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CALCULATION OF RESERVE POWERED VEHICLES NUMBER USING A RANDOM VECTOR

STANOVENÍ POČTU ZÁLOŽNÍCH VOZIDEL S VYUŽITÍM NÁHODNÉHO VEKTORU

Abstract

The contribution deals with determination of a number of reserve vehicles to be operated on cycle repeating transport routes. Too high number of the reserve vehicles causes economic losses of a transport company, while insufficient number of vehicles brings irregularities in observance of the timetable. The calculation uses a random vec-tor which characterizes the achieved level of trouble-free operation and maintainability of a rail powered vehicle.

Abstrakt

Příspěvek se zabývá stanovením počtu záložních vozidel při obsluze cyklicky se opakujících dopravních tras. Příliš vysoký počet záložních vozidel způsobuje ekonomické ztráty dopravní společnosti, nedostatečný počet vozidel způsobuje nepravidelnosti v dodržování jízdního řádu. Ve výpočtu je použit náhodný vektor, charakterizující dosaženou úroveň bezporuchovosti a udržovatelnosti hnacího vozidla.

1 INTRODUCTION

Employment of powered traction vehicles in the railway operation is controlled by a routing sheet - the powered vehicle running diagram. Within the diagram there are groups, into which traction vehicles of same or, with traction properties similar, vehicle classes are arranged. For each of the group the calculation can specify basic characteristics, as mentioned in [1]. An important parameter, calculated from the time of the full powered vehicle turn-round (see Fig. 1) is a number of vehicles Nt that ensure servicing on the cycle repeating transport routes.

2 THE TURN-ROUND COMPLETION PROBABILITY BY THE VEHICLE

The basic prerequisite for functionality of the group is a demand for a certain number of vehicles Nt which are in operational (failure-free) state and so they can perform the traffic work in the length Lv. If a failure occurs on the vehicle, or generally if there is a maintenance requirement, it is possible to use the turn-round as an opportunity to perform work on the traction unit Tp, without disturbing the locomotive daily duty. If the maintenance fails to be finished in the time Tp, however, it is necessary to use a reserve vehicle and thus to supplement the number of the serviceable vehicles up to the number Nt. The total number of vehicles Nc, necessary for operation of the group, can be specified according to the relationship (1).

$$Nc = Nt + Nz \tag{1}$$

Where:

Nc... - total number of vehicles in the group.

Nt ... - number of vehicles in the group, serving the transport routes.

Nz... - number of reserve vehicles.

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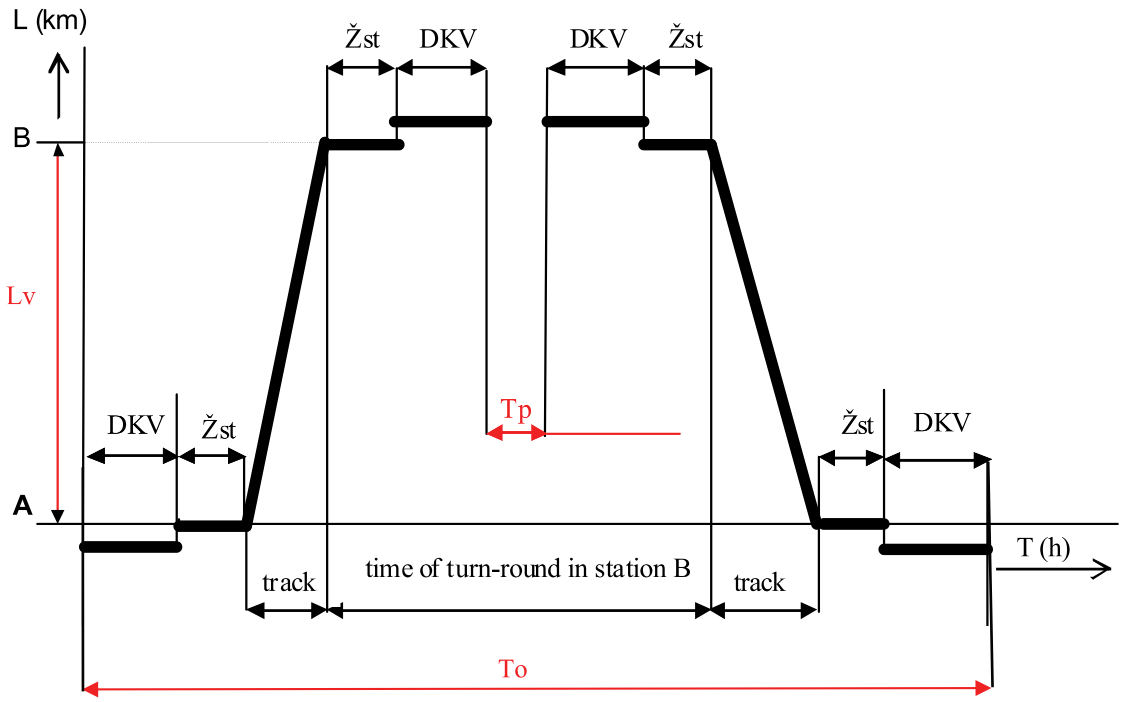

Fig. 1 Diagram of the powered vehicle planned daily duty

Legend to Fig. 1
To - time of the full powered vehicle turn-round [h].
Tp - time of technical pause within the full turn-round [h].
Lv - line moved by the powered vehicle within the full turn-round [km].
DKV- a rail vehicle depot.
Žst - a local railway station.

Further, it holds that vehicles that do not complete their full turn-round are replaced by reserve ones, otherwise the number of serviceable vehicles would drop below the value Nt. Number of the reserve vehicles can be specified from this relationship:

$$Nz = Nt \cdot (1 - P(l,t)) \tag{2}$$

$$P(l,t) = 1 - [F(l) \cdot (1 - F(t))] \tag{3}$$

Where:

P(l,t) .. - probability of the vehicle full turn-round completion [-].

F(l) .- distribution function for line division probability between the vehicle failures [-].

F(t) .- distribution function for probability division of the vehicle maintenance time [-].

Derivation of the function P(l,t) exceeds possibilities of this contribution, this has been done in the work [3]. The function specifies probability with which a powered vehicle concludes successfully the full turn-round in dependence on the achieved level of trouble-free operation and maintainability.

Let´s suppose that the line moved between the failures and the time of the vehicle maintenance have exponential division of probability [2]. The relationship (3) passes into this form:

$$P(l,t) = 1 - \left[\left(1 - \exp\left(-\frac{Lv}{Ls} \right) \right) \cdot \left(\exp\left(-\frac{Tp}{Ts} \right) \right) \right] \quad (4)$$

Where:

Lv - line moved by the vehicle within the full turn-round [km].

Ls - mean line moved between the failures [km].

Tp - time devoted to maintenance within the full turn-round [h].

Ts - mean maintenance time [h].

Graphic presentation of the course of a function P(l,t) can be seen in Fig. 2, the quantities are represented using standardization of a random quantity Lv to the mean value of probability division.

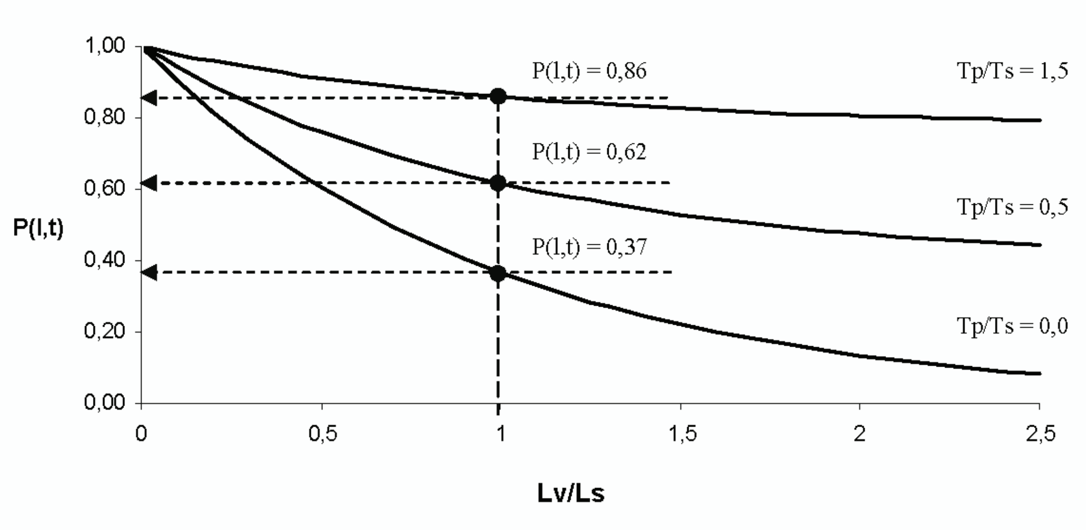

Fig. 2 Course of the fulfilment probability P(l,t)

Legend to Fig. 2:

- providing that no maintenance time is given (Tp/Ts = 0), the probability of completion of the whole turn-round falls because the vehicles must work failure-free
- specifying the maintenance time Tp, at first the probability of completion of the full turn-round rises quickly, gradually it is approaching the value of 1
- considering the relation (3), it is obvious that with rising probability value of the full turn-round completion the number of reserve vehicles is falling

3 CALCULATION OF THE RESERVE VEHICLES NUMBER

Transport companies keep at disposal a certain number of reserve vehicles ***Nz*** considering a demand ***Nt.*** This gives a relation ***Nz/ Nt***, which is constant for the given group and so the probability value P(l,t) must be constant as well. The relationship (2) passes into the form:

$$\frac{Nz}{Nt} = \left(1 - P(l,t)\right) = konst \tag{5}$$

$$\frac{Nz}{Nt} = \left(1 - \exp\left(-\frac{Lv}{Ls}\right)\right) \cdot \left(\exp\left(-\frac{Tp}{Ts}\right)\right) \tag{6}$$

Numeric value of the mean distance between the vehicle failures Ls and the mean maintenance time Ts in the relation (6) is given by the achieved level of the vehicle reliability; without changing the vehicle design this cannot be changed. The distance moved by the vehicle within the full turn-round Lv and the time defined for maintenance Ts are variable quantities, the relation Nz/Nt is a constant. It is, therefore, efficient to compile a function which shows a mutual relation of these values (Fig. 3).

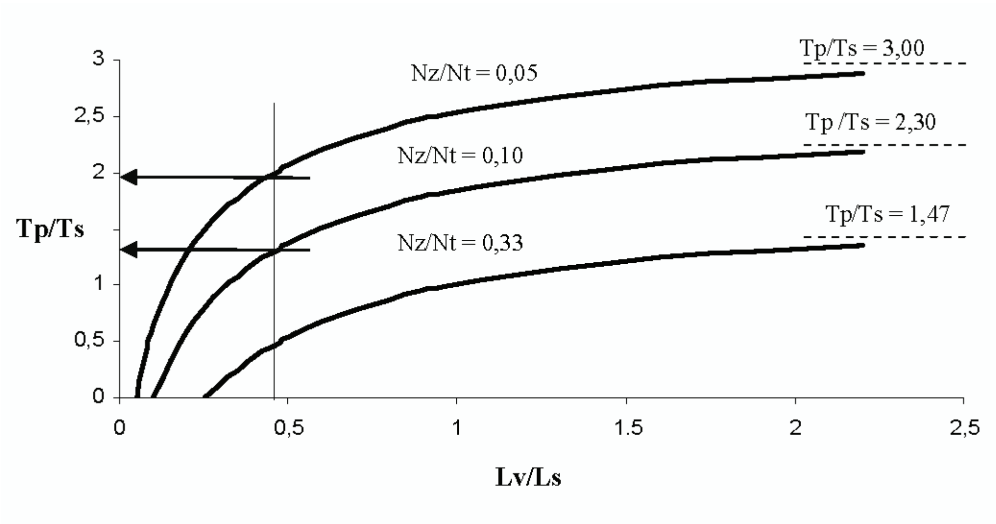

Fig. 3 Dependence of maintenance time on distance moved by a vehicle

Legend to Fig. 3:

- separate curves correspond to various numbers of reserve vehicles. For example, Nz/Nt = 0.10 means that for 10 vehicles in operation there is 1 vehicle in reserve
- if we reduce number of reserve vehicles, we have to prolong the maintenance time. The extended maintenance period is bound by the course of a relevant curve
- at a given number of reserve vehicles it is efficient to prolong the maintenance time Tp only to a certain limit (a limit value). Its further prolongation is purposeless

4 CONCLUSION

The mentioned model shows a mutual relationship between the vehicle reliability, construction of the full turn-round and number of reserve vehicles. With knowledge of a course of trouble-free operation and maintainability of the vehicle it is possible to specify a suitable number of reserve vehicles.

key words: trouble-free operation, maintainability, random vector

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