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Influence Resistance at Advancing on Fuel Consumption for Vehicles that use an Internal Source of Energy

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Abstract

In the case of railway traction, an analysis on the influence the running resistance about the fuel consumption for the motors vehicles equipped with an internal source of energy(diesel engine or gas turbine) is necessary and from the perspective of the optimal way of their exploitation. This paper aims to determine the influence they have the aerodynamic phenomena on the running resistance and therefore to the fuel consumption, in case of traction vehicles equipped with diesel motors which are operated by the railway companies in Romania. To achieve the study, we considered the following vehicles: diesel electric locomotives LDE 060 DA of 2100 CP, LDE 060 DD of 4000 CP, LDE 060 EGM of 2100 CP, Carpathia DEM of 2300 CP and railcar Siemens Desiro. The calculation of fuel consumption is achieved in case of a path segment with a length of 1000m. In this sector, the above-mentioned vehicles were analyzed in three distinct situations: when moving with the maximum design speed kept constant; when towing of maximum tonnage when moving a constant speed; and when it is in the process of starting. This article is developed in the programs postdoctoral studies at the University Politehnica of Bucharest.
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Keywords: the running resistance; the fuel consumption; the rail vehicles with diesel motors

1. Introduction

During the movement of the engines railway vehicles (such as diesel locomotives or railcars) about their, acting on the one hand the traction force developed by electric motors and on the other hand, the amount of resistance

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forces that oppose the movement in the desired direction. These forces must be smaller or equal to the threshold limit of adhesion of wheel rail contact

Mathematical relationship that describes the movement of vehicles between two points of the railway sector in traction, can be written according to the thrust, the total resistance at advancing and limit force of adhesion contact wheel rail as (Chiriac, 2002; Lukaszewicz, 2001; Arsene, 2013; Hong-qi, 2009; Orellano & Schober, 2006) as follows

$$F_{0(v)} - R_{t(v)} \leq F_{a(v)} \quad (1)$$

The sum of resistance forces encountered by a vehicle during driving in alignment and plane is dependent on a number of friction such as: friction on the axles bearings, rolling and / or sliding friction, road surface friction, air friction, between the collector current (patina, pantograph) and contact line, etc.

General formula used of the vehicles resistance to motion is named W.J. Davis's relationship. This mathematical expression may be described as a polynomial function of the second degree as specified in the papers (Arsene, 2013; Raghunathan, Kim & Setoguch, 2002; Nicola & Cismaru, 2011; SYSTRA, 2011; Lukaszewicz, & Andersson, 2009; Lukaszewicz, Andersson, 2009; Winter, König, Kopp, Dittus & Holger, 2012)

$$R_t = A + B \cdot v + C \cdot v^2 \; [N] \quad (2)$$

Where: R_t - Total resistance to motion of the vehicle; A - Mechanical rolling resistances caused by the axle loads; $B \cdot v$ - Non-aerodynamic drag; $C \cdot v^2$ - Aerodynamic drag; v - Speed of the vehicle.

By reporting this resistance to vehicle weight will get specific resistance to motion (relation 3):

$$r_t = \frac{R_t}{m \cdot g} = a + b \cdot v + c \cdot v^2 \left[\frac{N}{kN}\right] \quad (3)$$

The coefficients A, B, C respectively, a, b and c are obtained experimentally, and they are characteristics of each type of vehicle in part. To exemplify this in the case of engine railway vehicles with internal energy source we presented some values of the coefficients in Table 1 Davis, found in the literature (Lukaszewicz, 2001; Arsene, 2013; LI, Dong, JI & Zhang, 2012; Orellano, 2010; Orellano, 2012; Arsene & Sebeșan, 2014)

Experimental determination of the values coefficients from formula of the resistance to motion can be achieved by three methods: traction method, torque method or traction bar and the method of launching free or deceleration method. (Chiriac, 2002; Arsene, 2013)

Table 1. The values coefficients of the resistance to motion for railway vehicles with Diesel engine

Vehicles type	A [N]	B [N/(km/h)]	C [N/(km/h)^2]	a [N/t]	b [(N/(km/h))/t]	c [(N/(km/h)^2)/t]
Locomotive LDE 060 DA (120[t]) 2100CP	2450,4	9,84	0,3924	2,08155	0,008359	0,000334
Locomotive LDE 060DD (123[t]) 4000CP	3185,7	9,84	0,4059	2,64016	0,008155	0,000336
Locomotive Carpathia DE – M (115[t]) 2300CP	4161,574	11,4929	0,46426	3,68885	0,010187	0,000412
Locomotive LDE 060 EGM (116[t]) 2100CP	4047,8375	10,8106	0,45518	3,5571	0,0095	0,0004
Siemens Desiro Railcar (80 t)	1557,7	12,8	0,40108	1,98484	0,01631	0,000511
Locomotive LDE 060 DA (120[t]) 2100CP	2450,4	9,84	0,3924	2,08155	0,008359	0,000334
4-axes loaded single-deck wagon (average 50t)	809,325	0	0,12263	1,65	0	0,00025

The percentage analysis of the components of the resistance to motion is the method also used in (Arsene, 2013; Diedrichs, 2006). This allows an assessment of the variation power used in train traction respectively of the energy

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