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Rapid test method for evaluation of thermo-technical condition of non-traction rolling stock car bodies

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Abstract

Reduction of energy use and polluting emissions of engines and is one of the challenges for ecological balance. For achieving optimal power-to-weight ratio of railway transport, rapidly developing special vehicles (SVs) equipped with power generating systems are considered as ambitious ones. SVs include refrigerator, passenger, and multiple unit cars. Optimization of energy consumed by SVs' heating and climatic installations helps minimize polluting emissions. Variable-speed drive, energy saving additives are commonly used to reduce energy consumption. However, expected results can be achieved only by compliance of SVs' car bodies to the thermotechnical standards, regular checks of total heat transfer coefficient K (W/sqm*K) by thermo-technical tests. Today, the transportation of agricultural products in refrigerated wagons and containers along the international North-South transport corridor (Russia-Iran) is relevant, which was the basis for the development of the Olymp software package, which allows you to quickly assess the thermal condition of the bodies used for transportation.

Introduction

Equilibrium method is internationally used for that: SVs are placed into homoeothermic environment, and their car bodies are heated from the inside by thermal source of certain capacity to the moment when air temperature stops rising and remains stable. Obtained air derivative represents equilibrium thermal condition; then K value is calculated. However, tests for calculation of K value are labor and time consuming and imply more 72 idle hours for tested SVs. A non-equilibrium method as faster process is proposed, which is calculation of K using the data obtained after first 11 hours of tests. Air heating process comprises irregular and regular phases. Difference between the two is in the heating rate behavior. During the initial period, temperature ratio change pace $d\theta/d\tau$ goes in accordance with equation: $d\theta/d\tau = \theta$1-B/A (1), where A and B are constant coefficients. 1-B to be read as power of θ. Then, irregular phase succeeds by a regular one in the point of contact of curve (1) and straight line (2). Then the pace is defined by heat balance equation: $d\theta/d\tau = P/W - K\cdot H\cdot\theta/W$ (2).

Testing Methods

Despite of the apparent simplicity of the testing method, K coefficient determination are not only labor consuming, but also related to significant downtime of the SV on the premises of a testing station. The experiment part itself takes more 72 hours. Fig.1 demonstrates actual graph of thermotechnical testing of passenger car body having the 284 m2 area in conditions of refrigerating test station [4]. Average temperature here was 14.7 oC. Testing activities implying a 7.09 kW electric heater took more than 84 hours. Fig.2 presents dynamic patter of K excursion. After stabilizing of equilibrium mode the recorded value was 0.87 W/m2 K.

- average temperature inside the car body;
- average temperature outside the car body;

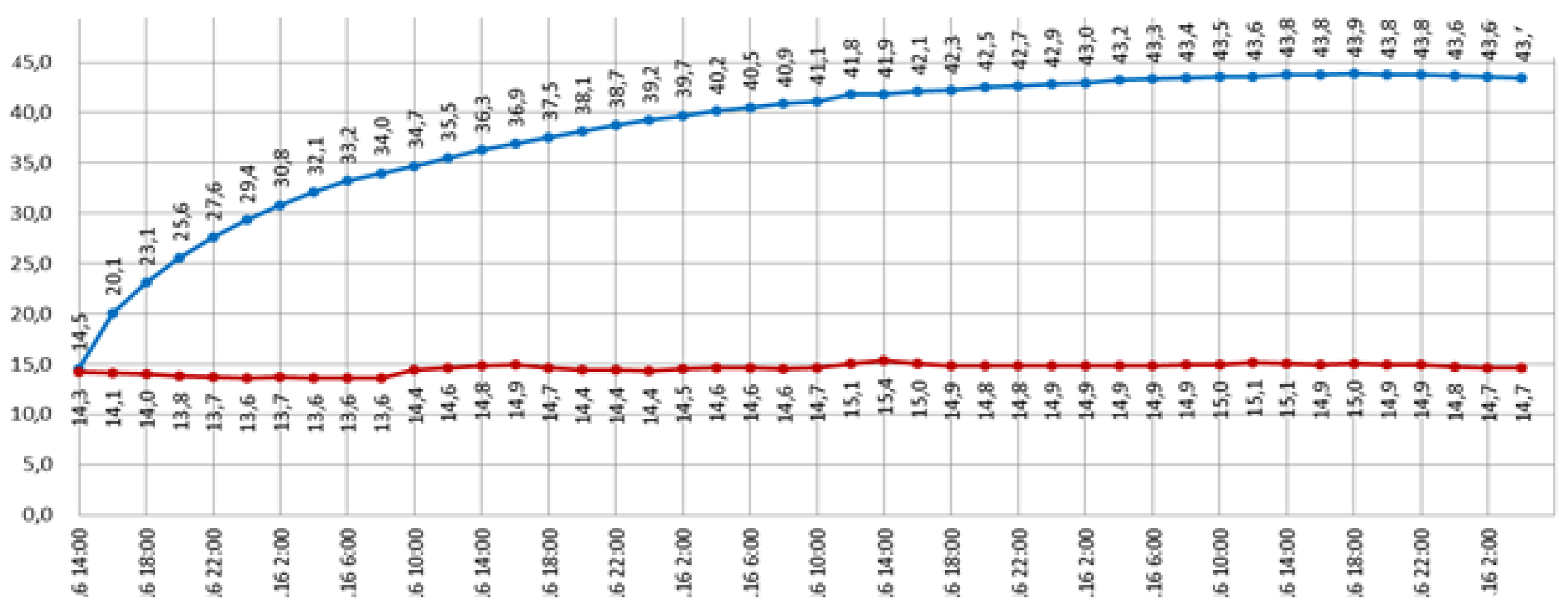

Figure 1. Temperature conditions inside and outside of a car during testing.

Methods of Express Testing

The authors of this paper had conducted a range of tests that allowed to establish that air heating and car body isolation process has two radically different modes, that are notionally named regular and irregular modes. Simultaneous solution of equations after a range of transformations leads to the expression that allows calculating total heat transfer coefficient value. Accuracy assessment of K determination by the abovementioned method was carried out by comparison of K values, derived for the same freight cars of refrigerating section in conditions of equilibrium mode on the premises of VNIIZHT Test Loop, and derived by calculation with the use of express method. Declination of K values derived by the express method from the values obtained by equilibrium method does not exceed 0.3% [5].

Calculation Program Complex "Olympus" as a digital tool for test centers

Developing the use of the abovementioned method digitally, in 2022 the Calculation Program Complex "Olympus" (hereafter referred to as "Olympus" complex) was designed [6]. Its significance is proved by the fact that all the parts of the Agreement on the International Carriage of Perishable Foodstuffs and on the Special Equipment to be Used for such Carriage [3], i.e. 50 world's major economies, agreed upon inspection of their SVs involved in international transportation of perishable goods. This includes commissioning inspections of SVs, and inspections after 6 year of operation. Inspections are aimed at checking of correspondence of K value to normative values.

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