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Decision Support for The Choice of Tire Manufacturer

The problem of used products is present in lot a of business processes. Commercial vehicle tires are one of examples and have a huge influence on exploitation parameters of the transportation companies. As a way of reducing these costs, retreading is a commonly used process, which also affects the reduction of environment pollution. Here, a choice of a tire manufacturer has important influence on exploitation parameters and adequate data analysis is necessary to support this decision.

Keywords: *used tires, retreading, commercial vehicles, exploitation parameters*

1. INTRODUCTION

There is a number of tire manufacturers on the market. Great transport systems usually use retreading in order to reduce their tire costs. In practice, there are different experiences regarding the exploitation of retreaded tires. In making a decision on the choice of tire manufacturer, the main criteria are the number of retreadings, traveled distance of tires, as well as costs per traveled distance of a new and retreaded tire. Having that in mind, the objective of this paper is to "help" great transport systems in decision making on the choice of manufacturer.

The question of profitability is one of the key elements for making adequate business solutions. This problem has got a huge attention in the world and using retreated tires is highly present, especially with commercial vehicles. According to data by Bridgestone Americas Holding, we can see the share of retreated tires in different parts of the world (Figure 1).

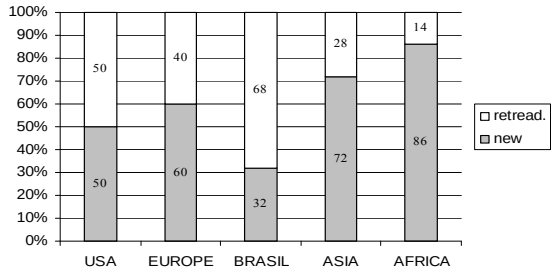

Figure 1. The share of new-retreaded tires in different parts of the world

In the favor of safety of using retreaded tires there is a data that in America buses transporting school children use retreaded tires every day. This method has allowed huge money savings without risking the safety of children. Besides, according to a US Government decision, all federal vehicles must use retreaded tires.

However, it is necessary to mention that besides the economical effect, usage of retreaded tires has a very important ecological aspect. For example, 35l of fuel oil is used to manufacture one new tire, while only 5-7l is used to retread one tire. Furthermore, instead of being treated as waste, by retreading tire is returned to exploitation, which protects the environment from pollution. That is one of the reasons why retreading tires and treatment of other used products has become one of the obligations of manufacturer of any product in developed countries.

In Serbia, like in other countries in transition, the solutions for treatment of used tires have not been well defined yet. A lot of experiences show that there is no possibility to import/transfer solutions for this problem from developed countries. The reason lies in many system and technological limits, as well as the non-existing law regulations. It is the fact that influence of scrapped tire is danger for the environment and that it needs some sort of treatment, so that it can't threaten the environment. For that reason, Serbia, like other countries, shall solve the problem in a special, specific way, eventually using some of the conveniences of the existing solutions from the countries that have already solved (totally or partially) this problem.

The paper includes several parts. The literature review is followed by a brief description of retreading treatment restoring the original function of a tire. The next point includes basic issues regarding the management of tire retreading with a proposal of potential improvement of retreading in Serbia. Furthermore, there is a key issue that specifies the role and importance of the deciding parameters for choosing a tire that the company will use for commercial vehicles (assuming that the installed tires will be retreaded), which is the main objective of this paper. It shall be noted that tire retreading is very important for the preservation of the environment and natural resources.

2. LITERATURE REVIEW

Literature analysis shows that numerous authors have dealt with the problem of used tires, so that it gain in significance every day and it is becoming a bigger challenge for experts of this area. The studied problems had different levels of complexity, different tools were

Received: April 2012, Accepted: November 2012
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used to get results, but limits specific for the area in which problems were solved were respected. But we can conclude that few authors and their researches have dealt with retreading of used tires, especially from the logistics aspect.

The paper [6] dealt with the development of EOL (end-of-life) strategies for treatment of products that finished their work life. Respecting EU laws, they directed their researches into electronic products, having in mind 3R concept (Reuse, Re-manufacture, Recycle). Their modified researches could be used for used tires. Research [4] and [11], dealt with the development and usage of EPR (Extended Producer Responsibility). Now, the manufacturers are responsible for their products both during their exploitation and their treatment at the end of their work life. Authors in [5] point to the significance of choice of more high-quality materials different parts of vehicles are made of and by that the aspect of ELV treatment. When speaking about retreading tires, this could be the basis that would provide their simpler return into re-usage. The paper [8] paid attention to solving the problem of collection of vehicles in the Netherlands, which, in the treatment of ELV, has chosen to deal only with processing of old tires. The so-called Mexican model dealt by [1] deals with the problem of collecting and increasing of recycling percentage of used parts of ELV. Some of the proposed solutions could be used when speaking about retreading tires. The analysis in [2] deals mostly with the treatment of old tires and locating of objects for that purpose. Author in [9] explains the correlation between capacity levels needed for recycling of ELV vehicles and their parts, which also means old tires, and companies for which recycling represents a key activity. In the domain of treatment of used vehicles [3] propose solutions that could be used on used tires. The aim of Directive 2000/53/EC is to increase the recycling level of used car and their parts as pointed out in [7]. With adequate law regulations, tires could be relatively easy to put into re-usage by retreading. Research [10] mostly dealt with analysis of used vehicles from the ecological aspect. He shows that tires are a permanent source of pollution, analyzing them during exploitation and after the end of their work life.

A retreated tire is put back into service (on the vehicle) by an appropriate treatment ensuring almost the same technical and exploitation characteristics as a new tire. The only difference is that exploitation costs of such a tire are much smaller than the costs of exploitation of a new tire from the same category. There is no doubt that retreading is a cost effective procedure, especially for big transport companies. However, the problems of retreading itself, starting form the management to the use of retreaded tires has not been elaborated well enough yet. Such facts represent motivation for further research of this type of treatment of used tires. Nevertheless, the problem of tire retreading in the world has not been treated enough in literature and, that is why obscurities and dilemmas are frequently encountered while making decisions. The aim of this paper is to give some answers that could facilitate making optimal business decisions in companies with intensive exploitation of tires.

3. RETREADING AS ONE OF USED TIRES TREATMENTS

Retreading is the process which is lately that has been increasingly represented in commercial vehicles. There are many reasons for that, and they are based on the premises that retreaded tires comply with new tires in technical-exploitation performances, at the same time providing conditions for cost reductions.

In order to identify the problems and steps in the retreading process. Figure 2 presents a cross-section of a tire. Regarding construction parts, tread – protector is the part of the tire that is exposed to load in exploitation, that is – this is the part which is worn and damaged the most. When thickness of tread reduces to the allowable minimum, the question is what to do with that tire. If the detailed tire structure control determines that only the tread is worn out (with no other damages), than retreading (tread coating) is one of the options for used tires treatments aiming at further exploitation the the tire.

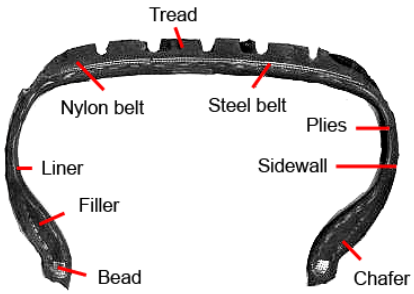

Figure 2. The structure of the tire

In practice, two basic procedures are performed – cold cure and hot cure retreading. Cold Cure Retreading is the procedure in which the protection in shape of ring or stripe (Figure 3a, 3b) is coated on worn tread. New tread is glued to the tire while heated on the temperature lower than 100°C in a special chamber, the so called autoclave.

Figure 3. Protector setting (a) in shape of ring and (b) stripe

This kind of heating has no influence on the tire structure and therefore cold cure procedure can be performed several times on the same tire. The described procedure is used for the retreading of tires for commercial use.

Hot cure retreading is the procedure where the tread in shape of stripe is put in an appropriate press and is heated at the temperature of approximately 140°C. Due to the use of high temperature, the tire can be retreaded only once. This procedure is used for the tires for passenger vehicles.

According to the methodology, after described retreading process, the next part is the approach to the analyses of basic exploitation parameters. This analysis is performed on the sample of tires used in one of the plants of GSP Belgrade.

4. KEY CHARACTERISTICS OF TIRE RETREADING MANAGEMENT

Retreading of used tires represents one of several ways of treatment of used tires. Having in mind environmental, economical and other aspects, this is one of the methods increasingly used with old tires. It is especially significant because the tire can be returned into exploitation and therefore its working life can be extended. Other types of treatment are: recycling, crushing and burning, but these are not the subject matter of this paper and therefore they will not be further discussed.

In order to retread a tire, besides the material for tread layer applied (explained in the previous chapter of the paper), it is necessary to have other resources. This procedure requires appropriate facilities, space, technology, man-power, etc, which means that in case of a larger volume of manufacture, retreading requires a specific industrial complex.

The starting point of each industrial complex is the organizational structure, i.e, the management, in order to provide the conditions for a successful work. The management of retreading unit itself is not a subject matter of this paper, but in order to attain the objective, which is the choice of an optimal tire manufacturer by large transport companies, it is necessary to examine the key parameters of retreading management.

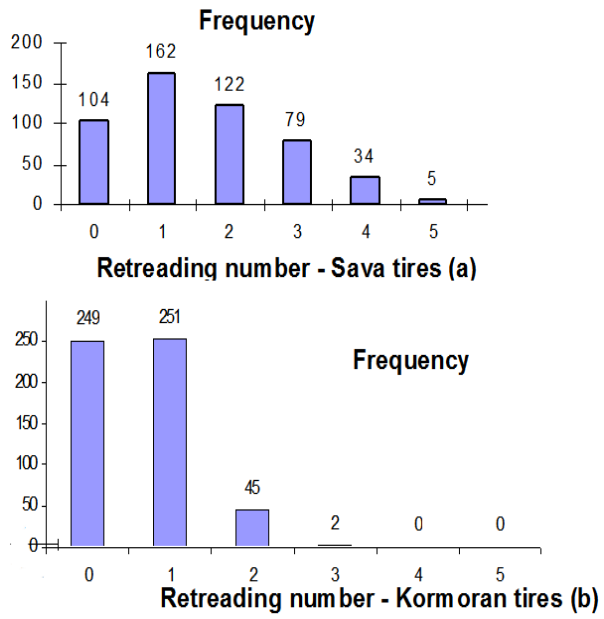

Figure 4. Retarding number distribution density for "Sava" and "Kormoran" tires

5. COMPETENT PARAMETERS OF RETREADED TIRES

The overview of realistic indexes from exploitation of retreaded tires is very significant for optimization of the logistics processes and transport companies. To provide this, it is necessary to determine basic parameters directly related to logistics costs and they are:

- number of retreadings of tire
- traveled distance of tire (as new one and after average number of retreading), and
- exploitation costs of exploitation (€/km) of retreaded tires that consists of the price of new tire and price of retreaded tire multiplied by number of retreadings of one tire.

Retreading number of the tire depends on its quality, load quantity, road characteristics, style of driving etc. In practice, there are extreme situations present - due to some damage, the tire was not retreaded at all, while some tires are retreated up to 12 times (for aircraft tires - http://www.reifensuchmaschine.de/reifen/runderneuerte_reifen.html, accessed 15.09.2011).

In order to investigate this parameter, the authors have approached data analyses for tire exploitation of the company GSP Belgrade, public transportation company. Analyses included tires (sample of more than 1100 tires) in one of the plants of the company. The sample itself included tires from different manufacturers, where differences were noted in duration, price, retreading number etc. Analyses included tires from the manufacturer "Sava" (506 pieces) and "Kormoran" (547 pieces), which are similar in price and belong to the relatively cheap tires on the market. They make the biggest part, about 90% of the analyzed sample of tires (other 10% is a small number of tires of many other manufacturers and are not further analyzed). This characteristic of the vehicles of this plant is that they are driven in harder conditions compared to the busses in other plants. They cover routes that connect city center to the suburbs, so that vehicles are driven on damaged infrastructure. Results of tire retreading number analyses are presented in the Figure 4 with the distribution density for products "Sava" (a) and "Kormoran"(b).

Based on diagram in the Figure 4(a), it can be noted that retreading number of "Sava" tires is a random variable with the mean $\mu=1.59$. Assumed distribution is according to Poisson distribution law, which is confirmed with chi-square test ($\chi^2=2.227$ (which is less than appropriate adopted statistical value for defined number of parameters)). For "Kormoran" tires, significantly different distribution of tire retreading number is observed (Figure 4(b)). Mean value of retreading number is $\mu=0.63$, but the hypothesis on accordance with Poisson Distribution Law is not confirmed, which points to significant differences for this exploitation parameter for these two manufacturers.

Traveled distance of tire is very significant for optimization of logistics processes and transport companies. It is clear that this parameter depends, on the one hand, on the manufacturer and, on the other hand, on the potential number of retreadings and traveled distance of a new tire or a tire which has been retreaded one or more times.

Traveled distance presents the value which is analyzed (for each tire) in two ways:

- traveled distance of a new tire (whether it is being written-off or not) and partial traveled distance after each retreading process, and
- by determination of total traveled distance (till writing-off) - sum of travel distance of new tire and after different number of performed retreading processes (this number can be 0,1,2..)

Table 1 presents a comparative description of diagrams of traveled distance (km) of tires for different number of retreadings (0, 1, 2..) till writing-off, for two manufacturers: "Sava" and "Kormoran" and sum - total traveled distance.

From information on mean of traveled distance value, it can be noted that tires manufactured by "Sava" reach greater total traveled distances compared to tires manufactured by "Kormoran", but that the ratio changes in the function of number of retreadings. "Sava" tires can be retreaded up to 5 times, compared to "Kormoran" tires, which can be retreaded 3 times at the most (presented in Table 1), but reached traveled distance (for same retreading number) of the second ones is longer, having in mind that it is an average traveled distance till the end of work-life (till writing-off).

Trend analyses of traveled distance mean values point to the high correlation coefficient (above 0.98) with assumed linear trend (Figure 5). Comparing line ascent of trends, it is concluded that "Kormoran" tires are favorable compared to "Sava" tires.

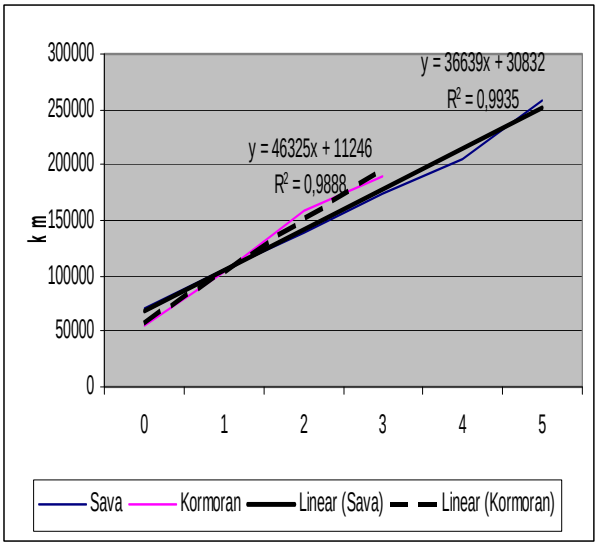

Figure 5. Total travelled distances sum trends in function of number of retreadings for "Sava" and "Kormoran" tires

Exploitation costs of the tire are used for decision making on a choice of a tire manufacturer and depends on the two previous parameters. Costs per traveled distance of new tire (before retreading) and retreaded tire are of a great importance in choosing the tire manufacturer for the big transport system. Previous analyses have shown that there is an important difference in traveled distance, a well as in the possible number of retreadings between the two analyzed manufacturers (Sava and Kormoran). However, exploitation costs per unit of traveled distance (€/km) are the same for both manufacturers; exploitation costs for new tires (c_0 = 0.194€/km) and retreaded tires (cp = 0.164€/km) (cost is determined by technical services of GSP Belgrade).

The results of analysis shown here points out that business with usage of retreaded tires, because of potential savings, is of large importance for business decisions of various companies, and especially for the ones dealing with transport of goods and passengers by cars, trucks and buses.

6. CONCLUSION

Usage of retreated tires is of great importance for economical management of companies having a great car park (motor pool). The question of profitability is one of the key elements for making adequate business solutions. This paper shows the results of analysis necessary as inputs for basic economical analysis for this subject. Also, it is mentioned that safety aspect during exploitation of these tires is solved. In practice, it is proved by giving the same warranty for these tires as for new ones, and at the same time there are positive effects in the domain of ecology and natural recourses. It is necessary to point out that such analysis, depending of company's business policy, has to be realized permanently for concrete conditions of exploitation of its vehicles. Such analysis should be as detailed as possible, related to every tire separately, to increase the number of tires whose working life is extended by retreading and the increase of the following positive effects.

The choice of a tire manufacturer itself usually requires the application of certain DSS tools (Decision Support System). Regarding this issue, besides the analysis of the mentioned input values, there can be efficiently applied the Decision tree, as well as some other appropriate tools. It is specifically noted that the described analyses shall be carried out separately for each company, depending on the number and types of vehicles in their car park, conditions of exploitation, manufacturer, types of the used tires, etc.

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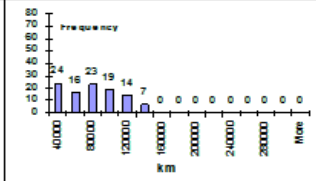
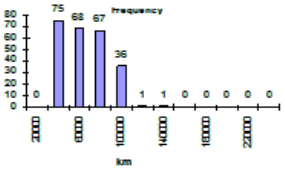
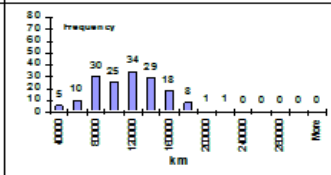
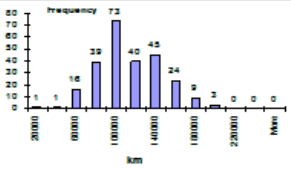
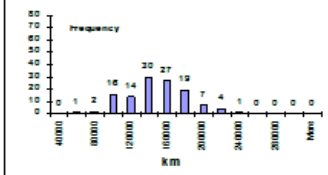
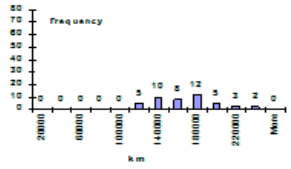
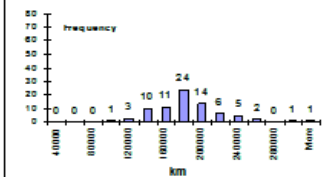
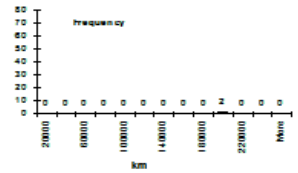
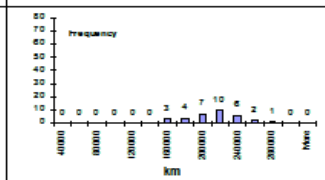
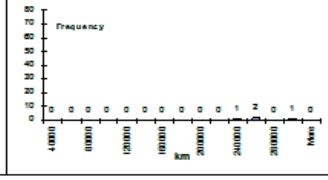
ПОДРШКА ОДЛУЧИВАЊУ ЗА ИЗБОР ПРОИЗВОЂАЧА ПНЕУМАТИКА

Светлана А. Дабић, Момчило Д. Миљуш, Небојша Ј. Бојовић, Ненад Д. Видановић

Коришћени производи представљају проблем у многим пословним процесима. Један од таквих примера су пнеуматици комерцијалних возила и као такви имају значајан утицај на параметре пословања транспортних компанија. Као начин за смањење трошкова ових компанија везаних за коришћене пнеуматике, уобичајена је примена протектирања као процеса који у исто време утиче на смањење загађења животне средине. Стога избор произвођача пнеуматика има значајан утицај на експлоатационе параметре возила и неопходно је анализирати расположиве и потребне податке који би послужили као подршка овом одлучивању.

Table 1. distribution of traveled distnance sum in the function of number of retreadings

	Tires manufactured by „Sava“	Tires manufactured by „Kormoran“
New tires		
After 1. retrading		
After 2. retreading		
After 3. retreading		
After 4. retreading		Not retreaded 4. times
After 5. retreading		Not retreaded 5. times