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Improving the environmental and industrial safety of the locomotive depot

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Introduction. The article is devoted to improving the process of waste disposal in a locomotive depot as a factor for increasing its environmental and industrial safety. In particular, the issue of regeneration of wiping material contaminated with motor oils is considered. Oil waste occurs when replacing waste oils in diesel locomotives.
Problem Statement. There are four reasons for changing the oil: dilution, increased viscosity and water content, and contamination by mechanical particles. Oil is replaced by draining, the rest, which cannot be cleaned by this method, is removed manually with a rag. The oil obtained by draining is placed in a tank for subsequent combustion in a boiler depot, and the oil collected with rags is stored in separate containers for subsequent transportation to an industrial landfill. Such oiled rags have the potential for processing, the task of implementing the method of which is solved in this study.
Theoretical Part. The paper reveals the design features of a patentable device for pressing-out oiled rags, the introduction of which will provide the opportunity to increase the allocated waste oil in the form of a liquid suitable for burning in a furnace, and the possibility of recycling rags.
Conclusion. The main environmental effect of the introduction of a device for processing oiled rags is the reduction of the flow of waste oil into the environment. The decrease in the annual amount of waste oil entering the environment will be about 26.5 t/year. In addition, the use of the device will improve the safety of workers when disposing of rags due to its processing in a closed container and will reduce the content of harmful oil vapors in the air of the working area.

Keywords: oil processing, locomotive depot, environmental effect, rag pressing device, engineering.

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Introduction. The analysis of the distribution of waste received during the operation of railway transport shows that the main sources of pollution of natural systems are railway stations [1-3]. At a railway station, one of the key sources of waste is locomotive depots, which generate waste materials that have been replaced during ongoing, preventive and major repairs. Waste generated during repairs is dangerous, first of all, for employees of depots where repairs are carried out. They are a threat from the point of view of industrial and environmental safety. It was found that the negative impact of pollution on the environment spreads not only in the immediate vicinity of the roadside, but also within a radius of several kilometers from the railway tracks [4]. Therefore, the timely and most complete disposal of the resulting waste is one of the main factors of labor safety.

In this regard, there is a need for a wider use of scientific and technical achievements at railway transport enterprises by introducing waste-free and low-waste technological schemes for pollutants processing in addition to the existing innovations [5]. The article is devoted to improving the process of waste disposal in a locomotive depot as a factor affecting environmental and industrial safety.

Problem statement. Railway locomotive depots use six- and eight-axle locomotives with a capacity of 750 to 2000 kW for shunting. The arrangement of locomotive depots serves to fulfill the tasks facing it. This means the following buildings and structures on its territory: a fuel warehouse (for storing diesel fuel, oils and lubricants); a turning circle or a turning triangle (for carrying out periodic or technological turns of the locomotive); a locomotive equipment point; a locomotive maintenance point; a locomotive repair shop; stations of rheostat tests (for carrying out rheostat tests of locomotives and diesel trains); auxiliary shops (for performing repairs of individual units and locomotive units), administrative and household buildings and structures.

Railway transport enterprises generate up to 5 million tons of industrial waste annually, of which up to 70% is not disposed of [6]. The production processes of the industry are characterized by a wide variety of these processes, which leads to a wide classification of industrial waste, shown in Fig. 1.

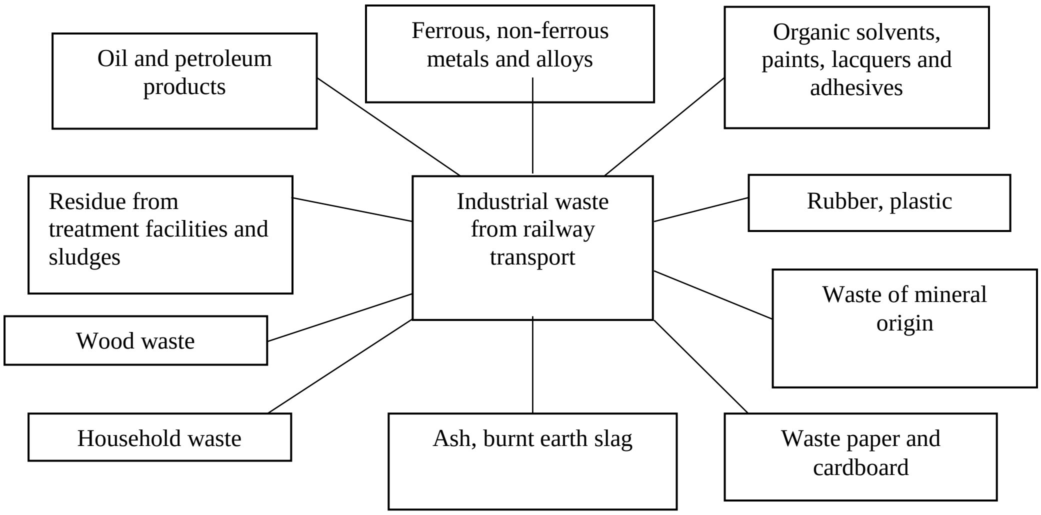

Fig. 1. Types of rail transport waste

Despite the variety of types of waste indicated in Fig. 1, in the context of this article, waste of mineral origin in the form of spent mineral motor oils is of interest [7-9].

The main activity of the depot is the maintenance of railway transport, which means current, preventive and major repairs. The number and type of diesel locomotives under repair are diverse, with about 550 vehicles serviced per year. The depot is usually located on a site about 800×900 m in size. The number of employees is about 250 people. Fig. 2 is the depot diagram showing the source and types of waste generated.

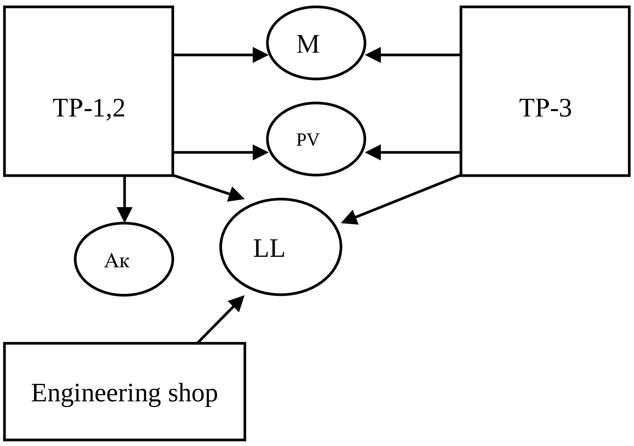

Fig. 2. Locomotive depot diagram:
TR-1,2 — shop of capital and preventive repairs; TR-3 — shop of current repairs
(Aк — used batteries; LL — used fluorescent lamps; M — used oil; PV — oiled rags)

All waste received during the operation of the locomotive depot is divided into two types:

1. Waste disposed of at the enterprise itself.

2. Waste disposed of outside the enterprise. This waste is disposed of in various designated locations, and the locomotive depot is only responsible for collection and storage before removal.

The waste disposed of outside the enterprise mainly includes fluorescent lamps, used batteries, oiled rags. The consumption of lamps is about 2500 pcs/year. Lamps are sorted by type and stored in their original packaging (cardboard boxes) in undamaged condition. The transfer of lamps for demercurization is made under an agreement with a third-party company. Used batteries and used electrolyte in the containers in which they are stored, are loaded one by one and transported by rail for processing at special enterprises. The source of waste oil in the form of oiled rags is exported to a special landfill for industrial waste.

Table 1 shows that the amount of used motor oils, and waste in them is significant. It can be seen that the cleaning material contaminated with oils is not completely neutralized and therefore is a source of potential contamination.

Table 1

Amount of used motor oil at the enterprise

Name of the types of waste oils	Waste generation, t, average per year	Use of waste, t	Waste neutralization	Amount of waste for potential disposal, t
Used mineral oils of various categories in liquid form	279,719	279,712	–	0,000
Cleaning material contaminated with oils (oil content of 15 % or more)	33,67	–	12,27	21,40
Cleaning material contaminated with oils (oil content no more than 15 %)	0,151	–	–	0,151

Waste lubricating oils is generated in the process of diesel locomotives waste oils replacement. There are four reasons for oil change: dilution, increased viscosity and water content, and contamination with mechanical particles (sand, dirt). The oil is changed by draining, and the residue is removed manually with a rag. On average, it is necessary to drain up to 50,000 kg of oil per year due to its liquefaction. The oil obtained by draining is placed in a container for subsequent combustion in the depot boiler room. Oil collected by rags is stored in separate containers, which are taken to the landfill for burial. Such oiled rags need to be recycled. The task is to develop an acceptable method for its environmentally safe disposal.

Development of a device for oiled rags pressing

A patentable device for oiled rags pressing is intended to be used in the shop of routine repairs — TR-3 (Fig. 2). Fig.3 shows the scheme of such a device.

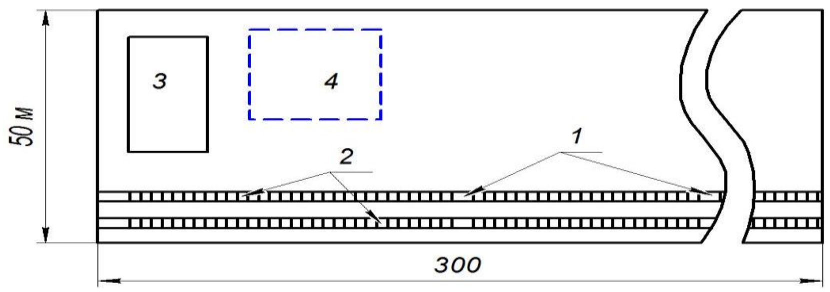

Fig. 3. Structure diagram of the device for oiled rags pressing:
1 — service passageways; 2 — inspection pits; 3 — washing machine;
4 — location of the unit

The workshop is a rectangular building of 300×50×4 m. The main place of work is the observation pits laid under the tracks, and the washing machine. At the inspection pits, the necessary inspection of the wheel pairs is performed, the waste oil is drained, and the rest of the oil is collected by rags.

The goals of developing a device based on the technical solution described in the patent [10] are:

— the possibility to increase the allocated waste oil in the form of liquid suitable for combustion in the boiler depot;

— the possibility of reusing the rags used to collect oil.

The principle on which the operation of this device is based: oiled waste rags containing up to 1.5 kg of oil per 1 kg of rags are placed in the container where the piston is located. Next, the piston squeezes the rag with a screw drive, resulting in the oil being squeezed out, and a semi-dry rag suitable for further use remains in the container. Laying oiled rags and cleaning semi-dry rags is done manually, and the movement of the piston is by means of a screw drive and an electric motor. The pressed oil is removed to a separate container for further processing.

The structure of the device for pressing oiled rags is shown in Fig. 4. Table 2 shows an approximate list of the main components of the unit and their dimensions.

Table 2

Main components of the device and their dimensions

No.	Major component	Number, pcsт	Dimensions, mm			Wall thickness, mm
			Length	Width (diameter)	Height	
1	Electromotor (4А132S6У3)	1				
2	Gearbox (1Ц3у-355-50-22м)	1	150	250	400	
3	Tube (pipe GOST 8732-78)	1	800	402		16
4	Coupling rod	1	24	380		
5	Screw	1	1600	40		
6	Protective cover of the screw (pipe GOST 8734-75)	1	800	48		1.0
7	Stop (I-beam)	1	790			–
8	Oil collection tank	1	400	400	400	2
9	Bricks	146	250	120	65	–

Electric motor 1 through gearbox 2 rotates screw 3, which rests on the support 13. Due to the movement of the screw, the piston, rod 5 inside container 4 begin to move. During the movement, the volume occupied by the cloth decreases continuously, and the oil begins to squeeze from rags, which through valve 7 begins to flow from tank 4 into tank 8. After the rags would give most of the oil, valve 7 closes and motor 1 starts to move in the opposite direction. After the rod reaches the stop, the electric motor is stopped, and then the semi-dry rag is manually removed from container 4.

When a sufficient amount of oil is collected in container 8, it is poured into container 11 with the help of tap 10 for further processing. Gauge glass 10 is used to determine the presence and quantity of water in the oil mixture. If there is water, it is lowered, controlling the flow through gauge glass 10 until it completely escapes.

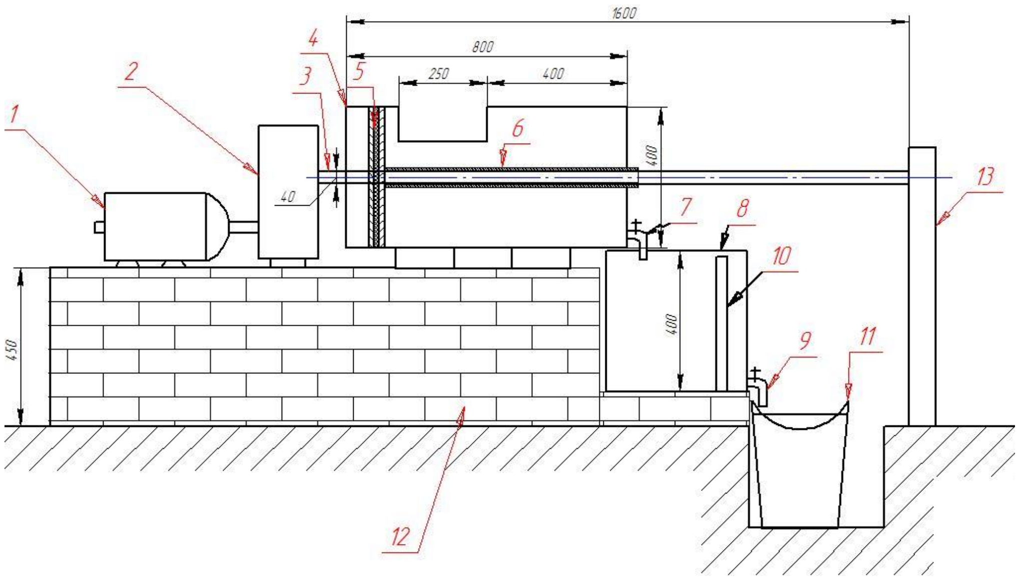

Fig. 4. General view of the installation:
1 — electric motor; 2 — gearbox; 3 — screw; 4 — container; 5 — rod; 6 — pipe connected to the rod; 7 — oil tap from the container 4; 8 — oil tank; 9 — oil tap from container 8; 10 — gauge glass; 11 — bucket; 12 — foundation; 13 — screw stop

The mode of operation of the device is determined by the amount of oiled rags during the shift. This amount is on average 35-40 kg, increasing up to 60 kg during major repairs. Therefore, the device must process this amount of oiled rags in 1 shift. Given the intermittent and uneven flow of oiled rags, which is caused by different rates of oil collection in different parts of the shop and during repairs of different models of locomotives, it is assumed to load the oiled rags as they arrive in one container.

Based on the presence of a daily receipt of rags in the amount of 35–40 kg and, taking into account their physical properties, it is necessary to have a container 2-2,5 times bigger than the volume occupied by the rags. 100 liters can be considered as the optimal volume.

For container 4, the most convenient form is cylindrical. Then the container volume is calculated as:

$$V = \pi \cdot R^2 \cdot H , \quad (1)$$

where V is the volume of the container, l; R is the radius of the container 4; H is the total length of the container 4 (H = 0.8 m).

The main parameter used for calculating the operation of this unit is the speed of oil flow from container 4 to container 8 through tap 7. Taking into account the oil viscosity to avoid splashing, the oil flow rate is no more than 20 l/min. It follows that the volume of oil displaced is equal to

$$V = \pi \cdot R^2 \cdot h , \quad (2)$$

where V is the volume of oil being displaced, R is the radius of the cylinder, and h is the length that the rod travels within a minute.

From formula 2, we get the value of h equal to 0.08 m.

When using a screw mover to move the rod, its speed can be calculated using the formula:

$$h = \omega \cdot t , \quad (3)$$

where ω is the number of revolutions of the screw in 1 minute, t is the pitch of the screw.

In this case, the calculation is based on the value of ω, which gives electric motor 1 through gearbox 2. The available gearbox has a value of ω equal to 18 rpm. It follows that the pitch of the screw should be 0.45 sm or 4.5 mm. Gear ratio Z = 55.5.

From the available electric motors, a 5.5 kW 4a132s6u3 electric motor with a rotation speed of 1000 rpm was selected. The rationale for choosing an electric motor is the number of revolutions provided together with the gearbox.

The calculation of oil collection container 8 is based on the fact that it should contain all the oil that flows from container 4. Based on the volume of daily receipt of oiled rags, and taking into account the oil content in it, up to 20-25 liters of oil is formed per shift. Given the same criteria as for container 4, it is necessary to have a volume of 2-2.5 times bigger than the volume of oil. For the ease of manufacturing, a cube with dimensions of 40×40×40 sm is accepted.

The main environmental effect of the introduction of the device for processing oiled rags is the reduction of the flow of petroleum products (waste oil) to the environment. This is due to the fact that the main amount of oil will be released in its pure form and disposed of by burning in the boiler room at the depot premises. The reduction in the annual amount of waste oil entering the environment will be about 26.5 t/year. The economic effect of implementing the device is determined by the speed of its payback. At the same time, it is necessary to take into account the cost of manufacturing the device, its operation, as well as reducing the cost of removing waste oil/rags.

Conclusion. The issues of improving the industrial and environmental safety of locomotive depots can be solved consistently based on the analysis of pollution sources. Locomotive depots are a source of waste of various hazard classes, starting from the first and ending with the last: scrap of ferrous and non-ferrous metals, fluorescent lamps, batteries, etc. Some of the waste is disposed of outside the enterprise and therefore does not pose any danger to the natural environment. So, in relation to this study, the disposal of used rags occurs outside the depot by burial at a special landfill. Waste oil is disposed of by burning in the depot boiler room, except for the oil collected by rags. At the same time, this rag contains a large amount of oil — up to 1.5 kg per 1 kg of dry rags. In this regard, for more rational use of oiled rags, a special patentable device for extracting oil from used rags for the purpose of its reuse, at least twice, has been proposed and constructively developed. The environmental effect of using the device will be achieved by reducing the amount of oiled rags disposed of (from 50 to 10.5 t/year) and by reducing its oil content (from 1.5 to 0.5 kg of oil per 1 kg of rags). This will reduce the flow of oil to the environment from 30 to 3.5 t/year.

In addition, the use of the device will improve the safety of workers when disposing of oiled rags due to its processing in a closed container and will help reduce the content of harmful oil vapors in the air of the work area.

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