Acta Tecnología - International Scientific Journal about Technologies
Volume: 11 2025 Issue: 2 Pages: 87-91 ISSN 2453-675X

https://doi.org/10.22306/atec.v11i2.280 *Received: 23 Apr. 2025; Revised: 14 May 2025; Accepted: 02 June 2025*

Study of tyres sustainability in the specific field of industry

Lucia Knapcikova
Technical University of Košice, Faculty of Manufacturing Technologies with a seat in Prešov,
Department of Industrial Engineering and Informatics, Bayerova 1, 080 01 Prešov, Slovak Republic, EU,
lucia.knapcikova@tuke.sk (corresponding author)

Matus Marticek
Technical University of Košice, Faculty of Manufacturing Technologies with a seat in Prešov,
Department of Industrial Engineering and Informatics, Bayerova 1, 080 01 Prešov, Slovak Republic, EU,
matus.marticek@student.tuke.sk

Keywords: sustainability, waste tyres, circularity, industry.

Abstract: Tyre sustainability is an important aspect of environmental responsibility in the automotive industry. This paper encompasses the processes of tyre production, use, wear and disposal in a way that minimizes negative impacts on the environment and human health. It focuses on extending the life of tyres, reducing their ecological footprint and recycling them efficiently. From production to use to recycling, a number of measures can be taken to reduce the negative impacts of tyres on ecosystems and society. These steps include innovations in materials, improved recycling technologies and a responsible approach to waste management.

1 Introduction

With the development of the automotive industry, tyres have become an integral part of everyday life [1]. We use them almost every day, whether when driving a car or riding a public transport bus, they are also widely used in air transport, but they are also an important link in freight traffic [2]. As a result of the development of society in the world, the demand for tyres is increasing, and the production of waste tyres is proportionally related to this [3].

The tyre manufacturing process can be divided into the following parts [2].:

- Material acquisition,
- Compound production,
- Production of individual tyre components,
- Tyre assembly,
- Vulcanization,
- Production quality control,
- Storage and delivery to sales.

Waste tyres represent a global problem and an increasing risk to the environment, because they are not biodegradable, are often improperly stored and disposed of. These stocks pose a threat of uncontrolled fires and other environmental risks. It is estimated that almost 1000 million tyres end of life each year and more than 50% are discarded without any further use [4]. Recycling and recovery of waste tyres are therefore being studied in many countries [5]. This step has necessitated a rethinking of the view and approach to waste in order to increase its recovery and drastically reduce the amount that needs to be disposed of or stored [3].

2 State of the art of the problematic

The basic components of any tyre are rubber, synthetic rubber, various fillers (such as silica or silicon dioxide) (Figure 1), and reinforcing and hardening agents [4]. Oil, resins, and other chemicals are used as plasticizers to improve the elasticity of the tyres [5]. The total number of components is over 200, and each has its own role in ensuring optimal tyre properties, such as fuel economy, performance, environmental protection, and safety. However, each manufacturer carefully protects the exact composition and ratio of the individual components contained in the tyres [3].

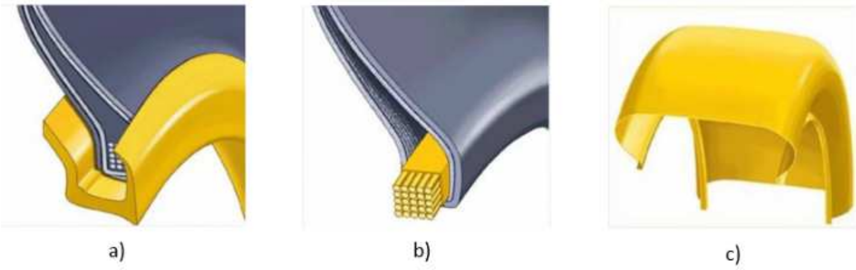

Figure 1 a) heel b) heel cord c) rubber layer [4]

The sidewall (Figure 2) is an essential part of every tyre. There are no steel reinforcements in the sidewalls, because the role of the sidewall is to resist external influences, bending and vibrations [3]. They are mainly made of natural rubber. In practice, when driving on the track, it is the sidewall that keeps the tyres "in place", since when cornering at high speeds, under the influence of the laws of physics, it looks like the rim is pushed inward and the tyre is pushed outward from the car [3]. To the naked eye, in slow motion footage, it looks as if the tyre is jumping in and out. In these situations, it is the flexibility of the sidewalls that ensures the proper functioning of the tyre [2]. The largest part of the tyre is made up of the carcass otherwise called the radial cord layer, and the composition of this layer determines the basic properties of the casing [4]. It is a high-strength fabric, composed of aramid fibers, polyamide, polyester, viscose and other materials. Depending on the composition of the cord layer, tyres are divided into diagonal and radial, depending on the direction in which the cord layers are laid [5].

Figure 2 a) sidewall b) carcass[4]

The composition of different types of tyres is not identical. Each type is designed for different conditions and must therefore meet different, specific requirements (Figure 3). The proportion of individual components in the tyre and their production itself depends mainly on the vehicle and terrain the tyres are intended for [6]. Important production parameters are, for example, the type of vehicle and its weight, tyre dimensions and speed index.

Figure 3 a) bumper b) tread [4]

The construction of the finished tyre is the most demanding part of the entire manufacturing process. The other components are inserted into the construction machine and the finished tyre is created. Its inner diameter is formed by a steel, or bead, cord, which is covered by an inner rubber layer that replaces the tyre's inner tube. The inside of the tyre and the sidewall are separated by a tread. The tread is made of steel cords and natural rubber (Figure 4). The steel cords absorb road irregularities. If the sidewall is cut, the tyre becomes unusable and cannot be repaired.

Figure 4 Flat Spot [4]

3 Work methodology

The selection of tyres is carried out according to two basic criteria: the characteristics of the circuit and environmental impacts [7].

First of all, the individual appearance of the track is assessed, how many fast corners, slow corners, straights it has [8]. In slow corners, i.e. those that make sharper angles, the pressure on the tyre is less and therefore overheating occurs later. In this case, it is better to choose softer tyre compounds [9]. In fast corners, the car has more downforce and the force that acts on the car is transferred to the tyre in the form of lateral force. These quantities are directly proportional, i.e. the higher the speed, the higher the downforce and the greater the force acting on the tyres and therefore it is better to choose harder tyre compounds [10]. If the track has long straights or more short straights, the tyres have room to cool down, softer compounds are suitable, otherwise, if there are few straights, harder compounds are preferred [11]. The second step to consider when choosing tyres is the track surface. We know two basic criteria for track surfaces: macro roughness and micro roughness. To understand, it is important to imagine the composition of asphalt itself. Bitumen is a mixture of hydrocarbons that have been extracted with organic solvents from sediments containing organic matter. Similar hydrocarbons are also found in gasoline, tar, oil, and plastics [9]. Bitumen is a substance with a thick, sticky liquid consistency like syrup that solidifies at normal temperatures. It is mixed with aggregate, which forms gravel and stones. When looking at the track, this mixture is visible to the naked eye [11].

4 Results and discussion

After the new asphalt is laid, the surface is not perfectly laid and compacted for several years and the aggregate, which contains stones, causes the surface to be rough (Figure 5). Macro roughness makes the track more grippy and the car has more grip, but it is very aggressive towards the tyres [12]. This raw asphalt guarantees the selection of harder tyre compounds. In addition to the aggregate, there is a second problem caused by the new asphalt [13].

Figure 5 Asphalt [1]

The oils found in bitumen are sensitive to temperature changes and at higher temperatures they separate from the compound and coat the track surface [10]. This in turn causes less grip and the risk of the tyres slipping on the track [4]. After a few years, depending on use, the aggregate slowly compacts and the surface becomes smoother. This process is closely monitored and when comparing the compounds used on one circuit, we see different compounds over the years [7]. Micro roughness is the texture of the surface itself. It assesses the connection and relationship between the rubber on the surface of the tyre and the road surface [9]. It looks at this problem from a chemical point of view so that the molecules in the tyres and the molecules in the asphalt have the best possible grip. Another major factor influencing tyre choice is environmental factors. The temperature of the road has a significant impact on tyre choice. In many cases, a colder track is flatter and more conducive to energy distribution in the tyres during corners [12].

The higher temperatures can cause the bitumen in the asphalt to deform and release oils, which will cause the tyres to have less grip [11]. Of course, Pirelli doesn't know in advance what the weather and temperatures will be during the race weekend, so they will be given a clue as to what the climate is in the country [13]. If the country has alternating periods of rain and dry weather, this will keep the track cold and wash away the rubber. So tracks without a rubber layer will be better suited to harder compounds, but only if it's not too cold [14].

Conclusion

Tyre sustainability focuses on minimizing their negative impact on the environment throughout their entire life cycle, from production, through use, to recycling and disposal. This issue is important because tyres are made from materials that can have harmful effects on nature if not properly processed. From the research carried out, it is important to focus on:

- the development of tyres with a longer lifespan and lower maintenance requirements. These technologies can reduce waste and improve overall sustainability.
- the production of smart tyres, which include technologies that monitor tyre wear and pressure, which allows for better management of their lifespan and reduce inefficient use.
- the proper recycling of waste tyres so that technological systems are designed to minimize the environmental impact of tyres on the environment.

In conclusion, supporting the circular economy of tyres is the process of recycling and reusing tyres with the aim of minimizing waste and maximizing sustainability.

Acknowledgements
This work was supported by the project VEGA 1/0210/25 and KEGA 014TUKE-4/2025 granted by the Ministry of Education, Research, Development and Youth of the Slovak Republic.

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Single-blind peer review process.