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Analysis of the Wear of Railway Turnouts in a Combined Method and Hardening Model

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ABSTRACT: Nowadays, the increase in axial load and speed in railway transportation systems has increased the amount of pressure applied to the surface and energy loss and has caused severe wear of turnout profiles, especially in turnout intersections. One of the major financial and physical losses to the country's railway is the train derailment in the turnout intersections. Due to the importance of turnout, it has been tried to study the role of damages caused by turnout wear of railway system and explain the necessity for such research, particularly in Iran, by studying this phenomenon and examining the ruling theories as well as collecting information. In fact, these studies are the starting point for a more precise investigation into this phenomenon. In the following, the movement of the train on a turnout is simulated in the universal mechanism software and the amount of force applied to the turnout and the wear energy is extracted. Furthermore, the effect of different parameters such as speed, axial load, friction coefficient, arc radius, and turnout profile on the rate of wear will be investigated. Then the turnouts are modeled on CATIA software and the forces extracted from the universal mechanism simulation are exerted to the turnout in the finite element method software, and the stress, strain, and deformation of the turnouts are investigated.

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1. INTRODUCTION

The turnouts are the most important parts in railway tracks, which involved in more than 50 percent of problems and delays in railway systems [1]. Therefore, this subject is interested in by many scientists in this decade. Petz et al. [2] has examined the crack of Rolling Contact Fatigue (RCF) in turnout, particularly in crossing nose, by applying Finite Element Method (FEM) analysis, considering three different material and simplified model. Blanco-Saura et al. [3] has investigated the vertical dynamic response by two different models (FEM and multibody dynamic), particularly in the frog and switch blade. Ma et al. [4] has studied the wear in the switch by defining a modelling strategy and considering an experimental validation of impact which is happened in crossing nose. Xu et al. [5] have introduced a numerical method in order to examine the wear of switch by considering the variation in input data. This method is on the basis of the multibody dynamic model of the switch. Xin et al. [6] has studied some dynamic response, for example, acceleration, contact force, and displacement of crossing nose by using a model. Xin et al. [7] has studied the welding and grinding effect which are the main part of the maintenance process of switch that operates on the crossing nose. He studied by a model which has built by combining main cross-sections geometry. Xin et al. [8] has studied the fatigue life of turnouts by considering a wheelset on crossing nose and using the FEM model. Nielsen et al. [9] has examined the wear and Rolling Contact Fatigue (RCF) in a turnout on the basis of the Archard model and theory of shakedown in the simulation of the turnout and wheel interaction.

In this article, the multibody dynamic model and FEM model have been provided and the new combination of these models has been used in order to investigate the wear and deformation in turnouts. Moreover, Kinematic and isotropic hardening has been considered which are caused by impact in the crossing nose. The longitude creepage, lateral force, frictional energy based on Archard model, and vertical load in railway turnout and wheel have been obtained by using multibody dynamic model and considering the variation in velocity, the load of wagon and profile of turnout. This result has been used in the FEM model to investigate the deformation on crossing nose.

2. MODELING

A freight wagon has been modeled in Universal Mechanism (UM), which is multibody dynamic software. The model has been shown in Fig. 1.

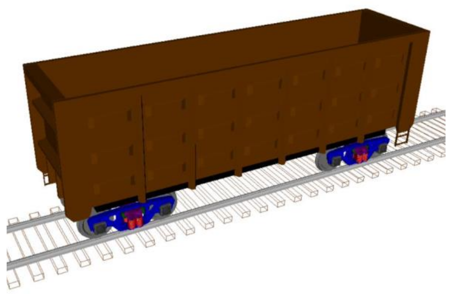

Fig. 1. Model of freight wagon using 18-100 bogie

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The model has been validated by the Ref. [19] which has investigated the derailment factor. The result can be seen in Fig. 2.

As it can be seen in Fig. 3, The FEM model has been provided in ABAQUS software by considering the kinematic and isotropic hardening for the material of turnout. The result has been compared by [7], that the error is less than 15 percent for different distance from the tipoff crossing nose. The result can be seen in Fig. 4.

3. RESULT

The result comparing different parameters such as creepage, vertical and lateral force and frictional energy for a variation of velocity, profile, and radius of curvature in multibody dynamic. The result has been shown in Fig 5.

The result of the vertical load and the most critical spot

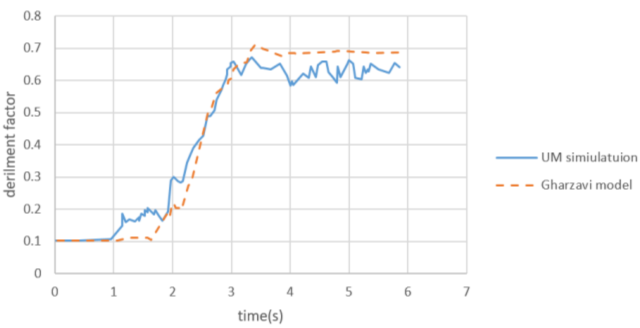

Fig. 2. Comparison of derailment factor in 200 meters curve

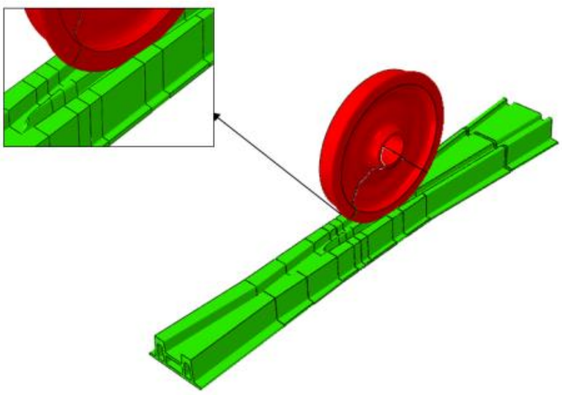

Fig. 3. The FEM model

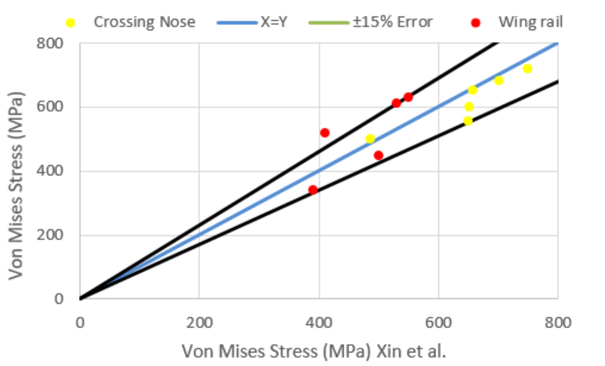

Fig. 4. Comparison of stress in turnout at a different distance from the tip of the crossing nose

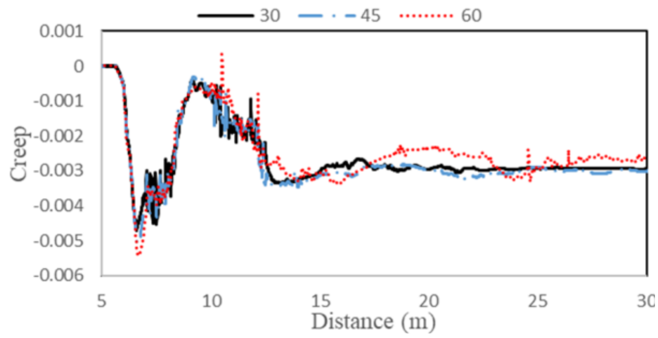

Fig. 5. Creepage in rail/wheel interaction as the velocity has change

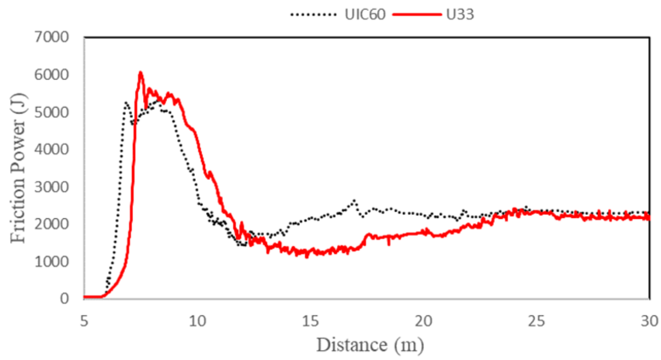

Fig. 6. Frictional power for different profile (UIC60 and U33)

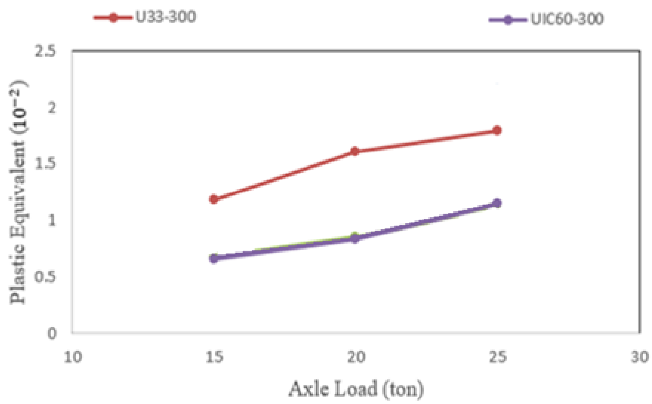

Fig. 7. Result of different plastic deformation by considering the kinematic and isotropic deformation.

has been obtained by the multibody dynamic analysis and applied to FEM analysis the result can be seen in Fig. 7.

4. CONCLUSION

The results show that incising the axle load by 66 percent, frictional energy has been increased by 80 presents at the curve and 86 percent at the crossing nose. The plastic deformation in U33 is larger than UIC60 by 94% which is caused by the differences in their geometry.

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