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CONDITIONS FOR INCREASING THE RECYCLED CONTENT IN NEW TIRES FROM ASPECT OF INCREASING THEIR QUALITY

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ABSTRACT: The tire usually contains 40 to 50% rubber, 25 to 40% carbon black and 10-15% additives. The exact content of the components depends on the type of tire and due process in production. Among the many applications that can be found from the waste of tire rubber the preferred application is in the manufacture of new tires. However, the ecological impact of chemical and physical degradation of compound tires, along with the basic chemical components, set limits in production methods which would be used by recycled rubber from discarded tires to manufacture new products.
KEYWORDS: tire, rubber, recycled materials, rubber granules

INTRODUCTION

Grinding old tires on the ambient temperature is a major recycling process for technological and economic reasons. This procedure leads to less quality rubber granules, as used in the production of new tires makes less attractive in comparison with other applications in other areas such as energy production or use in construction. Due to technological constraints associated with the separation of components from old tires, it is hard to get a recycled material that is comparable in features and capabilities with the new rubber. Strict standards during the production of new tires restrict the application of recycled materials. Table 1 shows data of how were used discarded tires since 1992 year in the United States.

Table 1. Discarded tires since 1992 year in the United States

Use	1992	1994	1996	1998	2001
Fuel from the tire	57	101	115	114	115
Construction	5	9	10	20	40
Ground rubber granules	5	4,5	12,5	15	33
Export	1	24	27	28,5	30
Total utilized	68	138,5	164,5	177,5	218
Total waste	252	253	265	270	281
Utilization in%	27%	54,70%	62,10%	67%	77,60%

During 1998 utilized 67% of discarded 270 million old tires. As a substitute to other forms of fuel utilized is 64% or 42% of all discarded tires, 13% was used as granules, 11% construction, 8% were exported and 3% was used for agriculture and for various purposes.

By the end of 2001 year, 77.6% of the old tire was used, of which 53% was used as the fuel, 18% in construction, 15% as granules, and 14% for export and other uses.

According to estimates, about $25 \cdot 10^3$ tons in 2001 year, nice basic rubber from waste tires was used in the manufacture of new tires. This is approximately 11.7% of the total base rubber produced in the U.S. in 2001 year. In the course of 2002 year, 12.5% of the rubber from waste tires was used in the production of car parts. There is no information about what percentage was used for the production of new tires.

RUBBER MARKET SITUATION

Based on the method, the apparent diversity in the quality and quantity of recycled material and it is of primary importance for use in new tires. The methodology of production, optimization costs, and quality control require further research and efforts to standardize these processes.

In the last decade, passenger tires and light truck tires contain from 0.5 to 5% recycled material. In some cases, there were 10 to 15% recycled content in new tires. Due to economic factors,

security of supply and consistency of quality, marketing factors, tire manufacturers generally use up to 5% of recycled material.

The consumer sees the use of recycled content in new tires as a concession to the worst material in comparison with the new raw materials. As a result of this observation, consumers are not willing to pay the same or higher prices, than tires made of all-new material. Because of the tendency of the public to react negatively to the use of recycled materials, it is necessary to encourage the marketing and familiarize users with the environmental benefits of using recycled materials.

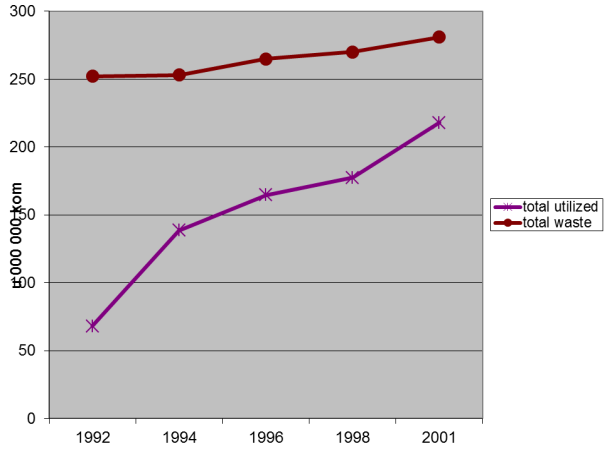


Figure 1. Utilization of total discarded pneumatics

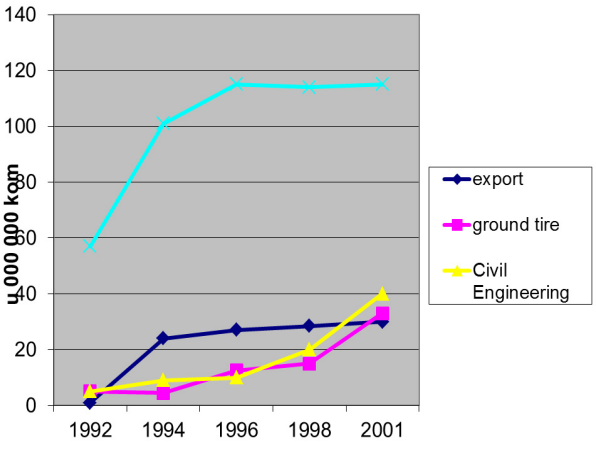


Figure 2. Area of use of old pneumatics

Automotive industry aims to increase the use of recycled components for 25% in their products and it is encouraging that its suppliers deliver components with recycled content. The request came from the car manufacturers to component suppliers deliver products with recycled content, can be an efficient way which the state agencies could coordinate the promotion of recycled content in new tires.

The tire manufacturer's expectations are that prices of natural and synthetic rubber can increase significantly, which can match the aggressive support of recycled content in new tires. Currently, the market price of raw materials is relatively stable. However, with the significant increase in the number of car manufacturers in the market, such as China, accessibility of materials can be difficult.

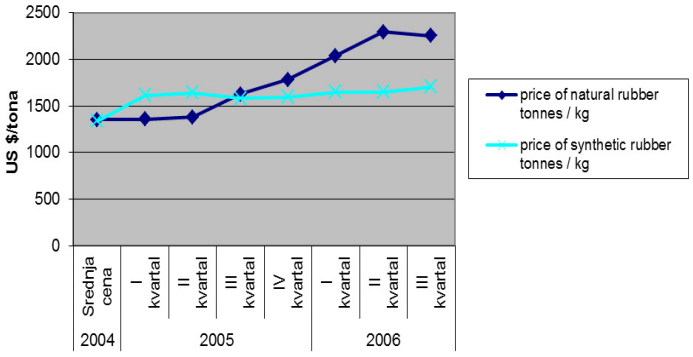


Figure 3. Rubber price changes

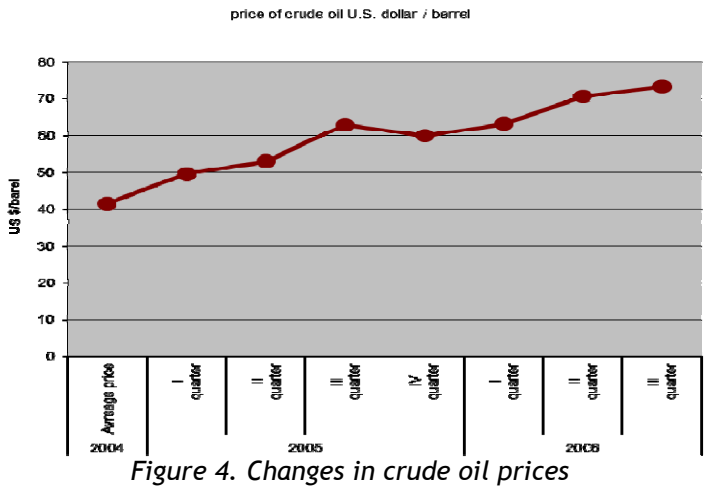
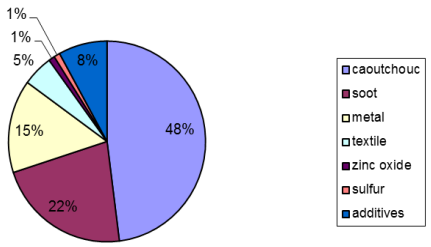


Figure 4. Changes in crude oil prices

Figures 3 and 4 shows the changes in the prices of natural and synthetic rubber and crude oil price changes on the world market.

FACTORS AFFECTING THE COST AND PROFIT IN USING OF RECYCLED CONTENT IN NEW TIRES

A number of technologies for derivation ground rubber is present in the market. There are ongoing efforts to develop technologies that can be competitive with the price, but the tire industry has no acceptable technology for use in the production of new tires. There is an increasing need for grinding waste tire size 80 mesh or finer, for production of a smooth surface parts. Finer powder also improves the physical properties of components in the tire and need to be considered short mixing time when the rubber granules are using as a partial substitute for the pure rubber.



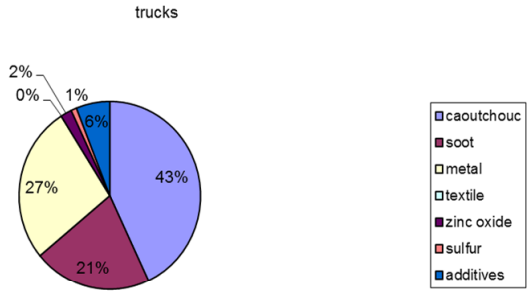


Figure 5. Composition of car pneumatics *Figure 6. Composition of truck pneumatics*

To adequately increased use of recycled rubber in new tires must be implemented the following factors:

- ☐ *reliable source of recycled rubber granules with constant physical properties: size, shape and surface structure, and certain chemical characteristics: the proportion of natural and synthetic rubber in recycled tires. Because there is a big difference between a mixture of rubber tires for cars and tires for trucks,* [2]
- ☐ *recycling of collected waste tires, transport, processing waste tires, raw materials, mixing process and separation technology. The planning and implementation of collection and transportation of waste tires to the factory for processing or transport to the factory processed rubber for further processing,*
- ☐ *constant composition of recycled rubber for use in new tires,*
- ☐ *processing methods must be in accordance with the methods of manufacture rubber granules, ways of mixing the components and methods of making tires. Properties of recycled rubber compounds must be appropriate to the properties of pure compounds because they are substituting or mix in order to avoid a negative impact on the general characteristics of the tire,*
- ☐ *economic incentives are needed, especially in developing new technologies for producing high quality granules rubber,*
- ☐ *low price of pure rubber, its availability, and many years of use of pure rubber determinate the price of rubber granules. Significant investments in basic resources by the manufacturers of tires in production process of pure rubber in their industrial plants. Production costs were excluded using recycled rubber,*
- ☐ *development of new tires put into effect in order to implement higher percentage use of a recycled content and that it does not lead to changes in performance and reliability of the tire.*

This is a list of factors that influence the development of technology and increase use of recycled compounds in new tires.

The major manufacturers indicate that there is a option of installation of recycled rubber in new tire about 5% by weight of tires, primarily for passenger cars, vans and light trucks.

Adding rubber granules in raw components reduces the physical characteristics approximately 10 to 15%.

Adding recycled rubber in mixture for tire production, reduces tensile strength to materials, increases fatigue and reduces the penetration of air and moisture. Penetration of air and water is critical to the security system inside the tire.

Available information indicates that the research being carried out in determining the performance of rubber compounds with recycled content in pure raw, and not for the complete pneumatics system.

Not specifically considered the most convenient ways of uniting with other recycled rubber components for making tires. Rubber granulates can play accelerators role in these processes. This would allow the rubber granulate replace costly components such as zinc oxide.

Mixture of rubber granulates and other components for making tires should have acceptable properties such as: resistance to grinding, size value of wet and dry friction, increased resistance to cracking and breaking, low hysterezis to reduce internal heat and rolling resistance.

Reducing rolling resistance is one of the factors that are considered when designing a new tire. Large rolling resistance reduces fuel economy (10 to 20% increases the expend). Research to reduce the loss of energy due to resistance, can be classified according to:

- *tire material,*
- *construction of the tire,*
- *interacts tire-vehicle.*

Adding rubber granulates to raw material increases hysteresis. Increasing the hysteresis reflects the increase of internal heat, and consequently increases rolling resistance.

Due to the characteristics of the internal elastic-hysteresis (typical for rubber compounds) within the material of tire heat is developed. Due to the low thermal conductivity of rubber, this heat raises the temperature inside the structure to a level that can lead to total disintegration of tires. Disruption, reduced tensile strength in tire causes tread separation and melting layer steel cord.

With tires containing rubber granulates leads to greater warming than the rubber tire without granulates. The use of tires with recycled content is limited to final technical requirements, including a limited life expectancy.

ANALYSIS COST WHEN USING RECYCLED COMPONENTS IN NEW TIRES

The amount of rubber granulates that can be used for diagonal tires is higher than the amount of radial tires. Diagonal tire production decreases to the point where it ceases to be significant.

Casing and the side walls are designed for radial tires to have high characteristics: tensile strength, static strain at start up, flexibility and resistance to aging. Relative reduction of diagonal tire production at the expense of increasing the use of radial, as they have proven longer life and improved fuel economy, as well as the final result in reduced use of recycled content in tires.

According to the literature, requires a high-quality granulates as a recycled component of the new tires. Limited quantities of high-quality rubber granulates and high price compared to only raw materials are the reason for non-use of recycled materials.

Despite the inclusion of recycled content, processes in factories for the production of tires remain unchanged. The process of obtaining recycled rubber is considered as the most influential factor to increase recycled content.

The literature does not indicate benefit due to increased environmental protection. The activities are aimed at preventing and mitigating the adverse effects of waste tires, with the conduct of the market to recycling.

One of the critical factors in cost-benefit analysis is to define the area in which the analysis is conducted. One of analysis area is the end of life tires, re-use of components, especially recycled material.

Based on the analysis can be done the following conclusions:

- *the main impetus for the tire manufacturer is the availability of a reliable source of high quality rubber granules,*
- *there is a demand for high-quality rubber granulate from manufacturers of tires,*
- *substitution are necessary or incentives for using and processing of discarded tires,*
- *regulations relating to the use of recycled tires as a fuel will not change their current status.*

TECHNOLOGY TO INCREASE THE RECYCLED CONTENT IN NEW TIRES

Most of the technologies and processes is associated with the manufacturing process for rubber granules. There are no changes or modifications of equipment or processes for the manufacture of tires which would increase the share of recycled content in new tires. In this is the advantage in the production of tires that do not need major capital investment to accommodate recycled rubber to this process. Because of this attention is focused on producing high-quality rubber granulates for use in new tires.

The composition of the mixture to produce a tire is unique for all producers. Manufacturers make use of waste tire rubber mainly from its plant as recycled content in new tires.

A mixture of the tire sidewall with the tire tread and other impurities during the process of milling in most cases reduce the possibility that the rubber granules can be replaced only raw materials to a higher percentage. This is a limitation that always stands out. Rubber used in the tire sidewall is designed to withstand cyclic bending. The compound of the tread is to provide traction, reduced rolling resistance and better casting, the corresponding period of the resistance to wear and tear due to the contact with the road. This compound, although it is compatible within the system tire, has very different mechanical properties.

The influence of the environment on the tire (due to heat aging, exposure to ozone which creates a crack in the outer wall, wear and tear) and ingredients such as fiber and steel material can degrade the quality of the recycled rubber from whole tires, for use as recycled content in new tires.

Grinding at ambient temperature and cryogenic grinding remain commercial options currently available to generate rubber granulates for different purposes.

The relative purity of tire tread and the fact that the recycled rubber granules used to just for tread on the new tires, it becomes very attractive to manufacturers of tires and it is in the center of attention for the potential use of recycled content.

Rubber granules 80 mesh fineness price ranges around 400 $ per ton (Fig. 7). Price range reflects the impact of having a regional conditions, supply of raw materials, competition, incentives for local manufacturers, users, state and local regulations, substitutions, credits and other market incentives.

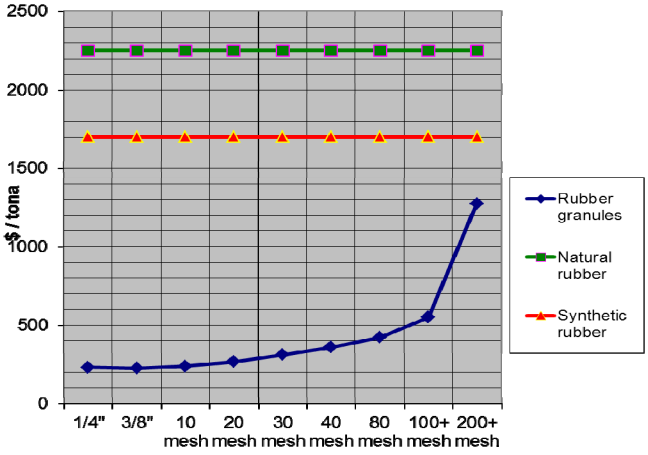


Figure 7. Average prices of rubber granules, depending on the fineness[2.a]

The assumption is that 3 kg granulates can be obtained from the tread of a tire, it means you need 330 tires for getting a ton of raw material. Average price of material sized to one inch used for TDF in 2002. is about 32 dollars per tone (use 100 tire is approximately 10 kg weight each tire). Ratio of 3.3:1 was used tires per ton of material, and 5:1 for the price of one ton of material.

Proceeds from the raw material are in the range of $ 100-190 dollars. Benefits of rubber granulates in relation to the burning of whole tires is twofold. The value of by-products from waste tires is increased. Other components from the tire, such as rubber hose, can be used later in other processes, including the production of fuel (TDF).

The following benefits are given to the source of rubber granules to increase recycled content in new tires:

- *rubber is already clean enough before further grinding,*
- *large mass of pure material, which means more useful material will be transported to the producer than transporting whole tires. On the other hand, when the processing operations are performed in the vicinity of the factory for the production, factors such as packaging and technical requirements for the storage of chopped tires can have a major impact on the viability of the model.*

Reduction of size from 1 inch to ¼ inch price increases 7.2 times.

CONCLUSIONS

There are technical possibilities for a quality rubber granulates in rubber compounds without significant degradation tire performance or without modification of production lines. This can be a indication for the tire manufacturer to accept an increase recycled content, if they meet the technical requirements and a competitive price granules.

Some of the barriers to increasing the content of rubber granulates in new tires are:

- *the high cost of collecting, sorting and processing of waste materials,*
- *lack of standardized quality control procedure at the reprocessing plant*
- *consumer awareness about the inferior quality of the tire with a higher content of recycled material*
- *the costs of transporting the rubber granulates to tire factory for production,*
- *the required high dynamic characteristics of the tire limit the amount of recycled content,*
- *excess capacity in the production of synthetic rubber affects can SBR, so that the inclusion of recycled rubber in the production of new tires depends on changes in prices of synthetic rubber,*
- *liquid nitrogen required for cryogenic grinding can be responsible for 75% of variable costs. Liquid nitrogen price depends on the price of electricity.*

Production of high-quality granules from whole tire has a high cost due to low prices of raw rubber. Another factor is the market for rubber granulates in other markets. Technical innovations are needed to overcome the technological and economic barriers in the production of quality rubber and development of resin rubber mixture. The goal is to obtain recycled materials without sacrificing performance or reliability. Technologies such as tire repair and other thermochemical processes are at the stage of research and development. These technologies have the potential if it could be implemented commercially.

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