Sborník vědeckých prací Vysoké školy báňské - Technické univerzity Ostrava
číslo 1, rok 2006, ročník LII, řada strojní
článek č. 1520

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ESTABLISHING DATA PARAMETERS IN RAIL TRACTION VEHICLES

VÝCHODISKA PRO STANOVENÍ PROVOZNÍCH PARAMETRŮ HNACÍCH KOLEJOVÝCH VOZIDEL

Abstrakt

Při stanovení výkonových parametrů hnacího kolejového vozidla je nutné velmi pečlivě posuzovat vlivy dopravní cesty a parametry dané uvažovanými technologickými procesy. Rozhodujícím parametrem je stanovení potřebného příkonu pro trakci. Při jeho stanovování je nutno hodnotit podíl vlivu vstupních parametrů vyplývajících z dopravní cesty a realizované technologie práce vozidla.Tento podíl je demonstrován na příkladě.

Abstract

To establish the power parameters of a traction rail vehicle it is necessary to carefully consider the influences of permanent way as well as parameters dictated by considered technological processes. Establishing the power input demand is a decisive parameter. It is however, necessary to define the proportion of influence exerted by the permanent way, and by the rolling stock vehicle technology. The proportional parameters are illustrated by an example.

1 INTRODUCTION

Setting of operational parameters of traction vehicles is an important step in determining the requirements for traction rail vehicles, both for new designs for vehicles, as well as modernised or re-engined vehicles, already in operation.

One of these operational parameters is definition of the power demand for traction which provides mobility of the vehicle and subsequently definition of the primary source power of the vehicle. The latter covers requirements of the traction as well as of any other devices of tractive and towed vehicles.

2 THEORETIC INITIAL DATA FOR SETTING OF THE POWER PARAMETERS

To advance further in the setting of the power parameters it is possible to start from a schematic presentation of a traction vehicle and associated rolling stock (see diagram 1).

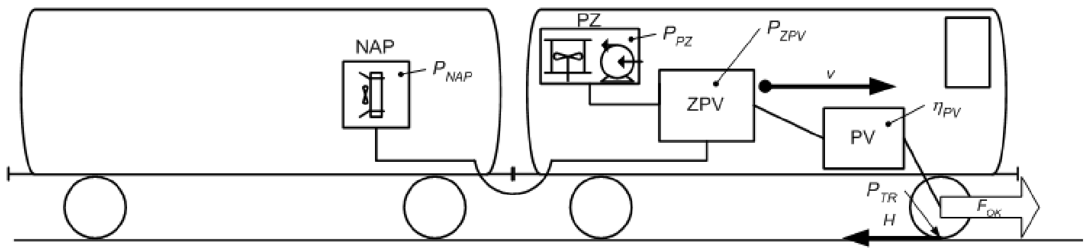

Diagram 1: Diagrammatical principle of vehicle tractive effort.
(ZPV-primary power source, PV-power transmission, PZ-auxiliary equipment, NAP- power supply)

Relation for definition of an installed power of the power primary source P_{PZV} can be described as:

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$$P_{PZV} = P_{TR} + P_{PZ} + P_{NAP} \text{ [W]} \tag{1}$$

where:

P_{TR} [W] power input for the traction
P_{PZ} [W] power input of the vehicle auxiliary equipment
P_{NAP} [W] power input of the energy supply of attached vehicles

Individual items of the installed power will be set according to the steps as follows.

2.1 Power input for the traction

The power input demand for vehicle traction motion can be defined in this formula:

$$P = F \cdot v \text{ [W;N,m.s}^{-1}\text{]}$$

Then the tractive power input P_{TR} can be defined according to [Široký, 2005, eqv. (2.2)]:

$$P_{TR} = P_{Oj} + P_{OT} + P_{OZ} \text{ [W]} \tag{4}$$

where:

P_{Oj} [W] power input demand to cover the vehicle resistance
P_{OT} [W] power input demand to cover the track resistance
P_{OZ} [W] power input demand to cover inertia stresses

The following formula can be used for **the power input demand to cover the vehicle resistance** $\boldsymbol{P_{Oj}}$:

$$P_{Oj} = O_j \cdot v = O_j(\dot{x}) \cdot v(t) \text{ [W]} \tag{5}$$

where:

$O(\dot{x})$ [N] vehicle resistance which is dependent on speed, being described by a second-degree rational function

$$O_j = G_{VL} \cdot \left(a + b \cdot v + c \cdot v \right) \cdot \quad ^{-} \text{ [N]}$$

$v(t)$ [m.s^{-1}] prospective instantaneous vehicle speed

Then the power input demand to cover this resistance is

$$P_{Oj} = f\left(v^3\right) = G_{VL} \cdot 10^{-3} \cdot \left(a \cdot v + b \cdot v^2 + c \cdot v^3\right) \text{ [N]} \tag{6}$$

The following formula can be used for **the power input to cover the track resistance** $\boldsymbol{P_{OT}}$**:** $P_{OT} = O_T \cdot v = O_T(x, s_r) \cdot v(t)$ [W], i.e. that

P_{OT} is dependent on the value of the reduced gradient s_r [10^{-3}] at the considered place x and on the value of the given instantaneous speed v [m.s^{-1}].

In such a case, the calculation $O_T(x,s)$ is reduced to defining the track resistance for an integral track parameter, designated as a decisive gradient s_{rk} , set for the given track section. For setting the relative information the following formula can be used:

$$s_{rk} = \frac{1}{l_s} \cdot \int_0^{l_s} s_r(x) dx \text{ [}10^{-3}\text{]} \tag{7}$$

Providing that $s_r(x)$ is described as a continuous function, it is possible to set the decisive gradient according to this formula:

$$s_{rk} = \frac{\sum_{i=1}^{j} s_{ri} \cdot l_i + s_{rk} \cdot \Delta l_k}{l_s}, \qquad (8)$$

where $\Delta l_k = l_s - \sum_{i=1}^{j} l_i$ providing that $\sum_{i=1}^{j} l_i < l_s < \sum_{i-1}^{k} l_i$,

where:

l_i	[m]	length of the gradient section s_{ri} = konst.
s_{ri}	[10^{-3}]	reduced section gradient according to [Široký, 2004, p. 35]
l_s	[m]	given length (in case of general setting it is l_s = 1,000 m, at analysis of a specific example it is $l_s = l_{VL}$, where l_{VL} is length of train

Power input to cover acceleration resistance P_{OZ} can be stated by this formula:

$$P_{OZ} = O_Z(\ddot{x}) \cdot v(t) \text{ [W]} \qquad (9)$$

The acceleration resistance $O_Z(\ddot{x})$ is given by a size of inertia forces at speed change:

$$O_Z(\ddot{x}) = \frac{G_{VL}}{g} \cdot (1+\rho) \cdot \frac{dv}{dt} \text{ [N]} \qquad (10)$$

where:

ρ [1] coefficient of the influence of rotating mass

3 COMPARISON OF THE INFLUENCES ON SETTING OF POWER INPUT DEMANDS

For projection of power of primary source power demand of the traction vehicle, it is necessary to consider also influences of individual power input items and their mutual comparison.

The traction power input P_{TR} is influenced by required parameters of the train motion on the permanent way.

Decisive parameters are:

- required vehicle speed v_p;
- decisive gradient on the permanent way s_{rk};
- acceleration value *a* by which it is necessary to achieve the required speed v_p on the decisive gradient s_{rk}.

These parameters are formulated from the projection and consideration of technological processes related to the rail transport.

Relation for consideration of the influence of these parameters on P_{TR} can be described after modification of the relation (4):

$$P_{TR} = G_{VL} \cdot v \cdot (o_{VL} + o_T + o_Z) \text{ [W]} \qquad (11)$$

after the modification:

$$1 = \frac{G_{VL} \cdot v}{P_{TR}} \cdot (o_{VL} + o_T + o_Z),$$

where under the considered conditions the share is:

$$\frac{G_{VL} \cdot v}{P_{TR}} = k = \text{konst.}$$

Then it is possible to express ratio of the individual items P_{TR}:

$$P_{Oj} : P_{OT} : P_{OZ} = o_{VL} : o_T : o_Z = \left(a + b \cdot v + c \cdot v^2\right) : \left(s_{rk} \cdot 10^{-3}\right) : \left[\frac{a}{g} \cdot (1+\rho)\right] \qquad (12)$$

This comparison can be illustrated by the analysis of a concrete example of an operator.

Based on analysis of work technology the following parameters of the considered train motion were defined:

$v_p \sim V_{max}$=30 km.h^{-1}, G_{VL} = 10,5.10^6 N, vehicle type Bo´Bo´+T4 (see [Široký, 2004, p.32], a = 0,1 m.s^{-2}, s_{rk} = 5 ‰.

The resulting proportional share of individual items P_{TR} is set in Table 1, which also gives values of necessary P_{TR} and a track for achievement of set vehicle speeds. Comparison is worked out for speed range $V_p \in \left(10; V_{\max}\right) \mathrm{km} \cdot \mathrm{h}^{-1}$

Tab. 1: Comparison of power input items P_{TR}.

V [km.h^{-1}]	*P oz*	*P oj*	*P ot*	*P OK [kW]*	*lr [m]*
10	86,0%	11,4%	2,7%	365	39
20	85,5%	11,8%	2,7%	734	154
30	84,9%	12,5%	2,7%	1109	347

Diagram 2 offers a graphic presentation of the results.

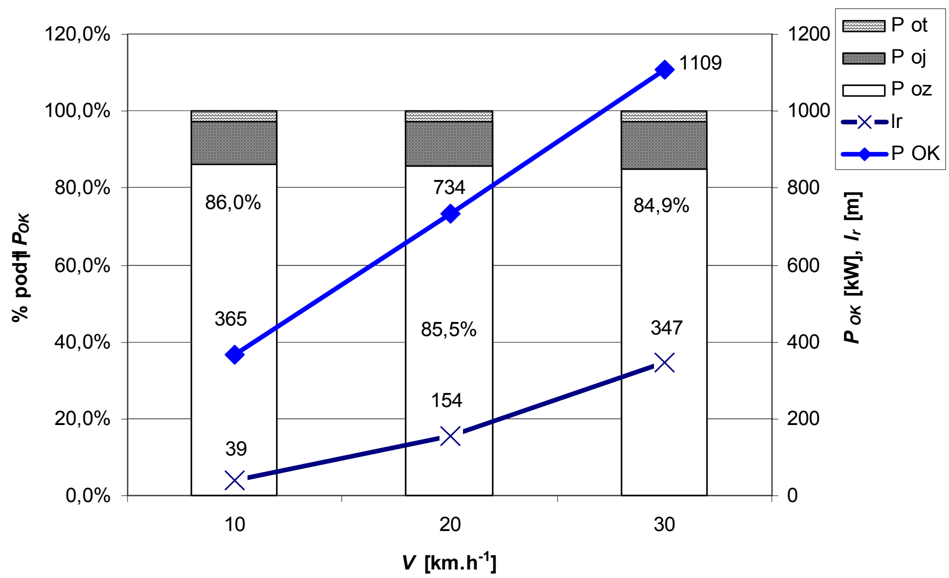

Diagram 2: Graph depicting the comparison of influence of individual items.

4 Conclusion

To establish the power parameters of a traction rail vehicle it is necessary to carefully consider the influences of permanent way as well as parameters dictated by considered technological processes.

The established comparison suggests that size of traction power input P_{TR} is influenced considerably by vehicle acceleration performance. In this case the power input for achieving the required acceleration was some 85% of the total power input. In establishing the optimum setting of traction performance, consideration must also be given to other work technological requirements, involving railway station or yard shunting. Therefore, in projecting the total power of the primary source of the vehicle, the results of inertia resistance influenced by acceleration must not be ignored.

The groundwork for this contribution, and its text originated by the help of OP RLZ-3 program means.

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