Determination of electrodynamic and aerodynamic resistance for maglev train with an electrodynamic suspesion system

Dipl.-Ing. Arkadij LASCHER
Technische Universität Dresden, Institut für Elektrische Verkehrssysteme
Mommsenstr. 13, D-01062 Dresden, Germany
Phone: +49 231 / 24 10 41, Fax: +49 231 / 589 52 14
e-mail: a.lasher@gmx.de

Dr.-Ing. Evgeni FRISHMAN
Lecturer, Jerusalem College of Technology.
21 Havaad Haleumi St., Jerusalem 91160, Israel
Phone: +972-2 / 5352861
e-mail: f688349@netvision.net.il

Dr.-Ing. Mark UMANOV
Faculty Railway and Railway Economy, Dnepropetrovsk National University of Railway Transport 2, Academy Lazaran, 049700 Dnepropetrovsk, Ukraune
Phone: +38 0567 / 33 19 - 12, Fax: +38 0562 / 47 18 - 66
e-mail: diit2000@a-teleport.com

Dipl.-Ing. Helen PRISHEDKO
Institute of the Transport Systems and Technologies of the National Academy of Sciences of Ukraine "Transmag" 5, Pisarzhevsky St., 320005 Dnepropetrovsk, Ukraine
Phone: +38 0567 / 37 21 - 85, Fax: +38 0562 / 37 21 – 86
e-mail: itst@westa-inter.com

***Abstract* - Now development of Maglev transport has reached its practical application. Therefore, one of the most important question is determination of the area of effective application of Maglev transport systems. Resistance forces acting on the train largely determine its is calculation of these forces technical and economic parameters. The main task of this work.**

***Keywords* - High-speed ground transport (HSGT), Superconducting magnets (SCM), Maglev-transport systems (MTS), Electrodynamic suspension (EDS), Aerodynamic resistance of a train.**

I. Introduction

At the present time the most important is the commercial applicability of maglev transport. Correct methods of an estimation of resistance forces allow to determine areas of effective application of such systems and to optimize their parameters depending on operation conditions.

II. STATEMENT OF THE PROBLEM

Tests results of tests of various maglev trains have shown, that both electrodynamic and aerodynamic resistance forces depend on the length of a train.

The executed calculations have allowed to find dependences of electrodynamic and aerodynamic resistance forces on the movement speed and the length of train (as an example of the train of system "Transmag"*) is considered).

III. MATHEMATICAL MODEL

According to [1-2], the electrodynamic resistance to movement of the Maglev-train of system "Transmag" is determined by the expression:

$$F_D = 8 * K_{coil}^{korr} * K_{coil} * \frac{3{,}6 * V * v_{c1}}{V^2 + (3{,}6 * v_{c1})^2} * \left(n_w^{ed} + 1\right) \text{ [кN]} \quad (1)$$

where

- K_{coil} - is the factor independent on the speed, K_{coil} = 1,1433 [кN];
- K_{coil}^{korr} - is an additional correction factor, K_{coil}^{korr} =1,3509;
- **8** - is a number of superconducting magnets in a car "Transmag";
- V - is a speed of movement of a train [m/s];
- v_{c1} - is a some characteristic value, v_{c1} =13,9 [m/s];
- n_w - is the number of cars in a train of system "Transmag".

*) System "Transmag" it is developed in Institute of Transport systems and Technologies of the National Academy of sciences of Ukraine [8]

With the account of [3-7] the expression for calculation of aerodynamic resistance force to movement of a train of system "Transmag" takes the following form:

$$F_{aero} = f_{Tu} * \left[\begin{array}{l} W_X^{zug^{2endsek}} + \left(1 + L_{endsek} * k_{1m}\right) * \\ * \dfrac{\lambda_p * S_p}{98{,}0602} + \\ + \dfrac{\left(L_{zug}^{ed} - 2 * L_{endsek}\right) * \left(tg\alpha_{zug} + tg\alpha_{air}\right)}{1000} \end{array} \right] * \left(V + {}_{\Delta}V\right)^2 \text{ ,[kN]} \quad (2)$$

where

f_{Tu} - tunnel factor, depending on the length of the tunnel and the train's configuration:

$$f_{Tu} = 1{,}22 + 0{,}07 * n_w \quad (3)$$

where

n_w - is the number of cars in a train of system "Transmag";

λ_p - is an factor of aerodynamic resistance of an air gap, λ_p = 0,004;

$W_X^{zug^{2endsek}}$ - is a factor of aerodynamic resistance for a train with two cars;

k_{1m} - is a specific size of a gain of factor of aerodynamic resistance for a train 1m of its length, k_{1m} = 0,013;

α_{air} - is a factor of aerodynamic resistance in a gap between the train and track depending on the length of the train (**Fig. 1**);

L_{zug}^{ed} - length of the train [m];

α_{zug} - is factor of frontal and lateral aerodynamic resistance of a train depending on its length (**Fig.1**), $\alpha_{air} + \alpha_{zug}$ = 0,132°;

V - is a speed of movement of a train of system "Transmag" [km/h];

${}_{\Delta}V$ - is an additional speed which takes into account the presence of a wind:

- in the tunnel: ${}_{\Delta}V$ = 0 [km/h];
- on an open site: ${}_{\Delta}V$ = 15 [km/h].

$L_{2endsek}$ - is the length of a train of system "Transmag" consisting only from 2 cars:

$$L_{2endsek} = 2 * L_w^{st} = 2 * 28 = 56 \text{ [m]} \quad (4)$$

where

L_w^{st} - is the length of one section of a train of system "Transmag", L_w^{st} = 28 [m].

S_p - is a cross-section section of an air gap between the car and the track, determined from expression:

$$S_p = W_{car} * h_{air} \text{ [m}^2\text{]} \quad (5)$$

where

W_{car} - is a width of the car of system "Transmag", W_{car} = 2,9 [m];

h_{air} - is a height of an air gap between the car of system "Transmag" and track.

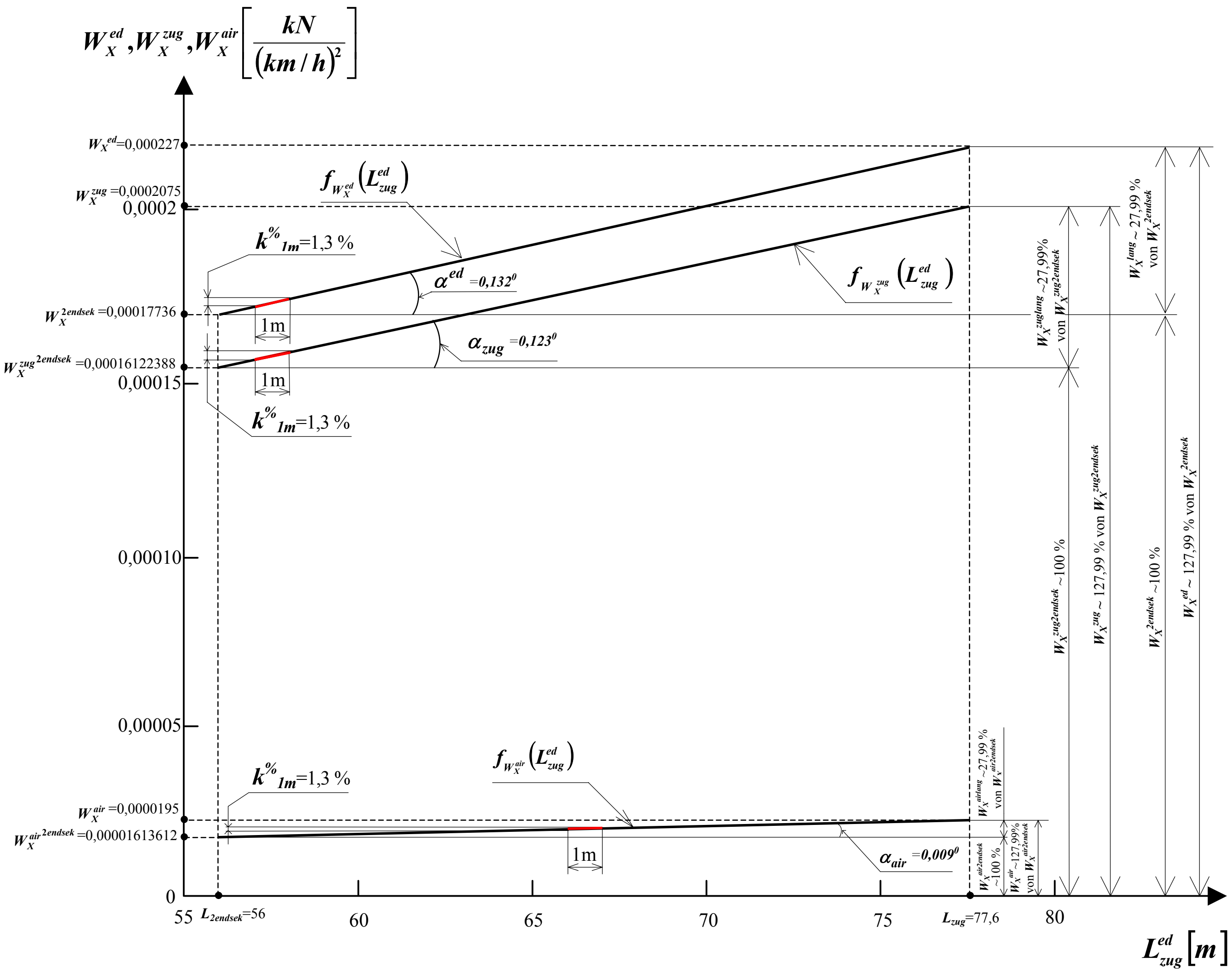

Fig. 1 Dependence of the factor of an aerodynamic resistance on the length of a train "Transmag"

IV. INITIAL DATA

As the varying parameters, the speed of a train within the limits 25-500 km/h and the number of cars in a train (2-10) were considered.

V. CALCULATION RESULTS

The calculation results are presented in **Fig. 2-4**.

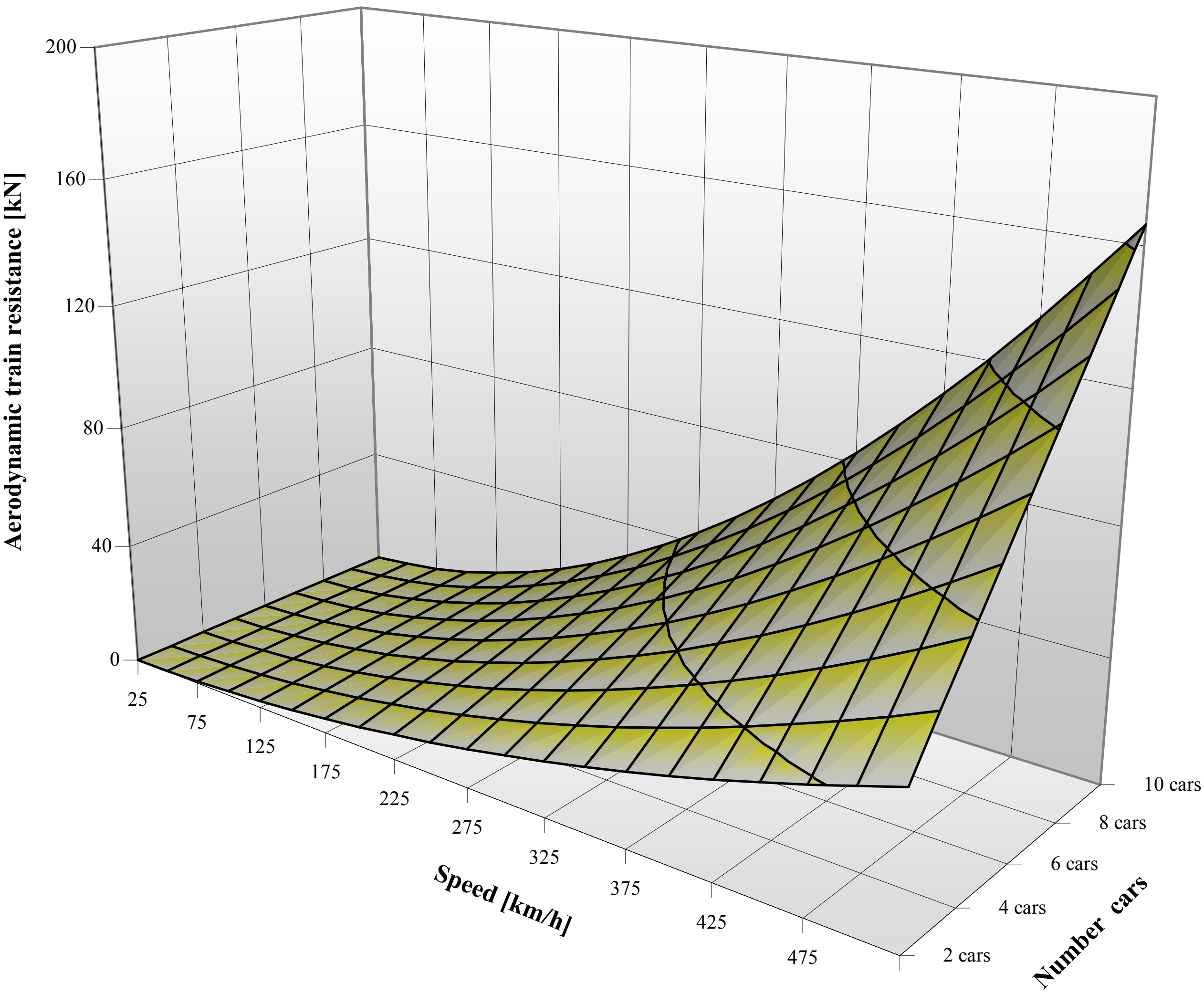

Fig. 2 Aerodynamic resistance

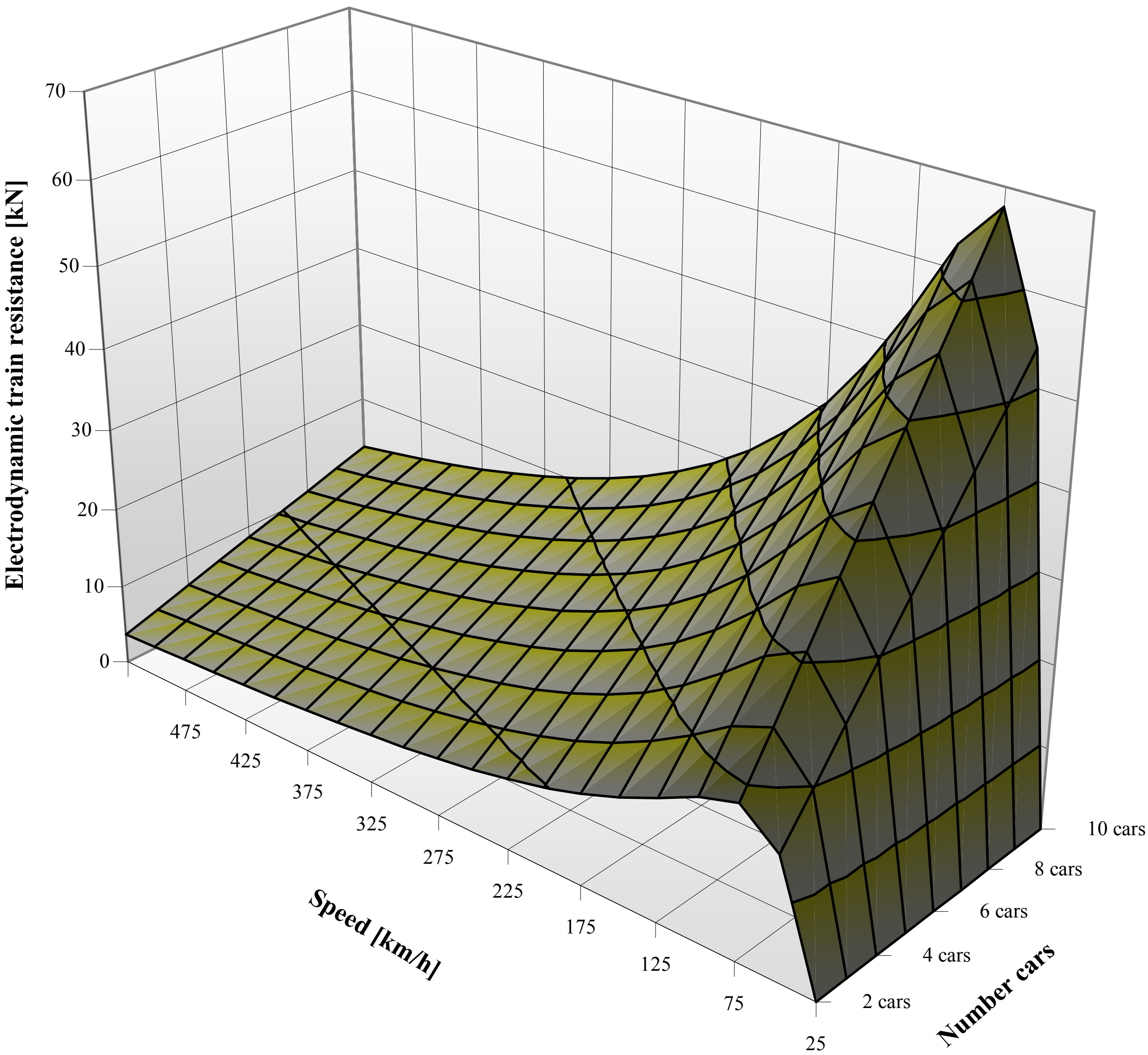

Fig. 3 Electrodynamic resistance

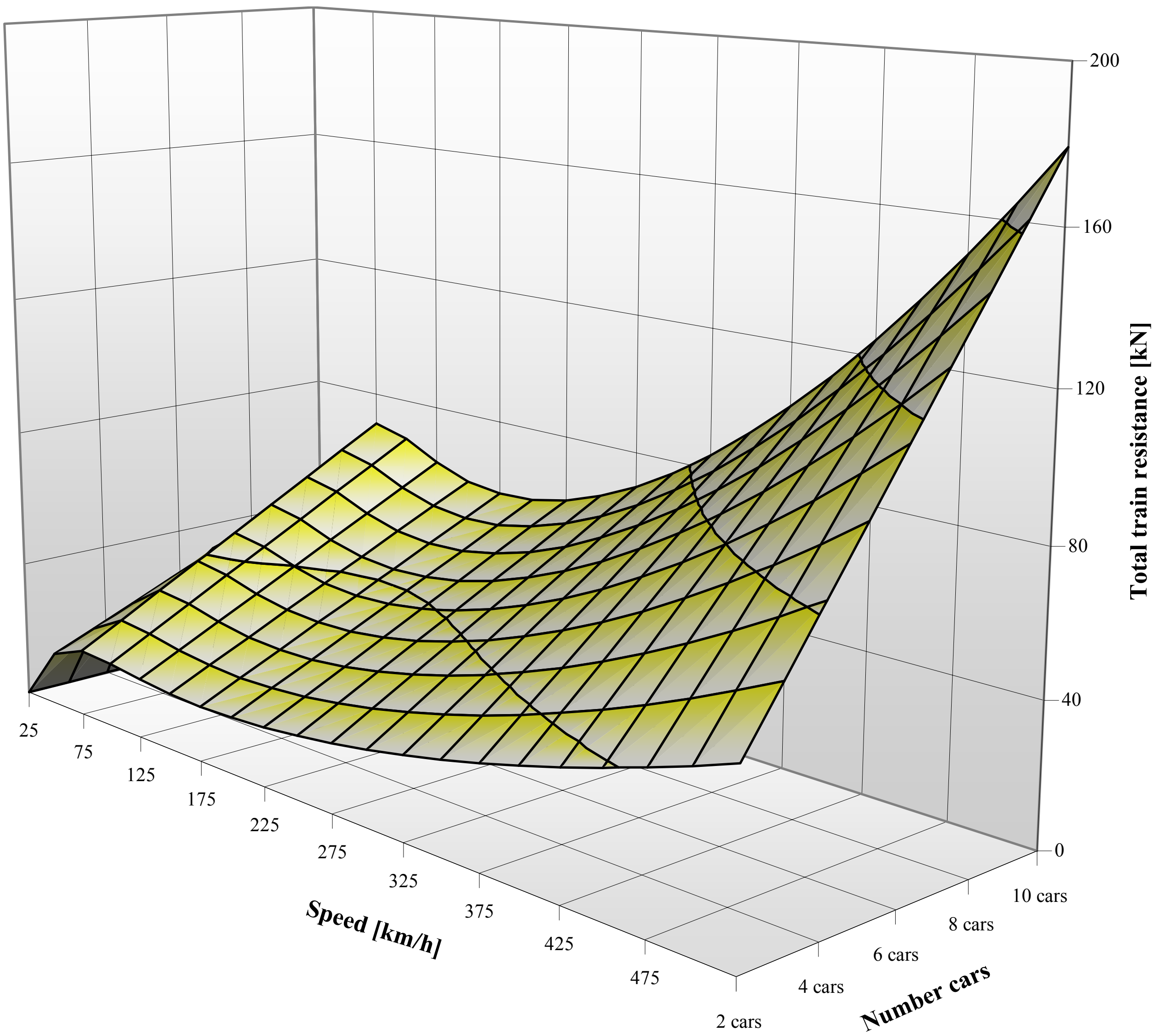

Fig.4 Total aerodynamic resistance and electrodynamic resistance

VI. CONCLUSIONS

The executed calculations have shown that

- the maximal value of electrodynamic resistance is observed at the speed of 50 km/h;
- the electrodynamic resistance is in a direct ratio to the number of superconducting magnets in the train ;
- for the speed over 50 km/h, the electrodynamic resistance decreases with the speed;
- aerodynamic resistance increases proportionally to a square of the length and speed of a train.

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