March 2013. Vol. 2, No.3 ISSN 2305-8269

International Journal of Engineering and Applied Sciences

www.eaas-journal.org

RECYCLING OF TIRES IN BRAZIL: A LUCRATIVE BUSINESS OR AN IMPORTED PROBLEM

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ABSTRACT

Tires are seen as a "finite" product, considering its life cycle, but "infinite" as a physical substance. The Ninth Conference of the Basel Convention took place in Bali, Indonesia, during June, 23rd – 27th, 2008, with the theme of "Controlling Tranboundary Movements of Hazardous Wastes and Their Disposal". Brazil occupies a leading position is the area; this is due to the Brazilian government Resolution 258/1999. This paper aims to show the panorama of recycling used tires as a lucrative option for many entrepreneurs and also how it can be a problem for countries that do not control this hazardous material. The paper also presents some creative initiatives and alert to the contaminations possibilities related to the residues burned in the clinker furnaces can cause some adverse effects in human health. One example is the used tires, which can be permanents sources of environmental contaminations and of the own produced cement.

Keywords: *used tires, recycling, cement, contaminations, environment*

1- INTRODUCTION

There is a popular Brazilian saying that everything that comes from nature and it must go back to it. It should be saying that: everything the man produces must be treated by him and then returned to nature without contaminating it. Following this thought – everything that is produced by industry must go back to it to be treated. This is the concept of the Life Cycle Assessment (LCA) of the product: since the conception, planning, extraction and use of the raw material, expenses of rational energy, industrial transformation, transport, use, reuse, maintenance, discarding, waste disposal work, recycling, composting or incineration and the final decomposition. The life of the product "cradle-to-grave" is the follow up, that through the series of the 14040 of the International Organization for Standardization (ISO), an international regulatory agency, encloses this important segment in relation to production.

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"Nowadays, the urban solid residue produced by the contemporary society is huge; therefore this society is based on the principle of the consumption. Intensified for the population increase, the speed of the industrial growth, as much in technology, as in volume, creating the "money market of the consumption/discarding". This culture takes the production of tons of solid residues that in its majority, in Brazil, does not have a certain destination. Most of it is taken to waste landfills or sanitary earthworks, burnt or simply left without a destination; and only a small percentage receives some sort of treatment or adequate treatment.

After the signature of Agenda 21 (Action Plan for Sustainable Development, from the global to the local, in order to reduce the impacts of the human action on the environment) these solid residues began to be considered as potential raw material for a new industrial segment.

CAMPELL [1] defines it as: "the residues are always described as a potential raw material source for somebody, in the wrong place and the wrong time". For the producers it is a "problem" and for others it can be the "source". This definition presents the recycling concept, under the focus of reusing/recycling.

The Brazilian Association of Technical Standards (ABNT), in 2004, through NBR 10.004/2004 [2] classifies the solid residues by reason of its aspect (dry or wet), by its composition (organic or inorganic) and by the criteria of its potential damage to the environment or man, foreseeing the handling and the adequate destination of it. They are classified in Class I - dangerous, Class II-A (not inert) and Class II-B (inert).

The residues of Class I are the residues that require the greatest attention, because the most serious accidents and the greatest ambient impacts are caused by this class of residues.

The residues of Class II-A (not inert) can be disposed of in landfills or recycled, however, the components of these residues must be observed (organic substances, paper, glass and metals), so that the potential for recycling is well evaluated. The residues of Class II-B (inert) can be disposed of in landfills or recycled earthworks.

The tire is classified in Class II-B - not dangerous and an inert residue, being a residue that can be soluble or burnt according to ABNT NBR 10.006/2004 [3] and does not have any of the components in superior concentration to the standards in aspect, color, turbidity and flavor that modifies the potability of water. In the same class are: rubbers, some plastics, rocks and bricks.

2. THE TIRE COMPOSITIONS

The substance is rubber, it was discovered by the South-American Indians and used for many purposes, but the vulcanization process happened in 1839, when Charles Goodyear accidently added a small amount of sulfur to the warm sap. The viscous material and chewing became elastic and not stickier. Later the process was improved and the rubber industry developed and created many synthetic rubbers. Natural rubber is a polymer or macro-molecule, found in the sap of the rubber tree (Hevea brasiliensis), with 35% colloidal

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dispersion of isoprene (constituent of natural rubber) [4, 5].

The vulcanization process consists of heating the natural rubber with sulfur derivatives (sulfur bridges), reorganizing in a tangle, with stiffening characteristics, an increase of the hardness and resistance of the polymer. In synthetic rubbers the bridges are not made of sulfur, but by organic molecules (Figure 1).

In a simplified description, the industrial process for producing tires uses a mixture of 40% natural rubber, obtained from latex, which is a substance extracted from a Brazilian rubber tree, called "seringueira", and 60% synthetic rubber obtained from chemical processing [5].

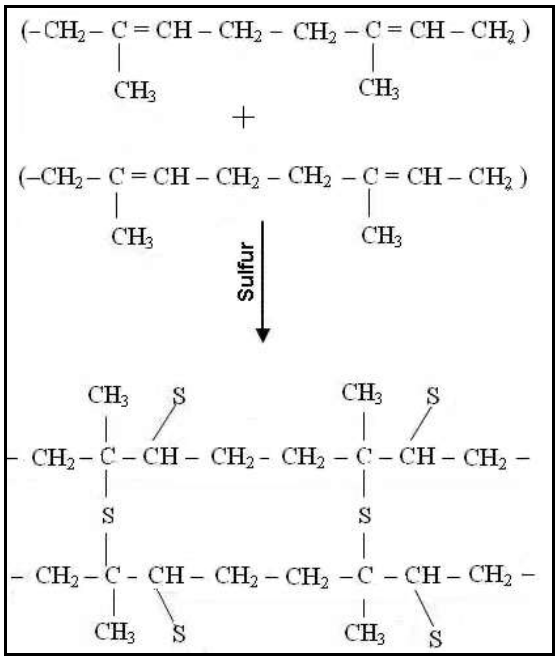

Figure 1 – Reaction of rubber production

In general, the components of synthetic rubber from in tires are presented in table 1, based on the composition of synthetic rubbers of the tire.

Table 1 - Rubber approximate composition [6]

Composition	Weight,%
Carbon- C	82.7
Hydrogen, H	10,8
Sulfur, S	1.7
Nitrogen, N	0.4
Oxygen	4.4

Tires all around the world are associated with big companies such as Michelin, Bridgestone, Continental, Goodyear, Toyo, Silverstone, Kelly, Sumitomo, Pirelli, Dunlop, among others. These brands have invested in technology to make their products competitive in the market, creating different compositions and characteristics, but very similar in their production and processes.

Tires consist of a synthetic rubber compound usually reinforced with steel and textile. Depending on their size and utilization, tires vary in design, construction and total weight. The weight of a used car tire is about 7 kg and that of a truck/bus tire is about 60 kg. Currently, tires intended for cars, buses e trucks account to about 85 % of word production. On Table 2 presents a formulation for as average passenger car tires.

Table 2 – Formulation for passenger car tires [5, 6]

Materials Composition	Weight,%
Rubber/elastomers	47.0
Carbon black	21.5
Metal (steel)	16.5
Textile	5.5
Zinc oxide (ZnO)	1.0
Sulfur (S)	1.0
Additives	7.5

However, other manufactures exist around the world that uses unknown substances in their products, as well as in their manufacturing processes or their reuse of the product are not well known.

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Each plant manufactures a product in agreement with the demand, and seeks to match the characteristics of the use of the product, such as: road conditions, speed limits and driving styles. Each tire producer varies the composition, process of manufacture and technology; this influences, directly and indirectly, the durability, resistance and, consequently, the way the tires can be reused.

The main technical characteristics of the automobile tire, depending on their use, are shown in Figure 2.

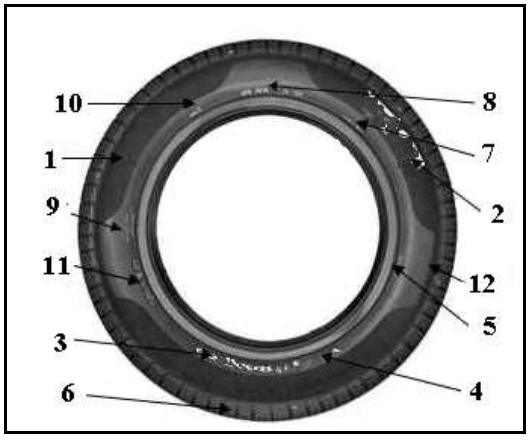

Figure 2 - Presents the main characteristics of a car tire with printing on its edge
LEGEND: 1)Manufacturer's/Brand name; 2)Tire model; 3)Dimensional and constructional characteristics – width, height, diameter; 4)Load index/speed symbol; 5)Type – tube or tubeless; 6)T.W.I.(Tread Wear Indicators); 7)Country of manufacture; 8)Department of Transportation, serial number; 9)Tire structure data; 10)Symbol of certification agency; 11)Maximum load and pressure; 12) Manufacturer's site.

Europeans, who have well projected and constructed roads and excellent driving conditions, prefer tires that allow for more speed, with the guarantee of integrity, considering climatic and geographic conditions. The design developed for high speed is obtained by a selection of compounds that resist low temperatures and have a strong, continuous traction in a narrower physical form. Americans and Japanese search more for stability, they prefer wider tires in order to obtain more adherences while the tire is rolling.

Thus, the Brazilian National Environmental Council (CONAMA) Resolution 258/1999, in its 2nd article defines tires as follows [7]:

- I - tire: all inflatable devices, consisting basically of rubber and reinforcing materials used as wheels in vehicles;
- II - tire or new tire: one that has never been used as a wheel under any form, being categorized for importation purposes, under the code 4011, in the "Common External Tariff (CET)" ;
- III - tire or remolded tire: all tires that have been submitted to any type of industrial process with the specific target to increase its useful life as a wheel for transportation, such as recasting, retreading or remolding, being categorized for importation purpose, under the code 4012, in the "Common External Tariff (CET)";
- IV - tire or unserviceable tire: one that no longer lends itself to the reform process and does not, allow for any additional mileage.

To prevent the usual practices and pollution in Brazil, the National Environmental Council (CONAMA) through Resolution 258/1999 [7], has regulated the discarding of tires since the date of its publication.

Discarding them in sanitary landfill, the sea, rivers, lakes or streams, in swampy or vacant land or even burning in

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the open air is forbidden and it is considered an environmental liability. Brazil is trying to revert the serious picture created by the problem that is harming some sectors of the population and causing public health problems.

The Resolution, in its 1st article, compels that:

- The manufacturers and the importers of tires are obliged to collect and dispose of in an environmentally sound way the existing unserviceable tires in the domestic territory, in the proportion set out in this resolution in relation to the quantities produced and/or.
- Single paragraph - companies that undertake the reform process or dispose of in an environmentally sound way the tires are exempt from complying with the provisions of this article, solely with regards to the quantity of tires collected in the national territory".

In the third article, about new tires, deadlines and quantities are determined and it also determines deadlines and quantities for remolded tires:

Article no. 6 demands that from January 1st, 2002 the importing companies must prove to the Brazilian Institute of the Environment (IBAMA), before discharging the imported tires, the final destination of the unserviceable tires, as established in article no. 3 to then receive the Department of Foreign Trade Operations (DECEX) guide from the Ministry of Development, Industry and Foreign Trade (MDIC).

Article no. 7 demands the same evidence from the tire manufacturing companies.

Article no. 8 requires that the manufacturers and importers must have proper installations or to contract, under their responsibility, the specialized services of third parties, according to Brazilian Environmental Legislation and the disposal license. They are the permitted incinerators, that in the case of Brazil, are very few and therefore they charge a lot, around a thousand dollar for the processed ton. Or it is done in adapted conditions in small proportions in industrial furnaces, inside rotating kilns for clinker or lime, which still leads to an environmental liability to the already huge cement industry.

This solid residue is classified as "special garbage" because of its characteristics as being difficult to dissolve, voluminous and inert. Brazil produces approximately 32 million tires/year, that with the high index of retreading in Brazil, increase their useful life by 40%, but their discarding is inevitable [8, 9].

Tires can be simply left by the side of road, or in landfills (Figure 3), where 0.5% of all urban garbage is deposited) or left in the yards of houses, where they finish accumulating water that attracts insects which transmit illnesses, such as dengue, yellow fever or encephalitis. This places them as enemy number 1 of the public health authority for being a breeding-place of the dengue mosquito.

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Figure 3 – Unserviceable tires

3. BUSINESS OR PROBLEM

It is clear that more forceful actions must be taken by the private sector instead of waiting for governmental or regulatory acts. Civil society glimpsed a niche in the market that in terms of crisis, not a lack, but an excess of product, created a business.

Some possible initiatives are being created by institutes or competent agencies such as the Residues & Businesses Stock Market idealized by FIEC- Federation of Industries of the State of Ceara, in the northeast of Brazil, implanted in 1991 as a part of the action program of the Euvaldo Lodi Institute.

The Stock Market is characterized by creating a network to disseminate the potential markets for the solid residues generated by local industries, thus stimulating its economic exploitation and spreading the importance of the culture of environmental management to the companies. This is a kind of social responsibility at a local level, but also with regional effects.

If it is to give an economic activity to a large part of the population that survives by collecting garbage in the streets or in the landfills, this is a solution to a social problem of environmental and industrial liabilities (search for material to be burnt in ovens without using natural resources). However it is premature to say anything, because it does not analyze the cumulative effects produced over the years on the public health of this population that is encouraged to work with these materials, or at the end of the chain - the new consumers.

3.1 News Uses

A set of tires was successfully used as slope containment, or slope protection for highways. It was during the construction of a containment wall by the Pinheirinho Stream, in the city of Porto Feliz, São Paulo, Brazil, where 18,000 tires were piled up to a height of 2.40 meters instead of using the traditional gabion cages filled with stone, which is a natural resource [10].

The tire was used as a rigid, inert material, with increased resistance to radial stress, good mechanical properties and standard dimensions. They were placed horizontally in layers and tied with wire or more durable polypropylene ropes and, after compacting, finished off with a coating of concrete and thus a wall of excellent quality had been made.

Tires are used in agriculture, using its entire structure, for the construction of drains, aeration pipes for gases in sanitary landfill, etc. Nevertheless, these alternatives are officially recognized by the Brazilian Institute of the Environment and Renewable Natural Resources (IBAMA) recognizes none of these

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alternatives, officially, in accordance with the Resolution 258/1999 [7].

The decomposition occurs with the mechanical transformation (milling) of the tire into various granules. To have an idea, in the wet process, fine particles of the asphalt rubber are incorporated in the cement, producing a ligament called asphalt-rubber. In the dry process, larger rubber particles substitute the gravel.

The hot-mix asphalt (HMA) applied in the conventional way obtained excellent results and is called ecological asphalt, for the quality of the pavement and the improvement of the bituminous binders, being more resistant to fatigue, reduction of wear and aging [11, 12].

However, the applications on Brazilian roads are very recent to prove that it will really have the durability and the resistance desired. On the other hand, there is research that evaluates the effect of solar radiation on the aging of the bituminous concrete [13], as well as, the level of noise on the highways that used the unserviceable tires in its asphalt composition [14].

3.2 Concerns about the possibility of environmental contamination

The industrial residues incineration on rotary kiln has been discussed in the entire world, because to the environmental problems caused on the atmosphere and the quality of the produced cement (Figure 4). This promotes on a lot of sustainability problems in the cement industries because they have to guarantee the raw and fuels as well as to obey the environmental legislation.

Some society segments hope the necessary study of the environment impact of the contaminants residues in the cement production.

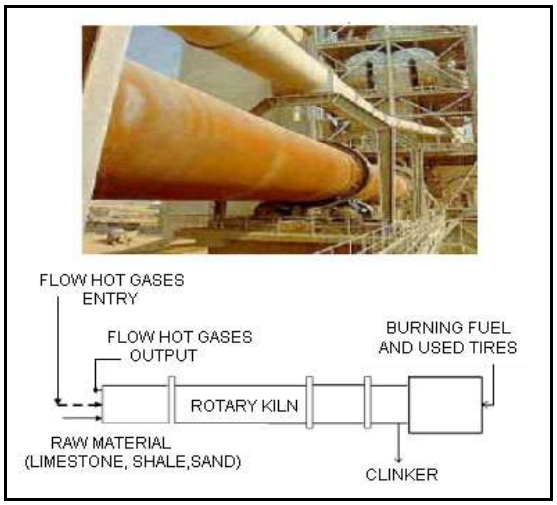

Figure 4 –Cement rotary kiln

The residues of retorted tires can also be destined as fuel for the thermal plants for the production of electricity, and as a raw material for the cement and ceramics industries, in the place of the oil coke, fuel oil or coal (no–renewable sources). The Brazilian Association of Portland Cement discloses that it is possible to burn in a single oven about 5,000 tires a day.

For the cement industry the co-processing is a form of mitigating the impacts caused by the sector that is responsible for about 5% of the total of CO_2 emissions. The ash volume increases with the residues incineration and the metals contaminants present in the residues are a great source of environmental contaminations.

Analyzing the process of burning of 1 ton of unserviceable tires on rotary kiln for the production of clinker estimates an emission of 2,5 tons of CO_2 and 26 kg SO_2 into the atmosphere.

In relation to the contamination of heavy metals and toxic compounds

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present in the tires it was suggested in 1999, by a work group of the Basel Convention, on the Control of Transboundary Movements of Hazardous Waste and their Disposal, that the specifications on tires should be more rigid as shown in Table 3 [15, 16].

Table 3 – Level of contaminants) [15, 16]

Contaminant	Proprieties	%
Copper	Added to improve the quality of the reinforcing steel.	0,02
Zinc	Zinc oxide (ZnO) used in the rubber	1,0
Cadmium	Trace element contaminants from zinc oxide	0,001 (max)
Lead	Trace element contaminants from zinc oxide	0,005 (max)
Acid compounds	Stearic acid in the solid form	0,3
Organ halogen compounds	Rubber of the chlorobutyl type	0,1 (max)

The cement plants authorized to act as co-processors end up burning several types of fuels, such as the unserviceable tires. Depending on the industrial origin and the raw materials used in the manufacture of these tires, it is possible to find random levels of contaminants in the output gases as well as in the cement produced.

Another point that deserves special mention in tire manufacturing is quality of sulfur used in the vulcanization process of rubber. Generally, low levels of arsenic (As), antimony (Sb) and tellurium (Te) should not significantly affect the physicochemical properties of the rubber. From a commercial standpoint these contaminations present in sulfur generates a low cost of this raw material in international markets. The amount of price reduction can vary from 20 to 40% when compared to sulfur of high purity. Usually this type of sulfur is obtained in pyrometallurgical processes [17, 18].

The sulfur obtained from underground reserves of geological deposits using the Frasch process or recuperated from hydrogen sulfide (H_2S) from natural gas supplies is of the highest quality, without harmful elements such as arsenic (As), cadmium (Cd), antimony (Sb), tellurium (Te), etc. However, in the production of sulfur from sulfide compounds such as pyrite (FeS_2), nickel sulfide (NiS), copper sulfide (CuS), lead sulfide (PbS) and zinc sulfide (ZnS) it is quite common to find levels of arsenic in the sulfur produced [19, 20].

Generally, the quality of the sulfur is a requirement in the manufacture of chemical products, for example, sulfuric acid (H_2SO_4). The lots of sulfur with contaminants, apart from being much cheaper, cannot be used in the manufacture of quality chemical products, however, it is known that the quality of the rubber is not modified during vulcanization, so, the properties of the tire are not affected by the impurities contained in the sulfur.

It is not possible to affirm that the sulfur used in the manufacturing of tires has or does not have arsenic, since its presence does not modify the characteristics of the product, but why do the lots of sulfur without arsenic cost more than the lots without it. Making an estimate of the sulfur contained in a ton of tires, there are, respectively, 0.1%, 0.5% and 1%, so the emission of arsenic trioxide (As_2O_3) into the atmosphere will be 17g, 85g and 170 g.

Due the large amount of air that enters into the burners during the process,

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there is a dilution of these oxides when they reach the atmosphere, becoming very difficult to identify and quantify, even in the plants or industries where there is control of the emissions. However the problem arises when it is projected, in an annual perspective, since the arsenious oxide (As_2O_3) mass becomes relevant [21].

In MONTEIRO & MAINIER [21], laboratory tests carried out by burning, at a temperature of 500°C, vulcanized rubber samples containing Sulfur of a high pureness and Sulfur contaminated with arsenic, showed the formation of arsenic trioxide (As_2O_3), being diluted in the gaseous mass together with the carbon dioxide (CO_2) and the sulfur dioxide (SO_2).

4. CONCLUSIONS

Based on the cited references and on laboratory tests we may conclude that:

After accounting that there are about 45 million unserviceable tires with inadequate disposal, Brazil opted to make the manufacturers and distributors responsible for collecting and giving a final destination to the unserviceable tires. And to regulate the entrance into Brazil, in particular, the importation of carcasses for the retreading industry, as well as the entrance into the country of discarded substance from other countries that are outside the specifications for use as raw materials

With the publication of Decree 3179/99 the importation of unserviceable, used or reformed tires, and the marketing, transporting or storage of these is prohibited in Brazil and considered an environmental violation with an applicable fine. However, since 2003 the importation of these tires still occurs pursuant to a decision of the Court of Arbitration of MERCOSUR which requires Brazil to maintain released the importation of useless tires with the countries that constitute the Mercosur (Argentina, Brazil, Paraguay and Uruguay).

The European Union feeling undermined questioned the Brazilian position at the World Trade Organization (WTO) and the organization authorized Brazil to maintain the ban on the importation of tires until December 2008, when Brazil has to choose to apply this restriction to all countries or to allow free entry without restrictions. In 2006 the case came to the Federal Supreme Court, which, on June 24th, 2009, finally vetoed the importation of such tires.

Until then the population suffers with the bitterness of the illnesses that occur because of the badly preserved carcasses or the loses with the reduction of the raw material for its local art-craft or their jobs in the promising business.

The present work aims are not to decide point if Brazil must or must not allow the entrance of unserviceable tires, by Brazilian companies or foreign ones, but rather to encourage them to rethink the habits of wastefulness and consumption.

Where consumption should always be the necessary without exaggeration. Where he makes the best choice of the products at the moment of purchase, looking for a balance in relation to the cost – benefit, taking into account that the focus must be the environment and the social responsibility related with the production and the consumption of the product, while waiting until science and

technology discovers new processes using the tires now classified as unserviceable

Finally, it is important to alert the authorities and environmental agencies of the possibility of contamination by arsenic (As_2O_3) from the burning of used tires.

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