Jaromír ŠIROKÝ

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:

* Ing. Jaromír Široký, Ph.D. VŠB- TU Ostrava, Institut of Transport, Faculty of Mechanical Ingeneering,
www.fs.vsb.cz, jaromir.siroky@vsb.cz
\[ P_{PZV} = P_{TR} + P_{PZ} + P_{NAP} \ \text{[W]} \]  \hspace{1cm} (1)

where:
\[ P_{TR} \ \text{[W]} \] power input for the traction
\[ P_{PZ} \ \text{[W]} \] power input of the vehicle auxiliary equipment
\[ P_{NAP} \ \text{[W]} \] 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)]:

\[ P_{TR} = P_{Oj} + P_{OT} + P_{OZ} \ \text{[W]} \]  \hspace{1cm} (4)

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

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

\[ P_{Oj} = O_j \cdot v = O_j(\dot{x}) \cdot v(t) \ \text{[W]} \]  \hspace{1cm} (5)

where:
\[ O(\dot{x}) \ \text{[N]} \] vehicle resistance which is dependent on speed, being described by a second-degree rational function
\[ O_j = G_{VL} \cdot (a + b \cdot v + c \cdot v^2) \cdot 10^{-3} \ \text{[N]} \]
\[ v(t) \ \text{[m.s}^{-1}\text{]} \] prospective instantaneous vehicle speed

Then the power input demand to cover this resistance is

\[ P_{Oj} = f(v^3) = G_{VL} \cdot 10^{-3} \cdot (a \cdot v + b \cdot v^2 + c \cdot v^3) \ \text{[N]} \]  \hspace{1cm} (6)

The following formula can be used for the power input to cover the track resistance \( P_{OT} \):

\[ P_{OT} = O_T \cdot v = O_T(x, s) \cdot v(t) \ \text{[W]}, \ i.e. \ that \]

\( P_{OT} \) 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 \( v \ [m.s}^{-1}\text{]} \).

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 \( s_{\alpha} \), set for the given track section. For setting the relative information the following formula can be used:

\[ s_{\alpha} = \frac{1}{l_t} \int_0^l s_r(x)dx \ [10^{-3}] \]  \hspace{1cm} (7)

Providing that \( s_r(x) \) is described as a continuous function, it is possible to set the decisive gradient according to this formula:
\[
\sum_{i=1}^{j} l_i + s_{rk} \cdot \Delta l_k \\
\frac{s_{rk}}{l_s}
\]

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 \( s_n = \text{konst.} \)
- \( s_n \) \([10^{-3}]\) reduced section gradient according to [Široky, 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:

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

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

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

where:

- \( \rho \) \([1]\) coefficient of the influence of rotating mass

3 \textbf{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):

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

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:

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

205
Then it is possible to express ratio of the individual items $P_{TR}$:

$$P_{Oj} : P_{QT} : P_{OZ} = \sigma_M : \sigma_T : \sigma_Z = \left( a + b \cdot v + c \cdot v^2 \right) \left( s \cdot 10^{-3} \right) \left( \frac{a}{g} \cdot (1 + \rho) \right)$$

(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:

$v_p - V_{max} = 30 \text{ km.h}^{-1}$, $G_M = 10,5 \cdot 10^6 \text{ N}$, vehicle type Bo'Bo'+T4 (see Široký, 2004, p.32), $a = 0,1 \text{ m.s}^{-2}$, $s = 5 \%$.

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 $V_p \in (10; V_{max}) \text{ km.h}^{-1}$

<table>
<thead>
<tr>
<th>$V$ [km.h$^{-1}$]</th>
<th>$P_{OZ}$</th>
<th>$P_{QT}$</th>
<th>$P_{OT}$</th>
<th>$P_{OK}$ [kW]</th>
<th>$L_{r}$ [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>86.0%</td>
<td>11.4%</td>
<td>2.7%</td>
<td>365</td>
<td>39</td>
</tr>
<tr>
<td>20</td>
<td>85.5%</td>
<td>11.8%</td>
<td>2.7%</td>
<td>734</td>
<td>154</td>
</tr>
<tr>
<td>30</td>
<td>84.9%</td>
<td>12.5%</td>
<td>2.7%</td>
<td>1109</td>
<td>347</td>
</tr>
</tbody>
</table>

Diagram 2 offers a graphic presentation of the results.

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.

Literature used:
