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ПРИМЕНИМОСТЬ МИКРОВОЛНОВОГО ВОЗДЕЙСТВИЯ В ОПЕРАЦИЯХ СЛИВА ВЫСОКОВЯЗКИХ НЕФТЕПРОДУКТОВ

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В обзорной статье описаны основные трудности при совершении операций по сливу высоковязких нефтепродуктов с железнодорожных цистерн при применении подогрева сырья водяным паром. Рассмотрена теоретическая основа действия микроволнового излучения и его применимость в рамках разработки системы нагрева нефтепродуктов. Экспериментально описаны перспективы сравнения микроволнового и ультразвукового воздействия на экспериментальной основе для разработки системы подогрева сырья на ЖД эстакаде в Дальневосточном округе.

Ключевые слова: Железнодорожная цистерна, слив высоковязких нефтепродуктов, подогрев водяным паром, микроволновое излучение, нефтепродукты, ультразвуковой эффект.

PRACTICAL APPLICATION OF MICROWAVE EFFECT IN UNLOADING OPERATIONS OF HIGHLY VISCOUS OIL PRODUCTS

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The article describes the main difficulties in unloading operations of highly viscous oil products from tank-cars by the use of the steam heating. The theoretical basis of the microwave emission and its applicability in the engineering of a reheating system for petrochemicals are considered. Prospects of comparing microwave and ultrasonic effects for the development of a reheating system for petrochemicals tank cars in the Far Eastern District are provided.

Keywords: Tank-cars, unloading of highly viscous oil products, steam heating, microwave emission, petrochemicals, ultrasonic effect.

The oil's applicability as a raw product for fuels is undoubtedly an important aspect for the existence of modern industry. Petrochemicals are used not only as fuel for transport and heat power plants, but also as lubricating agents to increase the durability of the parts of the unit. The main problem related to highly viscous oil products is its transportation and unloading operations.

Transportation of petrochemicals from refineries to the point of consumption is carried out by rail and road. Railway transport is more acceptable for long distances on the basis of economic analysis. Oil products usually are transported in car tanks (Figure 1).

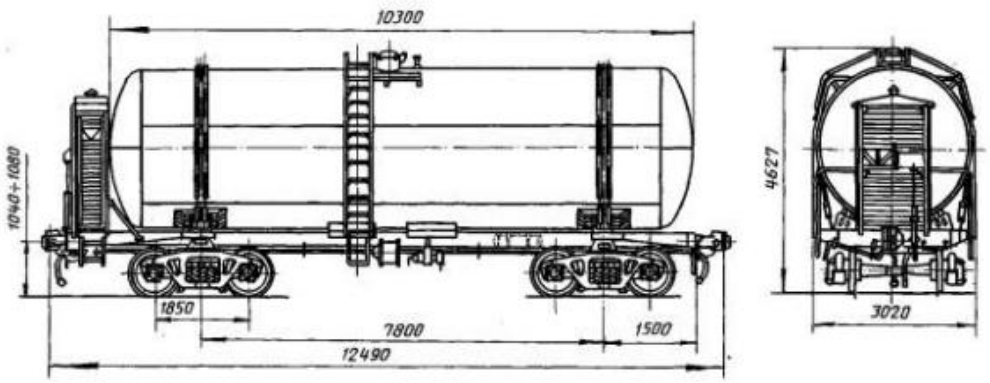

Figure 1 – Four-axle tank for oil and petroleum products with a brake platform model “15-Ц864"

Source: Specialized tanks for the transportation of hazardous materials -Reference manual / Ministry of Railways and Communications

The Russian Federation has unique climate conditions due to an impressive territory. The climate in many subjects can be harsh. Climatology, in turn, complicates commercial unloading operations of highly viscous oil products (for example, various grades of fuel oil, tar, semi-tar, compressor or aviation oil) by tank-cars with a boiler volume of 50 to 60 m^3. The discharge of these oil products is carried out through the low hole with reheating of the tank under the temperature below 0 ° C. Paraffin and high-paraffin oil products are heated at 10 ° C or more above their solidification temperature. Heating is performed by steam supplied to the lower point of the tank or its supply through the upper hole of the tank for the transportation.

The unloading of heavy oils and highly viscosity petroleum products in the cold season is a labor- and energy-intensive operation running over 10 hours. The standard method of the product’s reheating by steam carries a fairly large number of drawbacks. Firstly, a large loss of heat-intensive agent and a large water consumption are observed. Secondly, a consumption of steam for heating the steel shell of the tank and heat exchange with the environment increases heat losses of the system. Thirdly, when the lower part of the tank is heated, the contact layer of the petrochemicals with the inner wall of the tank is overheated [2]. Based on the above-mentioned problems the applicability of the method of microwave reheating of the product is proposed in this paper.

For the sustainable use of energy, it is possible to consider volumetric thermal effect (microwave heating). The microwave region of the electromagnetic radiation is called the frequency range from 300 GHz to 300 MHz (wavelength range from 1 mm to 1 m), which is located in the interval between infrared and radio frequency. A more scientific term for "microwaves" is the term "super-high frequency" or "SHF" [3].

The following benefits of microwave heating in comparison with traditional (contact heating) are distinguished on its physical basis:

1) Uniformity of heating. The polarization process occurs in the entire volume, due to the uniform effect of the electric field on the substance i.e., the heating process occurs in each conditional part of the body.
2) Decrease in heating time. To eliminate the temperature gradient of the substance in traditional heating methods (from the edge to the middle of the body), the process of

thermal exposure is increased. In most cases, it is possible to avoid overheating of the surface layers of the processed material only due to slow heating. At the same time, the microwave heating occurs evenly, the time of the temperature increase process is significantly reduced.

3) High efficiency of conversion of microwave energy into thermal energy. Heat losses in the supply paths and working heating chambers, due to the originality of the technology, are small. That is why the theoretical value of the efficiency is close to 100%.
4) Ecological cleanliness. Firstly, the temperature of the walls of the heating chambers remains almost unchanged, which significantly reduces the thermal impact on the environment. Secondly, this technology does not involve the actual flammable materials (firewood, coal, liquid or gaseous fuel), which significantly reduces the smoke and heat emissions into the atmosphere. Thirdly, the technology does not use any kind of burners, which eliminates the formation of carbon deposits on the equipment and the combustion chamber.
5) The possibility of regulating the heating temperature by changing the power of the microwave emitter. A well-known example of heating regulation is found by everyone in daily living - a household microwave oven.
6) Thermal inertiality – the possibility of almost instantaneous switching on and off of thermal effects on the processed material. Hence the high accuracy of the heating process adjustment and its reproducibility are observed.
7) Selective heating. The heating happens only in parts of the system with high values of dielectric losses are heated.

In this particular case, the temperature increase occurs with the help of an electromagnetic field without contact of the emitter and the object. Polarization is the directional movement of bound electric charges and the reorientation of dipole molecules along the field lines of force, which occurs in the substance in an artificial alternating electromagnetic field. Thus, heat transfer proceeds not by the contact of the heated object with the substance, but due to the movement of molecules. Therefore, the heated body (oil product) is reheated throughout the entire volume.

When the magnetron (emitter) is located in the tank, for example, in a suspended state and pushed through the upper hole, the possibility of thermal influence on the oil product will appear. The walls of the steel tank, in the following case, will serve as a barrier to preserve the wave inside the tank volume, it will not release the microwave wave outside. The schematic diagram of the process is shown (Figure 2).

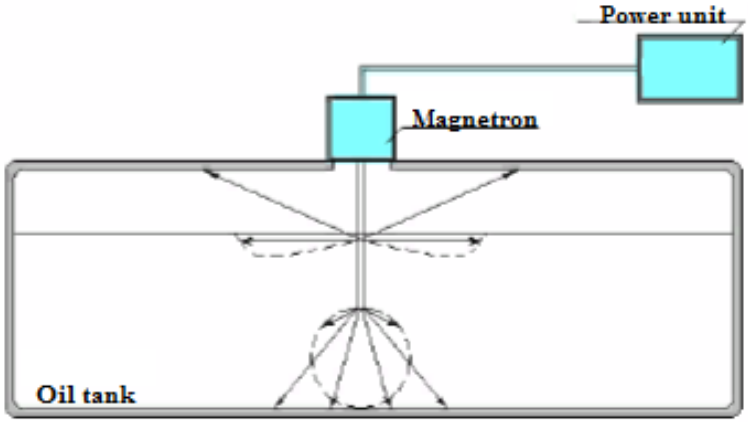

Figure 2 – Schematic diagram of the microwave reheating for the unloading of oil products *Source: Galanov Evgeny Konstantinovich, Yakovenko Evgeny Konstantinovich, Filatov Maxim Konstantinovich, Kytin Yuri Alexandrovich The use of microwave and IR radiation to improve the efficiency of heavy oil discharge // News of the St. Petersburg University of Railway Transport.*

The main advantages of this technique are: high efficiency of the heating process, inertiality when the magnetron (emitter) is turned off, heating speed, uniform heating (without overheating of the contact layer).

To draw the conclusion, it is necessary to mention that an experiment will be conducted as a part of the project. It will allow us to confirm and develop a microwave heating system for petrochemicals within a stationary tank-car for unloading operations which will be suitable for the oil and gas industry of the Far East. Moreover, the research provides us with an opportunity to make a comparative analysis with other innovative methods of heating oil products (for example, ultrasonic treatment) according to the characteristics of the processing time, the effeciency of the method, environmental safety and applicability in the Far Eastern District.

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