INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

KKS/ZDMT Basics of traction mechanics

Presentation 11

Ing. Vladislav Kemka

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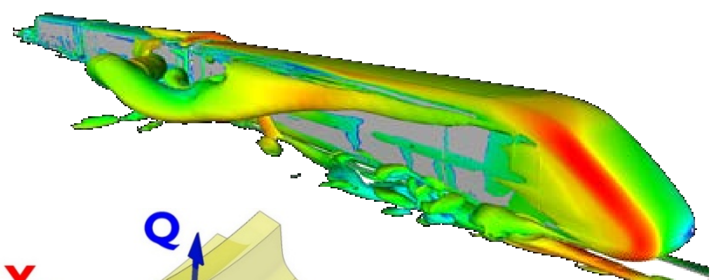
BASIC TRACTION MECHANICS OF TRAINS

Traction mechanics assesses the movement ratio of vehicle and train, sets the size of traction resistance (resistance to motion), and pulling force and power of the pulling vehicle.

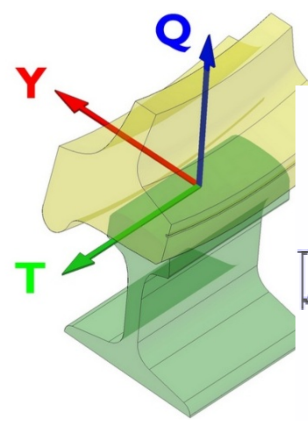
Traction resistance

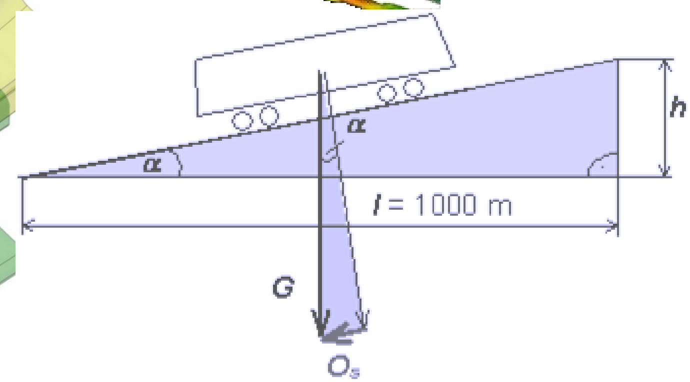
Resistance forces are O_i [N], more often specific resistance o_i [N/kN]

$$o_i = \frac{O_i}{G}$$



- **Track resistance**
  - Resistance from incline of track
  - Resistance from curve of track
  - Tunnel resistance
- **Vehicle resistance**
  - Travel resistance
  - Resistance from inertia





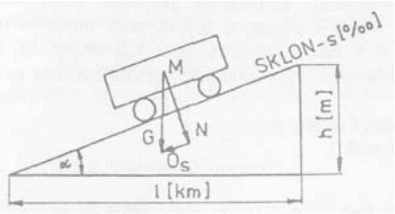
TRACK RESISTANCE

- **Resistance from incline of track**

Acts on a vehicle moving on an inclined track. When climbing it is positive (vehicle slows), when descending it is negative (vehicle accelerates).

$$O_s = \pm G \,.s$$

$$o_s = \pm s$$



- **Resistance from curve of track**

Solving the movement of a vehicle on a curve is complicated, so an empirical model is used.

- Normal gauge line-main line (example)

$$o_r = \frac{650}{R-55}$$

- Normal gauge line – siding line (example)

$$o_r = \frac{500}{R-35}$$

- **Tunnel resistance**

Aerodynamic resistance arising when travelling through a tunnel.

- Single track tunnel o_t = 2 N/kN
- Double track tunnel o_t = 1 N/kN

VEHICLE RESISTANCES

- **Travelling resistance of vehicle**

  $O_o = A + B.v + C.v^2$, or $O_o = A + C.v^2$

More often used is specific resistance o_o

  $o_o = a + b.v + c.v^2$, or $o_o = a + c.v^2$

Many factors influence size of travel resistance:

- Resistance of wheels rolling on track (rolling resistance)
- Resistance of bearings in wheel set
- Aerodynamic resistance

The constants A (a); B(b) are dependent on rolling resistance and resistance in bearings, and constants C (c) are determined by aerodynamic resistance. Travel resistance is set during run-out tests.

Specific travel resistance, as used by ČD (Czech Railways) (example).

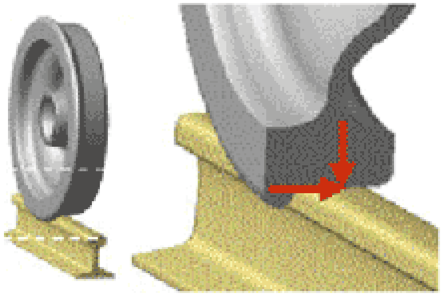
Drive vehicle, electric and diesel

  four axle $o_o = 2.8 + 0.00085.v^2$

  six axle $o_o = 3.8 + 0.02.v + 0.0004.v^2$

Passenger wagon

  four axle $o_o = 1.35 + 0.008.v + 0.00033.v^2$



VEHICLE RESISTANCES

- **Acceleration resistance**

During acceleration, the forces of inertia must be overcome. Apart from sliding parts there are also rotating parts.

$$O_a = \xi.m.a$$

Specific acceleration resistance:

$$o_a = \frac{\xi.m.a}{G}$$

ξ - coefficient of rotating parts

For diesel locomotives ξ = 1.1 ÷ 1.2

Electric locomotives ξ = 1.15 ÷ 1.3

Passenger carriage ξ = 1.03 ÷ 1.06

TRACTION CHARACTERISTICS OF LOCOMOTIVES AND THEIR USE

Resistance force is necessary to overcome the traction ability of a locomotive. The traction ability of a vehicle is manifested as the size of pulling force which the vehicle is able to exert either at the perimeter of the wheels (F_{to}) or on the vehicle couplings (F_{ts}).

$$F_{ts} = F_{to} - O_o = F_{to} - G \cdot o_o$$

If we know the power of the engine (electric, diesel) at the shaft P_h, we must know the efficiency of transfer η_p, in order to determine power at wheel perimeter P_{to}.

$$P_{to} = P_h \cdot \eta_p$$

Power at the wheel perimeter also determines the relation between pulling force at wheel perimeter and speed of travel, where:

÷

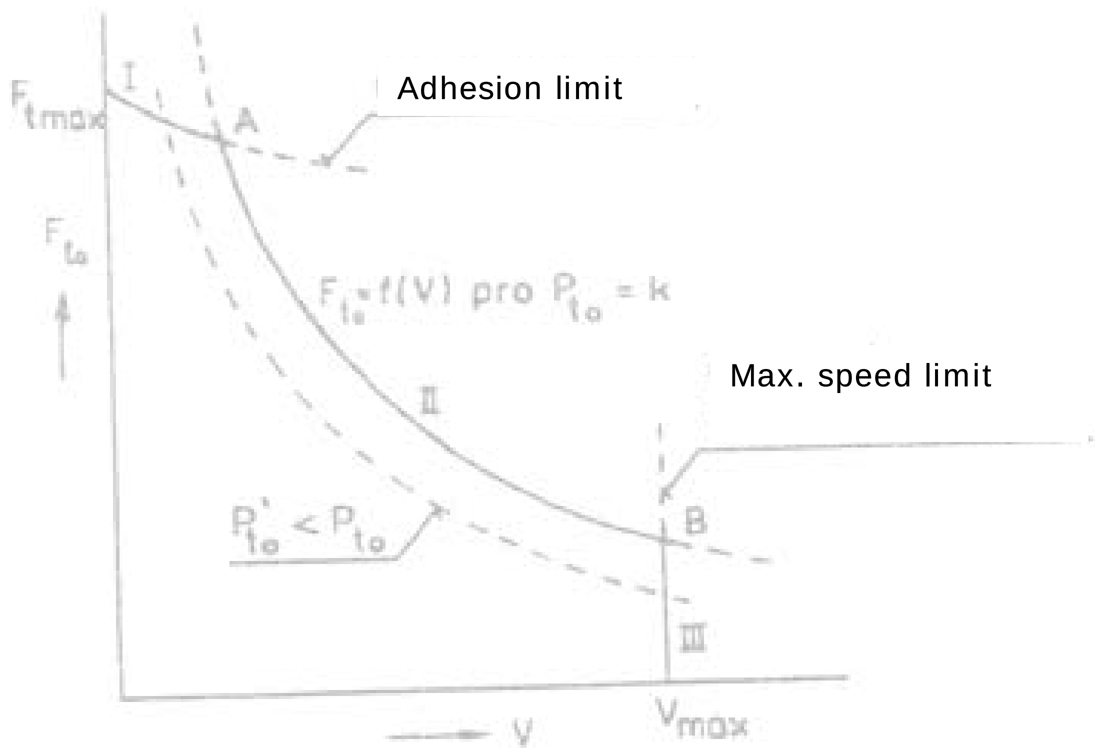
$$P_{to} = F_{to} \cdot v$$

Power of drive wheels is also lowered by losses from slip. Adhesion of rolling wheels along the track means that the peripheral speed is not the same as forward speed. The difference between these speeds is slip speed w . Thus slip power is defined as:

$$P_{zo} = F_{to} \cdot w$$

TRACTION CHARACTERISTICS

Basic traction characteristics have limit points A and B, which are given by the adhesion limit, and from the max. speed limit of the vehicle. The total 'package' of traction characteristics has three sections, marked I, II, III.



TRACTION CHARACTERISTICS

- Section I.

$F_{toadh} = \mu_v \cdot G_a$

G_a adhesion weight of vehicle. $Ga = G \cdot \eta_a$ where η_a is utilization of adhesion weight of vehicle $\eta_a = 0.9 \div 0.92$

μ_v vehicle adhesion coefficient

Resultant vehicle adhesion coefficient is lower than the achievable adhesion coefficient for a wheel set. Adhesion is very different on dry, wet and dirty tracks.

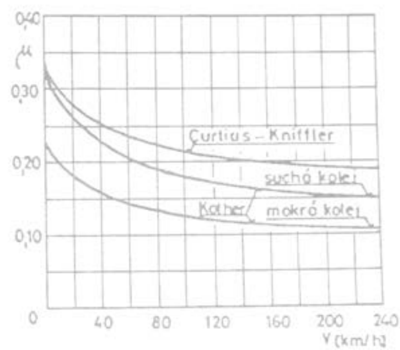
The relation $\mu_v = f(v)$ is used for all traction vehicles, obtained from measurements according to Curtius - Kniffler or Kother.

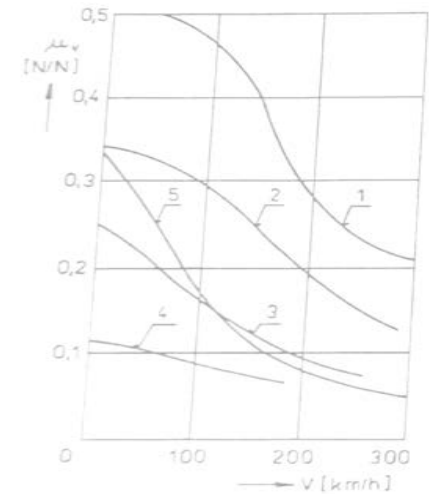
The Curtius – Kniffler curve is for middle values

$$\mu_v = \frac{7.5}{v+44} + 0.161$$

The Kother curve is for dry track

$$\mu_v = \frac{9.0}{v+42} + 0.116$$





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Součinitel adheze dle měření SNCF

- Section II is an equiaxial hyperbola of constant max. power
- Section III is the max. design speed

Actual traction characteristics are determined using a traction source and equipment for power transmission.

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