to analyse the maximum contact pressure using the phenomena of surface contact analysis module. The model generated should be accurately calculating the 3D stress response at the contact region of wheel - rail.**

Keywords :: Wheel – Rail Contact, CATIA, ANSYS

I. INTRODUCTION

Railway transportation system, as one of the notable means of commuting systems, has served for human societies and has pursued its improvements as other promoted aspects of life. The track or Permanent Way is the rail-road on which trains run. The track or Permanent Way is the rail-road on which trains run. It basically consists of parallel rails having a specified distance in between and fastened to sleepers, which are embedded in a layer of ballast of specified thickness spread over the formation. The rolling contact of a wheel on a rail is the basis of many Rail-Wheel related problems including the rail corrugation, wear, plastic deformation, rotating interaction fatigue, thermo-elastic-plastic behaviour in contact, fracture, creep, and vehicle dynamics Vibration. Therefore, it has attracted a lot of researchers to various railway networks. The stress distribution is an important factor at the Rail- Wheel contact interfaces, that is, two materials contacting at rolling interfaces which are extremely influenced by geometry of the contacting surfaces material attributes, and loading and boundary conditions.

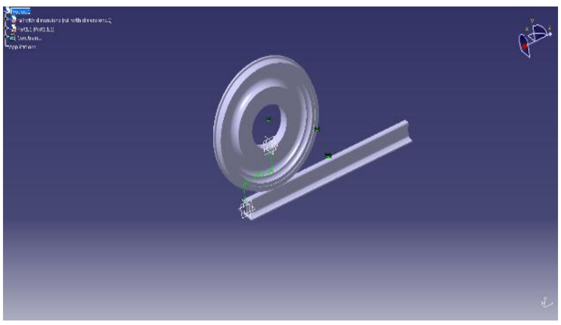
The contribution of this project is to establish a FEM model of rail and wheel interaction in order to evaluate the stresses, strains and the contact forces by considering the real condition of wheel and rail including boundary and loading conditions.



"Fig 1" : Assembly of wheel and rail.

II. CREATION OF THE MODEL

In CATIA V5, the components wheel and rail are modelled individually and assembled in order to obtain the complete model. The required data for the rail are obtained from [1].The slope of the rail in international railways can be either 1 : 20 or 1 : 40. The standard UIC 60 profile is considered for the interaction of contact forces and 1800mm is considered as the length of the rail. The standard wheel profile of 920mm diameter is considered for the modelling of the wheel[2].



"Fig 2": CATIA model of wheel and rail assembly

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A. MATERIAL PROPERTIES

Young's modulus 210Gpa

Material density 7820kg/m3

Yield strength 500Mpa

Ultimate tensile strength 880Mpa

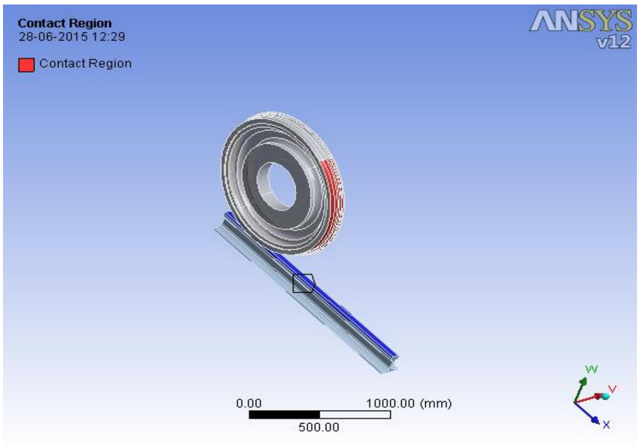
Tensile yield strength 540Mpa

Compressive yield strength 540Mpa

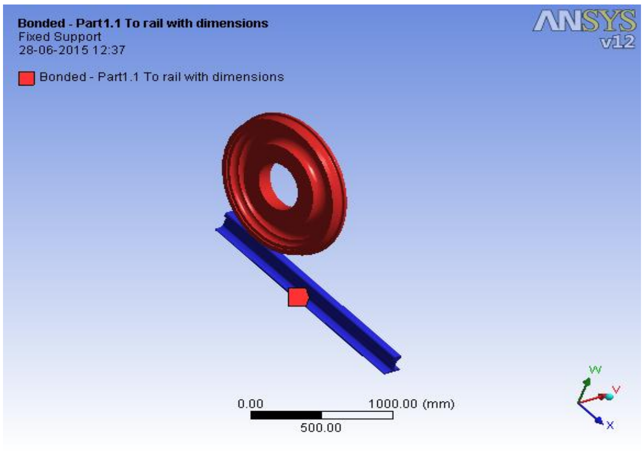
III. ANALYSIS

Fem is the process of breaking a complex structure into smaller parts to gain a better understanding of it. The model is divided into finite number of elements and analysed in order to view the displacement, stress, and thermal distribution plot etc. A 3-D finite element model for element model for wheel/rail rolling contact is developed on the most critical section of the railway track.

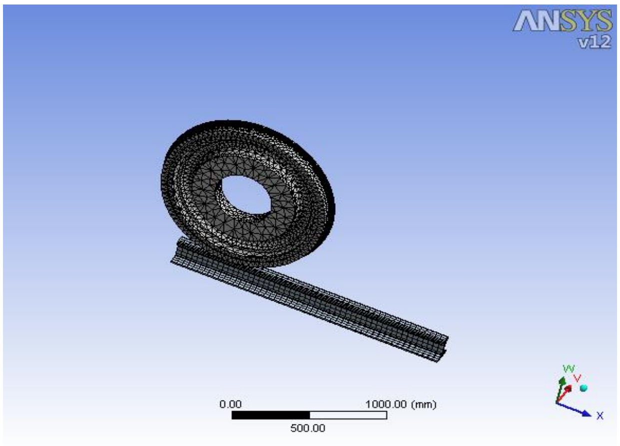
A 3D CAD model is imported in IGES format in ANSYS [4]. .The contact region is established to the imported model by selecting the interacting regions of wheel and rail. A Bonded contact is established between the two regions by selecting the interacting surfaces of wheel and rail. The meshing is performed by to the model with 49614 nodes and the 21263 elements.



'Fig 3": contact region of the wheel and rail



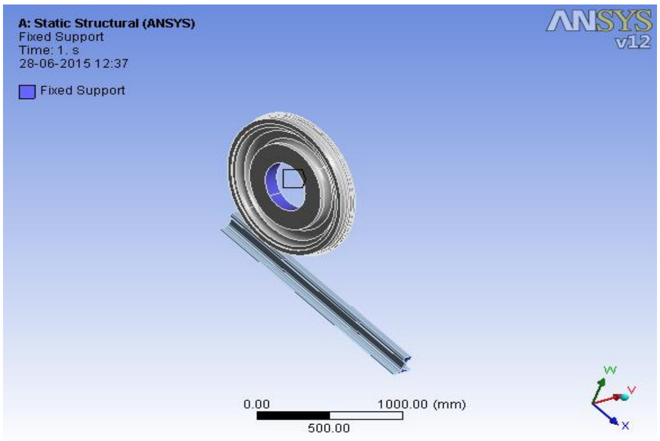
"Fig 4": Bonded contact of the wheel and rail



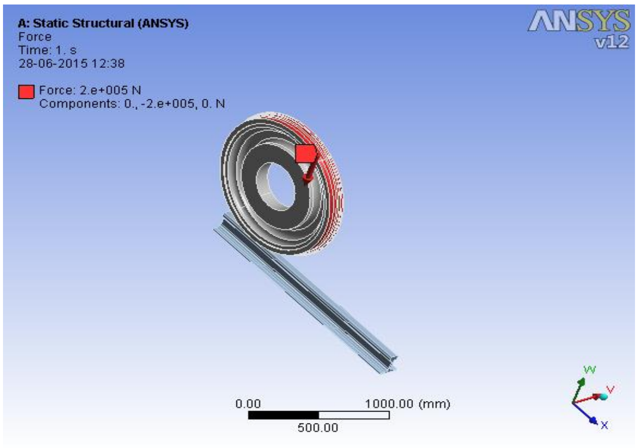
"Fig 5": Meshing

Now considering the boundary conditions of wheel and rail a static structural analysis is performed to the model.

The two ends of the rail is fixed las they are joined by the rivets and the centre of the wheel where the axle is placed fixed as the rotation of the wheel is not considered for static structural analysis. And the quasi static load of 200KN[3] is applied on the wheel in order to calculate the stress and strain. After applying all the boundary conditions on the model the solution is solved and the results are evaluated.



"Fig 6": Fixed supports

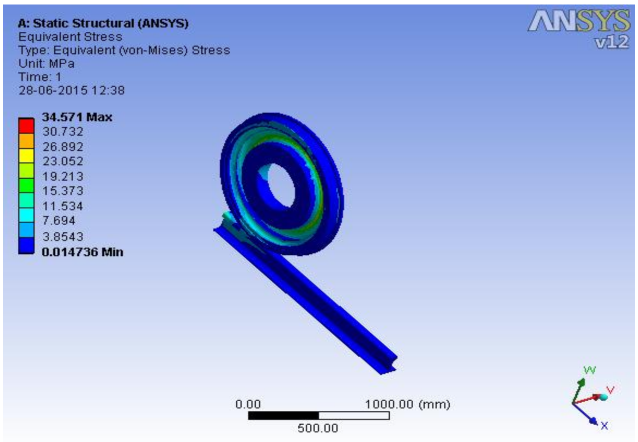


"Fig7" : Force of 200KN

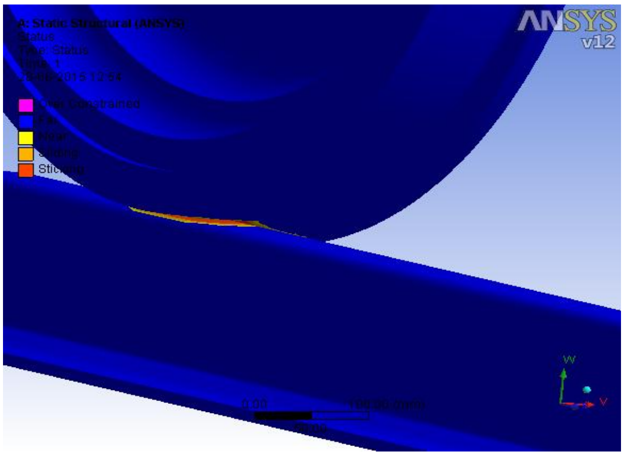
TRANSIENT STRUCTURAL ANALYSIS

The transient structural analysis is performed at varying time loads by applying the boundary conditions of static structural analysis. In this analysis the stresses at time interval t = 0, t = 0.25, t = 0.5, t = 0.75, t = 1 are evaluated and the contact status and pressure are analysed.

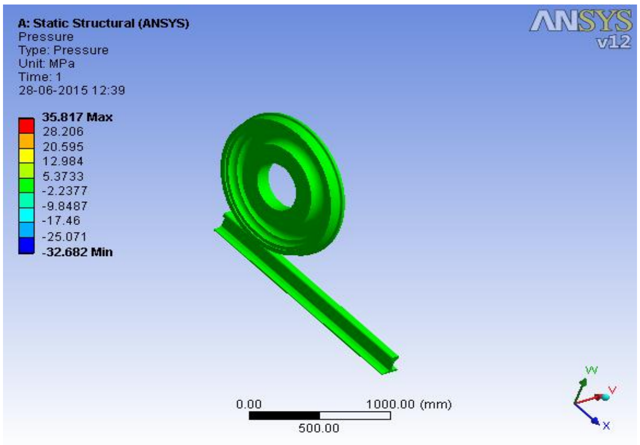
IV. RESULTS



"Fig 8": Von – mises stress

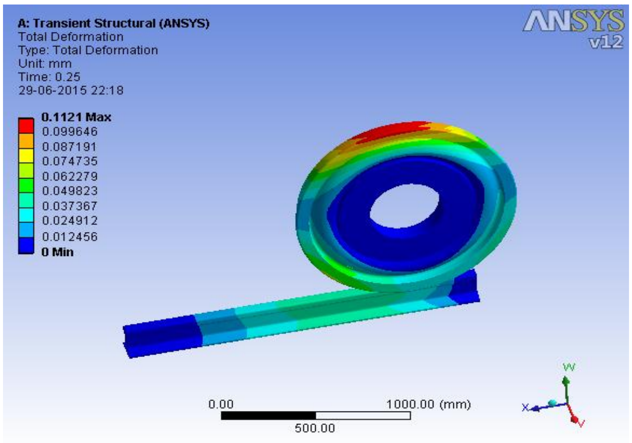


"Fig 9" : contact status of wheel and rail

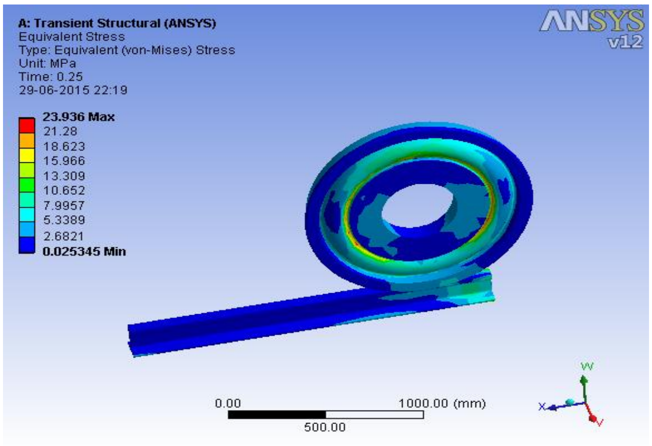


"Fig 10": Contact Pressure

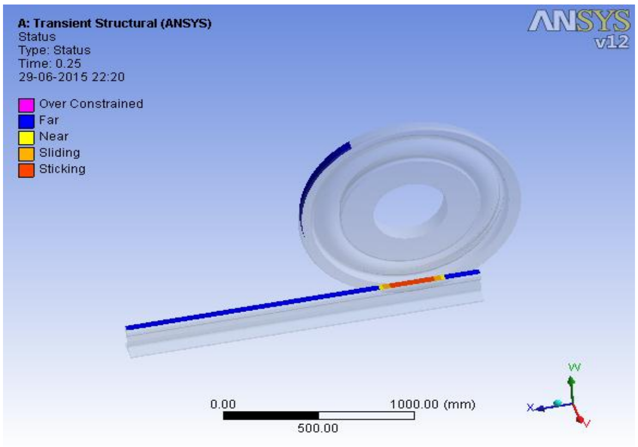
Transient structural analysis :



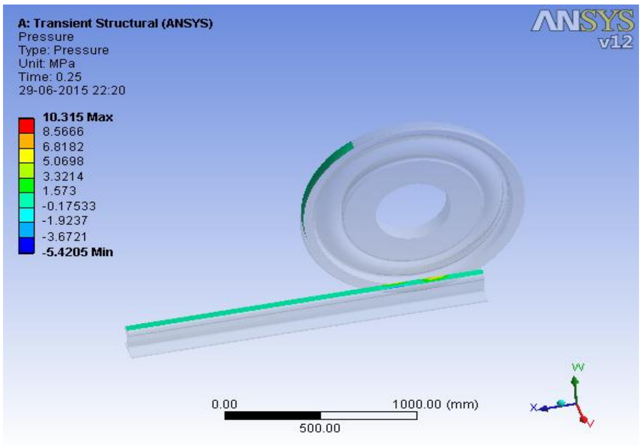
"Fig 11": Deformation at t = 0.25s



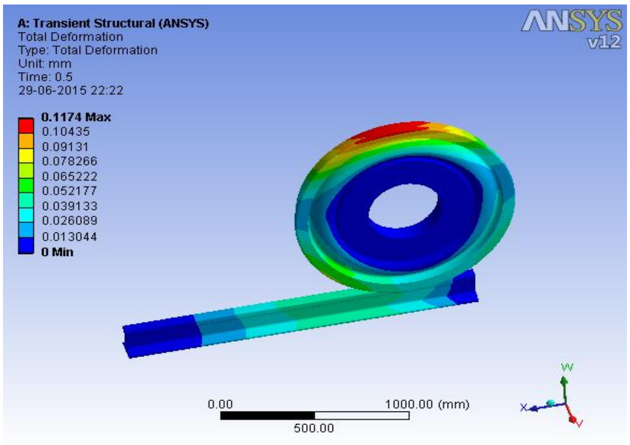
"Fig 12": Von – mises stress at t = 0.25s



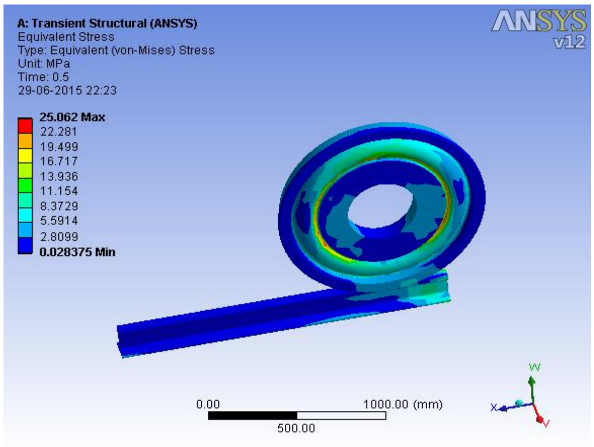
"Fig 13" : Contact status at t = 0.25s



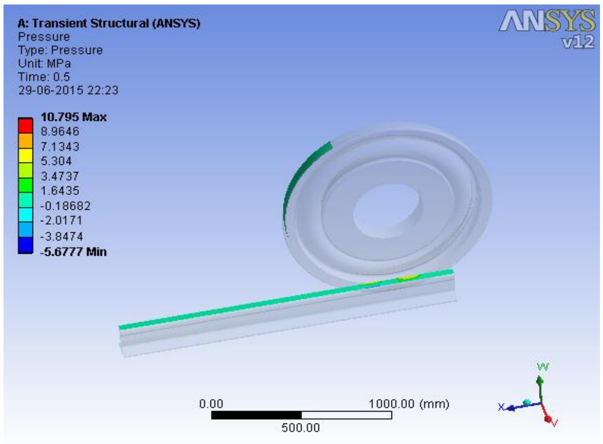
"Fig 14": Contact pressure at t = 0.25s



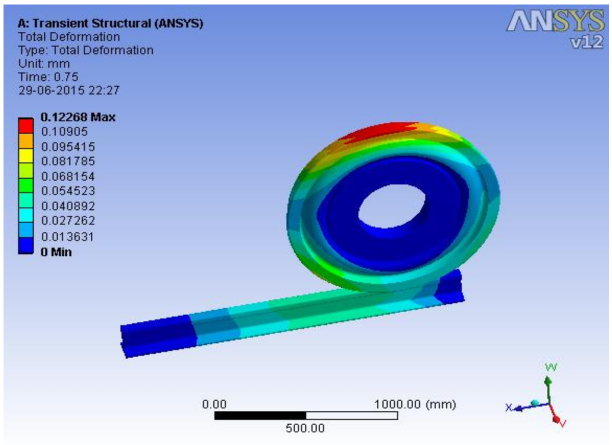
"Fig 15": Total deformation at t = 0.5s



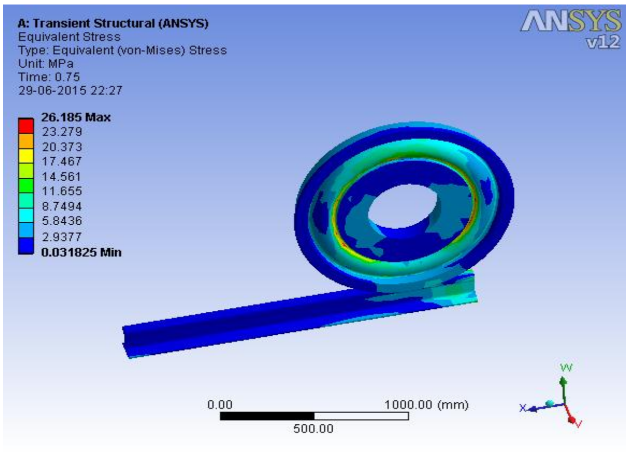
"Fig 16": Von – mises stress at t = 0.5s



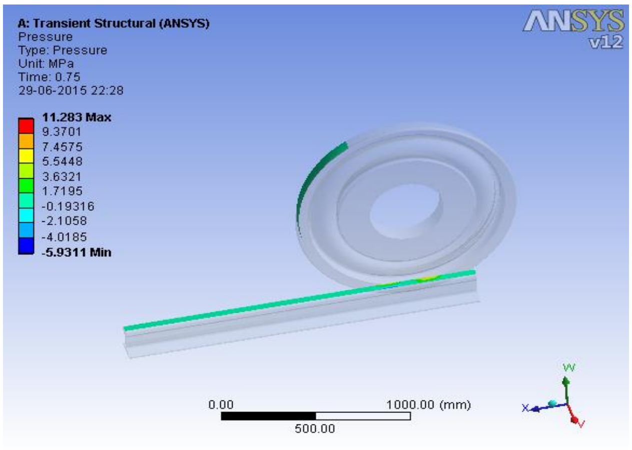
"Fig 17": Contact pressure at t = 0.5s



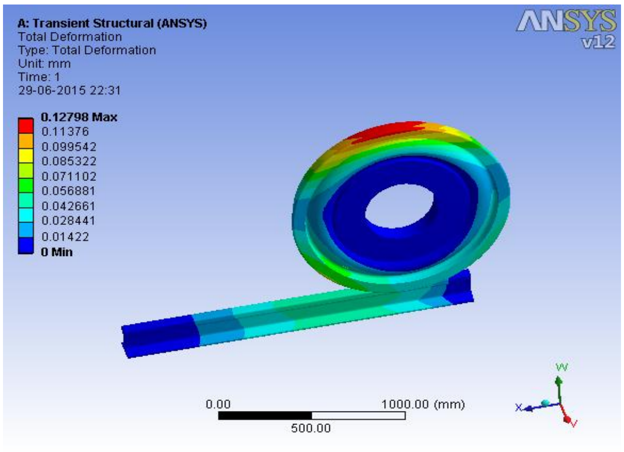
"Fig 18": Total deformation at t = 0.75s



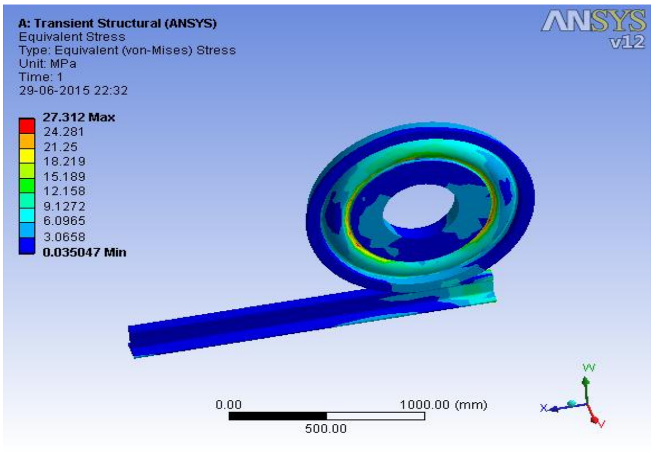
"Fig 19": Von – mises stress at t = 0.75s



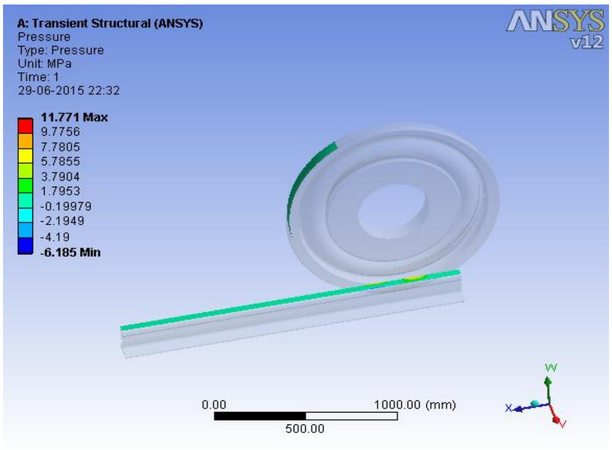
"Fig 20"; Contact pressure at t = 0.75s



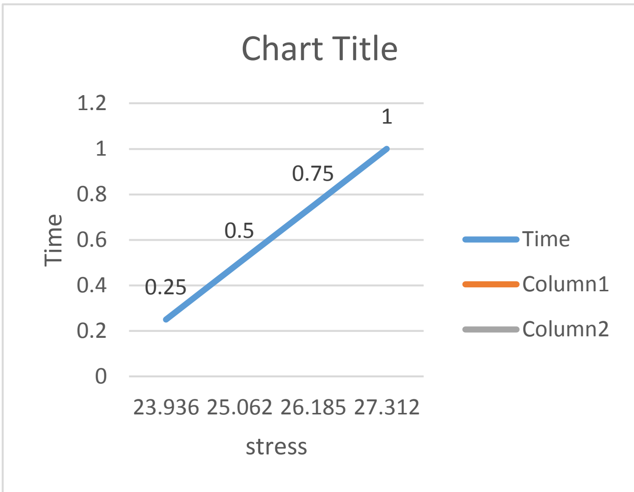
"Fig 21": Total deformation at t = 1 s



"Fig 22": Von – mises stress at t = 1 s



"Fig 23": Contact pressure at t = 1s



"Fig 24" : Time vs Stress

V. CONCLUSION

The analysis of stresses in rail and wheel are evaluated. The quasi static load condition is considered for the loading conditions on rail and wheel. Two analysis are performed and the results include :

1) Static Structural analysis :

- the maximum von mises stress is at value of 34.571 MPa.
- Contact pressure is maximum at 34.817MPa.

2) Transient structural analysis:

- At t = 0.25s, the von mises stress is maximum at 23.936 MPa, contact pressure at 10.315 MPa.
- At t = 0.5s, the von mises stress is maximum at 25.062 MPa, contact pressure at 10.795MPa.

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[2] Rail Profiles-Types UIC 60 and 60E, The International Union of Railways, 3rd edition,2002.
[3] UIC Leaflet 510-2: Conditions Concerning the Use of Wheels of Various Diameters, The International Union of Railways, 4th edition, 2004.
[4] A. Sladkowski andM. Sitarz, “Analysis of wheel-rail interaction using FE software,” Wear, vol. 258, no. 7-8, pp. 1217–1223, 2005.
[5] “ANSYS,” http://www.ansys.com.