through the electric locomotive and the rails back to ENP as shown in Figure 1.

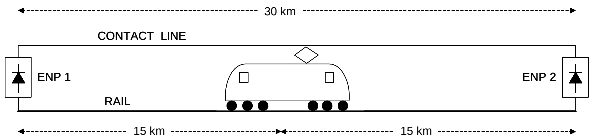

Figure 1. Operating circuit of the electric traction vehicle

All ENP of Slovenian Railways operate in parallel, which means a two-way supply of the traction vehicle, which can be seen in Figure 1. Consequently, the return current flows through the return rail back to ENP in both directions, to ENP 1 and to ENP 2. As the locomotive approaches ENP 2, the load of ENP 1 decreases. When the electric traction vehicle is very close to ENP 2, a minimal return current is still flowing in the direction of ENP 1.

One-way supply of the electric traction vehicle on Slovenian railways exists only at the exit of our electric traction system to the neighbouring countries, which use single-phase AC systems of electric traction (Austria and Croatia), and during accidental outages of ENP or during maintenance works.

Rails are laid over wooden or concrete sleepers on the road metal and represent at the same time the earthing electrode of the operational circuit of electric traction of the DC system at 3000V, which can be seen in Figure 2.

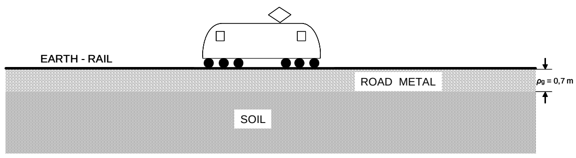

Figure 2. Earthing of the operational circuit of electric traction

As can be seen in the figure, the rails are placed on a road metal, which is on average 0.7m high. The road metal is spread on soil. This means the earthing electrode lies on non-homogeneous soil, whereby the road metal has a higher specific ohmic resistance than the soil. In that case, the earthing resistance of the total earthing system is calculated according to equation [1]:

(1) $$R_0 = \frac{\rho_g \cdot h_g}{D^2 \cdot \frac{\pi}{4}} + \frac{\rho_z}{2 \cdot D} (\Omega)$$

where:

R_o is the earthing resistance of the rail in Ω,

P is the specific resistance of crushed stone in Ωm,

h_g is the height of road metal in m,

D is the diameter of earthing electrode in m,

ρ_z is the specific earth resistance in Ωm.

The earth electrode – rails, which represent a strip-type earth conductor, consists of two or more strips – the rails. Since the distance between the two strips – the rails is smaller than 5% of the length of rails, the following equation is valid for calculating the diameter of the equivalent plate [1]:

(2) $$D = 1{,}13 \cdot \sqrt{S} \quad (m)$$

S is the surface of earth electrode – rails, in m

The surface of the earth electrode - rails is calculated according to the following equation [2]:

(3) $$S = a \cdot (n \cdot b) \quad (m^2)$$

where:

n is the number of rails (2 rails for a single track line),

a length of rails in m

b width of rail base = 0.125 m

Specific resistance of earthing electrode – rails per unit of length is calculated according to the following equation [3]:

(4) $$R_t = \frac{\rho_t \cdot L}{2 \cdot m \cdot A} \quad (\Omega / km)$$

where:

R_l is the specific resistance of earthing electrode – rails per unit of length in Ω/km,

ρ_t is the specific resistance of rails = 0.20 $\Omega mm^2/m$,

L is the length of earthing electrode – rails in m

m is the number of tracks ($2n$ = 2 for single track line),

A is the cross-section of one rail = 6250 mm^2.

From the known specific resistance of the earth electrode – the rails, and from the known earthing resistance of the rails, the amount of stray currents outside the return conductor – the rails, can be calculated according to the following equation [3]:

(5) $$I_b = I_t \cdot \left(\frac{R_t}{R_l + R_0} \right) (\%)$$

where:

I_b is stray current in %

БЛУЖДАЕЩИ ТОКОВЕ В ЖЕЛЕЗНИЦИТЕ С ПОСТОЯНЕН ТОК В СЛОВЕНИЯ

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Резюме: *Блуждаещи постоянни токове са токове, които не текат през проектираните проводници, а по пътека с най-малко съпротивление. Тези токове са много вредни за различните метални конструкции и в дългосрочен план водят до корозия. Най-значимият източник на случайни постоянни токове в Словения могат да бъдат открити в електрифицираните влакове, използващи система от постоянен ток от 3000V. Не всеки връщащ се ток може да тече обратно към токоизпревителната подстанция през релсите, но голям процент от този ток се разпръсква в земята в зависимост от проводниковите магистрали. В някои случаи тези блуждаещи токове даже пресичат лъкатушещата железопътна линия. Докладът представя извеждането на уравнение за изчисляване на блуждаещите токове на основата на телеграфично уравнение, от което е изведена цялата проводимост но железницата (релси+ пътен метал). Всички дадени уравнения са напълно удовлетворяващи за анализа на споменатите по-горе проблеми и потвърждават факта, че токоизправителните станции в системите с постоянен ток за електрическа трябва да бъдат разположени колкото е възможно по-близко една до друга.*

Ключови думи*: блуждаещи постоянни токове, електрическа тяга, релси, токоизправителни станции, пътен метал, заземяване, електрод, локомотиви.*