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THE SOLUTION TO THE PROBLEM OF DISPOSAL OF USED TIRES, TAKING INTO ACCOUNT LABOR SAFETY IN A SMALL MOTOR TRANSPORT ENTERPRISE

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When organizing a site for the processing of used tires at a motor transport enterprise, a wide range of harmful and hazardous production factors leads to increased noise levels. The source of his education is a disintegrator. It was established that at the studied workplace the equivalent sound level is 88 dBA with a norm of not more than 80 dBA (for the 2nd class). Not only the operator, but also workers performing their labor functions nearby are exposed to noise in the study area. The solution to the problem of reducing noise exposure is associated with a preliminary calculation of acoustic screens, determining the necessary area of sound-absorbing material, fasteners, etc. The performed studies show the need to install 7 screens with a total area of 20 m^2 to satisfactorily reduce the sound level to the values regulated by sanitary and hygienic requirements. A decrease in the prevailing factor will entail a general decrease in the class of working conditions by hazard and hazard of the operator by one degree.

Keywords: tire recycling, grinding plant, disintegrator, chopper, working conditions, harmful and hazardous production factors, noise reduction.

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РЕШЕНИЕ ЗАДАЧИ УТИЛИЗАЦИИ ИЗНОШЕННЫХ ШИН С УЧЕТОМ БЕЗОПАСНОСТИ ТРУДА НА МАЛОМ АВТОТРАНСПОРТНОМ ПРЕДПРИЯТИИ

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На участке по переработке изношенных шин фиксируются различные вредные и опасные производственные факторы, в том числе повышенный уровень шума от дезинтегратора. Здесь эквивалентный уровень звука равен 88 дБА при норме не более 80 дБА (для 2-го класса). Причем воздействию шума подвергается не только оператор, но и сотрудники, работающие поблизости. Задача по снижению шумового воздействия может быть решена, если использовать акустические ширмы. Важно правильно рассчитать их необходимое количество, площадь шумопоглощающего материала и пр. Исследования показывают, что установка 7 ширм общей площадью 20 кв. м обеспечивает уровень шума, соответствующий санитарно-гигиеническим требованиям. Как следствие, может быть снижен класс условий труда по вредности и опасности.

Ключевые слова: переработка шин, установка по измельчению, дезинтегратор, измельчитель, условия труда, вредные и опасные производственные факторы, снижение шума.

Introduction. The activities of small road transport enterprises involve the generation of waste such as used engine oil, batteries, worn or damaged vehicle components and tires. The latter are extremely flammable. The burning temperature of tires is equal to the temperature of combustion of coal; harmful products, including carcinogens, are emitted into the air [1]. Tires are virtually biodegradable, and when stored and buried, serve as an ideal breeding ground for rodents and blood-sucking insects, vectors of infectious diseases. However, valuable raw materials can be extracted from tires: rubber, metal and textile cord. These materials do not change their original properties during operation.

Rational use of worn tires is of significant socio-economic importance. Transport enterprise "TransLogistikExpress" (Sarapul) solves the problem of reducing the volume of waste and involving

them in the resource cycle in order to reduce costs and form a careful attitude to the environment. This actualizes the development of technologies for recycling. A centralized tires collection system has not yet been established. In case of introduction of a physical method of their processing (cutting) in crumbs, the technological process will be accompanied by the raised levels of harmful influence (mainly vibroacoustic and chemical). When creating the technology of waste disposal at the transport enterprise "TransLogistikExpress", it is necessary to solve a number of problems, taking into account the requirements of labor safety.

1. To identify the main types of waste generated at the enterprise.

2. To analyze the quantitative composition and identify the dominant types of waste with the assessment of their impact on staff health.

3. To analyze the existing methods of processing and utilization of the main types of waste generated at the enterprise.

4. To develop technologies of utilization of used automobile tires taking into account safety of work of the operator on the disintegrator.

Main part

Analysis of the existing methods of tire recycling and selection of a suitable option for implementation. According to the survey of the owners of motor transport companies, about 40% of them use the services of waste disposal enterprises, 60% dispose of them in other ways, including on their own. Recycling of worn tires is a difficult technical task, which is further complicated by the use of metal cord.

Tires consist of rubber, which is made from natural and synthetic rubbers, and cord. Tire fabric can be made of polymer, textile and metal (metal cord) threads. The tire consists of a frame, cap plies, a tread, a bead and a lateral part. Fabric and polymer cord are used in passenger and light truck tires, metal cord - in trucks. Depending on the orientation of the cord threads in the frame, radial and diagonal tires are distinguished.

Car tires can be recycled in a variety of ways. One of the simplest is burning. In this case, there is a complete destruction of the initial products with the release of a significant amount of thermal energy. The energy potential of the tire is comparable to high-quality coal: its heat-carrying capacity is about 30 MJ/kg [2]. On the other hand, tires burning is accompanied by the formation of toxic substances, and the organization of an adequate cleaning system requires significant investment.

Another method is pyrolysis, that is, the chemical decomposition of rubber without access to oxygen. In this way, we get products for reuse in the petrochemical industry. Carbon black and other solids remaining after pyrolysis can be used as fillers. However, the organization of pyrolysis production (as well as any chemical production) requires significant resources and energy, which is not always advisable in a small enterprise.

The technology of tires grinding at moderate cutting speeds seems promising. In this case, we perform alternately: washing, beads cutting, pre-crushing, coarse crushing, fine crushing, separation and grinding. At the stage of preliminary crushing, a debeader, mechanical knives and a tire cutter are used, at the subsequent stages — crushing and grinding rollers, a separator for extracting metal particles and a vibrating screen. Currently, various types of equipment for rubber tires grinding are developed, which differ in the nature and speed of loading, the design of the working body, etc. For these purposes, abrasive belts and circles, guillotines, disc knives, presses, rollers, rotary knife crushers and other equipment are used. Domestic and foreign manufacturers develop technologies for worn tires crushing. For example, the company Cumberland (Germany) [3] produces high-performance plants for the processing of worn tires. Netmus companies (http://netmus.ru) and Polimech (https://polimech.ru/) are actively working in this direction on the Russian market. 1 ton of tires contains 600-650 kg of rubber, 130-150 kg of textile, 130-200 kg of metal. Waste tire is a valuable secondary raw material containing 65-70% rubber, 15-25% car-

bon black, 10-15% high-quality material. So, an acceptable option for tires processing in a small enterprise is the technology of mechanical grinding.

Brief description of the technological process of mechanical grinding of tires and working conditions of the operator. The disintegrator (shredder) produced by Tekhnoresursy [4] is shown in Fig. 1.

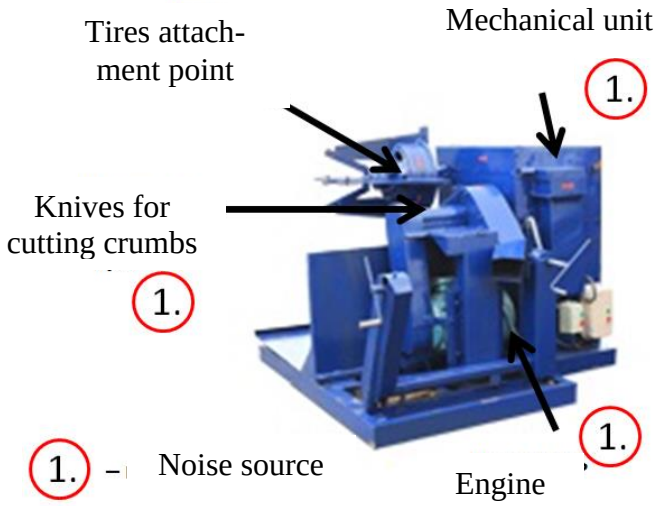

Fig. 1. Tire recycling plant

The equipment allows you to process all types of tires into crumbs. Its main characteristics:

— diameter of a landing ring of tires — from R15 to R33;

— outer diameter of tires — up to 2000 mm;

—weight of the tire — up to 600 kg;

— dimensions of the device (L×W×H) - 2200×2000×3000 mm;

-— weight of the device is not more than 1500 kg;

— cutting group — 10 milling cutters;

— service life of cutters — 180-350 tires (depending on the condition of the tire and its size);

— optimal performance of the machine-6-20 tires/h (up to 120 kg of rubber crumbs).

Up to 20 kg of clean rubber crumb (depending on the degree of tread wear) is removed from each worn truck tire with a diameter of up to 1200 mm. Next, the rubber-cord layer is removed, and the output is crumbs with pieces of cord, requiring additional cleaning. When processing large-sized tires with a diameter from 1600 to 2000 mm, it is possible to produce a clean crumb with small inclusions of textile fiber or metal wire weighing 60-150 kg. The productivity in the processing of large-sized tires is much higher than in the processing of standard truck tires of smaller sizes. In addition, the mechanical grinder has additional technical features to optimize the grinding process. As raw materials they used: used mine giant tires of "BelAZ", tractor, truck and off-road tires of various sizes with radial and diagonal construction of the cord.

When working on the installation, the operator performs the following actions:

1. Delivery of tires to the machine by rolling method.

2. Installation of the tire in the gripping drum manually (with a tire weight of 25-35 kg), installation of heavy tires using the lifting and landing mechanism.

3. Fixing the tire in the device by hydraulic latch mechanism.

4. Turning on the rotation drive of the latch mechanism and the beginning of the tire cutting — mechanical removal of the rubber layer at a fixed speed of rotation of the tire (more than 2000 rpm).

5. Adjusting the speed of supply of the cutting edge of the cutters to the tire in order to obtain a fraction of the rubber crumb of the required size, on which the productivity of the installation depends. It is higher in the production of large granules and decreases in the production of small fractions.

6. Then the clean rubber crumb is cut off before the appearance of the cord, and the second stage begins — the processing of the cord layers of the tire.

The management of the company "TransLogistikExpress" approved the following production parameters:

1) minimum area of the section — 25 sq. m;

2) number of operators per shift — 1 person;

3) electricity consumption — no more than 10 kW/h.

The finished products are stored in a metal foot container with a capacity of up to 30 thousand kg of crushed rubber. So, the production is divided into three areas: raw material storage area, crumb production sector, finished goods storage area.

Characteristics of harmful and dangerous factors created by the work of the installation. A specialist in labor protection at the enterprise notes that when working with a small-sizes grinding plant, harmful and dangerous production factors are recorded, shown in table 1.

Table 1

Actual state of working conditions

Name of the production factor	Permissible level	Actual level	Excess
Noise: equivalent sound level, dBA	80	88	8
Infrasound: equivalent sound pressure level, dB Lin	100	95	–
General vibration: equivalent level of vibration speed, dB on X/Y/Z axes	92/92/92	70/68/73	–
Local vibration: equivalent level of vibration speed, dB on the X/Y/Z axes	126/126/126	118/120/118	–
Microclimate: air temperature, ºC (category-Ib)	21–23	22	–
including air velocity, m/s	0–0.2	0.2	–
including humidity, %	15–75	48	–

Noise, vibration, etc. occur due to the work of the cutting edges of the knives, the motor and the mechanical transmission (see Fig. 1). The general class of working conditions is the third, the second degree of danger.

The analysis of the table allows us to draw a conclusion that at work on installation the dominating negative factor is the raised noise level. General class of working conditions — 3.2. Practice shows that, as a rule, exceeding the noise level is a key aspect of the work of all types of small-sized plants, which implement cutting processes. These are drilling, turning and other machines.

Measures to improve working conditions when working on the installation. The level of noise in the workplace exceeds acceptable standards and should be reduced. Technical safety measures take precedence over organizational ones. Workers should be provided with personal hearing protection equipment.

The simplest method of noise suppression is the organization of obstacles to the propagation of sound from point A to point B. In practice, this is realized by the installation of noise screens. If the source emits sound in all directions, it is appropriate to manufacture a noise protective casing. On the one

hand, a logical solution may be the construction of a brick fence, but it is not always profitable. The conditions for placing such a fence in the general layout of the territory may not meet the requirements of ergonomics and rational use of available space. There is a need to build a portable or collapsible device. As a measure to improve working conditions at the workplace of the operator, it is proposed to establish a set of noise screens — corner and front screens (Fig. 2).

Fig. 2. Noise screen

The effectiveness of such devices depends on many factors, including the "impermeability" of the fence as a whole.

The corner screen is structurally two panels lined with foil acoustic felt enclosed in a metal frame. The screens are mounted on wheel supports, two of which are located on the inner side and equipped with a braking device. Thus, the bulk structure can move freely and be installed anywhere in the production area. The degree of protection of the cabin or room depends on the number of screens used. In the conditions of the enterprise "TransLogistikExpress" seven screens with a total area of 20 m^2 are needed.

The analysis of the market of noise-proof materials and designs showed that the best option in the conditions of work of the motor transport enterprise is application of acoustic felt with the foiled surface. This safe and eco-friendly solution improves vibroacoustic characteristics of passenger car interiors [5]. Thus, acoustic felt "HL Komfortmat" has the following characteristics: thickness 15 mm; size of one sheet 1500×1000 mm; specific gravity 0.7 kg/m^2; sound absorption coefficient 0.5 at a frequency of 1000 Hz [6]. Felt occupies one of the first positions among noise-absorbing materials. In addition, it is characterized by a low ability to form dust, resistance to high humidity, low weight, fire resistance, absence of abrasive materials in the composition, environmental friendliness.

According to preliminary estimates, the installation of a noise barrier in the form of screens is sufficient to ensure that the noise level meets the requirements for the class of working conditions 3.1 (82 dBA, with 80 dBA for the second class of harm and danger).

Fig. 3 shows the distribution of sound pressure levels at the operator's workplace.

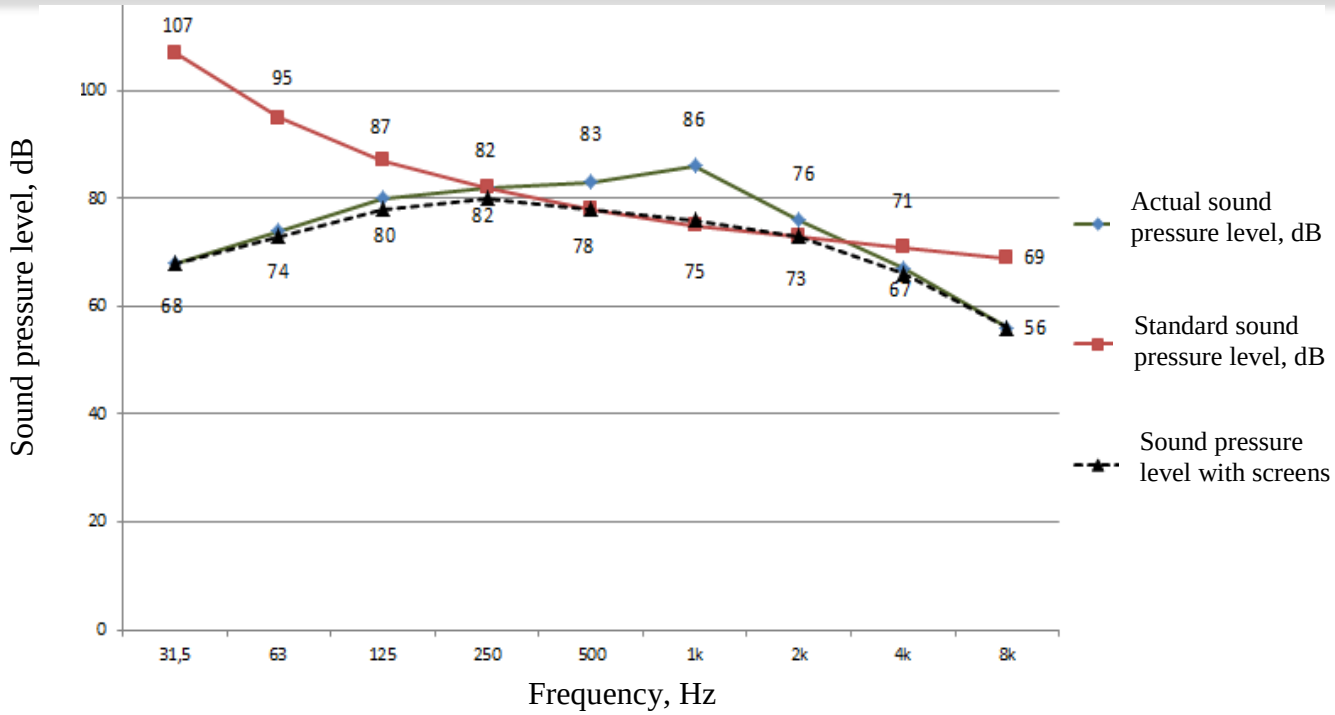

Fig. 3. Distribution of sound pressure levels at the operator's workplace

The initial data for plotting the normative values of the sound pressure level are given in [7]. The actual sound pressure level in the workplace is 88 dBA. The actual sound pressure level without the installation of the machine and the level of sound pressure achieved due to the noise screen during operation of the equipment are calculated according to the reference books [6, 8, 9]. The achieved level of sound insulation is calculated by the formula [8]:

$$\Delta L = 10\lg \frac{1+\frac{4r^2Q}{\Phi}\left(\frac{1}{A}-\frac{1}{S}\right)}{1+\frac{4r^2Q}{\Phi}\left(\frac{1}{A'}-\frac{1}{S}\right)},$$

where Φ — the source directivity factor; r —the distance from the source to the calculated point, m; Q — the spatial angle of radiation, steradian; S — the area of sound absorbing material, m^2; A, A' — the total and equivalent area of sound absorption, m^2; ΔL — the achieved level of sound insulation, dB.

It is possible to reasonably compare the real sound pressure level before and after the introduction of collective protection equipment only after the relevant activities. However, preliminary calculations show their feasibility and sufficiency.

Conclusion. Motor transport companies replace the used parts and components of vehicles and form production waste: tires with metal cord, tires with fabric cord, used metal car parts, batteries, cardboard air filters, used brake pads, and other types of waste. It is economically and ecologically expedient to recycle used tires (waste of hazard class IV), to involve them in the resource cycle. During the operation of the tire shredding plant on the production site, harmful factors, especially noise, begin to act (or worsen). The sound pressure distribution characteristics should be calculated at the design stage of such installations, which is not always possible. If the technological process is already established, the installation of collective protective means leads to the redistribution of sound levels in the room. Measurement of the actual sound level and its comparison with the maximum permissible values allow you to justify the

need for additional noise protection measures. With regard to the study conducted on the basis of calculations, it is assumed that the installation of noise screens in the circle around the machine for cutting used tires will reduce the actual sound level to indicators corresponding to class 3.1.

Further work in this direction involves the study of more large-scale industries for the processing of tires and improving the noise properties of acoustic screens by changing their design. As a result, the class of working conditions will be reduced to the second class.

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