Modern trends and problems of the railway transport development in Russia. Resource-saving technologies and new materials for the railway transport.

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«Energy saving processes in refrigerating equipment of rolling stock»

The report reveals the actual continuity of the problem of energy saving in the sector of refrigerating and climatic technology in rolling stock on railway transport. The energy saving mechanism is disclosed; the results of domestic refrigerator tests are presented together with the realization of energy saving cooling agents in air-conditioning setting in passenger vehicles and railway refrigerating technology.

This day, integration of the Russian Federation alongside with other CIS nations into the European or the worldwide systems depends in many aspects upon its compliance with the strict environmental requirements applicable to the railway rolling stock selection.

In this regard, the JSC “Russian Railways” (“RZD”) in compliance with the Montreal Protocol requirements concerning "Substances that Deplete the Ozone Layer" and other international conventions is at the final stage of implementing its program aimed to substitute chladione-12, condemned to be ozone-depleting, with transitional ozone-proof refrigerant mixtures of C10M1 type in refrigerating equipment operable in refrigerator and passenger rolling stock.

Chladione C10M1 has been listed as a legal substitute for R12 and labeled as ozone-proof by the UN-based agency – Industry and Environment Centre (UNEP IE, 1998). In Russia it is manufactured under the trade mark "Astron 12™" and shall be valid till 2030. At present, it is widely used in refrigeration engineering.

1.1 Global Warming factors

One of priority problems concerning the Earth's ecology preservation is the decrease in energy consumption (raising efficiency) and respective diminishing harmful exhaust of combustion materials applicable to engines, thermoelectric power stations, etc. The UN Conference on the Environment and Development held in Rio de Janeiro 3-14 June 1992 has prioritized the process of global warming as the extremely dangerous source of environmental consequences.

1.2 Energy Saving Mechanism

With aim to decrease energy consumption by refrigerating plants at all stages – in operation, in manufacture, under design – we have investigated ways of modernizing the refrigerants employed in these machines. The gist of modernizing included enriching refrigerants with a novel fluorohydrocarbonic modifier which received a preliminary name "LE" – an abbreviation for "Low Energy".

LE Modifier constitutes a special group of additives possessing polarized molecules characterized by strong chemical affinity with metals able to cover the metal inner surfaces of a refrigerating plant with a monomolecular layer; in particular it is true for surface areas with electronic heterogeneities – zones of crystalline defects, stress concentrators, etc.

The resulting layer not only improves lubrication of the movable parts of compressor but also eliminates oil deposits on the inner surfaces of both condenser and evaporator, where oil may partially accumulate in the course of refrigerator plant operation.
Fig. 1 schematically shows the behavior of polarized additives' molecules within the "parietal" area of the metal parts. When dissolved in the refrigerant, the LE Modifier actually "bombards" with its molecules the inner piping surfaces covered with oil deposits in the course of routine oil/chladone mixture circulation throughout the heat-exchange apparatus. Herein the oil molecules "lose contact" and join the common oil/chladone mixture flow, while the heat-transfer factor of the refrigerating plant makes a substantial growth thanks to monomolecular layer recovery.

Hence, enriching refrigerants with LE Modifier allows:

- to decrease the friction factor in the compressor's plunger and barrel assembly,
- to intensify heat exchange in condenser and evaporator, and
- to increase the compressor's service life.

13 Experimental Study

In order to confirm such effects, a number of experiments have been held concerning employment of modifier-enriched refrigerants in household refrigerators.

The first stage of this job included an experimental evaluation of LE Modifier influence upon R12 regarded to be a single substance. Experimental results are shown in Fig. 2.

Fig. 2 shows the time-related specific rate of power consumption for ZIL-277 refrigerator. The curves clearly tell that modifier added to the refrigerant may substantially decrease specific rate of refrigerator plant's power consumption. Experiments have covered various trade marks of household refrigerators.

The next stage was devoted to testing non-azeotropic C10M1 refrigerant mixture. Experiments were alternated consecutively: with/without modifier. Modified refrigerant has got a preliminary name M1LE.

Experimental results for energy consumption parameters typical of M1LE refrigerant as compared to chladone-12 are shown in Fig. 3.

1.4 Application Perspectives

Widely used nowadays refrigerants R134a, R125, R404, R406a etc. may be enriched with LE Modifier thus resulting in energy consumption decrease.

Class "LE" refrigerants have been patented in Russia. They are manufactured in production quantities and are employed in refrigerating engineering, including railway applications.

Innovative refrigerants are employed in air-conditioning systems used for the passenger vehicles as well as in refrigerating plants for refrigerator rs and containers.
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«Basic research for innovations in Russian railways»

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Fundamental research aimed at the developments in the field of railway transport usually performed jointly by academic institutions, technical universities and other organizations in a frame of projects supported by the Joint Stock Company “Russian Railways” (JSC “RZD”) or by grants financed by the Russian Fund of Fundamental Studies (RFFI) or by other sources. There are many directions of these studies. These are new methods of environment, rolling stock, rail structure, railway bed, cantenary monitoring, development of new materials, new information technologies, including train operation control, computer simulation models, etc. In this presentation several examples of such researches are described. These are the development of computer tribodynamic model of vehicle-track interaction, new composite materials for electric current collectors and strips, models and studies aimed at development of new antifriction materials.

Computer-aided tribodynamic models of vehicle-track interaction enables to simulate railroad vehicle dynamics, wheel and rail profile simulation and solve many other problems. The task of creating tribodynamic model of railway vehicle-track interaction has been accomplished as a result of joint efforts of Bryansk State Technical University (BSTU), Institute of Problems in Mechanics of the Russian Academy of Sciences (IPMekh RAN) and All Russian Railway Research Institute (VNIIZhT). The base for this work is the program complex “Universal Mechanism”. Profile simulation due to wear was performed as multiversion calculation procedure in which wheel profile is changing at the end of the calculation procedure thus considering feedback from parameters that are changing in a process of wheel-rail interaction. Tribodynamic model of vehicle-track interaction is and will be used to solve diverse problems, wheel-rail profile optimization to achieve prolonged assets’ life and at the same time provides for safety requirements.

Another example is designing structural phases interaction models aimed at developing recommendations for composition of antifrictional alloys that are used in various sliding bearings, for instance diesel locomotive crankshaft bearings. The model consists of determination of temperature and stresses in the antifrictional layers, calculation of areas of plastic flow of the hard matrix and soft inclusions, calculation of quantity of soft phases on the antifrictional alloys. The work was accomplished by joint efforts of the Institute of Problems in Mechanics of the Russian Academy of Sciences and VNIIZhT.

One more example is developing composite, copper-based materials for electric contacts, current collection strips and the contact wire. The scientific base for material development is non-equilibrium thermodynamics. One of the goals of the study is to substitute silver in electric contacts for cheaper but reliable composite material. Another material is natural graphite carbon fibrous composite material for high speed current collection. The goal is to develop carbon-based material without metal additives that could successfully work for high speed electric trains. Other studies were performed to develop composite copper-based material for contact wire that possess increased performance characteristics required for high speed lines.
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These materials are being developed jointly by a laboratory on non-ferrous material of VNIIZhT, Moscow Steel and Steel Alloys Technical University and some other organizations.


Zur Zeit existieren folgende wichtigste Richtungen der Untersuchung im Gebiet der Energie- und Brennstoffversorgung:

- die Verwendung der neuesten Dieselmotoren mit höherem Wirkungsgrad im ganzen Belastungsbereich für Lokomotiven;
- die Benutzung des Erdgas und anderen alternativen Brennstoffen als Treibstoff für Lokomotiven;
- die Benutzung der Kondensatoren mit superhoher Energiekapazität für Speicherung der Energie, die beim Zugbremsverlauf gewonnen wird.

Ende des zwanzigsten Jahrhunderts waren etwa 10 Rangierlokomotiven mit Dieselmotoren in Betrieb, deren Treibstoff zu 50% aus Öl und zu 50% aus komprimiertem Erdgas bestand. Bis Heute wurden zwei weitere Versuchslokomotiven hergestellt, die ausschließlich Erdgas als Treibstoff benutzen. Die erste ist eine Rangierlok mit einer Gasturbine (komprimiertes Gas) und Kondensatoren mit superhoher Energiekapazität. Die Leistung der Energieanlage dieser Lokomotive beträgt 1 MW. Die zweite ist eine Streckenlok mit einer Gasturbine (flußiges Gas) mit einer Leistung von 8,3 MW.
Technical policy of Russian Railways (RZD) in the field of new rolling stock is focused on improvement of structure and quality of the rolling stock fleet.

Taking into consideration the prospective shortage of fuel and power resources in the near future one of the main areas of RZD activity are the studies focused on decrease in power consumption for traction, using alternative kinds of fuel and alternative power modules.

Another important area of the activity is development of rapid and high-speed trains and development of high-speed electric trains.

Information on some perspective developments and implemented projects on Russian railways will be presented in this paper.

1. Shunting gas-diesel TEM18G and ChME3G series locomotives
   A new power module with gas-diesel cycle is used. Natural gas is used as motor fuel, 50% of diesel fuel is replaced with gas. Five years operational experience of two diesel locomotives in Moscow and Ekaterinburg proved decrease in expenditures for fuel by 25%.

2. Shunting gas-turbine TGEM10 series locomotive
   A new transport gas-turbine module with regenerator, the efficiency factor of which is 42%, static converters and high performance energy storage devices are used.

3. Application of fuel cells
   Trials on a domestic sample of the fuel cells proved its correspondence to the requirements for traction purpose. Efficiency factor of the fuel cell sample was about 85%. For the perspective rolling stock with the power module on fuel cells variants with hydrogen and natural gas fuel supply have been developed. In the latter case the efficiency factor will be about 65% and it is considerably higher than coefficients achieved on diesel or gas-turbine engines.

   The present day high initial cost of the fuel cells can be considerably decreased at mass production of fuel cells and it will give an opportunity to consider them as a serious alternative to the traditional power modules.

4. Velaro Rus high-speed electric train
   RZD is realizing the project for implementation of high-speed traffic on the route St. Petersburg-Moscow-Nyzhni Novgorod. Siemens company was assigned as a partner of RZD. Many alterations have been made in the existing conception of Velaro trains for ensuring compatibility of the trains with the railway system of 1520 mm gauge.

   In September 2008 the electric train was exposed at Innotrans exhibition in Berlin. At present the first train manufacturing is completing, acceptance tests and commissioning on some components are being carried out.

   At the end of 2008 there is scheduled the first electric train arrival to the test center at Shcherbinka to carry out a complex of preliminary, acceptance and certification tests.
5. Pendolino high-speed electric train

Another large project is implementation of high-speed traffic on the St. Petersburg-Helsinki route. For several years joint work with the specialists of Finnish railways was carried out on working out Technical requirements for electric trains designed for interstate communication. In this connection a number of problems was solved, the main of which is compatibility of a new train with the normative base of EU railways and the space of 1520 mm gauge railways.

Alstom company won the tender on delivery of a batch of high-speed electric trains announced in 2006. Delivery of electric trains is expected from 2009.
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«Logistics at Russian railroads: automatic system for management of coordinated iron ore rawstock delivery by round trip trains»

1. Basing on rawstock shipment volumes declared for the planned period of time by the coordinated delivery planning subsystem, the time schedule is elaborated for round trip trains moving according to dedicated normative train schedule end-to-end threads. The management system having been developed is capable to elaborate the time schedule taking into account temporary limitations due to medium maintenance and major repair of railroad tracks as well as of loading-unloading machines at mining-and-processing and metallurgical plants.

A full trip schedule is charted for each round trip train as a combination of all trips during a planned period of time. Full trip schedules are built up basing on a precondition that empty round trip trains after unloading can be directed (addressed) to any of mining-and-processing plants. Full trip of a round-trip train can be obtained at the current trip completion time and tied up with start time of a next trip. This addressing method minimizes the round trip time. A minimum number of round-trip trains necessary for loading and transportation of declared amounts of iron ore rawstock corresponds to a sum of all full trips finding room in the planned time period.

2. Planned time schedule of round-trip trains is tested using management area simulation model. This testing allows to evaluate feasibility of the Time Schedule under influence of external disturbances upon the trips. As a result, a number of round-trip trains can be determined which should be added to a minimum number of trains obtained earlier as necessary for successive fulfilment of the plan. This number is the calculated value of freight car fleet intended for shipment and transportation of declared iron ore rawstock amounts.

3. After testing, a responsible person of Coal Transportation Dispatcher Center determines, basing on the calculated freight car fleet amount and on number of freight cars already available at the railroads, how many freight cars should be assigned for the planned time period. This number is an input for the Car Fleet Operation Subsystem basing on which this subsystem assigns a required number of closed-bottom gondola cars from operational fleet of Russian Railroads.

4. After having informed the executive personnel about the delivery plan, the system goes to the next phase called operational direction. It is performed by the Coordinated Delivery Dispatcher. The operational direction is aimed at maintenance of planned iron ore rawstock transportation volumes using assigned freight car fleet in accordance with the Time Schedule. Here the controlled entity is the specific loading facility: round-trip trains consisting of closed-bottom gondola cars whose turnaround is limited within a given railroad network area.

Main task of the Coordinated Delivery Dispatcher is ensuring of reliable departure times for empty round-trip trains after having been unloaded at the metallurgical plant in accordance with the pace defined in the Time Schedule. If a round-trip train’s delay as compared with the planned time during a current trip reaches a value making impossible timely departure for the next trip, the dispatcher removes this train from the trip and moves it to the dynamic reserve pool. In such a case, the planned trip is performed by another (earlier delayed) round-trip train.

The reserve train pool is a dynamic one, because it is updated on a permanent basis. It consists of all round-trip trains which, due to time deviations occurring during their current trips have been late for their next trip in accordance the Time Schedule.
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5. The tracking and supervision subsystem performs round-trip train position monitoring and keeping of train chart for the coordinated delivery area providing necessary information for all personnel involved in the operation. The proposed system can be adapted for any other delivery schemes for any goods transported by round-trip trains.
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«Infrastructure. Seamless Railways. Rail-Welding production of Russian Railways.»

The first Russian Railway was built 170 years ago, nowadays the railways network of Russia covers 130 thousand kilometers. 65% of the total Railways spread is laid on as seamless Railways.

Annually the length of seamless Railways increases by 4-5 thousand kilometers. In 2008 the Russian Government has adopted a new program on the Railways Transport development up to 2020 which in particular, envisages the construction of 30 thousand length new Railways and 5 thousand length high speed Railways trunks.

In the last 5 years to carry this Program out a powerful base of infrastructure was build up for providing construction, repair and current maintenance of seamless Railways.

These measures include:

- construction of 20 Rail-welding factories intended for 25 meters long Rails welding production with the aim to be transformed into 800 meters long tail extensions by the enterprises of the Metallurgical Industry of Russia;
- launching of 53 flow/line production for welding of the new Rails and renovating the old ones being in use;
- launching of 16 production lines of the old-used Rails re-profile and their welding into tail extensions;
- production of 93 mobile rail-welding machines;

More than 50 billion rubles were invested in reconstruction and modernization of 20 Rail-welding factories.

The Report presents the typical scheme of the Rail-welding factory and the production volumes of the Rails welding in the last 5 years including production at factories and on move with a glance to repeatedly used Rails. The pictures of mobile and stationary Rail-welding machines are presented including other types of equipment.

The problems of Rail-welding production are specified in particular, the Rails fractures along welding seams, the increase of places number for temporary reconstruction of long way tail extensions caused by the lack of the time intervals and the time shortage in the railway schedule required for Rail-welding production.

The experience of aluminum thermal welding practice is shared. The data on new developments of Rail-welding on move is described. One of the main problems is that the Metallurgical Industry of Russia produces 25 meters long Rails while many other counters of the world manufacture the Rails up to 100 meters long.