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STUDY OF DAMAGE TO VAE CROSS CROSSING

The paper considers issues related to the reliability of railway switches. In particular, the quality of the steel used in the switch elements is investigated. The Latvian Railway operates more than 1,500 level crossings of profile 60 E1. According to the regulatory documentation of the Railway Administration, the planned repair of the transition to the main roads will be carried out with a transverse tonnage of > 450 million tons. But on average, after the total passage of 115 million tons, there are blurring of borders and cracks at the crossings. After melting, the crucifix should, on average, pass a total load of no more than 10 million tons. The core of these transitions is polymetallic, consisting of two-component steel. The crucifix is made of 350 HT grade tracked steel with a carbon content of 0.72–0.77 %. The surface with a thickness of about 20 mm is made of Hadfield steel.

Keywords: steel, Hadfild steel, electrodes, current, transverse, wear, crouts, sparning threshold, defrosting of detachment, the carbon equivalent.

Introduction

The transition of rolling stock from one road to another shall consist of bodywork equipment connecting and/or crossing the roads. Road coupling shall be carried out with crossings (Figure 1) and crossings with road crossings [1]

Figure 1 – Simple switch-over scheme:
1 – threshold; 2 – axle; 3 – tipping threshold; 4 – core;
5 – cross-crossing top; 6 – counter-threshold [13]

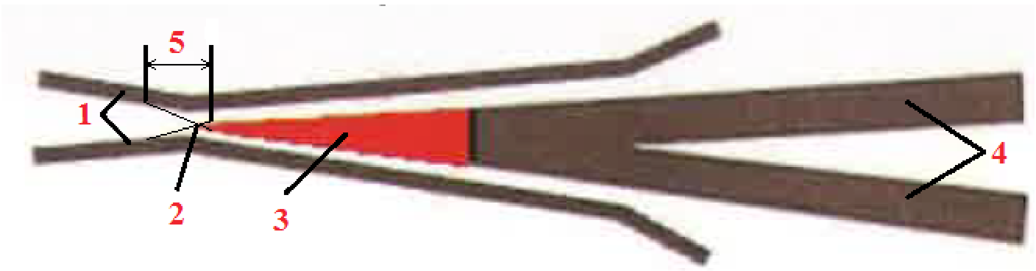

Figure 2 – VAE cross scheme:
1 – kicking rails; 2 – mathematical centre; 3 – core;
4 – crucifixion tail; 5 – harmful expanse [13]

All elements of the crossing and road crossing are of equal importance, but the crossover (Figure 2) moves between the switches and the crossings is a «weak element» because of the "most difficult" function. The crossing rail heads cross each other, enabling the wheel to move freely along a continuous rolling surface. A rigid displacement path along the edges of the crucifixion core and the working sides of the wing rails shall be provided to the wheel with the rim by an anti-rail (Figure 1), the wheel being closely connected to the wheelset's axis in firmly defined dimensions. The Latvian railway operates mainly crossings with rigid parts (Figure 2), which also include VAE crossings and, in rare cases, crossings with moving flexible cores which, with their moving parts, «close» the harmful expanse.

Latvian railway purchased approximately 1500 60E1 track-profile Austrian crossings with pointed VAE crossings for EU funds. VAE crucifixion is a assembled cross. Its main elements are one core and two wing rails. The intersection point of the edges of the core work is called the mathematical center of the crucifixion core. The angle formed by the edges of the core work is referred to as the crossing angle. After this, a unified cross mark is defined as the ratio of width to length, so it is about 1/11, 1/9 and 1/6 VAE crouts and, in very rare cases, uses VAE cross crossings with a level of non-standard cross. The narrowest place between the wings is called the neck of the crucifixion, but the distance from the neck of the cross to the actual core of the crucifix is called the harmful expanse [2].

VAE core crotch is polymetallic, i.e. it consists of two-made steel which is connected to one another. The crucifix base is made of track steel mark 350HT with a carbon content of 0.72–0.77 %. The surface of approximately 20 mm is made of Gadfild steel [3].

During the lifetime of the crucifixion, the VAE crucifixion has a variety of defects, but on average, after 115 million tonnes of gross passage, the crossings have marginal wear and cracks.

Materials and methods

1 Damage to VAE crouts

1.1 Failure of the core of the crucifixions

In most cases, following the gross passage of 20–40 million tonnes for the new VAE crossings in the wheel crossing area from the wing rail to the core, in the harmful expanse, there are shallow and deep shortages (Figure 3). When the wheel shifts these unevenings result in the dynamic forces of the impact leading to calamation, detachment and cracks in a highly alloy manganese layer [4].

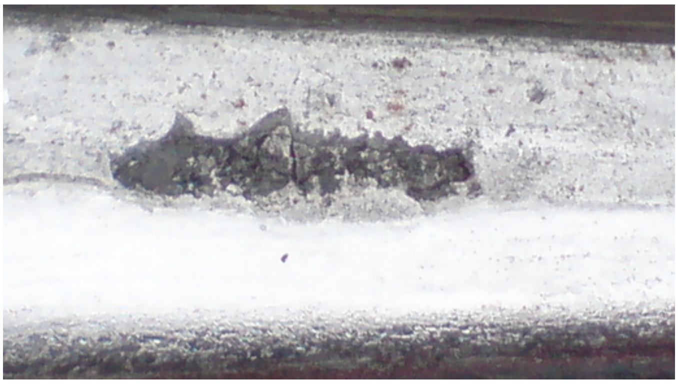

Figure 3 – Core fissures of VAE cross 60E1 1/11

Longitudinal cracks and fractures for VAE crossings on Latvian railways [12] are most commonly observed on the main roads (Figure 4) at loadload of more than 30 million tonnes gross per year.

Figure 4 – Breaking of the core of the VAE cross 60E1 1/11
and cracks at the Alotene station

In Latvian railways, it is not always timely that floodings are drowned, resulting in scarves (Figure 5), later breaking them down and the roughness begins to spread throughout the size of the core. From the vibrations caused by unevenings, the crucifixion gradually collapses and becomes unusable.

Figure 5 – VAE cross-over R-65 1/11 core burst at the yard station

In addition to insufficient maintenance: too wide anti-rail trays, worn counter rails and narrowed road widths, the rim of the wheel may remove the end of the core (Figure 6).

Figure 6 – Breakage of the end of the core of VAE cross R-65 1/9 at the Skirotavas station

By releasing approximately 115 million tonnes of gross cargo and independently operating THE VAE cross, a worn crucifixion sedli (Figure 7), visible as a hole from a distance of 15 m, occurs on the core and on the wing.

Figure 7 – VAE cross R-65 1/11 worn core at the Aizkraukle station

1.2 Failure of VAE crossing malfunction

Similarly, as the pelling, detachment and cracking of VAE cores (Figure 3) is common, the rolling surface of the winging rails is also damaged (Figure 8). The characteristic zone of the defect is the harmful expanse.

Figure 8 – VAE cross 60E1 1/11 cracks at Slampes station

Rebuilding the wing threshold in melting is not always as successful as it was originally expected. Non-welding causes deep and long longitudinal detachment cracks (Figure 9).

Figure 9 – VAE cross-cross R-65 1/11 detachment at Slampes station

Similarly to the lack of timely tapping of cores, there is no timely polishing of the winging rails for how connected these operations are. Similar problems arise with splinters (Figure 10).

Figure 10 – VAE cross R-65 1/11 at the Skirotavas station

Crossroads often form at the beginning of the harmful cracks (Figure 11).

Figure 11 – VAE cross, R-65 1/11 cross-slide, Aizkraukle station

2 Technical problems caused by vae crossing damage and measures to be taken to take the problems

The VAE crossing with its fixed parts is considered to be a road roughness that causes a sudden change in the wheel support trajectory when the train is running at high speed. These are mainly vertical dynamic loads between 200 and 400 kN [6]. Very often VAE crossings do not withstand the cyclic loads of 25 tons of wheels on trains in circulation on Latvian railway.

Shallow cracks and unevenness in the railway are corrected by grinding the damaged or uneven layer [9]. Due to grinding, the core rapidly loses its valuable layer of high-alloy manganese, which leads to service restrictions. For example, if the specified train speed is 120 km / h, the vertical wear or defect depth shall not exceed 5 mm. When the wear or crack depth is reached – 10 mm, the speed is reduced to 40 km / h, but after reaching more than 12 mm, the operation of VAE crossings is not allowed in accordance with Latvian railway regulations [5]. Inspection of the crossroads at the Latvian Railway shows that the grinding works of the crossing are not carried out in time, grinding up the surges and small cracks in their initial stage of development. In order to prevent the crossing from reaching a very defective condition, the operating parts perform melting of the damaged or worn parts by electric arc welding in a planned manner. In Latvian Railways, according to the regulations, the crossings are melted only up to a defect depth of 13 mm from the project surface, but deeper ones are replaced [7].

3 VAE crossing damage statistics

3.1 Technical information on statistics

Statistics are provided for all pointed VAE crossings on the Latvian railway with an angle of 1/11, 1/9 and 1/6 and the European track mark 60E1, which were put on the road together with the new Austrian type switches in the period from 01.07.2003. – 30.12.2021.

In order to reflect the topicality of this problem, SJSC «Latvian railway» will look at the cross-melting statistics of the Railway Administration and the Jelgava operation part of the period from 2018 to 2021 [14].

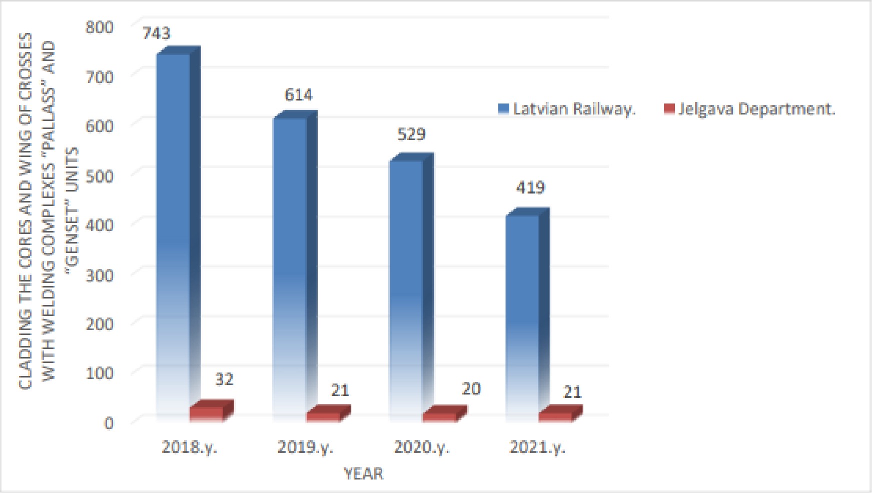

Figure 12 – Statistics of melting of the cross core and wing rail for the period from 2018 to 2021

On Figure 12 we can see how the melting statistics is gradually starting to decrease from 743 melted crosses in 2018 to 419 molten crosses in 2021. Track management for the structure. Jelgava operation parts are one of the number of crossings for the Latvian railway and damaged crossings. According to the smelting statistics (Figure 12), the average smelting statistics for the last three years from 2019 to 2021 in Jelgava consisted of the repair of 20 damaged crossings with welding complexes «PALLAS» and «GENSET», although in 2018 32 damaged crosses were melted. However, smelting technology remains one of the current methods of extending the service life of the cross in Latvia and abroad.

Results and discussion

Research projects. RTU Transport Institute studied the melting of VAE crossings in Latvian railway. During the field observations of RTU Transport Institute, one VAE cross was melted in Garozas st. switch No. 3, as well as in the RTU certified laboratory, metallography was performed on other fused samples of VAE cores and wing rails.

Relative welding quality criterion. The weldability of steels is characterized by the indirect carbon equivalent of weldability of metals [8]. The carbon equivalent of VAE crossings is calculated:

$$C_{ekv} = C + \frac{Mn}{6} + \frac{Ni}{15} + \frac{Cr + Mo + V}{10} \qquad (1)$$

where C – carbon content in hundredths of a percent;

Mn, Ni, Cr, V amount of chemical elements, %.

This formula and the like are purely empirical and their reliability is quite relative [8]. Steel welds with C_{ekv} up to 0.25, satisfactory – 0.25–0.35, limited weld – 0.35–0.45 and poorly welded if the carbon equivalent is greater than 0.45. The carbon equivalent of the manganese core of the VAE crosses is unfavorable – from 0.45 to 0.46. The core of the cross must not be overheated by more than 200 °C.

Investigations of VAE cross core melting field conditions at Garozas station. 23.11.2021. the core of the VAE cross was fused with a vertical wear of 6 mm. At the crust station, switch no. During the melting of 3 cores, some deviations from the work technology were found, namely, the core temperature was not monitored often enough by the thermometer by a manual touch welder, and the applied welding current could be in a wide range, inaccurately related to the electrode diameter. any remaining moisture was not dried with the burner.

After melting 25.11.2021. irregularities with hollow recesses formed at the depth of 0.8 mm (Figure 13) on the surface of the core, which was reported to the road master.

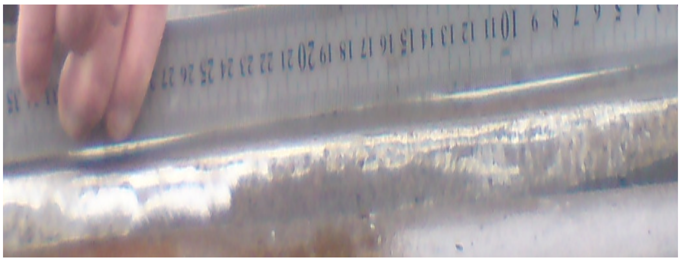

Figure 13 – VAE cross 60E1 1/11 core recesses at the Carozas station

One month after melting, longitudinal cracks appeared in the core [11] and defectoscopists determined that the defect had become dangerous, so 27.12.2021. melting was repeated, this time drying any residual moisture after paint defectoscopy and strictly observing the temperature regime during welding. However, in the first days after melting, non-weld inclusions 2 mm in diameter were discovered, leading to a longitudinal crack of about 90 mm (Figure 14).

Figure 14 – VAE cross 60E1 1/11 core longitudinal crack at Carozas station

The operation department decided to melt the VAE core for the third time – 23.02.2022. VAE cross cores 08.03.2022. showed long and small cracks during color defectoscopy (Figure 15). Spider was replaced as planned.

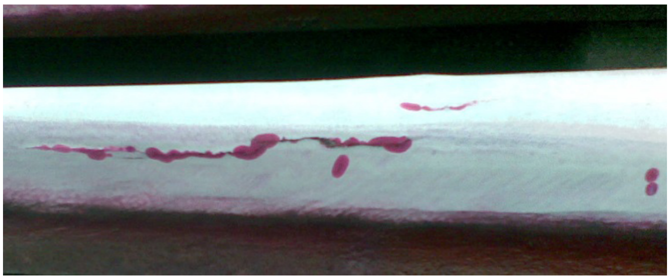

Figure 15 – VAE cross 60E1 1/11 core longitudinal crack at Crust station

Investigations of VAE cross wing rail melting field conditions at Crust station. The melting of the wing rail coincided with the melting of the core and took place on the same day. 23.11.2021 the wing rail was melted for the first time. Melting was performed with a reverse polarity current of 140 A using an OK83.29 electrode with a diameter of 5 mm. The current for an electrode of this diameter is not the most optimal, despite the fact that the instructions for the current range from 110 to 220 A. During melting, the temperature regime of the wing rail, which had to be between 350 and 400°C, was not always observed. Probably a month after melting, defectoscopes with an ultrasonic defectoscope found dangerous internal cracks in the wing rail. The wing rail was remelted on the same day as the core was melted – 27.12.2021. This time the temperature regime was fully observed, but the welding current was increased to 195 A, using exactly the same electrodes as before, evaporating any residual moisture after paint defectoscopy. No defects were found in the melting of the wing rail during subsequent observations.

Laboratory studies of melting of experienced VAE cores. For the experimental studies of smelting, the railway provided two previously used VAE cross cores, which were smelted in small sections separated by workshop conditions using different electrodes and currents.

Using the OK86.28 electrode (diameter – 4 mm, I = 155 A) in Sample 1, welding and melting were very successful. The electrodes were used dried and glued several times.

In Sample 2, the electrodes were pre-dried and annealed only once. Using the OK86.28 electrode (diameter – 4 mm, I = 155 A), the welding was even better than the first sample.

In sample 3, the UTP BMC electrode (diameter 4 mm, I = 160 A) was pre-dried and annealed several times before melting. There was an inclusion in the alloy, although the fusion of the molten layer was very good.

The current of sample 4 for the UTP BMC electrode with a diameter of 4 mm was increased to 165 A. An electrode that had only been dried and annealed was used. The core had no inclusions, the welding was successful.

By increasing the current to 180 A (electrode UTP BMC, diameter 4 mm), once the electrode was glued, the welding was very good without inclusions and cracks.

In all cases, the heating of the core did not exceed 200°C.

Conclusions of experienced VAE core melting. All core samples were fused with very good results under workshop conditions. Increasing the melting current improves the welding quality of the molten layer and the base layer. Although increasing the current in this case also increases the heating, it is necessary to wait periodically for the core to cool during melting. Recommended current for electrodes OK 86.28 – from 38–40 A per 1 mm electrode diameter, UTP BMC – from 38.2–40.2 A per 1 mm electrode diameter. The hardness of the hammer-melted VAE core layer ranged from 512 to 580 HB. The electrode UTP BMC hardness was on average higher in all cases than 45–80 HB. The melt hardness of single glow electrodes was on average higher than 15–23 HB. Welding with higher seams using electrodes with a larger diameter of 4–5 mm will give better results than melting with thin and wider seams.

Laboratory studies of experienced VAE wing rail melting. In the RTU laboratory at the Department of Railway Engineering, the previously fused 7 wing rail samples provided by the railway were studied. Electrodes OK86.28, CNII4, UTP BMC were used, as well as the welding current was changed. The given electrodes did not give a good result, because according to the railway technical regulations they are intended only for melting of manganese cores [7].

For example, when welding the wing rail (sample 1) with Tubrodur semi-automatic powder wire OK 15.41 (diameter 1.6 mm, I = 105 A), the welding proved unsuccessful. This is explained by the fact that the melting was not carried out in a gaseous medium but in an atmospheric environment. At the melting limit, metallography showed large oxide and the like. inclusions of unacceptable harmful elements. The boundary between incomplete welding was visible between the fused and the base layer.

The wing rail sample 2, welded with an electrode OK83.28 (I = 140 A, electrode diameter 4 mm, heating temperature – 400°C), collapsed in the laboratory along the boundary between melting and base layer. Melting was better in some places, but it had a lot of inclusions.

Welding of the wing rail (sample 3) with manual fusion using the electrode UTP BMC, but a wide non-welding crack was visible for the coating layer of the electrode – OK74.78. Electrodes UTP BMC and OK74.78 do not mate with each other due to the molten material. UTP BMC is intended for high manganese steel (only for VAE core), but OK74.78 only as a base layer for rail melting [7].

When the CNII-4 electrode was applied by hand-melting, a crack was also visible between the welded layer and the base layer, but it was less pronounced than in the previous samples. There were even fewer inclusions in the molten layer than in the rail layer. CNII-4 electrodes (Russian production) are also intended only for melting high manganese steel.

The OK86.28 electrode was used in Sample 6. Welding was successful by completely welding the base layer and the molten layer. However, the electrode used is for melting manganese-containing steel [7].

The melting of the 7th sample with the UTP BMC electrode (diameter 4 mm, I = 160 A) was also welded cleanly, without porous inclusions and cracks. The fusible layer even turned out to be cleaner than the rail material.

Conclusions

The average service life of the VAE crossover, including smelting, is 148 million. t gross. The melting of VAE crossings begins when the VAE crossing has reached an average of 115 million. t gross. The average depth of the ground defect for the core and the wing rail [10] during the first melting is about 10 mm. Starting the restoration of switches with the melting method, the average time between meltings is 10 million. t gross, which, for example, in a section such as Jelgava – Krustpils on the main road at an average annual load of 37 mln. t gross / year, means that the VAE will withstand no more than 3.2 months on average. In the absolute majority of cases, one core and one wing rail were always melted in one day. And only in rare cases is fused only one of the elements, or all three - both the wing rails and the core. Before replacing the VAE cross, each cross is melted on average 4–5 times. In addition, 30 % of the time (i.e. almost a month before the regular melting) between the melting of the crossings on the main roads, the speed limit of 60–25 km / h is constantly applied, depending on the size of the damage. From the beginning of VAE operation, Jelgava operation part 4 crossings 1/11 have been replaced with crossings with moving flexible cores of the same manufacturer on the main roads. At the remaining 121 VAE crossing operation sites as of 15.03.2022. 98 crosses have never been fused, 6 of which have reached 165–215 million. t gross tonnage released. But 23 crosses have been melted, 12 of which have reached 155–205 million. t gross tonnage released.

The number of all VAE crossings in operation is heterogeneous by age groups. The sample included crosses of almost all depreciation levels in the range from 0 to 215 million. t gross.

When evaluating the defects of the fusible crosses, the average depth of the defect for the core and wing rail is approximately – 12 mm, the length of the grinding – 400–450 mm.

The average load of VAE in the operating part of Jelgava is 26 mln. t gross per year.

It is very important to keep the temperature of the fusible wing rail within the recommended temperature range of 385–400°C [8]. This criterion must be observed with particular caution in winter, as the wing rail loses heat rapidly. When using an electrode, the recommended current is 38–40 A per mm of electrode diameter. Welding depends on the technological performance of the welding work. The choice of an appropriate electrode for both the wing rail and the core is important [7].

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ИЗУЧЕНИЕ УЩЕРБА ОТ ПЕРЕКРЕСТНОГО ПЕРЕСЕЧЕНИЯ VAE

В статье рассматриваются вопросы, связанные с надежностью железнодорожных стрелочных переводов. В частности, исследуется качество стали, используемой в элементах железнодорожных переводов. Латвийская железная дорога эксплуатирует более 1500 железнодорожных переездов профиля 60 E1. Согласно нормативной документации Железнодорожной администрации, запланированный ремонт перехода к основным дорогам будет проводиться с поперечным тоннажем более 450 миллионов тонн.

Но в среднем, после общего прохождения 115 миллионов тонн, на переходах наблюдается размытие границ и трещины. После сварки соединение должно, в среднем, выдержать общую нагрузку не более 10 миллионов тонн. Сердцевина этих переходов полиметаллическая, состоящая из двухкомпонентной стали. Распятие изготовлено из стали марки 350 HT с содержанием углерода 0,72–0,77 %. Поверхность толщиной около 20 мм изготовлена из стали Hadfield.

Ключевые слова: сталь, сталь Гэдфилда, электроды, ток, поперечный, износ, кручения, порог искрообразования, размораживание отслоения, углеродный эквивалент.

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VAE АЙҚАСПАЛЫ ТІЗБЕДЕН КЕЛТІРІЛГЕН ЗИЯНДЫ ЗЕРТТЕУ

Мақалада теміржол бағыттамалы бұрмалардың сенімділігіне байланысты мәселелер қарастырылады. Атап айтқанда, теміржол аударма элементтерінде қолданылатын Болаттың сапасы зерттеледі. Латвия темір жолы 1500 E60 Профильді теміржол өткелдерін пайдаланады. Темір жол әкімшілігінің нормативтік құжаттамасына сәйкес негізгі жолдарға көшуді жоспарланған жөндеу көлденең тоннажбен 450 миллион тоннадан астам жүргізілетін болады.

Бірақ орташа алғанда, жалпы 115 миллион тонна өткеннен кейін, өткелдерде бұлыңғыр шекаралар мен жарықтар байқалады. Дәнекерлеуден кейін қосылыс орташа есеппен 10 миллион тоннадан аспайтын жалпы жүктемеге төтеп беруі керек. Бұл өтулердің өзегі екі компонентті болаттан тұратын полиметалл болып табылады. Айқыш 350–0,72 % көміртегі бар HT маркалы болаттан жасалған. Қалыңдығы шамамен 20 мм беті Hadfield болаттан жасалған.

Кілтті сөздер: Болат, Гэдфилд болаты, электродтар, ток, көлденең, тозу, бұралу, ұшқын шегі, қабыршақтану, көміртегі эквиваленті.

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