ABSTRACT

Main scope of this study is to determine whether train set layout is an important factor in deciding train wheel wear. Furthermore the study explores if wheel wear distribution is influenced by distance crossed by the track.

In order to analyze above relationships, in this research it is followed a two case scenario comparison methodology. In order to simulate real life conditions of wheel friction with train set surface, an experimental mechanism has been created. Firstly, an algorithm is modeled in MATLAB, and thereafter it has served as input for VAMPIRE to perform a dynamic analyze where in order to achieve representative results, simulation of train track journey is repeated various times.

From this paper results it was verified that: (1) when comparing wear depth in different train set design there emerge significant differences between train sets with severe curves and train sets with light curves, where in severe curves train sets layout wear occurred faster (2) train wheel wear percentage is greater during the first kilometers of journey and it comes decreasing during last kilometers in curved train sets and tend to be uniform in straighter train sets layouts.

Key words: Wear, Train Set Layout, Vampire, Distance

INTRODUCTION

Prediction of wear in mechanic structures is becoming more and more important in recent year, including a wide range of industries.

John M. Thompson and Mary Kathryn Thompson (2006) highlight a severe limitation of most part of wear computation papers. They emerge and interpret their results in terms of finite element analysis. But as Williams (1999) points out in real life situations trainsets are characterized by detailed component of the structure, which should be addressed.

But, given the devolvement stage of technology nowadays, it is possible to undertake a detailed analysis of several outside conditions implicate wear, without being conditioned to the number of elements.
included in the model (as posed to finite element analysis undertaken until recent years). It is a must that in these computations, simulation should be as close as possible to real life conditions.

To evidence this type of advanced methodological approach, train wheel ear will be subject of analysis in this paper. During the research, the interest relationship analyzed is: correlation between wear and complicated geometries of train set layout.

**LITERATURE REVIEW**

In the spectrum of wear computation papers, there have emerged several models which aim at best framing real life conditions.

According Stoker (2006) the most relevant equation that predicts wear is Archard Equation. According it, wear is derivative of integration of surface conditions, applied load and the wear per unit load per sliding distance. Another wear prediction tool is wear map developed firstly by Lim and Ashby (Ludema, 1996; Lim, 1998). They correlate asperity temperature and create several dominant wear models. Holm calculates wear as function of the dimensionless wear coefficient, the Brinell hardness of the softer material, and the normal force (Mukras, Kim, Sawyer, Jackson, & Swanson, 2006).

In recent years have emerged studies which implement the so called scenario methodology. They use sophisticated software’s in order to fully explore relationship between different variables (Pombo, 2012; Asadi & Brown, 2008; Wu, 2009; Ohlsson & Rosén, 1993; Barone, Borgianni, & Forte, 2004).

From all these models, the most important conclusion which may be derived is: there dies not exist one best universal model which predicts wear in all possible conditions and situations.

Given this, in this paper a simplicity model is designed which aims at addressing the direct relationship between the interest variables.

**METHODOLOGY**

How does train set design impact railway wheel wear \(^{(1)}\)?

In order to analyze a potential correlative relationship between these two variables, in this research it is followed a two case scenario comparison methodology.

**EXPERIMENTAL PREREQUISITES**

Control variable in this model is of course train set design. For study purposes, chosen train set have the following characteristics: (a) numerous curves, (b) mostly straight segments.

Apart from these different characteristics (train set layout design), both these experimental trainsets will be subtracted to exactly the same conditions: (a) distance length (7000 km), (b) track, (c) traveling distance, (d) number of track journeys, (e) starting conditions of track wheels (new wheels, never used before), (f) train velocity during crossing of the selected distance (belonging the interval between 70 km/h to 90 km/h), (f) processed with the same software: VAMPIRE\(^{(2)}\).

In order to achieve representative results, simulation of train track journey is repeated various times.

It must be noted as well that in order to initially design train wheel wear simulation model, MATLAB was exploited. It was this model that was used as input for VAMPIRE, which was responsible for transforming this model into dynamic mechanism, which aim at approaching as close as possible to the real conditions of traveling by train.

Graphical representation of the second trainset design is given in figure 1. As may be seen this experimental trainset design, more than 80% of the second one it is composed by curves greater than 500 radius, while the first chosen trainset design is characterized by approximately 70% by curves less than 500 radius.
Train Wheel Wear Variability In Terms of Train Set Layout

RESEARCH RESULTS

General Results
Wear evolution results in both train sets (first train set: 70% of it composed by curves less than 500 radius and second train set: more than 80% composed by curves greater than 500 radius), for left and right wheels, after experiment has finished are presented in the following graphs.

As can be easily perceptible from the above graphs, when evaluating differences between right and left wear evolution (mm) in the train set, the following results emerge:

- There are irrelevant differences from wheel wear evolution in the dominated from strong curves trainset and in the train set dominated by a few light curves.
- Software results after processing the data given in prerequisite experiment section of this research, suggest that train set layout design is not a statistically significant influencer over train wheel profile.

Figure 1 Total curves (%) according intervals of curved radius of the second trainset design
General relationship between wear depth values in different trainset design

Wear depth values obtained when travelling on the two tracks, after 7000 km of operation, is presented in Fig. 13.
Figure 3 Right and left wheel wear depth in trainset 1 and 2

Wear depth of right and left wheel are calculated as a product wear depth value in mm, divided by maximal wear depth achieved during experiment.

When comparing wear depth values of left and right depth in both transets (light and strong curved) following results emerge:
• Maximum difference between wear depth values of left and right depth in both transets is 42% (where wear depth in curved trainset is 35 % and wear depth in straight trainset is 20 %).
• Minimum difference between wear depth values of left and right depth in both transets is 35% (where wear depth in curved trainset is 91 % and wear depth in straight trainset is 68.25 %).
• Train while wear depth is not the same in all the trainset crossed by it. It is observed that maximal wear depth in both curved and straight trainset are observed in extremities of profiles while, and in intermediate segments wear values range from 18% to 65%).

Correlation between train wheel wear level and trainset design, when using distance as a control variable:

In curved train set, it is has resulted that most of wear is accumulated in the first half part of the journey and in the segments where flanges are concentrated. In straight train set it was observed an equal distribution of wheel wear evolution among all the journey.

CONCLUSIONS

This paper has presented a step by step approach in evaluating and predicting train wheel wear in terms of trainset layout crossed by track. Methodology used in for this research purposes is case study scenarios approach. In this research it has resulted that when comparing wear depth in different train set design there emerge significant differences between train sets with severe curves and train sets with light curves.

Train wheels are consumed 35% to 42% faster in curved train sets then in straight train sets. Furthermore, train set layout is a very important variable when controlling for train wheel wear percentage distribution. From this paper research has resulted that train wheel wear percentage is greater during the first kilometers of journey and it comes decreasing during last kilometers in curved train sets and tend to be uniform in straighter train set layouts.

REFERENCES