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RAILWAY SWITCHES WEAR IMPACT ON DYNAMIC ACTIONS

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Abstract: *Railway switches represent sensible points of the rail superstructure, which have to be replaced with a higher frequency than the rest of the railway track components. Switch failures can lead to major safety problems and have in the same time, a high impact on the annual cost of rail maintenance. Dynamic loads severely damage the turnouts due to discontinuities in rail geometry in the switches area. The dynamic performance of a railway vehicle depends on the track geometry, vehicle conditions or curve negotiation. The dynamic forces that occur in the switches area are affected by the geometrical proprieties both of the wheel and of the rail. The paper presents geometrical measurements for new and for worn switches, comparing the two situations regarding the importance of maintenance works with its effects on the dynamic forces from the vehicles in the switches area.*

Key words: *railway switches, rail maintenance, dynamic load, crossings*

1. Introduction

Railway switches or turnouts have an important part in railway superstructure, being the elements that allow trains to be guided from one direction to another along the tracks, at junctions. Turnouts are sensible points on the track, causing frequent failures and derailments due to insufficient maintenance and dynamic forces that occur between rail and vehicle wheel. Due to switches discontinuities at the crossing nose, the impact loads from the wheels cause various types of imperfections, damages and failures, causing disturbances and delays in the railway network [3] (Figure 1).

Damages of the crossing nose are the result of high frequency impact loads that are located at the transition point where the wheels are switching from the wing rail to the crossing nose of the turnout at junctions. The forces that occur are present in cases of rail geometrical imperfections (short waves irregularities) [1].

The impact loads have a cyclic behaviour causing plastic deformations until the rails develops small cracks in the crossing nose area (Figure 2) that propagates, a process with a significant impact on the life span of rail structure [3].

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Fig. 1. *Railway switch – crossing nose*

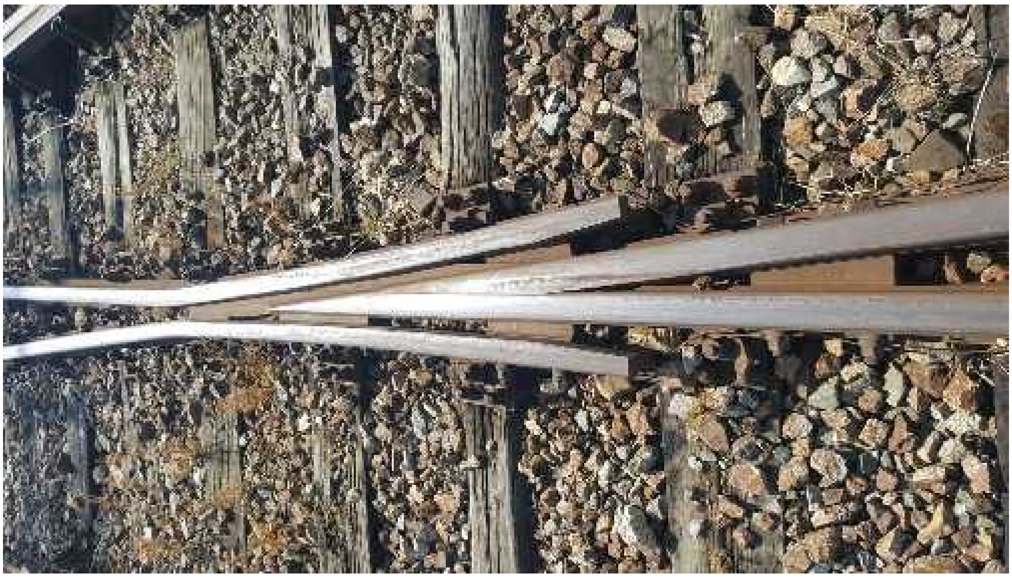

Fig. 2. *Crossing rail*

2. Switches Geometry

The most used types of switches are the straight switch, the curved switch and the semi-curves switch. Turnouts can be used both for continuous welded track as for joined track. Switches consist of stock rails, switch rails, base plates, slide chairs, switch rail studs and anti-creed lock. The sleepers along the switch have various lengths, according to the switches radius and deviation.

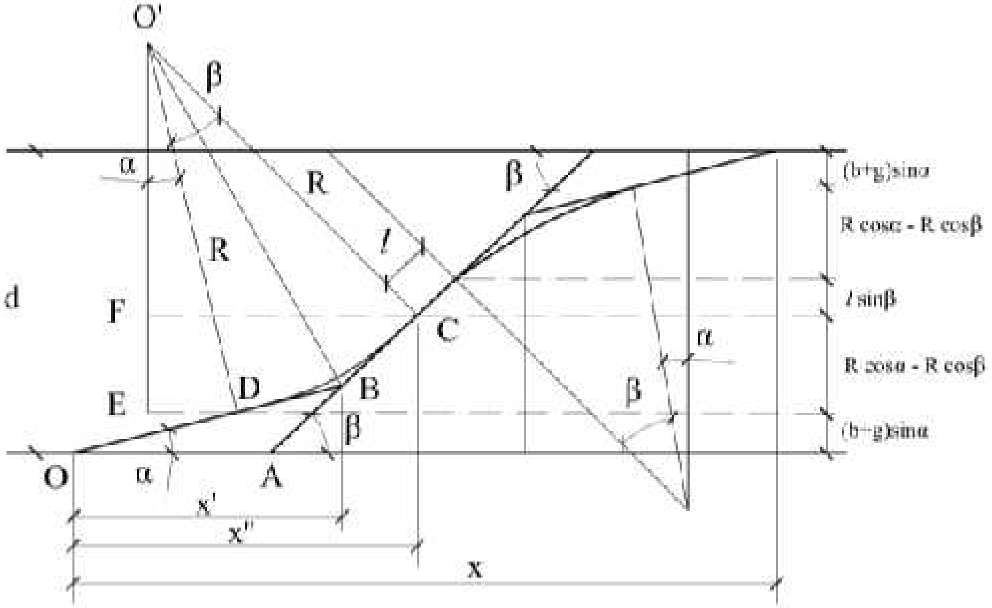

Fig. 3. *Geometrical elements for turnouts*

Figure 3 presents the geometrical elements for turnouts:
R – Radius of the switch
l – Alignment between the two adjacent curves
α – Switch deviation
d – Rail gauge.

Passing through a turnout, at the wheel/rail contact, high lateral forces and accelerations can develop, especially in the switch point and crossing nose area that can determine a lower operating speed with adverse effect on the railway network and ride quality. Some additional measures can be taken, in order to improve the switch geometry such as: reducing the switch point angle (the cause for the highest lateral forces) and realignment of the closure curve in order to compensate for the length increase of the switch and the reduced switch angle, as shown in [4].

The smaller the switch tangent is, the bigger the length of the switch, therefore, the radius of the curved line may be larger and thus the switch will allow the trains to travel at higher speeds on the deflected line. By way of example, switches with tangents smaller than 1/10 with the radius of curvature of 500 m allow trains to run on the downhill line at a speed of 65 km/h and in the case of 1/8 tangent switches with curve radius between 160 and 180 m, the speed circulation is much lower.

Turnouts are subjected to dynamic loads; the dynamic coefficient varies with the speed and wheel/rail imperfections [2].

3. Gauge and Level Switch Measurements

The admissible toleraces for railway switches are mentioned in three different points of the turnout: in any point with the exception of the frog and heart, at frog point and at the heart point. The values are presented in Table 1 and are regarding to maintenence works, replacement and repares.

Admissible tolerances for rail switches Table 1

Intervention type	Admissible tolerances regarding the switch wit standard gauge [mm]		
	In any point with the exception of the frog and heart	At frog point	At heart point
Turnouts assembling with new materials	+2 -1	+1 -1	+1 0
Turnouts assembling with refurbished materials, radical repairment and periodical repairments	+3 -1	+2 -1	+1 0
In use: - Gauge 1435 mm - Gauge 1433 mm	+5 -3 +5 -1	+4 -3 +4 -1	+3 0 +3 0

Measurements were made for two similar switches, both with the radius of 300 m and deviation 1:9, the first one recently set into place, the second with important imperfections.

The values measured in different points of the two turnouts considered, are presented below, in Table 2.

Gauge/level dimensions Table 2

Gauge/level dimensions [mm]	First joint	Flangeway	Frog heel main rail	Frog heel curved main rail	Curved main line half length	Hell block main rail	Hell block curved main rail
New switch	0/4	0/5	5/2	5/4	10/3	-1/5	3/6
Deteriorated switch	15/-16	12/-13	13/-11	12/11	15/11	7/-10	8/10

The values measured were noted with the symbol + for the cases where the right rail was detected lower than the left rail and with the symbol – for the cases where the left rail was higher than the right rail.

Table 2 shows important deviations from admisible values for the deteriorated switch, its geometry contributing to high stress in the frog area due to stock rolling, compared with the admissible ones, presented in Table 1. The deteriorated geometry of the switch can lead to a more pronounced wear, both to the rail and to the wheel, propagating vibrations and noise.

Figures 4, 5 and 6 show the measurements made on the deteriorated swich:

Fig. 4. *Gauge measurements at first joint*

Fig. 5. *Gauge measurements at frog heel main rail*

Fig. 6. *Deteriorated switch, frog area*

Liftime distributions for turnouts depend on failure reparement or replacement, parts used and equipment type. A strong influence on the possible early life failures is an ineffective maintenence and a too long observation period [5].

Deflecting forces can be reduces by optimising geometry and wheel/rail contact: layout geometry (circular curve turnouts, asymmetric clothoids etc), load optimisation turnouts and wheel transition, self steering efect for special aplications and wheel contact geometry. The turnouts can be optimised using the principles of vehicle dynamics together with high wear resistant materials and invovative technologies [6].

4. Conclusions

Tournouts are subjected to dynamic loads transmited from the vehicle wheel to the rail, and further to the sleeper and ballast bed. Switches geometry has an important influence on the wheel – rail interaction, when the rolling stock passes trough the turnout at a certain speed. Stresses on the frog and hell block for railway switches depend on a large scale upon turnouts geometry and wear level. An important part to be considered is that the switches geometry should be kept in admissible tolerances, a vital requirement for the maintenance divisions of the railway system.

The relation between the material type and state and track geometry is very important, as it is not only the dynamic loads effect on the switches that can cause the track geometry degradation. Wear is also in important factor in keeping the railway track proper maintained. In order to fix the worn elements of the switches, the possibilities are repairs and replacements, depending on the measurements made at the site. Track geometry can be kept in standard tolerances by periodic maintenance: tamping and grinding.

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