An innovative method in the regeneration of waste rubber and the sustainable development

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ABSTRACT

Negative effects arising from the presence of waste materials on the environment is a major problem worldwide, requiring emphasizing of the recycling processes and reuse processes. In this context, the objective of the research was based on finding of a technology that enables a higher recovery of rubber waste for a sustainable development. To date, for a higher recovery of waste rubber is necessary to transform them into reclaimed rubber involving the use of polluting technologies. Thus, through the proposed technology, respectively through the grinding with tools activated in an ultrasonic field, has been possible to decrease rubber particle size and there was obtained a crumb rubber with a particle size of 100–150 μm. It can replace a large proportion of reclaimed rubber from the composition of a type of analyzed rubber, and the obtained results demonstrate changes in the physico-mechanical rubber properties thus produced with effects on the growth of the life of rubber products and reduce environmental pollution. Also, by applying new technology there is a clear improvement of sustainable development indicator (SDI) defined and analyzed in the paper.

Keywords:
Innovative technology
Waste rubber
Sustainable development
Ultrafine grinding
Crumb rubber
Physical and mechanical characteristics

1. Introduction

The economic models specific to market economy that rely on consumer satisfaction and getting of profit, have generated major imbalances and pollution, determining an unsustainable growth. Thus the problem of raw materials and energy crisis, depletion of natural resources, excessive environmental pollution and the damage to human health are just some aspects of a general crisis that threatens all humanity, in the context of challenges generated by their application. Therefore, applying the principles of sustainable development has become a necessity, imposing the replace-ment of the “homo economics” behavior type with the type “rational homo”. Moving from technology to ecotechnology may be the key to ensure sustainable development. But what is sustainable development?

Sustainable development is a concept extremely debated in recent years, though, can be identified a concern for its requirements with decades ago. Thus, the paper “Limits to Growth” (Meadows et al., 1972) is an important point in starting the debate on the rational use of resources. The bio-economy theory founded by Georgescu – Roegen contributed decisively to identify the correlation between technical progress and environmental protection. The theory of sustainable development is still under development and has generated numerous debates on environmental protection. In this regard, we can mention the Stockholm Conference, the Rio Conference (1992, Rio +5, Rio +10, Rio +20) etc. An important document, in which it is presented a definition of the concept of sustainable development, is the "Report of the World Commission on Environment and Development: Our Common Future" by approach perspectives. Thus, the authors of this report have an interesting opinion regarding the influences on sustainable development. They considered that “Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs”; but, it is absolutely necessary to require meeting the basic needs of people from worldwide, otherwise the poverty can be a negative factor for the environment. In this context, the sustainable development "is not a fixed state of harmony, but rather a process of change in which the exploitation of resources, the direction of investments, the orientation of
2. Literature review

The rubber from waste can be recycled normally by the grinding to produce fine powders with a wide domain of the specific surface. Until now, there could be produced powder in a wide range of specific surface using only grinding processes “at heat”, whose efficiency of the particle with granulometry ranging between 400 and 600 μm is quite low (Torretta et al., 2015). In order to increase the efficiency of recycling waste made of rubber the upside of the fineness of the rubber particle it was tried the cryogenic grinding of waste made of rubber (Dobrotă, 2006). Thus, the rubber granules are made brittle by cooling to −150 °C with liquid nitrogen and then grinded to become a fine powder using an impact mill fitted with a recirculation system for the cold gaseous nitrogen. Under the process of grinding of the rubber granules there was observed a marked increase in production capacity and degree of fineness with granulometry less than 500 μm. Although the cryogenic grinding was able to obtain granular size fairly low, even this technology is not one of the best due to high energy consumption. Thus, it requires finding innovative technologies allowing the production of very fine particles with a granulometry of less than 500 μm (Su et al., 2015). By obtaining particles with a small granulometry, there can be obtained a regenerated rubber with superior characteristics, as well as the direct use of the rubber particles in the composition of the various mixtures of rubber (Liang and Zhang, 2012; Fang et al., 2001).

However the uses of reclaimed rubber are limited by the fact that it can reduce abrasion resistance, according to Rajan et al. (2006). Tear resistance can also be affected adversely, although cases are known (the use of regenerated rubber from tyres) when the influence is positive, fact was confirmed by De et al. (2000) and Thomas et al. (2016). The moisture absorption of reclaimed rubber is relatively high compared to the compositions of new rubbers and therefore its use is not recommended when the absorption of water is an essential criterion, (Dobrotă and Amza, 2012).

In terms of recovery and regeneration of waste rubber, in recent years various technologies have been developed and numerous equipment and technology manufactured to recover the rational use of waste rubber, facts confirmed by Kohler and Neill (1997), Hunt and Kovalak (1999) and Sutanto et al. (2006). Thus, steel wire cord obtained by magnetic sorting is a quality raw material for obtaining steel cord, silk waste can be recycled in light industry and rubber granules can be used after size separation, to manufacture isolated carpet, insulation layers for special buildings or as a constituent in the manufacture of asphalt roads to give the necessary flexibility.

The technological flow used most often in the recovery of rubber waste includes the following, according to Kojima et al. (2004), Adhikari et al. (2000), Tripathy et al. (2004) and Buggy et al. (1995):

- cutting rubber waste into several pieces to ease their subsequent processing on simple type cutters;
- pre-shredding and rubber waste shredding multiple cutters;
- rubber waste crushing with crushing rolls type creeker;
- fine grinding of waste in different types of mills;
- sorting chopped waste, depending on size, with vibrating sieves;
- separating rubber particles from any metallic inclusions with magnetic separators;
- de-vulcanization in the autoclave that is supplied with rubber powder obtained in the grinding process with a blowing a regeneration agent (medium oil or aromatic oil such as Aktilast, Renacit etc.);
- Refining reclaimed rubber that is done on a fine straining line.

All these issues were the basis to the researches conducted for the establishment of a technology that enable advanced use of the rubber waste. The main contribution of this paper is the identification of a superior valorization of rubber waste method, with very low cost compared to current methods and reducing negative effects on the environment thus creating the prerequisites for sustainable development. To meet the demands of solving this problem, the remainder of this paper is organized as follows: specialty literature review; theory and calculation; obtained results; discussions and conclusions.
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