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PROSPECTS OF AUTOMOBILE TIRE RECYCLING

Statement of the problem. The legislative system of legal handling of waste in the Russian Federation is focused on governing the handling waste as an environment pollutant. There is almost no legal regulations for handling waste as secondary material resources. Therefore, there is a pressing need to describe directions to be taken in the recycling of automobile tires.

Results and conclusions. The system of legal regulations for handling wastes has been analyzed. A growing need to utilize automobile tires has been indicated. Physical and mechanical indicators have been established and the residual durability of metal cord as a product of tire processing has been evaluated. The comparative analysis with an industrial fiber has been carried out. The most technological and economic directions to be taken in the recycling of rubber scraps in order to domestically manufacture tile and of metal cord to manufacture fiber-concrete of various types are suggested for a “floating floor” structure.

Keywords: recycling, waste, processing, secondary resources, powder rubber, fiber-concrete, metal cord.

Introduction

Presently industrially developed economies pursue the concept of industrial metabolism which involves the repetitive inclusion of wastes into industrial manufacture, extraction of useful minerals which are necessary for the manufacture of production and its removal after the end of its lifespan [1, 2]. Meanwhile the RF current waste legislation makes provisions for the environmental safety, i. e. monitoring the waste management activities as an environmental pollutant. The waste legislation regarding it as secondary material resource is actually not in place [3].

1. RF waste legislation

The major disadvantages of the current waste legislation regarding its management are

- no guidelines regarding the state policy in the development of the secondary raw materials market;
- putting the waste management activities at the heart of the political agenda;
- the controlling bodies as well as local authorities, owners of production and consumption waste and production manufacturers having no responsibilities and liabilities regarding the waste management activities;
- no set of guidelines concerning the details involved in ascribing waste to the category of secondary raw material as well as on raising awareness about waste as well as calculating the costs associated with movement of waste;
- no economic policies to regulate waste management activities thus offering a boost to relevant small and medium businesses.

It is primarily economical but not technological factors that are a major contributor to low levels of waste recycling. Local authorities that are legally put in charge of how wastes are dealt with do a poor job of improving the quality of waste management locally without the Federal authorities stepping in. Massive reserves of natural raw materials the industry makes use of have negative implications on the level of waste management particularly with prices on major raw materials and fossil fuel energy reserves soaring worldwide. This makes the extraction of natural resources far more profitable compared to the recycling of waste into secondary raw materials [4, 5].

The Secondary Material Resources Act is currently in the pipeline [6]. A fundamentally new economic approach to waste management (collection and recycling) involves a long-term recycling tax imposed on the package and the product itself. This tax will not be invested into the budget but a special fund to subsidize those engaging in different in the management of different kinds of waste (plastic, rubber, glass, etc.) and cash flow distribution is meant to be controlled by self-regulatory organizations that bring together recycling market participants [6].

In order to improve the legal guidelines for waste management, to develop the secondary raw material market, the new law makes provisions for the following two: 1) creating more com-

fortable legal conditions for the use of traditional mechanisms of economic incentives for waste management businesses; 2) legal introduction of special compelling and incentive mechanisms of waste management.

Special tools and mechanisms for regulating waste collection and recycling are

- administrative and economic coercion into recycling wastes into raw materials, fossil fuel due to the restrictions on the consumption of primary raw materials provided that there are resources of interchangeable secondary raw materials;
- ban on the dumping of waste in landfill sites and household waste landfills of wastes which are considered valuable raw materials in this particular region;
- high payment rates for disposal of wastes at landfills when they can actually be reprocessed or used as a secondary raw material (a list of such wastes is specified by local control authorities);
- promoting the demand for secondary raw materials products by employing the mechanisms of the state and municipal order;
- creating mechanisms of economic incentives for the use of waste as a secondary raw material (as well as taxation and bank loan benefits, land charge, rent, railway benefits).

All these are tailored to be economically attractive to medium and small businesses in the organization of industrial waste recycling and consumption, its further use and thereby in tackling the pressing economic problems of today.

2. Recycling directions

One of the most common type of wastes is worn car tyres of automotive enterprises which are increasing in number. These days handling of scrap car tyres in part is regulated by two international conventions, fourteen federal laws, nine regulations of the RF government, twelve legislation guidelines of federal and executive authorities [6]. The above standards have no direct effect therefore most scrap tyres are still not recycled in Russia by their simple burial in the vicinity of roads, landfills and dumping sites.

Penza region has a total of 138835 cars with 500 scrap tyres 250—280 of which the Rostekhnadzor estimates to be annually reprocessed and recycled [7]. At the moment each waste-producing enterprise has to report on a number of wastes produced. Countless tire fitting

shops, garage cooperatives just dump tyres in landfills or pile them up in neighboring ditches and waste areas. Besides most automotive vehicles are privately owned and part of the non-organized sector. Therefore most automotive wastes are scarcely recycled and aggravate the environmental problem. In particular for the city of Penza and Penza region the non-organized private sector that is not in fact overseen by environmental agencies make up 90 % and this problem needs to be addressed as a matter of urgency [7].

There are several organizations in Penza region that deal with accepting scrap car tyres for recycling. These organizations join efforts in cutting, pressing and selling tyres. Pressed tyres are used as a fuel source for industrial furnaces. However, this method of recycling is most harmful to the environment and human health. This is due to zinc and sulphur oxides being released into the air. Smoke of burning tyres contains carcinogenic substances and a great number of dioxides.

There is no production of tyre recycling for a further use of processing products as environmentally friendly secondary raw material on the industrial scope in Penza region. At the same time the analysis of the existing methods of recycling indicates a possibility of obtaining and utilizing recycling products of scrap car tyres as secondary resources. The most economically and environmentally viable is mechanical recycling of scrap car tyres.

Currently the base LLC Penzmash (Penza) piloted the line КПШШ-1 for tyre recycling. The advantage of this line compared to many similar ones is a chance to recycle tyres of cars and trucks. The productivity of the setup КПШШ-1 is up to 3 t of types per shift. This results in crumb rubber of the fraction of 1…4 mm, metal cord and textile. Many applications of these recycling products should be an economic incentive for more use of the developed setup. Not only recurring wastes but also wastes in landfills, woodlands, rivers and lakes.

3. Resource saving construction materials based on the products of car tyre recycling

In order for the line to perform well, materials and technologies are needed that would contain the recycling products and prove to be more cost-efficient but have better quantity and quality characteristics since it is not always helpful in getting a kickstart in the market. In part there are such technologies available.

Therefore Chinese companies developed and implemented a hot forging press mainly made of crumb rubber. It is known as fact that after recycling of car tyres the resulting metal cord is

taken for scrap at the price of metal though being a top quality and efficient material [8]. Hence the need to develop and create more common and cutting-edge materials with the use of waste becomes more obvious.

The performed analysis of tyres from different manufacturers domestically and abroad suggests that these day a tyre is a complex heterogeneous structure whose recycling products are identical in their physical and mechanical properties and have strong durability indexes that slightly change their original properties in the process of operation [8].

In order to find out changes in durability properties the residual strength of the metal cord was estimated after a tyre failed. The coefficient of wear (averaged wear percentage) was used as a characteristics of residual strength and is given by

$$K = \sum_{i=1}^{i=n} K_n ,$$

where K is the averaged coefficient of wear of the entire metal cord; n is a number of the tested tyres.

It was found out that strength characteristics of tyre metal cord by all popular manufacturers are identical in their chemical and geometric characteristics and are in accordance with the steel type 80—90 according to GOST 14959, i. e. they are as good as steel used to manufacture industrial fibre. The averaged coefficient of wear is 8…10 %. The experimental data shows that the quality of the domestic wire after it fails is as good as that of foreign analogues (Table 1, 2).

The performed research shows that the use lines for mechanical processing of tyres allows to obtain 65…90 t of metal fibre a year which makes more than 10000 m^3 of fibre concrete. Of course the problem of complete purification of this metal from rubber impurities and textile fibre is yet to be addressed. This might be due to the fact that there is no great demand for this production as well as for fibre concrete even though the advantages it offers are well known about [9].

Domestic constructions require high-strength fibre concrete and thus high-quality materials to obtain it. At the same time the use of fibre with incompletely purified metal cord to obtain fibre concrete of medium types used in industrial and civil construction.

Table 1

Strength characteristics of metal cord

Tyre type	Number of samples	Sample diameter, mm	Acceptable deflection of the diameters	Compression strength, kg/mm^2		Wear coefficient, %
				Acceptable, kg/mm^2	Residual, kg/mm^2	
Belshina (Belarus Tyre Plant)	3	0.22	+0.01	269	242.6	8.2
Kama (Nizhnekamsk Tyre Plant)	3	0.22	+0.01	270	244.2	8.1
Michelin	3	0.22	+0.01	268	243.1	8.8
Goodyear	3	0.22	+0.01	266	242.6	9.2
Bridgestone	3	0.22	+0.01	275	255.2	8.0
Pirelli	3	0.26	+0.01	235	213.7	9.5
Continental	3	0.22	+0.01	252	228.5	11.0

Presently a construction design of the closure includes a closure plate and a bracing wire with the thickness of 20—40 mm. This construction is in formal compliance with the requirements of Sanitary Code (SNiP) 23-03-2003 “Noise Protection”.

The used structure is flawed in a way that it shows to be inefficient with impact noise. The “floating” floor thus seems to be most technologically viable. Its structure is such that noise insulating material is laid onto the closure plate in a pan on which cement covering with the thickness of 60 mm is put. This construction solution involves no contact between the wall and closure plate which allows the impact noise frequency to decrease by 11—19 dB. In order to ensure crack resistance, the cement covering is reinforced with a grid with cells of 50×50 mm and the wire diameter of 3—5 mm.

The laying of the grid takes long (2—3 h) with the failure to adhere to the technological requirements not really preventing cracks but giving rise to them. The cost of a square metre of the grid is 90—250 roubles.

The most technological is the fibre concrete use in the construction of the bracing wire. This is caused by a rise in the productivity rate, decreasing labour costs, structure weight and cost.

Table 2

Comparative characteristics of steel fibre and metal cord

Name	Length, mm	Diameter, mm	Strength, kg/mm^2	Cost, roubles/t
1. Metal cord	15…50	0.2…1.0	210…280	5000…10000
2. Metal fibre (industrial)	10…50	0.1…1.0	110…300	30000….72000

Conclusions

The use of industrial fibre in a bracing wire is not economically viable since the loads are not high and the cost of fibre concrete with the use of industrial fibre goes up as high as 3000 roubles/m^3. Therefore it becomes a reasonable option to recycle car tyres to design a bracing wire.

The use of fine powder rubber to produce flexible rubber tile domestically is of practical and scientific interest. The resulting flexible and elastic material is easy to cut, which allows it to take on a variety of shapes and sizes. Tile provides good vibrant noise isolation and waterproof.

In order for the roofing to take its original shape there can be a granular covering on the upper tile base to promote the resistance to ultraviolet [10].

The implementation of the suggested directions is helpful in tackling an environmental problem of transport waste recycling and also in expanding the raw material base of construction materials by the use of secondary resources.

By and large the use of secondary materials based on anthropogenic formations and wastes enables a sharp decline in the production rate and special construction materials also provide a reduction in anthropogenic burden on the environment.

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