Evaluation of Cyclic Stress Damage to the Mechanism of Rail Steels on the Curved Lines, Using the Soldworks Software.

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Abstract Title

Evaluation of cyclic stress damage to the mechanism of rail steels on the curved lines, using the soldworks software.

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Abstract

Rail transport systems are very important for the future to reduce fuel consumption and provide sustainable solutions to reduce carbon emissions. They enable more mobility with better energy efficiency, and they produce long-term cost-effective benefits. However, it should be noted that the cyclic force between the wheel and the rail on the curve line always cause problems and difficulties during the operation of the rails.
Maintaining rail transport systems is a priority by following a preventive maintenance program. Planning a preventive maintenance intervention requires good fault diagnosis.
Our study consists in modeling the fatigue effect on a simultaneous inner and outer rail section by the finite element method using solidworks software according to our analysis results. The traces of fatigue appearing on the inner rail are less significant compared to the outer rail. Accurate prediction of rail profile fatigue evolution to improve safety and reduce preventive maintenance costs.

Keywords: *Railway , Wheel-rail contact, Impact force, Fatigue, Solidworks.*

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1. INTRODUCTİON

Today, the railway is the most used method of transport. Transporting goods and passengers from one location to another Therefore, the safety and the dynamics of railway vehicles are strongly influenced by the interactions between weel rail and rail.

The alternation contact can cause severe damage on railway . Indeed, in curved line contact, the high frictional forces induce ratcheting below the contact surface, up to the formation of inclined surface cracks.Therefore, studying the interactions of the rail wheel and rail and analysis of the contact stress developed in this area is a crucial area in railway engineering.

Tramway transport is an effective achievement in the cities of Ouargla, in southern Algeria, as it has contributed to solving the transport problem. It also helped reduce greenhouse gas emissions from the combustion of fossil fuels.

Maintaining this gain is a priority, and this is by following a preventive maintenance program, in this study the use of the solidworks software it shows us the areas of high stress concentration in inner and outer curved rail.

Failures caused by rail wheel contact fatigue are unavoidable operational problems on the tracks due to the high stresses developed from the contact of these two elements and progressive damage assessment of cyclic stresses on the mechanism of rail steels on curved line railway [1].

Rails are of great importance in ensuring the safety and reliability of rail transport.

This study consists in modelling the fatigue effect on a section of tram rail, simultaneous, inner and outer by the finite element method using the software solidworks [2] [3].

The stresses generated by the passage of the wheel on the rail are obtained by applying a static load to the contact zone (wheel, rail) existing in the middle of two fixing points [4] [5][6].

The loads considered in our study are respectively:

- Vertical force equal to the weight of the tram and the passengers
- Horizontal friction force with a direction opposite to the movement of the tramway
- Centrifugal force relative to the speed of the tram and the radius of the rail.

2. METHODS

Table of main characteristics

N°	Description	Dimension
1	Length	43 760 mm
2	Width	2 400 mm
3	Empty weight in running order	54,92 t
4	Mass under normal load	75,92 t
5	The loading weight tram and 6 passengers /m^2	80 t
6	Maximum power at the rim (traction)	880 kW
7	Average acceleration under normal load in level	1,15 m.s^{-2} de 0 à 40 km/h
8	The speed in the curved area	10 km/h
9	Distance between the two points of fixation	700 mm
10	Rail gauge	1435 mm
11	number of wheels of the tram	16
12	The diameter of the wheels (new)	590 mm
13	Minimum bending radius	25 m
14	Young's modulus (MPa)	207 MPa
15	Density	7800 kg/m
16	Number of bogies	4

Our study consists of modelling the fatigue effect on a simultaneous, inner and outer tram rail section using the finite element method using solid works software. The stresses caused by the wheel arch on the rail are obtained by applying a static load to the contact area (wheel, rail) existing in the middle of two attachment points. The charges considered in our study are respectively: Vertical force, Horizontal friction force and Centrifugal force, the two rails of a section of tram Figure N°1 and Figure N°2.

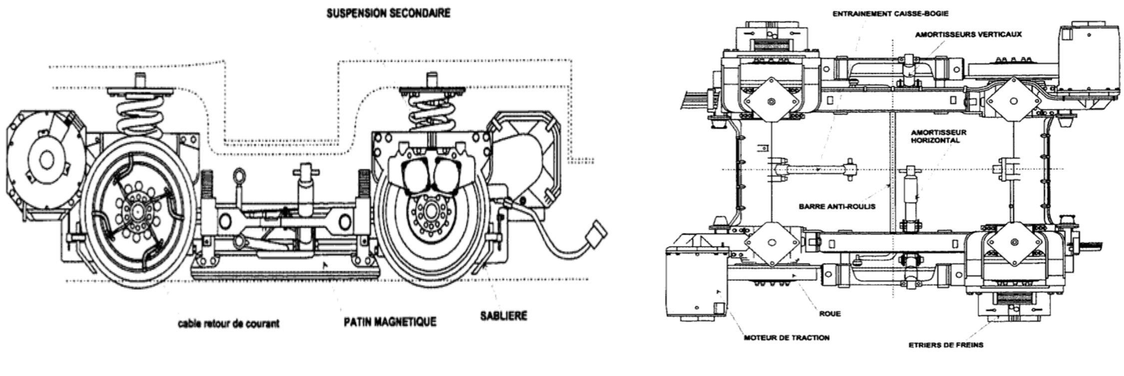


Figure N°1: Diagram seen from the side of the tram bogie

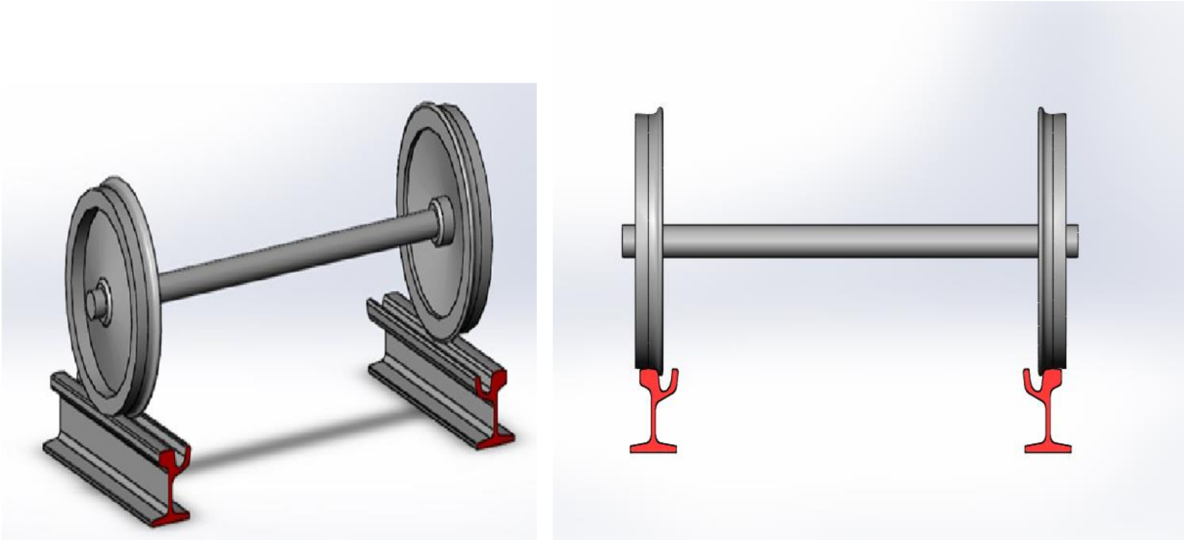


Figure N°2: 3D model of Wheel/Rail

Establishment of the calculation model:

All material properties and data of SETRAM Ouargla - Algeria, the company responsible for the operation and maintenance of tram lines.
The hypothesis considered in our study consists in blocking a section of inner and outer rail by its lower part with a recessed frame that prevents movement dx= dy=dz=0 and rotation redx=redy=redz=0 for points A and B shown in Figure 3.
That case her self-Translated in reality by the presence of bolts with platinum on two sides rail.
The distance between the two points of fixation is of L = 700 mm.

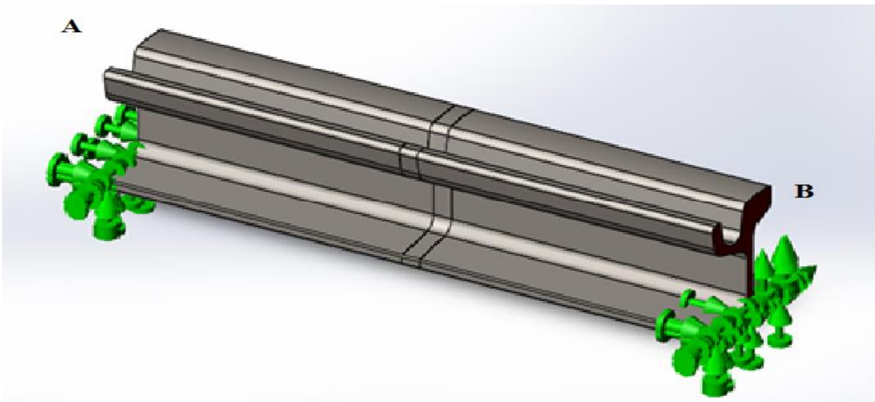


Figure 3: Points of fixation

The maximum weight of the tram is distributed distinctly on the rails outer and inner in two ways in the middle of the section on an area that does not access 10 mm wide. It represents the point of contact of the wheel with the rail. This maximum weight is schematized by a vertical vector equal to the sum of the weight of the empty tram plus the weight of the passengers that currency on 16 (16 represents the number of wheels of the tram). Figure 4

The vertical force

F_v = 80 Tone / 16 = 5 Tone = 50000 N.

The Friction force

F_f = μ x M xAcc = 0.1 x5000 x 1.2 =600 N with:

The coefficient of friction with lubrication between steel and steel is μ = 0.1
The acceleration in the curved area is 1.2 m/s^2

The centrifugal force

$$Fc = \frac{MV^2}{Rmin} = \frac{5000\,(\frac{10000}{36000})^2}{Rmin} = 1534\ N$$

The max weight is M= 5000 kg.

The speed in the curved area is V= 10 Km/h =2.77 m/s.

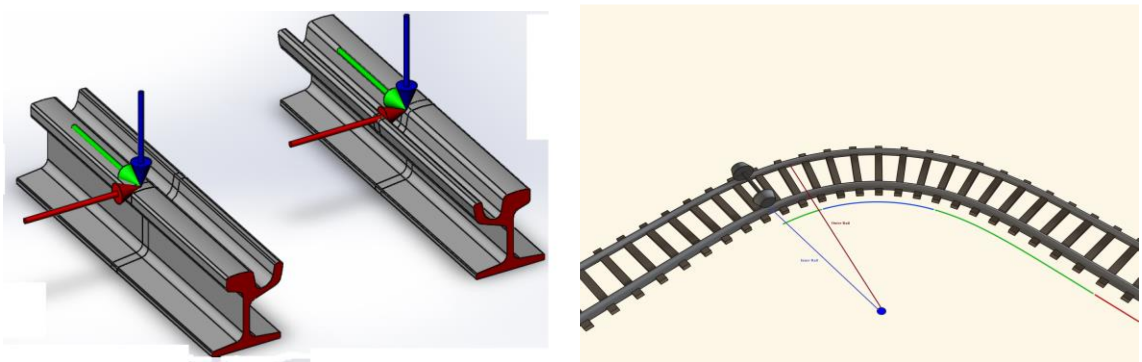


Figure 4: The distribution of forces acting tow rails (Inner and Outer)

3. SIMULATION RESULTS

The numerical fatigue analysis requires a static study of the forces applied to the outer and inner rail section. The cyclical loading of this event results in areas of fatigue appearing in the middle and lower parts of the rails.
The static numerical analysis of the 3D model under solidworks, allows us to obtain the distribution of the equivalent von Mises stresses , deformation and shear along the inner and outer rail.
Outer Rail In this case, static analysis was performed to determine the distribution of equivalent Von Mises, bending and shear stresses along the Outer rail. Figures 5,6,7, 8, 9 and 10 show the result of these constraints in the form of a gradient color diagram from blue to red. Blue represents the least infected areas and red represents areas of high stress concentration.

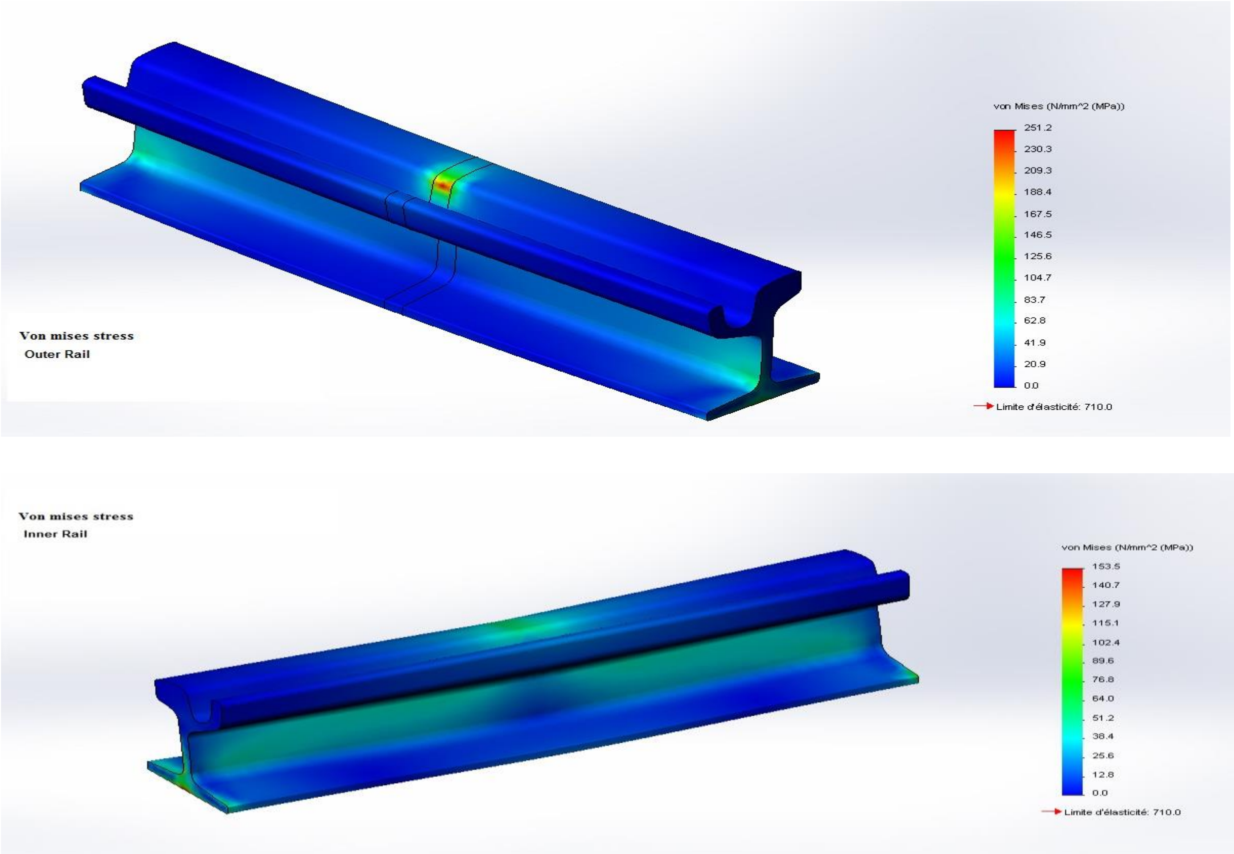


Figure N°5: Equivalent Von Mises stress

The curved track has a maximum Von Mises pressure of 153 MPa for the inner rail and 251.2 MPa for the outer rail, as shown in the figure above.

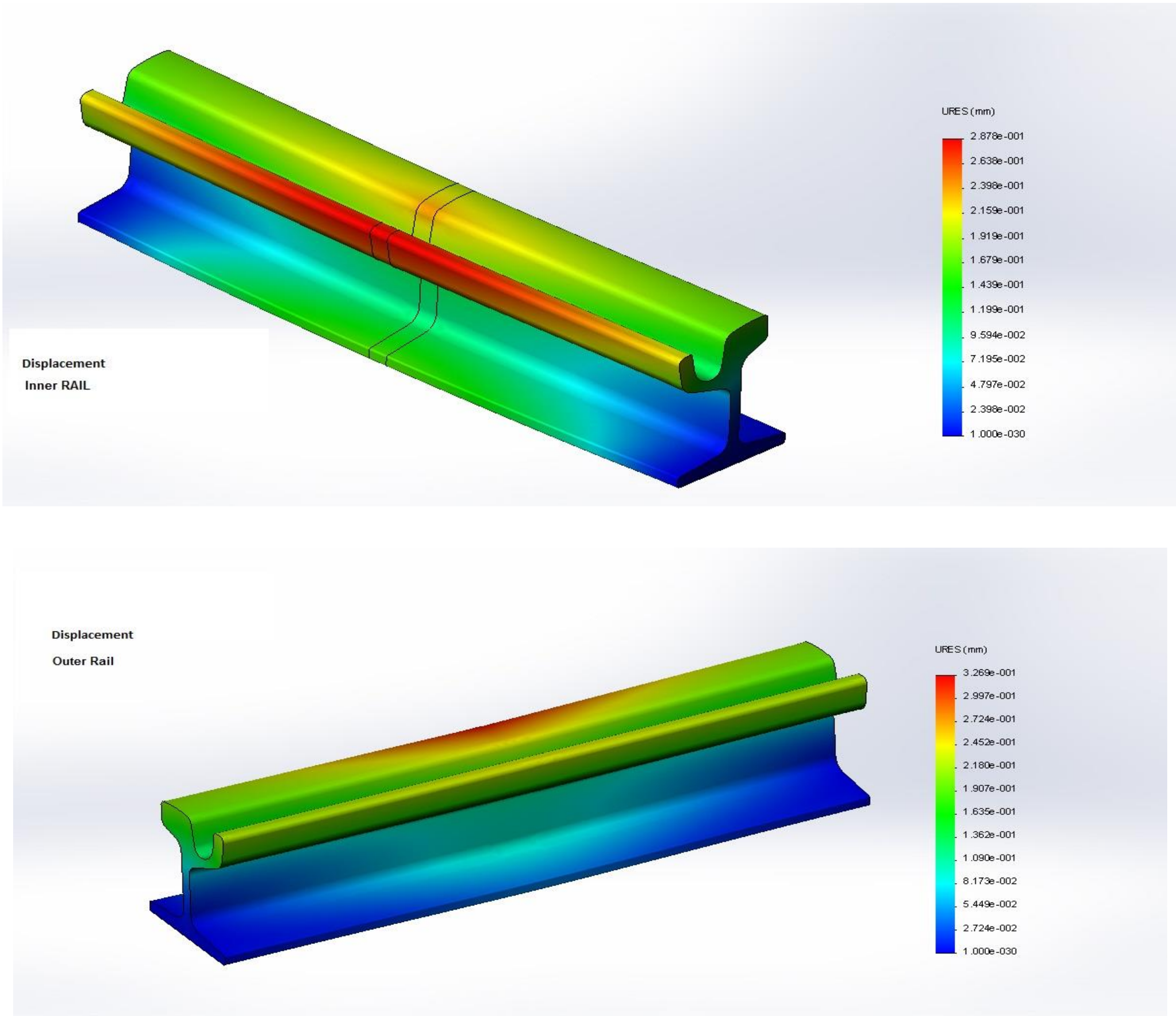


Figure N°6: Displacement

The curved track has a minimum displacement of 2.878 10^{-1} mm for the inner rail and has a maximum displacement of 3.269 10^{-1} mm for the outer rail, the blue color represents the places with minimal displacement and the red color represents the places with maximum displacement,as shown in the figure above.

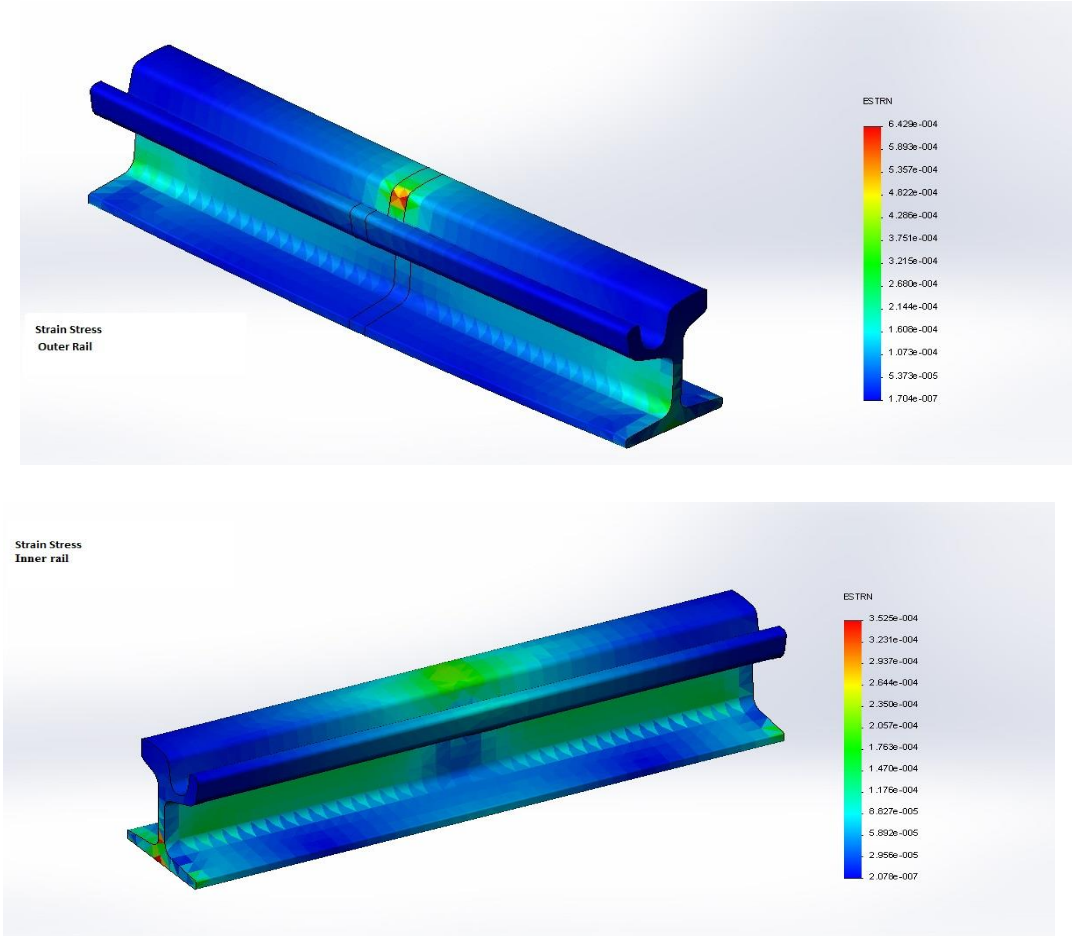


Figure N°7: Strain Stress

As shown in the figure above, the blue represents the least infected areas, while red represents areas with high stress concentrations (outer rail, inner rail).

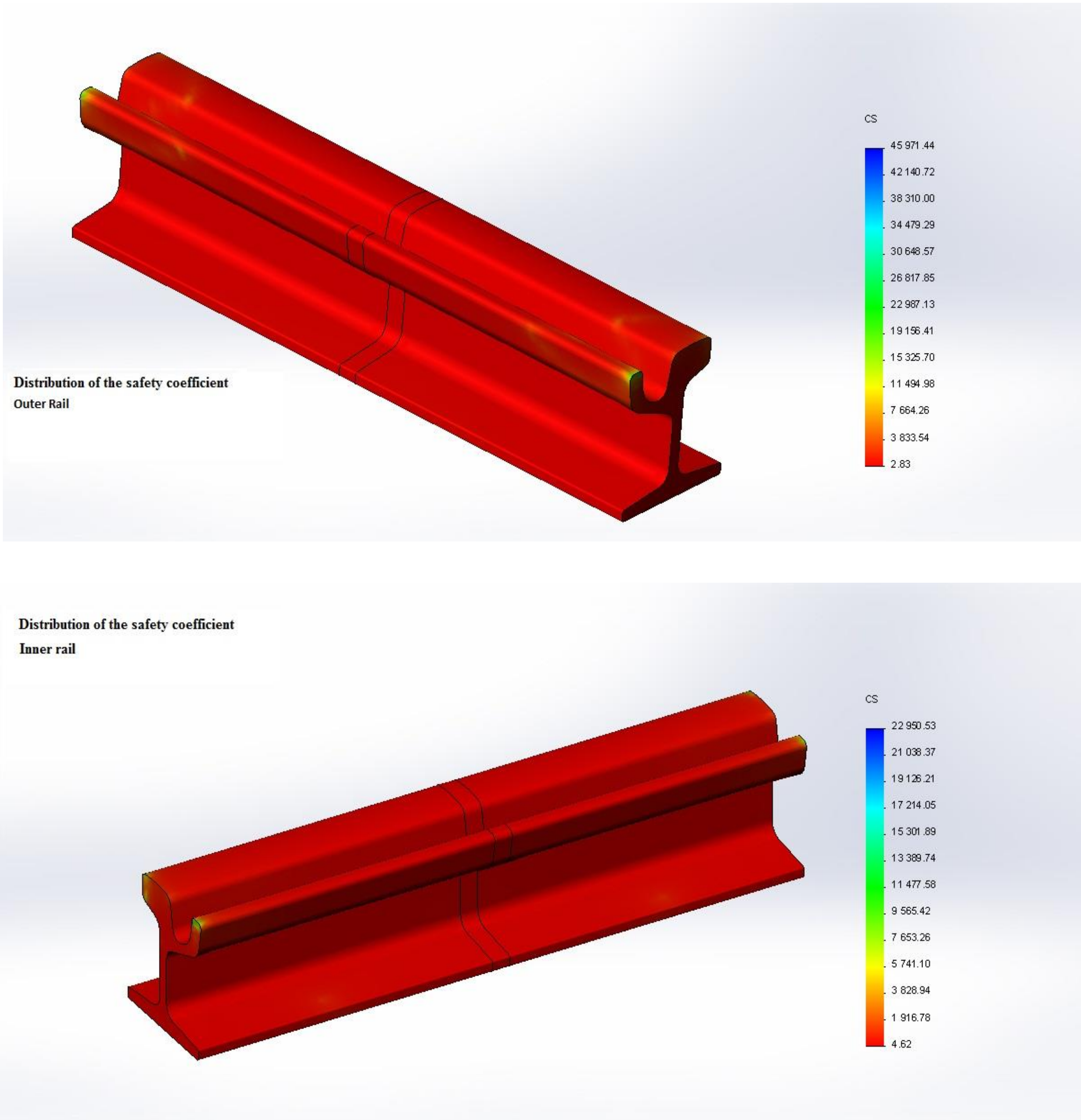


Figure N°8: Distribution of the safety coefficient

The curved track has a minimum safety coefficient is 710/251.2 = 2.83 for the outer rail a minimum safety coefficient is 710/153 =4.64 for the inner rail, as shown in the figure above.

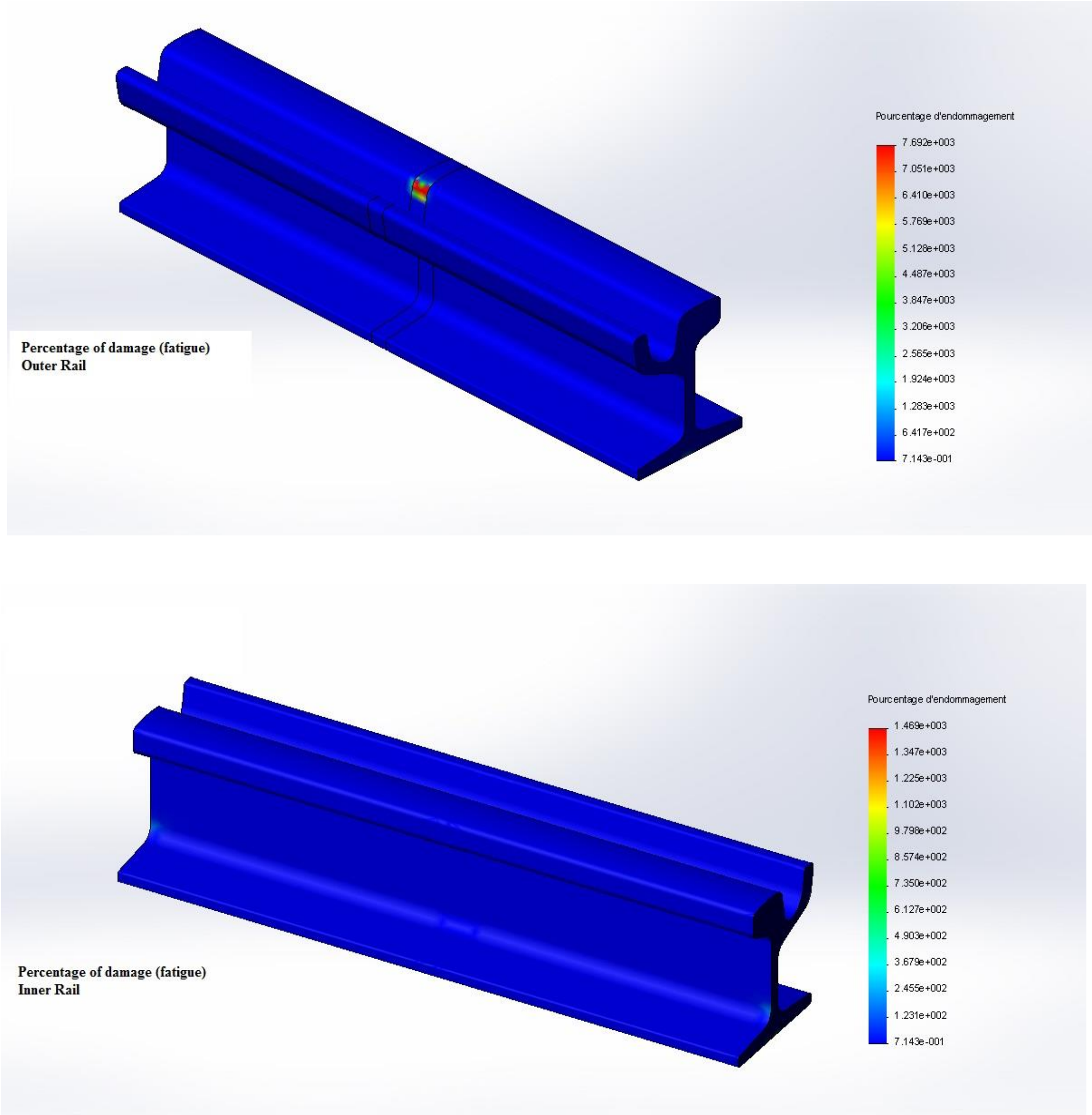
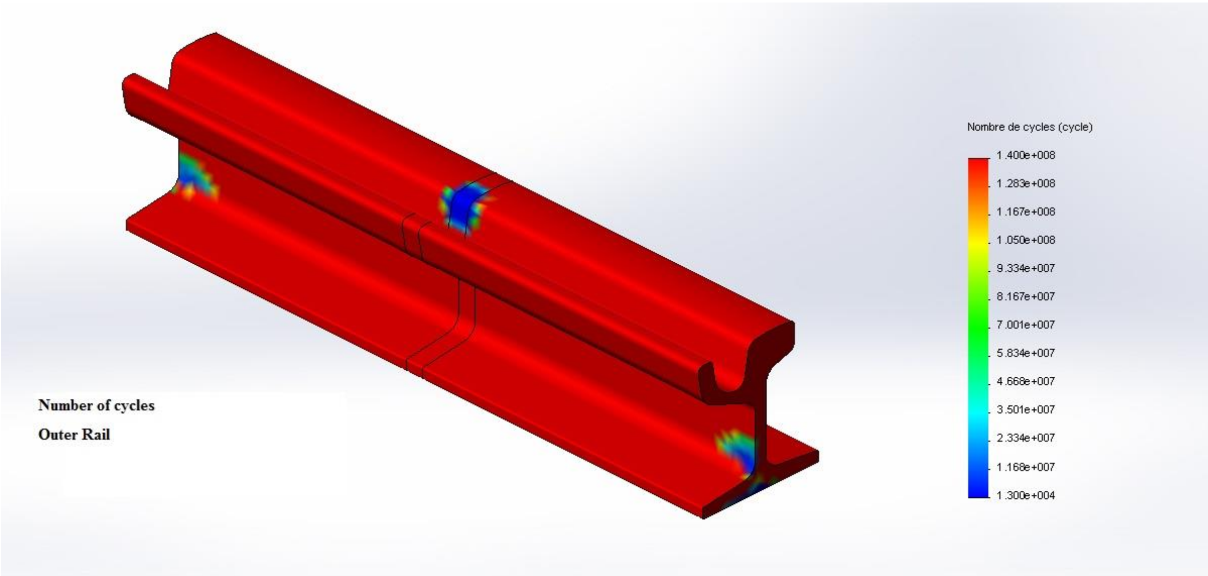


Figure N°9: Percentage of damage (fatigue)

As shown in the figure that the percentage of fatigue is more evident in the outer rail line in the curved rail line.



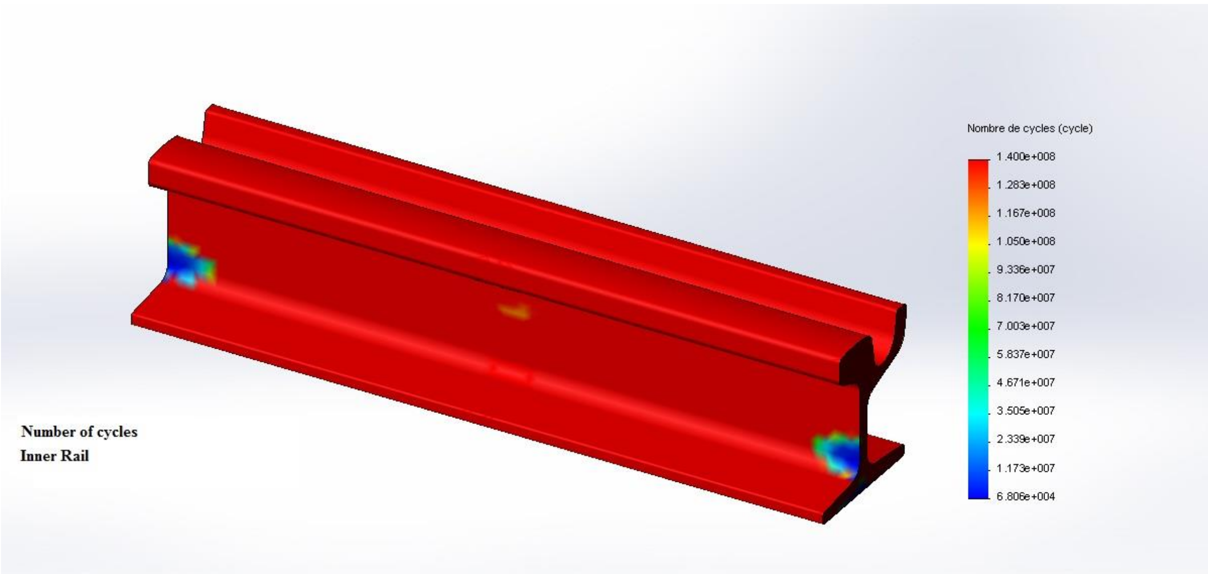


Figure N° 10 Number of cycles

As shown in the figure above ,the number of cycles for fatigue zone appearances is 1.4×10^8 for (inner/outer rail).

4. CONCLUSİON

The numerical analysis of a 3D rail under applied static load for the positions of a curved rail (Small radius)of transport has been investigated in this paper. The result was obtained using solidworks. Compressions of the rail between two sleeper attachment points.
According to our analysis results, the traces of fatigue appearing on the inner rail are less significant compared to the outer rail.
Good planning of non-destructive testing in the stress concentration zone will allow us to know the state of fatigue of the rail and perhaps the appearance of cracks for the treatment or to proceed with the change of rail in the curved area, to avoid failure.
An accurate prediction of the profile fatigue evolution of the rail to improve safety and reduce costs Preventive, it also contributes to the precaution against the sudden stop of the tram, which will affect the circulation of transport.

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