

A technique exploitation about anti-slide tire polyloid on ice-snow road in winter

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Abstract. Present studies focus on improving anti-slide property of tyres on ice-snow road by changing material modification of tyre tread and designing groove. However, the basic reason causing starting slide, long braking distance, turning slide slip and so on of tyres used in winter is that tyre tread materials are unitary and homogenous rubber composite which can't coordinate driving demands of tyres in winter under multi-work condition, and can't exert their best property when starting, braking and sliding slip. In order to improve comprehensive anti-slide property of tyres, this paper discusses about changing structure, shape and distribution proportion among haploid materials of tyre tread rubber. Polyloid bubble tyre tread technique based on artificial neural network which is in favor of starting, braking and anti-slide slip is optimized and combined. Friction feature and anti-slide mechanism on ice-snow road of polyloid rubber tyre tread are studied using testing technique of low-temperature cabin and computer simulation. A set high anti-slide theories and realizing method systems of polyloid rubber composite formed from basic theory, models and technique method are developed which will be applied into solving anti-slide problem of winter tyres, provide theory instruction for studies on high anti-slide winter tyres, and promote development of application and usage safety of winter tyres.

1. Introduction

High anti-slide is the important property of winter tires for safety. Friction and anti-slide mechanism of tire rubber on ice-snow road is the hot point studied on currently. Present studies focus on improving starting performance, braking performance, and anti-slide slip performance of tires on ice-snow roads by changing material modification of tire tread and designing tread groove. Whatever techniques mentioned above are used, winter tires usually have problems, such as sliding and idling due to less traction, long braking distance, turning slide slip, deviating and so on, which will cause serious traffic accidents. Certainly, except driving operation, basic reasons for these problems are that tire treads are made of unitary and homogenous rubber composite which can't coordinate imbalance among driving demands of winter tyres under the condition of multi-work state (such as : differences between non ice-snow road and ice-snow road, differences of demands on tyres when the properties of braking with anti-slide and starting improve, differences of demands on tyres when the properties of acceleration and anti-slide slip improve), traction and starting property, braking property and anti-slide slip property well. In order to improve comprehensively driving properties of tires, i.e. their starting property, braking property and anti-slide slip property can all be exerted on ice-snow roads, it is



difficult to achieve only relying on changing formulation of unitary and homogenous tire tread and structure of tread groove. Because unitary and homogenous rubber materials can't exert their best properties in different motion states of starting, braking, and sliding slip, then some motion states are possible out of control. So some attachments, such as anti-slide stud or anti-slide chain, which can't solve problems, are fixed on tires.

2. Technique exploitation about anti-slide polypliod

A lot of tread rubber standard specimens with different physical and mechanical properties are gotten from tread gross mix rubber of summer, winter, and all-weather tires with grooves and unitary, homogenous, and classical formulation through changing formulation system of gross mix rubber and vulcanization technique (temperature, depth, pressure and time and so on of vulcanization). Parameters of stretch strength, elasticity modulus, maximum elongation, stress at definite elongation, permanent deformation, tearing resistance and so on are achieved under the condition of low temperature cabin taking advantage of omnipotent stretch test machine. Moreover, physical and mechanical property parameters are obtained, such as hardness gotten by Sauer durometer, wearing resistance by Akron abrasion machine, elasticity by shock elasticity testing machine, fatigue durability by rubber fatigue and chap fracturing testing machine, brittleness temperature by rubber low temperature brittleness testing machine, heat and aging resistance by aging testing box, and so on. Friction property test platform is built under the condition of low temperature and many calculation numerical simulations are made using ABAQUS finite element software, in order to do research on friction properties of tread rubber standard specimens at different motion states (starting, braking and slide slip) and on different ice-snow roads. Mutual influence relation between friction property and physical and mechanical property is set up by experiment and computer simulation analysis. Which are main influence parameters on friction coefficient, traction (starting state), braking force (braking state), skid force (slide slip state) and so on among physical and mechanical property parameters will be clarified, considering conditions of load, turning radius, temperature and slippage speed. Then relativity between friction property and tread material property will be built.

In the research, butadiene styrene rubber, three-poly butadiene rubber, natural rubber, and cis-isoprene rubber are used as rubber base, then base rubbers of two kinds or several kinds from that mentioned above are chosen and optimized by changing corresponding amount, and then optimization of vulcanization system is made through changing species and usage amount of sulfur and accelerators, and some parameters, such as vulcanization temperature, vulcanization depth, vulcanization pressure, vulcanization time and so on, last optimization of reinforcement and packing system by means of changing species and usage amount of reinforcement, carbon soot, silica and so on. Optimized tread haploid will be gotten by combining application probability and statistics principle, ABAQUS finite element numerical value modeling, with thermostatic experiment in low temperature cabin, and integration of design, analysis, experiment, preparation and optimization is considered as principle. Three-stage mixing technique is used, and optimum mixing temperature, optimum time, rubber removal temperature, and rotor speed are controlled during mixing process. Flow chart of preparation technique of tread rubber haploid is shown as in the figure1. The key technique is to control rubber removal temperature of mixing rubber at the first stage and at the second stage which is higher than that of common tread rubber and rotor turning speed of banbury mixer is lower than that of the common one.

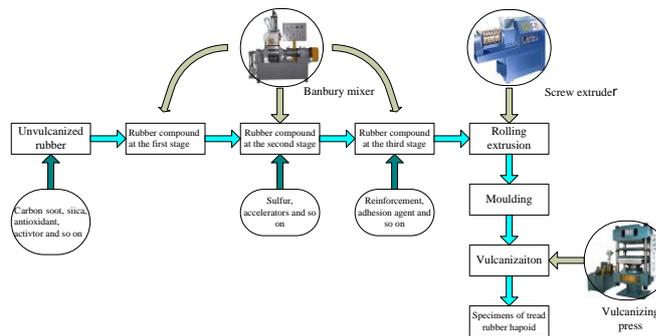
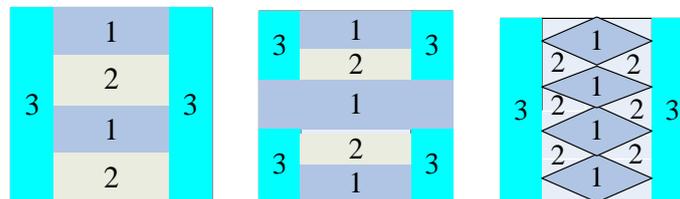


Fig.1 Preparation technique flow of tread rubber haploid

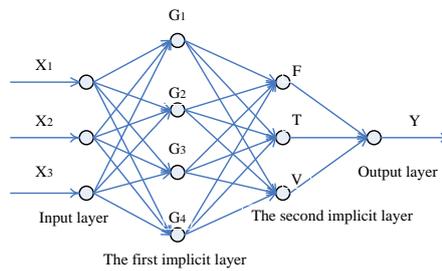
Distribution, combination, and optimization of tread rubber haploid is made aiming at being favor of three kinds of motion states of starting, braking and anti-slide, four kinds of classic working condition of snow roads, ice-snow roads, compacted ice roads and ice-water roads, and four kinds of condition of loading, environment temperature ($-5\sim-40^{\circ}C$), driving speeds ($10\sim60\text{km/h}$) and turning radius. So tread rubber polyploid with better comprehensive properties are achieved which are suitable to snow roads, ice-snow roads, compacted ice roads, ice-water roads, and starting, braking and anti-slide of vehicles under the condition of four kinds of working condition mentioned above. The optimum combination plan will be found by means of changing structure, shape and distribution of tread haploid which benefits to starting, braking and anti-slide. (distribution and combination are shown in figure 2). Multi-goal distribution and optimization problem is solved by using algorithm of multi-layer error opposite direction spread (BP algorithm) and genetic algorithm based on shared economic technique (pareto GA) in artificial neural network and Matlab software, then multi-layer forward direction neural network constituted by input layer, the first, the second implicit layer, and output layer is constructed. It is demonstrated in figure 3.

Preparation of polyploid is made taking advantage of cold feed extruding technique i.e. extruding technique using three compounding machine heads, tread die base planks of different distribution and combination, and by means of controlling different temperature (temperature of machine head, die base plank, rubber removal and heating area) and extruding speed. Structure characterization: Combination interface microstructure of tread rubber polyploid is characterized and analyzed through rubber processing analyser, scanning electron microscope (SEM), transmission electron microscope (TEM), sight difference heat checkout machine (DSC), thermogravimetric analyser (TGA), dynamic mechanical analyser (DMA), gas chromatograph analyser, and fourier transform infrared analyser. Property test: Tread rubber polyploid is tested about its properties of stretching, compressing bending, bonding strength, tearing, peeling and so on using universal tensile testing machine and cutting and stripping machine in low temperature cabin.



1-Starting haploid 2-Braking haploid 3-Sliding slip haploid

Fig.2 Distribution and combination plan of different proportions and shapes



X1—Haploid benefit to starting X2—Haploid benefits to braking X3—Haploid benefits to anti-slide G1—Snow road
 G2—Ice-snow road G3—Compacted road G4—Ice-water road; F—Load T—Environment temperature V—Driving speed
 R—Turning radius Y—Polyploid after being combined and optimized

Fig.3 Combining and optimizing neural network structure

3. Conclusion

It is significant for vehicles on ice and snow roads in winter in northern area to reinforce to do research on safely driving of winter tire, reducing damage or having no damage to road surface, reducing consumption of tire driving energy, especially for safely driving and keeping roads clear, and decreasing traffic accidents on intermittent, thin ice, hard ice roads in winter in cities of north of China. This paper exploits anti-slide tire polyploid technique on winter ice-snow roads from the point of changing unitary and homogenous material of tires, and many study technique plans of friction property on different ice and snow roads indoor or outside, last anti-slide mechanism of tire tread rubber polyploid composite is made known through applying the technique to tires, in order to lay foundation for design and application of winter tires.

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