REDUCING THE FUEL CONSUMPTION OF COOLING THE CARGO BOARD OF ISOTHERMAL-REFRIGERATOR CARS BY MEANS OF RECUPERATIVE BRAKING

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Аннотация: *Данная работа посвящена исследованию возможностей снижения расхода топлива на охлаждение грузовых бортов изотермических вагонов-рефрижераторов за счет рекуперативного торможения. В ходе исследования были рассмотрены основные технологии охлаждения, используемые в грузовых вагонах-рефрижераторах, а также принципы работы рекуперативного торможения. Была разработана модель для оценки потенциальных сбережений топлива при использовании рекуперативного торможения. Результаты исследования подтвердили эффективность данного подхода в снижении расхода топлива на охлаждение, что может привести к улучшению экологических показателей данного вида транспорта и сокращению эксплуатационных затрат. Работа представляет интерес для специалистов в области транспорта и энергосбережения.*

Ключевые слова: *Расход топлива, Грузовые рефрижераторы, Изотермическое охлаждение вагонов, Регенеративное торможение, Энергосбережение, Экологическая эффективность, Перевозка регистровых грузов, Холодильные системы, Эксплуатационные расходы*

Annotation: *This work is devoted to the study of the possibilities of reducing fuel consumption for cooling the cargo sides of isothermal refrigerator cars due to regenerative braking. The study examined the main cooling technologies used in refrigerated freight cars, as well as the principles of regenerative braking. A model was developed to estimate the potential fuel savings when using regenerative braking. The results of the study confirmed the effectiveness of this approach in reducing fuel consumption for cooling, which can lead to improved environmental performance of this type of transport and a reduction in operating costs. The work is of interest to specialists in the field of transport and energy saving.*

Key words: *Fuel consumption, Refrigerated freight wagons, Isothermal wagon cooling, Regenerative braking, Energy saving, Environmental efficiency, Transportation of registered goods, Refrigeration systems, Operating costs*

INTRODUCTION

Refrigerated freight wagons play an important role in the transportation of registered and perishable goods such as food and medical supplies. However, cooling the sides of these vehicles requires a large amount of fuel, resulting in high operating costs and a negative impact

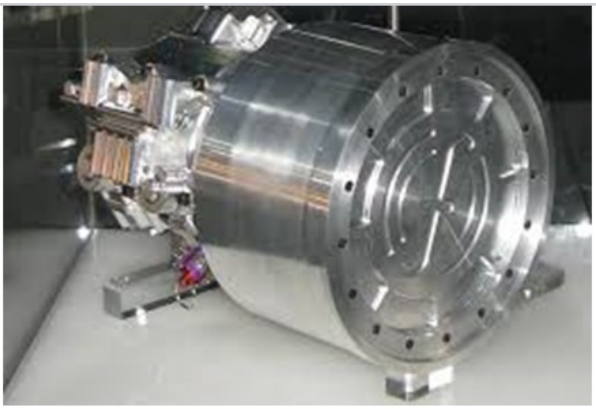
on the environment. In this regard, the development of effective methods of reducing fuel consumption for cooling cargo sides becomes an urgent task.

Main part

The purpose of this work is to study the possibility of reducing fuel consumption for cooling the cargo sides of isothermal refrigerated vehicles due to regenerative braking. To achieve this goal, a literature review on existing cooling systems and regenerative braking principles and the development of a model to estimate potential fuel savings are envisaged. .In this, retarder devices are installed on the wheels of semi-trailer trucks, and the generated energy is stored in batteries and transferred to refrigerators for use.

What is regenerative braking?

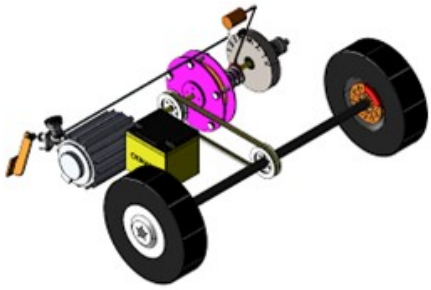
When you press the brake pedal on a petrol or diesel car, hydraulic fluid pushes the brake pads against the brake discs (or drums in older and cheaper models) on each wheel. The resulting friction slows the car, generates heat, and wears out materials in the pads and rotors.



Regenerative braking is a method of using the energy lost during the deceleration of the vehicle to charge the vehicle's batteries. In a normal car, braking simply wastes energy, but with regenerative braking, some of the energy can be reused.

Many modern cars are equipped with regenerative braking systems. In petrol and diesel models, they are used to charge the battery which activates various auxiliary systems in the car, meaning less work for the engine and less fuel burn. In these cars, the system is almost invisible to the driver, but in hybrid and pure electric cars, regenerative braking plays a more active and obvious role. In such models, brake regeneration helps charge the larger batteries that directly drive the car. The operation of the electrical recovery system is as follows. When there is a need to brake a vehicle (train or car), the traction motors (TEM) are disconnected from the power supply and switch to generator mode, that is, they start generating current

themselves. In this mode, a braking torque appears on the shafts of the electric motor, which causes a decrease in the speed of the car.



In recent decades, in international road transport, the total weight of road trains has increased and the average speed of their movement has increased, which was achieved by increasing the power of engines installed on tractors. Accordingly, the requirements for the braking dynamics of the road trains participating in them were strengthened, which could not affect the design of the components of the braking system. After all, the kinetic energy of a car train moving at a speed of 80 km/h is 4 times greater than the kinetic energy of a car train moving at a speed of 40 km/h! In 1960, the average road train was a tractor with a gross weight of 38 tons and a power of 240 horsepower. He developed an average speed of 40 - 45 km / h. In 1996, a 44-ton average road train had an average speed of 60 km/h on European highways, which required the installation of a 500 hp diesel engine on its tractor. Naturally, the brake system of the newest tractor had to have completely new components to ensure its safety. After all, the coefficient of friction between the brake linings and the disk (in the case of disk brakes) depends on the braking time, or rather, the temperature of the friction surfaces. Overloaded service brakes wear out quickly, which has a negative impact on transportation costs and, most importantly, forces drivers to slow down or even stop to allow the brakes to return to normal temperature.

Voith hydrodynamic retarders:

Since 1870, Voith has been engaged primarily in the design and construction of hydraulic power units for power plants. The company's designers have not created hydraulic turbines and mechanical gearboxes for 13 decades! The highest achievement in this regard is the equipping of the world's largest hydroelectric power station in Itaipu with a capacity of 13,200 MW. The company's specialists, who have a lot of experience in creating torque converters and fluid couplings, used them in land transport in the 20s of the last century: they tried to use it on railways and automobiles. In the late 1950s, they were approached by the Krauss-Maffei company with a request to equip several locomotives up to 4000 hp with hydraulic retarders, which were to be supplied to the railways of a number of countries. These locomotives had to work in teams of three and pull a freight train with a total weight of more than 10,000 tons. Voith designers created their first retarder or retarders using the fluid coupling principle, which reduced brake pad wear on these locomotives by 30%. It is noteworthy that this brake could work indefinitely without losing efficiency. The first unit was created in 1961, and in the same year, taking into account the prospects of a new business line, the company's management allowed the opening of a new specialized division of Voith Retarder - currently the leader in the production of retarders for heavy loads. trucks and buses.

Conclution

In the study, the problem of fuel consumption for cooling the cargo sides of isothermally refrigerated cars and the possibilities of reducing it through regenerative braking were considered. A literature review identified key cooling technologies and principles of regenerative braking, as well as their impact on reducing fuel consumption. The developed model made it possible to estimate the potential fuel savings when using this approach. The results of the study confirmed the effectiveness of regenerative braking in reducing fuel consumption for cooling the cargo sides of isothermally refrigerated vehicles. The proposed recommendations can be used in the design of new cooling systems or in the modernization of existing ones to increase their efficiency and reduce operating costs. Thus, the introduction of regenerative braking in the cooling systems of cargo sides of isothermally refrigerated vehicles can be a promising way to reduce fuel consumption. and increase the environmental efficiency of this type of transport.

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