

Special Feature Article

Accelerating tire innovation

-Electrification and environmental issues are increasingly being addressed-

Tires are the only security component of a vehicle's components that are in contact with the road surface and have a significant impact on safety and comfort. Rubber pneumatic tires were invented in the late 1800s. Since then, tire manufacturers have worked hard diligently to improve. The grip and comfort performance of tires in response to road conditions. In recent years, new technologies have been developed that break with conventional concepts, and are on the verge of practical application. This report details into the latest development trends, future possibilities and the challenges faced.

Over 100 years of working to reconcile the 'antinomy'

Tires are a major factor in the driving performance of vehicles. Although their black, round appearance has remained unchanged over the years, they have constantly evolved.

Their development can be described as a history of balancing two opposing performances. For example, in recent years there has been a demand for low rolling resistance products with low energy loss, but these are generally at odds with the grip on the road surface. The Japan Automobile Tire Manufacturers Association, Inc. (JATMA) allows products with a certain level of compatibility between 'rolling resistance performance' and 'wet grip performance', which are evaluated by grade, to be labelled and sold as 'fuel-efficient tires'. It requires that the tires not only contribute to improving the fuel efficiency of vehicles, but also ensure safety.

In addition, tires have various conflicting performance requirements, such as quietness and abrasion resistance, which have been a source of concern for engineers at various manufacturers. While studying rubber at the molecular level, the required performance has been improved by kneading in various raw materials, such as carbon black, which increases strength, and silica, which improves performance on wet roads. The pattern shape of the ground surface is also being optimized to suit the application.

Performance standards forced to accommodate electrically powered vehicles

Looking at the global automobile market, SUVs, which have larger bodies than sedans and coupes, have become more popular in recent years. In addition, EVs are also gaining market share, but both have one thing in common: they are heavy vehicles.

Brakes are being increased in diameter to cope with the increase in vehicle weight, but tire size cannot be increased to an extreme degree.

Therefore, it is necessary to use tires with a low flatness ratio and reduced side height without changing the outer diameter, in order to cope with the increased vehicle weight. This requires a more robust internal structure and requires advanced manufacturing technology.

The manufacturers position high-performance passenger car tires of 18 inch and above as 'premium tires'. They pay attention to the shape of the ground contact surface and the composition of raw materials, and work to add value by, for example, improving quietness and grip. By increasing the sales ratio of these higher-priced products, manufacturers are also working to improve their profit margins.

Bridgestone Corporation, for example, has named its lightweight, highly rounded tire design foundation technology 'ENLITEN' and is rolling it out in new products. While raising the level of performance, they intend to differentiate itself in the global market by introducing products that highlight specific performance characteristics, such as grip and quietness, to capture the needs of users.

Tires that change their characteristics depending on the situation

Recently, efforts have been made to develop new technologies that overturn conventional wisdom, such as changing the properties of rubber.

'ACTIVE TREAD' technology, which Sumitomo Rubber Industries, Ltd. will introduce to the market this autumn, is an unprecedented technology that changes its performance in response to road conditions. It changes the properties of the rubber in response to road surface moisture and the temperature environment to reduce the loss of grip. It was achieved by combining several materials provided by chemical manufacturers and research institutes.

Tires currently on sale can be broadly divided into two main categories, 'summer tires' and 'winter tires', but the actual driving environment changes from moment to moment, from dry roads to puddles, on snow and ice. If tires can change their characteristics to suit road conditions, this will lead to greater safety and comfort. This can be particularly effective in reducing non-operating time for tire changes in taxis and rental cars, which are required to drive in all weather conditions.

They intend to use the technology for all-season tires first, and then gradually expand it to EVs and other applications. Although there are still issues to be addressed, such as the supply of raw materials, the accuracy of performance changes and the application of the technology to large-diameter trucks and buses, they intend to continue development of this new technology, which has the potential to make winter tires, so-called studdles tires, unnecessary.

No air and no punctures

Manufacturers are also aiming to realize 'Puncture-free tires'. 'Run flat tires', which have reinforced sidewalls and can be driven on even when deflated, are already commercially available, but efforts are also being made to develop 'Airless tires' that are not inflated.

Airless tires do not have sidewalls with the manufacturer's name and size printed on them and have specially shaped spokes on the inside to absorb impact. In commercial vehicles, this can reduce efficiency and cost increases due to punctures, and also has the

advantage of reducing maintenance such as air pressure checks. If 'Retreading', in which the ground surface is replaced, is realized in the future, costs and raw materials can also be reduced.

Similar concepts are being studied by four Japanese manufacturers, as well as MICHELIN and The Goodyear Tire & Rubber Company, although the tire structure itself would need to be significantly changed. MICHELIN has already teamed up with transport operators in France and Singapore to demonstrate delivery by vehicles fitted with airless tires.

On the other hand, legislation is an issue in Japan. Under the Road Trucking Vehicle Law, airless tires have not yet been approved for use on public roads. Domestic companies have been developing them since the mid-2000s, but have only considered using them mainly on golf carts and small EVs that run on private property.

In March this year, Bridgestone Corporation began demonstration tests on public roads after consulting with Ministry of Land, Infrastructure, Transport and Tourism on legal compliance. It is hoped that their efforts will lead to a move towards driving on public roads in Japan.

Tires act like suspension

'I wish the hardness of the tire would change when going over bumps'. This simple thought of an engineer led The Yokohama Rubber Co., Ltd. To make a technological proposal for future tires at last year's 'JAPAN MOBILITY SHOW 2023'.

'Future Sport Tire concept', which was unveiled for the first time, incorporates 'Variable Hardness Stabilizer', a mesh-like structure, inside the tire. It is made of a special material that changes its hardness when electricity is passed through it, enabling the rigidity of the tire to be varied. The tire characteristics can be adjusted to suit the driving situation, such as on a circuit or in town. Assuming automatic driving, the system can also be used to change tire hardness in response to bumps or sunken road surfaces detected by on-board cameras and sensors, and to raise the vehicle height on one side at the moment of a side collision to prepare for the impact.

Currently it is still in the planning stage, but they have received positive feedback on the idea from car manufacturers and manufacturers of special materials for stabilizers. If realized, they expect the tire to function like an active suspension, creating new value.

Making tire production sustainable

In addition to improving performance, a common challenge for the industry is how to make the procurement of raw materials more sustainable. About 20% of raw materials for tires are synthetic rubber derived from petroleum, which emits CO₂ during production. Natural rubber, which accounts for about 30% of the raw materials, is also faces supply risks due to disease and natural disasters, as about 80% of the para rubber trees used as raw materials are unevenly distributed in South-East Asia.

In order to make tire production sustainable into the future, companies are rushing to develop tires made from recycled or renewable materials. In addition to polyester yarn derived from plastic bottles and silica derived from rice husks, they are working on demonstration tests to extract carbon black and other materials from waste tires. Toyo Tire Corporation is engaged in joint research with the University of Toyama on the practical application of a catalyst for synthesizing butadiene rubber from CO₂.

The search for alternative raw materials for natural rubber also continues. Bridgestone Corporation is researching 'guayule' shrub, while Sumitomo Rubber is working on producing rubber from 'Russian dandelion'. Bridgestone Corporation has already started using guayule-derived rubber for racing tires. Domestic and foreign manufacturers have set the goal of achieving '100% Sustainable Tires' in 2050, and are initially manufacturing prototypes and for limited applications such as for racing.

Sumitomo Rubber Industries, Ltd. unveiled tires made from 80% sustainable raw materials last year.

Many manufacturers have set an intermediate target for the use rate in 2030 for commercial products as well, and they intend to make a concerted effort, from researching raw materials to increasing supply, developing supply networks and appealing to consumers for their value.

Mobility is undergoing a major transformation, including electrification and automated driving. However, even as power sources and usage scenarios change, tires remain an indispensable part of land transportation. Tire manufacturers will continue to evolve tire products to meet new needs and support mobility.