STUDY OF USAGE OF RECYCLED RUBBER CRUMBS (RRC) FOR PRODUCTION OF THERMAL INSULATION PANELS

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Abstract: One of the greatest problems of the modern consumer society is the production of waste and its disposal. Current measures that are based on landfilling and incineration have not provided good results, therefore the process of waste recycling is gaining more ground every day. Special attention is being paid to production of ecological products with sustainable development in mind. The process of recycling is not economically worthwhile, thus a number of countries in the world offer financial help to rubber recycling centers, which has recently become the case in our country also. The products made from recycled rubber crumbs are very good sound and thermal insulators, they can be used as roof and floor thermal insulation in buildings and houses. Physical and mechanical properties (fire-retard, breaking strength, heat conductivity, and the heat conductivity coefficient) panels made of crumbs particle size from 0,1 to 3 mm are examined in this paper

Key words: Recycled rubber, testing, insulation properties

1. INTRODUCTION

One of the greatest problems of the modern consumer society is the production of waste and its disposal. Current measures that are based on landfilling and incineration have not provided good results, therefore the process of waste recycling is gaining more ground every day. Special attention is being paid to production of ecological products with sustainable development in mind. They have to be made from materials which do not pollute the environment on the one hand, and can be recycled and reused for manufacturing of various different products on the other.

With the increase in the number of vehicles in the world, as well as in our country, the amount of waste tires also increases. According to some estimates in Serbia, having in mind that the average life cycle of a tire is around 8 years and that the annual production is around 1,100,000 pieces, that is, around 15,000-18,000 tons, there are around 50,000 waste tires. If waste rubber from rubber-technical products is added to that number, the amount of 70,000 tons of waste rubber is obtained, which represents a serious hazard for the environment [1, 2]. The process of recycling waste tires

encompasses various recycling methods which depend on what one wants to produce in the recycling process. The process of recycling is not economically worthwhile, thus a number of countries in the world offer financial help to rubber recycling centers, which has recently become the case in our country also. With the aim of reducing the number of waste tires in Serbia, the government has passed the Regulation on the Amount and Conditions for Receiving Stimulation Funds [3] which regulates the amount and conditions for receiving those funds to reuse and exploitation of waste as secondary raw material or for producing energy. It deals with waste tires for which the following is prescribed:

- for reusing and exploiting waste rubber – as secondary raw material – 15,300 dinars per ton;
- for waste tires processing – for producing energy – 3,000 dinars per ton.

These funds are paid to the operator of the plant for reusing or processing waste tires. The amount of stimulation funds is adjusted annually, in line with the rate of increase in retail prices and according to the date of the republic organization authorized for statistical analysis (since February 28 of the current year, the Minister proposes adjusted amounts of stimulation funds). The funds are provided by the Environmental Protection Fund, on the basis of a public contest, pursuant to the Law, and in line with the contract concluded between the Environmental Protection Fund and the recipient (from the conducted public contest) [3]. In Serbia, a recycling center for processing waste tires "ECO-RECYCLING LTD." has been opened in Irig, near Novi Sad [4], with the plans for yet another recycling center which is to be opened within the corporation "Tigar" from Pirot with an estimated value of 250 million euros [5].

2. RECYCLING WASTE CAR TIRES

Scrap tires represent the highest quality ingredients, therefore, recycling systems are in most cases designed for them. The recycling systems are divided into several categories depending on the ways of recycling:

- mechanical systems,
- ground (ambient) grinding systems,
- cryogenic grinding systems,
- chemical-mechanical (devulcanization),
- pyrolysis [6- 8].

2.1. Mechanical recycling systems (ground)

At present, the major effort in tire rubber recycling is to reduce the number of waste tires and reuse them as a finely ground crumb, produced by mechanical grinding. Goodyear invented this method about 150 years ago. The processes used for grinding rubber are based on cutting, shearing, or impact, depending on the equipment (knife, shredder, granulator, extruder, disk grinder, or impact mill) and the grinding conditions (ambient, wet, or cryogenic grinding). Presently, there are two methods of grinding waste rubber:

- Ambient (ground) grinding,
- Cryogenic grinding.

2.1.1 Ground (ambient) grinding systems

Ground grinding consists of passing the vulcanized rubber through the nip gap of a high-powered shear mill, Figure 1, or two-roll mill at room temperature; the number of passes is determined by the size of the particle (mesh size).

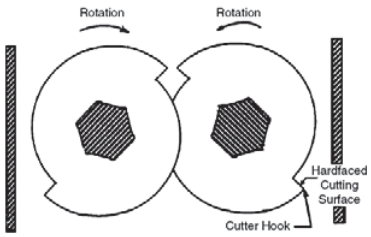

Figure 1: High-powered shear mill [7]

The higher the number of passes, the greater the size reduction; hence, the cost of ground rubber increases as the particle size decreases. In the case of scrap tires, the metal and fibber parts are first removed and the whole tire is cut into a chip form (~5 cm). The concept of jet mills is an acceleration of the pre-ground rubber granulate by air jet. Once the kinetic energy of the particles is high enough, collisions with other particles or different parts of the mill cause disintegration of the particles.

Disintegration of the particles can also be achieved by turbulences in the mill. A strong upside-down current of air is carrying the rubber granulate through the mill. Inside the mill the current is turbulent, and in this area particles collide and break. A high amount of energy is stored in the rubber material, making efficient cooling necessary. In the resonance disintegration process, a very fine powder with a particle size of less than 100μm can be generated, with a good separation of rubber and reinforcing material. The rotors of this machine are horizontally placed disks in vertically placed consecutive grinding chambers. The disks are equipped with guiding rails, and the rubber granulate is transported over the disks and through a centered opening of the separating

plates. The grinding effect is based on sudden direction changes of the particles (shearing, impact), as well as resonance forces. The scrap tire particle size can be further reduced by the use of granulators, cracker mills, and micro mills. The appearance of the plant is shown in Figure 2. [6- 8].

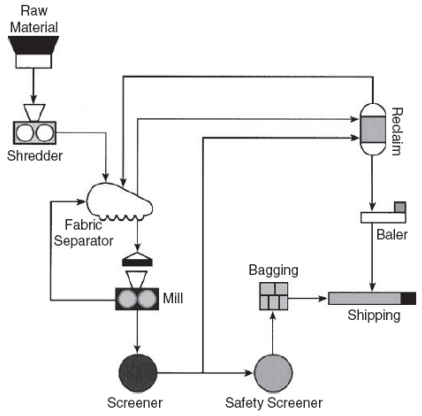

Figure 2: Plant for ground recycling scrap rubber [7]

3. EXPERIMENT

For the purposes of this paper, a single panel 500x500x33 mm, was produced out of recycled rubber granulate, recycled rubber crumb (RRC) in further text, with particle size from 0,1 to 3 mm. RRC was mixed with adhesives in proportion 85% of RRC and 15% of polyurethane adhesive. After mixing in the extruder, the blend was pressed in the mold for 15 minutes. Figure 3 shows the samples, while their surface is shown in Figure 4 [8,9].

Figure 3: View of research samples

Figure 4: View of sample surface

One of the most crucial characteristics of the products used for building insulation from the standpoint of safety is fire-retard. Therefore, the fire-retard of samples was tested according to ISO 11925-2 (1999) standard. The burner was positioned under a 45° angle in relation to the sample, Figure 5. The sample was subjected to the flame for 30 seconds and, after that, the time of extinguishing was measured [8,9].

Figure 5: Fire-retard test

The breaking strength was examined in accordance with DIN 53571 standard, where a type "3" specimen was used on a universal testing machine, with the clamp movement speed of 250 mm/min. The measuring place and test tube are shown in Figure 6 [8,9].

Figure 6: Breaking strength test and test tube

The maximum breaking load was examined at measuring place which is shown in Figure 7. A sample, 50x50x30 mm in dimensions, was cut from a panel with water jet, and was subjected to a force on a universal testing machine until the sample was destroyed [8,9].

Figure 7: Measuring place for testing of maximum breaking load

Heat-resistance testing, i.e. heat conduction of panels, was carried out in the Notified Test Laboratory at BUILDING RESEARCH INSTITUT (NISI) in Sofia, Bulgaria, within the laboratory plant for the examination of heat conduction in constructions and buildings, using a measuring method in accordance with BDS EN 12667: 2004 and BDS EN ISO 6946:2002/AC: 2004 test temperature was 20 °C.

4. RESULTS AND DISCUSSION

The fire-retard test showed that the sample was exposed to flames for 25 seconds, and that it was extinguished 5 seconds after the removal of the burner. Based on the tests, it was determined that the panels belonged to the flammability class B2, and that they were resistant to the presence of (cigarette) cinder making the starting of fire impossible [8].

The breaking strength was 0.71 N/mm² based on the tests. The maximum load before destroying the sample was a 34.5 kN/mm² (34,500 kg/mm²).

The heal conduction coefficient K was calculated after measurement and it was 0.171 m2K/W for 30.4 mm thickest of material and λ was 0.178 W/mK. Based on the test it was determinate that the material had good insulation characteristics, yet somewhat weaker in comparison with Styrofoam or similar thermal insulation materials.

The disadvantage of this product is the heavy weight of the sample because of great specific weight or rubber material (1100 kg/m3), where a panel of 500x500x33 in dimensions weighed 13.6 kg [8].

5. CONCLUSION

The test results show that:

- The products made from recycled rubber crumbs are fire-retard; so it can be used for thermal insulation from the standpoint of safety;
- The products made from recycled rubber crumbs are resistance to all static and dynamic loads, so it can be used without the danger of being destroyed while using as a thermal insulation panels;
- Heat conduction is small, although it can be used in thermal insulation, their its thermal insulation properties are weaker than those of Styrofoam but it mechanical properties are better;
- The disadvantage lies in its heavy weight because specific weigh of rubber is much greater then Styrofoam; therefore, it is more often used for floor insulation than roof of wall insulation.

The purpose of this paper is to instigate a greater application of recycled rubber and its wider use, all in the aim of reducing both the quantity of waste rubber and the product price and to prosper the usage of recycled materials in our country.

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