CIRCULAR PRODUCTION FUNDAMENTALS OF WASTE TYRES

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Abstract

In addition to a stable economy, the circular model should also ensure a healthy environment. The yield in this system is based on the efficiency of using natural resources through efficient recovery. The circular model mainly uses renewable resources and we call it regenerative. It focuses on material efficiency, waste of resources, reuse, repair, and change in product design. Instead of ownership, he prefers renting and maximum use of the product. Emphasis is placed on the design phase, repairability, degradability, and high recyclability. In the circular economy, we do not deal with the end but just the beginning, design is key in this, and it determines what happens to the material at the end of its life. And not only materials but mainly products or their components. It significantly minimizes waste and the cost of input materials and energy required to produce new products. The production of waste tyres is constantly growing every year. The presented manuscript aims to maximize the recovery of all components of used tyres that are returned to the manufacturing process. The research is focused on monitoring the fabrics component of waste tyres and their application in the manufacturing of new composite materials.

Keywords: Circular economy, circular production, waste tyres, sustainable manufacturing

1. INTRODUCTION

Around 6 million tonnes of end-of-life car waste is produced annually, of which just over 5 million are recycled. Compared to the percentages, just 87 percent of end-of-life vehicle waste is recycled [1]. From the borders of the EU countries, France is the largest producer of waste in this right, followed by the United Kingdom and Italy. These three countries produced just over 1 million tons of waste in 2018. For comparison, Slovakia produces only 38,000 tons of end-of-life vehicles per year [2]. The following **Figure 1** offers graphical processing of recycling capacity in the European Union between 1992 and 2019 [1,2].

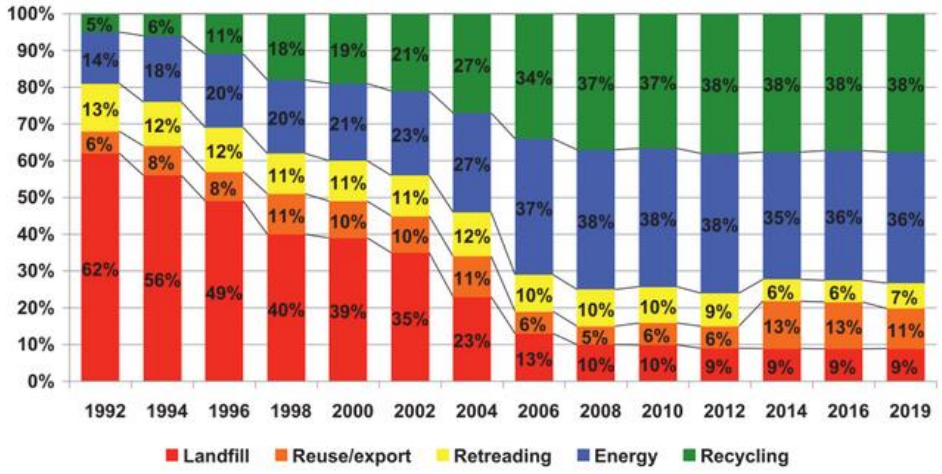

Figure 1 Recycling capacity of the European Union (years 1992-2019) [2]

Landfilling is slowly disappearing in the European Union, with its percentage declining from 62 % in 1992 to 9 % in 2019. The reuse share reached its lowest level in 2008 at around 5 %.[3] On the contrary, in 2019, we can state an increase in the reuse of waste tyres to 9%. Retreading as a possible way of using waste tyres has decreased in the EU to 7 %. [4] On the contrary, waste tyres' share of energy and material recovery is very close in percentage values from 1992 to 2019. In Hungary, a newly built plant also deals with the abovementioned issue of processing used tyres [5]. The new plant at the Hungarian Zala refinery recycles 10 % of all used tires in Hungary. Behind this plant are the oil, gas and petrochemical group MOL, whose portfolio to the Slovak refinery Slovnaft also belongs. Chemically stabilized rubber asphalt was patented in 2009, and later in 2014, it was awarded the trademark of an ecological product. The technology patented by MOL allows rubber asphalt to be transported, stored and later used so that it can be produced in bulk, and at the same time, its use can be off-site.[6] On the other hand, rubber asphalt made in the USA is produced directly on the road construction site, as it must be used within a few hours. Due to the extraction of rubber particles [7]. The mentioned plant can produce up to 20,000 tons of rubber asphalt per year. This production covers almost 10 to 15 % of domestic demand for asphalt. Hungary can thus secure the construction of nearly 200 kilometres of the two-lane road by recycling half a million used tires [2-5]. The conditions for expanding rubber-asphalt roads are favourable, as rubber-asphalt has excellent adhesion to mineral substrates. It reduces the probability of the formation of potholes, and its higher load capacity than conventional asphalt minimises the possibility of constructing rutted tracks on the road. [6] One of the cheapest and easiest ways to burn waste tyres is often used worldwide. From an ecological point of view, this method is very environmentally friendly. When worn tyres are burned, an oxidation reaction occurs, where many of the burned tires are converted to carbon oxides and soot. In practice, butadiene, styrene, aliphatic and aromatic hydrocarbons, benzene, toluene, and phenylacetylene are released into the air. Simply put, heavy metals, which have a negative impact on the environment, are released into the air. However, despite this fact, this method of tire recycling is used in many countries around the world [7]. The result of the tyre combustion process is fuel. To illustrate, if we burn 700 kg of waste tyres due to combustion, we get a secondary processing product, which is a fuel, but on the other hand, we produce 720 kilograms of toxins and soot [5].

Recycling used tyres is both an opportunity and a challenge. Used tyres are a potentially valuable resource for reuse and processing worldwide and in Slovakia. Safety rules must be observed in the case of reuse using tire retreading or tire recycling itself. And that is not only in Slovakia but also in the world. Over the years, various legal regulations have been formed that oversee the issue above of used tyre processing throughout the world and in individual countries. Every country in the world is aware of the limits of the environment that surrounds us and the importance of the issue of ecology. Even so, every year, we as a whole world produce a large amount of waste, gradually forcing us to change our attitudes.

2. RESEARCH METHODOLOGY

In Slovakia, a law on managing waste tyres states that every tire manufacturer and distributor must take back waste tyres. The final consumer also has this obligation to hand over the worn tire into the hands of a distributor or other authorized person. Only a natural person has the opportunity to hand over a worn tire to the collection yard [4-6]. The obligation to return the waste tyre to the distributor remains for legal entities. Every tyre manufacturer in Slovakia must register in the Register of Tire Manufacturers through an application for entry [3]. These obligations result from Act no. 79/2015 Coll. The Waste Act and the Amendment of Certain Acts (referred to as the “Waste Act”). Of course, the number of tyres launched during the year is affected by seasonal fluctuations, such as the months when the tyres are changed, i.e. November and April. The following chart (**Figure 2**) presents the number of mentioned tyres on the market from 2016 to 2018.

On average, the price of a car tire ranges from 50 euros to 150 euros. The price depends mainly on parameters such as the tyre's width measured in millimetres, the profile, which represents the ratio of the tyre's cross-section and its width expressed as a percentage, and, last but not least, the wheel diameter in inches. In the

following table, we can see the amount of the recycling contribution over three years.[7] The amount of the recycling allowance is determined as a multiple of the number of tires in kilograms placed on the market by the participants [8]. The participant is any tyre manufacturer or importer who enters the Slovak market and can fulfil its legal obligations to take back tyres through participation in the ELTMA producer responsibility organization. In 2019, all participants paid recycling contributions of € 3,567,000. [9]

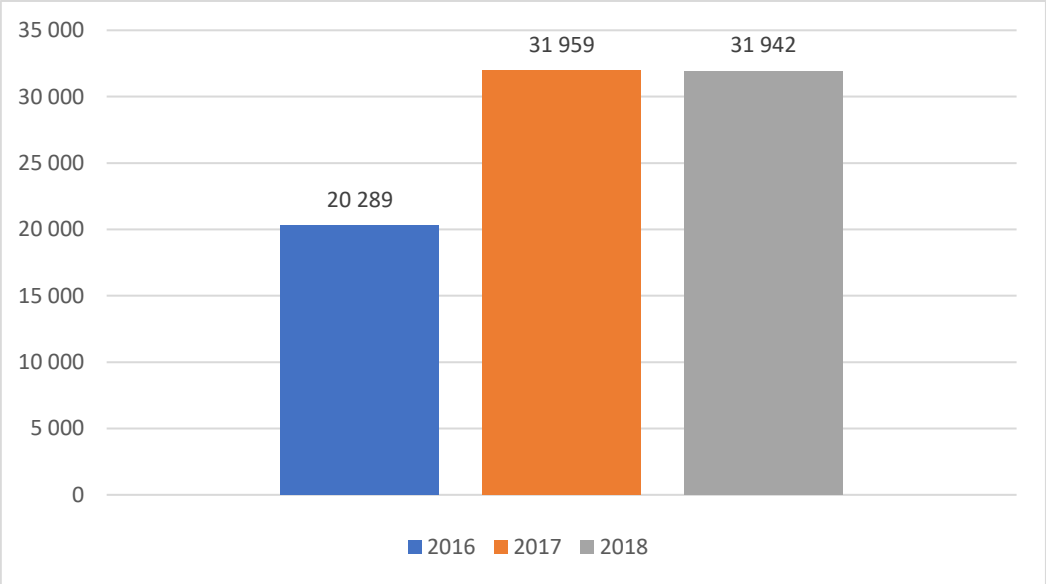

Figure 2 The number of launched tyres on the market [3]

Table 1 The amount of recycling payment [5]

Year	2019	2018	2017
The amount of recycling costs (without the tax)	0,135 €	0,099 €	0,12 €
The summary of recycling costs	3 567 7000€	2 692 000 Eur	3 093 000 €

The recovery of tyres itself is a time-consuming and costly process that is very expensive. **Table 2** provides an overview of the costs of collecting and recovering waste tyres in 2019, 2018 and 2017. As we can see, the costs climbed to € 2,746,000 in 2019, confirming the claim that the recovery of waste tyres is costly [9].

Table 2 Waste tyres collection and recovery costs [5]

Year	2019	2018	2017
Waste tyres collection and recovery costs	2 7462 000 €	2 075 000 €	1631 000 €

3. RESULTS AND DISCUSSION

Profitability financial metrics are the basic and subsequent relative indicators determining the company's financial health [6]. They quantify the ability of business entities to increase invested capital and generate new sources of financing [10]. Profitability expresses the company's ability to create new resources and make a profit with the invested capital [11,12].

• EAT (Earnings After Taxes) - represents the economic result after deducting income tax

• EBT (Earnings Before Taxes) - represents the economic result before deducting income tax

• EBIT (Earnings Before Interest and Taxes) - represents the profit before interest and taxes

• EBITDA (Earnings Before Interest, Taxes, Depreciation, and Amortization Charges) - represents the financial result before deducting interest, taxes, and depreciation.

The following **Table 3** offers the processing of the company's financial results during the years 2020, 2019, and 2018 [5,10,13].

Table 3 The selected financial metrics [4]

Index	2020	2019	2018
EAT	786 279 €	692 518 €	729 292 €
EBT	543 551 €	845 987 €	815 190 €
EBIT	633 725 €	974 995 €	964 225 €
EBITDA	1 496 955 €	2 086 965 €	2 154 284 €

In the following **Figure 3**, it can be seen a graphically displayed Profit of AVE SK for the last few years. The company's profit is essentially in line with the profitability indicator EAT (Earnings After Taxes), representing the profit after tax.

Figure 3 The company profit [5]

Material recovery has long prevailed over the energy recovery of waste tyres. The year 2018 indicates 89.8 % of material recovery of waste tyres and 9.15 % for energy recovery [11]. The Waste Management Program of the Slovak Republic for the years 2021-2025 aims to achieve by 31 December 2025 a rate of waste tyre recycling of at least 75 % and a rate of energy recovery of waste tires of a maximum of 24 % of the total weight of tires placed on the market. The possibility of different disposal of waste tyres was set at a maximum of 1 % [12].

4. CONCLUSION

The circular model primarily uses renewable resources, focusing on material efficiency, waste of resources, reuse, repair and change in product design. Emphasis is placed on the design phase, repairability, degradability and high recyclability. Therefore, we do not deal with the end but the beginning of the circular economy. Design is key in this and determines what happens to the material at the end of its life. It is important to draw society's attention to those ways that benefit the environment. Materials recycling and energy recovery offer alternative and complementary means of obtaining the greatest possible sustainable benefit from natural resources and their waste, which ultimately reduces the consumption of indigenous resources. Approximately

36% of waste tyres in the European Union and 46% in the United States are used as complementary non-fossil fuels. Due to waste tyre energy recovery processes, for example, by burning tyres in cement kilns or incinerators to burn tyres in cement kilns or incinerators to produce electricity or steam. As a result, the worn tyres from which we can obtain energy replace fossil fuels, which belong to the group of non-renewable energy sources.

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