IMPORTANCE OF EXPLOITATION PARAMETERS RELATED TO RETREAD TIRES OF COMMERCIAL VEHICLES

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***Abstract**: Most of the problems of waste treatment have not been solved and they are becoming more important every day, regarding its environmental, economic and other aspects. There is a special category of waste consisting of spent / used tires. One of the ways to treat them in order to allow tires to be reused on vehicles is retreading. This process, applied around the world and in our country, has a number of positive effects on the environment, logistics costs, etc. The practice has shown that successful use of retread tires depends on the type of tire, vehicle, etc., but also on the manufacturer. This paper has treated the most important exploitation parameters, based on a real sample of used tires in one of the units of GSP Belgrade, which can be used for the selection of manufacturers.*

***Keywords:** tire retreading, exploitation parameters, used vehicles.*

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1. INTRODUCTION

There is huge number of vehicles and its parts on the market, and every production and exploitation generates certain expenses. When speaking about tires, big transport systems, especially commercial vehicles, often use retreading (process in which tire with worn tread is putting back into function). This is consequence of price and exploitation of tires, since they are constituent parts of all vehicles – from passenger vehicles to heavy loads trucks, planes, industrial vehicles etc. Several experiences are met dealing with exploitation of retreaded tires. When making decision about tire manufacturer, main criteria/parameters are number of tire retreads, travelled distance, and also expenses for travelled distance for new tire and retreaded tire. Safety is factor is also present and literature shows that safety level of correctly retreaded tire is not declining in comparison to new one (Hammond at al. 2009).

Having above mentioned in mind, this paper aims to „help" big transport systems by choosing exploitation parameters of tires for making decision which manufacturer to choose. Input parameters (based on which such decisions are made) are gathered by analysis of real sample of used tires from one section of biggest company for public transport, GSP Beograd. For that reason, this paper has 4 parts. First part contains introduction and also present problem and aim of the paper. Second one gives short description of retreading and third part gives an overview of used literature based on which the orientation to deal with problem of choosing tires manufacturer is created, based on conditions and parameters of exploitation. Fourth, key part contains analysis of important parameters of exploitation of used tires – number of retreading and travelled distance by tire, as key parameters for making decision from which manufacturer should one company buy the tires. When choosing manufacturer, besides mentioned parameters it is also necessary to analyse environmental and economical aspects of using retread tires. Fifth part presents conclusive consideration of these, and potential further researches in this area.

2. ABOUT RETREADING

Retread is process that has increased usage for tires of commercial vehicles, but lately also for tires for passenger's vehicles. There are many reasons for that. One of main is that retreaded tire can be compared to new ones by technological-exploitation characteristics, with significant economical and ecological effects (Figures 1 and 2).

Tires got this way are cheaper from new one with equivalent standard and similar quality; money saving level is about 45%, retread tires have huge impact on surroundings – only 5l of fuel is used for tire retreading process instead of 35l used to produce new one (http://www.spiegel.de/auto/werkstatt/a-

169203.html (accessed 25.11.2011.)). Importance of retreading results that it became also an industrial process (Figure 3).

Figure 1. Landfills tires in Rakovici (part of the city where the most disposed tires) (Photo documentation "Politika", accessed 21.08.2012)

Figure 2. The fire at the landfil tires in Jagodina 11.04.2012. (Photo documentation "Blic", accessed 21.08.2012).

Demand for retread is created when tread is worn (cross section of typical tire is given on Figure 3), meaning that depth of channel of tread is lowered to allowed minimum. If according control determines that construction of other parts of tires is acceptable, he is sent to be retread in order to prolong its exploitation.

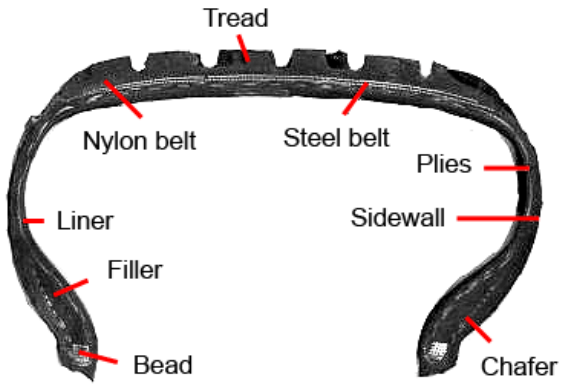

Figure 3. Typical structure of tire (cross section)

There are two basics process of tire retreading most used in praxis, so called cold and warm retreading [8]. Process of *cold retreading* is based on placing tread – already prepared warmed ring or proper length of tape of tread – on processed surface of „old“ tire (Figure 4a, 4b). New tread is glued to tire on temperatures below 100°C in special chambers. Retreading has no impact on tire structure, so that this procedure can be repeated several times on same tire and is common for retreading tires for commercial vehicles.

Figure 4. Types of treads - (a) ring shape, - (b) strip shape

Warm retreading is process is when prepared ring or proper size of tape of tread is put on tire in proper press and is heated to temperature of about 140°C. Due to high temperature, one tire can be retreaded only once, so this process is suitable for retreading tires of passenger's vehicles.

In literature almost doesn't have any papers dealing only with tire retreading, especially ones related to decision making for their exploitation. This is opposite to mass usage of retreaded tires, and present problems from this area, which was the reason to deal with by authors of this paper. For example, in praxis one of frequently asked questions is whether retreading and number of retreadings are useful. Answer to this question should include expenses of tire retreading, but also of their exploitation. Especially, that has to be considered having in mind that costs of tires are one of the biggest exploitation expenses of commercial vehicles [8], [2].

3. LITERATURE REVIEW

Due to overview mention problems, hereby follow short overview of papers related to ELV treatments and its parts. Practice has shown that these two classes of problems are tightly connected and it is not common to treat them separately. The first class of problems is related to all the activities performed on vehicles which have finished their working life and cannot be reused (or at least some of their parts, among which are the tires). This class concerns problems related to the influence of used vehicles on the environment, issues concerning the industry of disassembling of used vehicles, including those concerning technical-technological treatment of almost each part of a disassembled vehicle, as well as the problems related to the further exploitation of such parts. The second class contains the location-routing problems. All the problems

related to the location of facilities for treatment of described parts and complete ELVs are included in this class of problems.

Froelich at al. (2007) points out the importance of choosing the highest possible quality materials for manufacture of different parts of vehicles, which is also important from the aspect of ELV treatment [7]. When speaking about retreading tires, this could be the basis for making their return into re-usage more simple. The so-called Mexican model [3] by Cruz-Rivera and Ertel (2009) deals with the problem of collecting used parts of ELV and increasing the percentage of use of those parts. Some of the proposed solutions could be used when speaking about retreading tires. Le Blanc at al. (2006) have considered problematic of collection of ELVs in the Netherlands [10]. The authors have examined the ELVs treatment, without paying special attention to the used tires. Regarding the logistics aspect of ELV treatment, Dabic and Miljus (2007) [4] suggest a specific solution which might be applied to the tires with old and used treads. Dabic and Miljus (2008) have examined the treatment of used tires in general and proposed a model for location of facilities for their treatment [5].

4. IMPORTANCE OF SOME EXPLOITATION PARAMETERS OF TIRES FOR PROCESS OF THEIR RETREADING

Retreading is one of the methods to treat tires in exploitation with aim to prolong their work/life duration. Related to that, procedures of improving of retreading management and technology of this procedure are present (also seen as part of industrial treatment). At the same time, validity of this treatment is being permanently tested and proved, both from economical and ecological aspect, which is significant for tire manufacturers and their users (especially for big transport companies).

When analysing profitability of tire retreading, not only expenses and saving when realising this industrial-logistic process are calculated. Here are numerous parameters related to all that was happening with tire during its exploitation till the end of work life, when tire is written-off. Some of parameters are number of tire retreading, travelled distance of tire (new, after each retreading, total distance), exploitation conditions (load/speed of vehicles, road type where vehicle is driven on, driving style etc.). Also, one of important parameters/information is which company produce tires (Figure 5a and 5b (http://teretna-vozilacom/smf/tehnika/protekt-guma-postupak-i-općenito-o-njima-3336/ accessed 08.09.2012)).

Figure 5a. Part of the plants for retreading

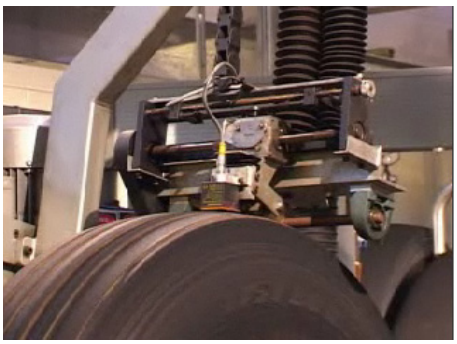

Figure 5b. Part of the plants for retreading

When the tread of a tire is obsolete or damaged, the decision related to its next retreading or dismiss should be made. In their paper, Beukering and Janssen (2001) assume that retreaded tires travel the same distances as the new ones. Ferrer (1996) presumes that service life of a tire does not depend on the number of retreading operations. However, the research made for this paper has shown that the travelled distance of a tire is reduced with every retreading procedure and that total number of retreading operations also depends considerably on the manufacturer – it is not unlimited. In that case, there are two important issues, the first one related to the number of retreading by that moment and the second one concerning the travelled distance during the exploitation. It can be assumed that these two parameters are random values, since they depend on a number of factors (manufacturer, driving conditions, road quality, type/load of vehicle, mode of driving etc.). In order to check this assumption, a detailed analysis of significant sample of written-off bus tires in one of the facilities of Public Utility City Transport Company "Beograd" (the biggest company for public city transportation in Serbia) has been done for two manufacturers – „Sava"and „Kormoran".

In this paper, analysis includes three key parameters for making decisions on choice of tire manufacturer whose retreading is expected during exploitation in transport company:

a) Number of retreading made on each of tire from sample to its writing-off

b) Total travelled distance by each tire in function from number of retreading to its writing-off
c) Partial travelled distance after each retreading

a) What is characteristic for tire exploitation is the fact that buses of vehicle fleet connects central area of town with its suburb. Those vehicles are running on damaged roadway. Results of analysis of number of tire retreading (till writing-off) of two manufacturers (507 tires „Sava“ i 547 tires „Kormoran“which are dominant in structure of used tires in this department), are given on Figures 6a and 6b.

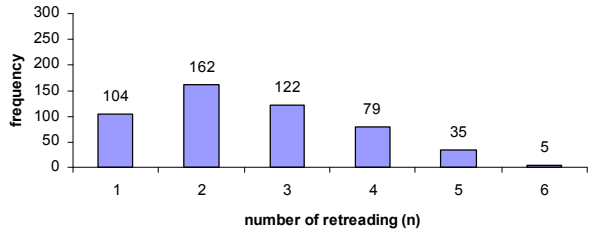

Figure 6a. Empirical distribution density of total number of retreading (till writing-off) on analysed sample of tires „Sava“

Based on the values from the Figure 6a, it can be noted that the number of retreading of “Sava” tires is a random value with mean $\mu_{Sava} = 1.59$ (retread/tire). The hypothesis on accordance of described empirical distribution with the Poisson probability distribution law is confirmed by the Chi-squared test ($\chi^2 = 2.227$).

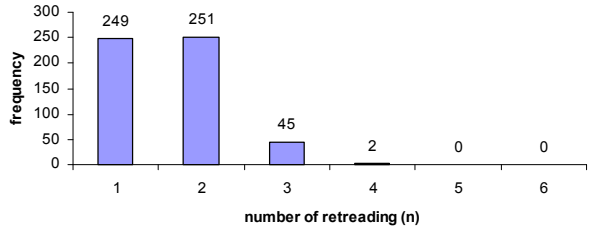

Figure 6b. Empirical distribution density of total number of retreading (till writing-off) on analysed sample of tires „Kormoran“

For “Kormoran” tires, significantly different distribution of retreading per tire is noted (Figure 6b). Mean value is $\mu_{Kormoran} = 0.63$ (retread/tires), while the hypothesis on accordance of described empirical distribution with Poisson probability distribution law has not been confirmed. This shows a significant difference between the exploitation parameters of those two manufacturers. Also, it should be emphasized that there are cases where a new tire, due to some damages, cannot be retreaded (in Figure 6a and 6b these are the frequencies for values of random variable equal to 0). For “Sava” tires this probability is $p_{0,\,Sava} = 104/506 = 0.206$, and for “Kormoran” tires $p_{0,\,Kormoran} = 249/547 = 0.455$.

b) One of the basic starting parameters for choice of tire manufacturers is total travelled distance by each tire till writing-off (travelled distance of new + distance travelled of retreaded tire). Analyses of mean travelled distance values show high correlation coefficient (above 0.98) with assumed linear trend (Figure 7).

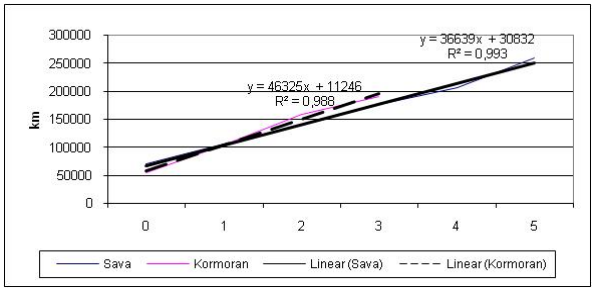

Figure 7. Trend lines representing the sum of the total travelled distances in function of number of retreading for “Sava” and “Kormoran” tires

Decision making about retreading of tires based on these analysis is not always reliable. The answer to this question based on the presented distributions and diagrams can be hardly gained. Namely, in a particular case it is not known what happened with certain tire, or in other words, how the “history” of its exploitation may influence its future behaviour. It is noted here that, due to characteristics of the analysed parameters, the results for “Sava” tires will be used in the rest of this paper.

c) Partial travelled distance after each retreading of one tire is also important parameter for making decision both about manufacturer and retreading itself. As „Kormoran“ tires are dominantly retreaded only once, this paper gives results (average values) only for „Sava“ tires (Table 1 and Figures 8 and 9).

Table 1. Partial distance travelled after each retreading

(n) number of retreading of „Sava“ tires	Average distance travelled by tire in function (n) in 000 km
1	40.2
2	41.1
3	34.3
4	31.9
5	24.1

In Table 1 it can be seen the rule - with increase of number of retreading, travelled distance by tire after each retreading decrease (also we can see small deviation after second retread). In order to research this parameter, analysis of trends which describes this relation was made. It was noted that linear trend (R_L) and exponential trend (R_e) describe this

connection with almost the same correlation (R_L = 0,9 for linear trend and R_e = 0,88 for exponential trend) – Figures 8 and 9.

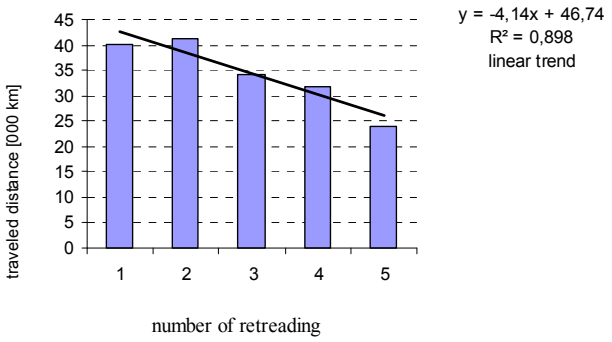

Figure 8. Dependence of distance travelled by tire on number of retread – linear trend

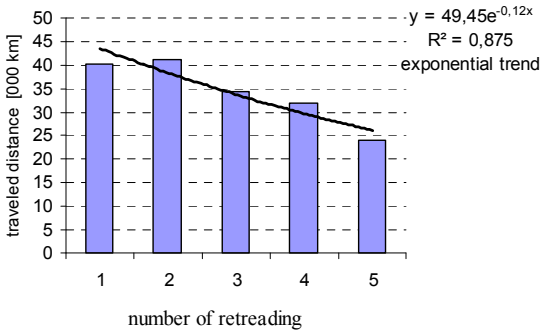

Figure 9. Dependence of distance travelled by tire on number of retread – exponential trend

Trends shown point high correlation of both functions, and choice could depend on eventual further analysis. Functions gained this way can be useful for making various decisions: whether to do or not retreading on one tire, choice of tire manufacturer, and usage of tire respecting driving conditions etc.

5. CONCLUSION

Tire retreading presents important ecological and economical problem which is not simple to solve. Special importance of making decision for one transport company whether to buy new tires or to retread used one. To make such decision, it is important to know exploitation parameters of tire, where the accent is put on distribution of probability of number of retreading and travelled distance after certain (number) of retreading. Aiming this, sample of tires of vehicle fleet of biggest company for public city and suburb transportation in Belgrade was analysed. Results point to important stochastic level of these parameters and important level of correlation between them.

To make final decision to retread or not, it is necessary that for each such problem proper data bases for each tire are provided and statistic analysis are made. It is also necessary that data are separated for each department, for homogeneous group of tires and vehicles, exploitation conditions etc. Of course, these analysis/results have to include homogeneous of exploitation conditions – regime of their exploitation. Only by that, one big transport company which chooses to use retreaded tires can provide quality parameters and based on them makes correct decision if and when retreading, as one modern industrial and logistic process, is justified.

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