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FUNCTION, STRUCTURE, AND OPERATION OF A CAR TIRE

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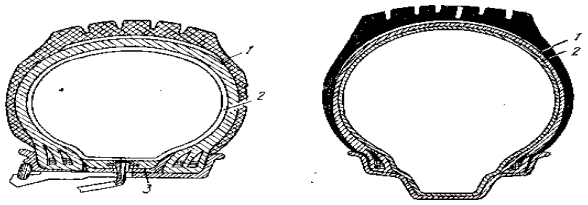
Abstract: The car wheel and its essential component the pneumatic tire.The car wheel, and specifically its crucial component, the pneumatic tire, plays a vital role in ensuring the vehicle's movement and safety. One of the primary functions of the pneumatic tire is to absorb shocks and impacts caused by road irregularities, potholes, and other mechanical effects, thereby reducing the dynamic load on the vehicle during motion. This process is achieved due to the tire's elastic properties and the air pressure inside it. The tire's elasticity enables it to adapt to road unevenness, thereby improving the ride quality of the vehicle. By softening shocks, the tire ensures smoother and more stable motion. Tires are mounted onto the wheel rim, particularly with the help of beads. These beads, under air pressure, take on a conical shape, securely fastening the tire to the rim and ensuring their mutual engagement.

Keywords: Car, wheel, pneumatic tire, tire, motion, dynamic load, unevenness, shock, damping, elasticity, air pressure, beads, tubed tire, tubeless tire, tire types, tire repair, road safety, energy consumption, pothole, repair.

Introduction: The most critical part of a car wheel is the pneumatic tire. It absorbs minor shocks and impacts caused by road irregularities during motion, softening and partially dampening these forces, thus reducing the dynamic loads on the wheel. This functionality is ensured by the tire's flexibility and the elasticity of the air it contains. Additionally, the tire improves the wheel's grip on the supporting surface. The tire is mounted onto the wheel rim, where it is held in place by beads that adhere tightly due to air pressure, forming a wedge-like contact with the conical surface. Tires are classified into two main types: tubed and tubeless. In tubed tires, the air is contained within a sealed inner tube, whereas in tubeless tires, the air cavity is formed directly between the tire and the wheel rim. Tubeless tires enhance safety during movement because they release air more slowly than tubed tires when punctured, reducing energy consumption and overheating. However, repairing tubeless tires on the road is more challenging [1].

Figure 1a illustrates a tire fitted to a flat rim, while Figure 1b depicts a tire mounted on a deep rim.



a) **b)**

Figure 1. General Structure of a Tire

A tubed tire (Figure 1) consists of the cover 1, inner tube 2, and wheel rim 3. The structure of tires is illustrated in Figures 1a and 1b. The most essential and valuable part of the tire is the cover. Its core is the carcass 3, which ends at the bead 10 and bolts 7, finishing with the sidewall 4.

Above the carcass lies a cushion-like layer called the breaker 11. The carcass is made of rubberized cord material and consists of multiple layers. The bead and the carcass are crucial for securing the tire onto the rim. The cord fabric, made of rubber-coated threads of cotton, nylon, or durable synthetic fibers, ensures the tire is strong yet flexible. Based on the orientation of the cord threads—either vertical (diagonal) or horizontal (radial)—tires are categorized as diagonal or radial-cord tires. The outer and side surfaces of the carcass are covered with tread rubber 1. The tread is the part of the tire that comes into contact with the road, ensuring good grip and protecting the tire from damage. It is made from a durable, thick rubber layer. The tread's pattern, designed to fulfill specific purposes and operating conditions, consists of grooves arranged in various shapes. Inside the cover, steel wires form concentric rings, strengthening the tire's beads and adding flexibility for easy mounting on the rim. The cushion layer (breaker) lies between the carcass and the tread, consisting of 2–6 layers for passenger cars and rubber-coated cords for trucks. This layer enhances the carcass's resistance to external impacts and improves its bond with the tread. The tire's sidewall surface 8, made from a rubber layer, protects the sidewalls from damage and prevents water ingress. The bead tape 4 is crafted from rubberized fabric, shielding the tire wall from damage and wear caused by contact with the rim[2].

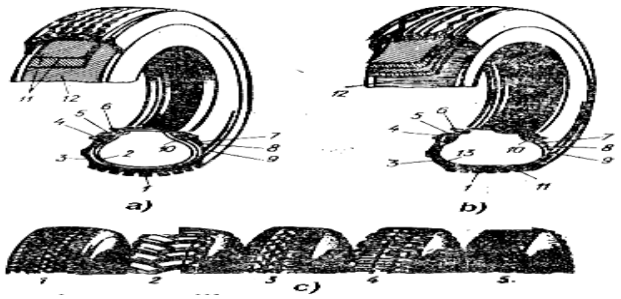


Figure 2. Structure of Tires
a – tubed tire, b – tubeless tire, c – tires with different tread shapes

In a tubed tire (Figure 2a), the inner part of the tire contains a valve 6 and inner tube 2. The inner tube 2 is a ring-shaped elastic rubber balloon, through which air is pumped or released via the valve. The bead tape, a rubber insert, is placed between the bead and the inner tube, preventing the inner tube from being damaged or worn out by contact with the tire's sidewall and the rim (flat rims). The valve is equipped with a unidirectional valve that allows air to pass in one direction. The valve consists of a metal casing, a valve stem, a spring-loaded valve, and a cap. The main part of the valve, the valve stem, allows air into the inner tube when inflated and prevents air from escaping back out. To release air from the inner tube 2, a pin is pressed, causing the valve to open through the spring and air pressure. Once the tire is inflated to the proper pressure, the valve casing is sealed tightly with a cap.

Main Section: The construction, size, and quality of materials used in tires for light vehicles differ from those used in heavy-duty truck tires. Light vehicle tires feature a high-elasticity carcass, a low profile, and a tread design optimized for road conditions, with a smaller external and transmission diameter. These tires are primarily designed for use on improved roads. The maximum specified pressure for light vehicle tires typically ranges from 0.2 to 0.30 MPa (2.0 to 3.0 kg/cm²)[3].

In recent years, tubeless tires have also been used in automobiles (Figure 2b). The key difference between tubeless tires and pneumatic tires is the absence of an inner tube. Instead, a thick 2–3 mm rubber sealing layer 13 is applied inside the tread. To inflate the tire, a valve 6 is installed in the rim itself, with two sealing rings placed at the junction. In heavy-duty trucks, especially for the leading wheels, the tires must have excellent grip with the road surface or the ground. To achieve this, the tread of these tires features various shapes and robust, durable tread blocks [4].

Conclusion: Both tubed and tubeless tires play a crucial role in ensuring the vehicle's movement and safety. Tubed tires manage internal pressure through an elastic rubber tube and valve system, enhancing the tire's elasticity and its ability to adapt to road irregularities. The valve system in tubed tires allows air to pass in only one direction, providing stable and consistent operating conditions. In contrast, tubeless tires use a sealing rubber layer instead of an inner tube. These tires offer advantages such as slower air loss and lower energy consumption. However, when the vehicle is stationary, air can accumulate in certain areas, creating discomfort. Specially designed tires for trucks improve road traction and the ability to overcome high road resistance. Radial tires help improve vehicle movement under harsh road conditions, offering ideal options for trucks due to their width and durability. The tread shape, strength of the tread blocks, and low internal pressure characteristics ensure reliable and long-lasting performance for these tires. Overall, both tubed and tubeless tires, as well as specialized tires for heavy vehicles, each have unique advantages and drawbacks. The selection of tire type should be based on the driving conditions and safety requirements.

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