WINTER TRACTION: EFFECT OF TREAD COMPOUND

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•IN winter driving conditions, we are concerned with tire traction on ice and snow. This paper considers specifically traction on ice because apart from the well-known benefits of winter tread patterns on snow similar considerations apply. The work was carried out by the Dunlop Research Center in Birmingham, England, using a laboratory friction tester.

The low friction of rubber on ice arises from its self-lubricating property. Frictional heating due to sliding rubber melts the ice and produces a film of water between tire and ice. Unlike in hydroplaning conditions, providing drainage of the water does not help because more water will be formed when the tire reaches unmelted ice.

Figure 1 shows the effect of ice temperature on the coefficient of friction of styrene butadine rubber (SBR). As the temperature of the ice is decreased, friction rises from about 0 on melting ice and then levels off at about 3.0. For comparison, a value of about 2.0 would be expected from the same compound on smooth dry surfaces under the same test conditions.

Friction on ice shows some dependence on compound hardness. Figure 2 shows data plotted for natural rubber and a 35 percent styrene SBR at various black loadings.

Figure 3 shows coefficients of friction of various butadiene-styrene polymers at an ice temperature of 27 F, plotted as a function of styrene content. A natural rubber compound is included. Again, the coefficients of friction are low, but they increase with decreasing styrene content. Increasing styrene content raises the second-order transition temperature of a polymer and therefore increases low-temperature stiffening. This suggests that the ice-friction of polymers is related to their hardness at the test temperature.

In Figure 4, hardness and ice-friction have been plotted for natural rubber, SBR, and a 45 percent styrene SBR over a range of test-piece temperatures. There appears to be a correlation between ice-friction and compound hardness with no evidence of specific polymer effects.

The hardness effect is thought to arise from the fact that the true area of contact is greater with soft compounds. In fact, a similar law holds for dry friction.

Winter road-hold tests in Sweden have confirmed these findings, but the effect of compound changes has been found to be small. Moreover winter tires are used for a considerable part of their life on either wet or dry pavements. Softer compounds would lead to loss in wear resistance, instability, and high heat buildup.

The use of very high polybutadiene blends would increase ice friction because of their low hardness in very cold conditions, but this would lead to loss of traction on wet and dry pavements. Natural rubber also performs well at low temperatures for the same reason, and NRPRA have shown that, when the material is oil-extended, it can have acceptable grip on wet surfaces although there is generally an abrasion penalty.

However, in the temperature range of 32 to 10 F, the influence of the polymer on winter traction appears to be small and the intermediate SBR-BR blends used in North America are probably near optimum for overall performance.

Figure 1. Effect of ice temperature on coefficient of friction of SBR.

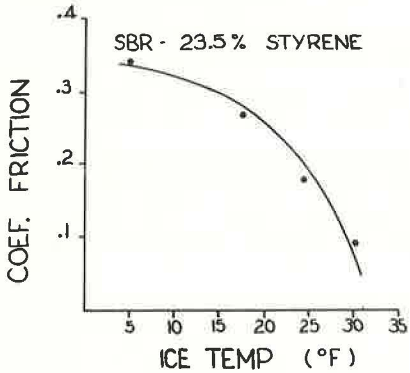

Figure 2. Effect of compound hardness on friction.

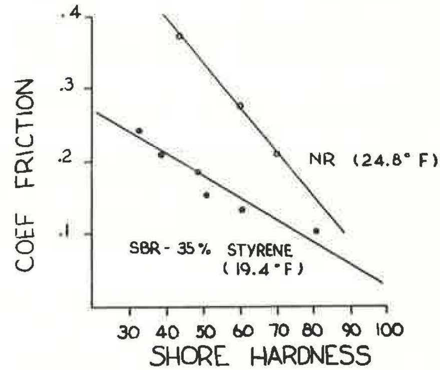

Figure 3. Effect of styrene content on coefficient of friction of various polymers.

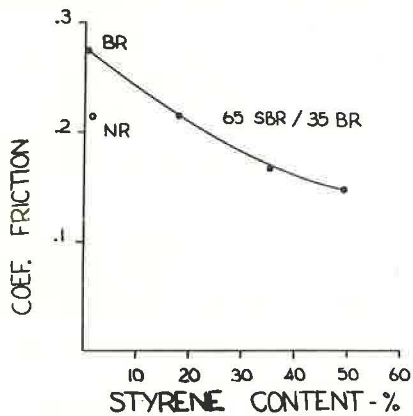

Figure 4. Correlation of ice-friction and compound hardness.