# How it Works: Towards understanding the tyre surface interface

The tyre / surface interface affects many road and runway properties ranging from friction, noise, rolling resistance to how dynamic load is transferred down through the constructed layers. These interface properties are of interest to engineers and material specialists from the vehicle, tyre and road construction sectors. Common terms are used by these sectors to describe their products e.g. safe, durable, sustainable, green, low energy. Despite this commonality, it may be argued that there is relatively little interaction between those who design, build and maintain roads and those involved in these other sectors.

This short paper illustrates some recent research relating to measuring this interface from the perspective of the surface. Space limits this paper to four simple questions. The first question is how does a pneumatic tyre interact with a surface? The simplest method is to paint the tyre, load it onto cardboard and get parameters such as gross contact area, groove area, contact length and width. The paint patch tends to be circular at higher tyre inflation pressures and lower load; and elliptical at lower tyre inflation pressures and higher load. Similar relationships between inflation pressure, load, contact length width and length apply for different types of tyre. With regard to road design, this circular contact patch still forms the basis of how a tyre is assumed to interface with a road surface and transfer of load down through the different layers in the construction.

Although paint can show the contact patch of an under-inflated tyre to be different to an over-inflated tyre it cannot quantify the actual values and distribution of contact stress. Greater detail can be obtained using pressure mapping. Figure 1 compares the contact patch for two tyres fitted to the same vehicle with the same loading and inflation pressures on a smooth surface. Although the contact areas are comparable, the distribution of vertical stress is significantly different. The semi-slick tyre has been designed to maximise grip in dry conditions, whilst the treaded tyre has been designed to optimise both dry and wet skid resistance.

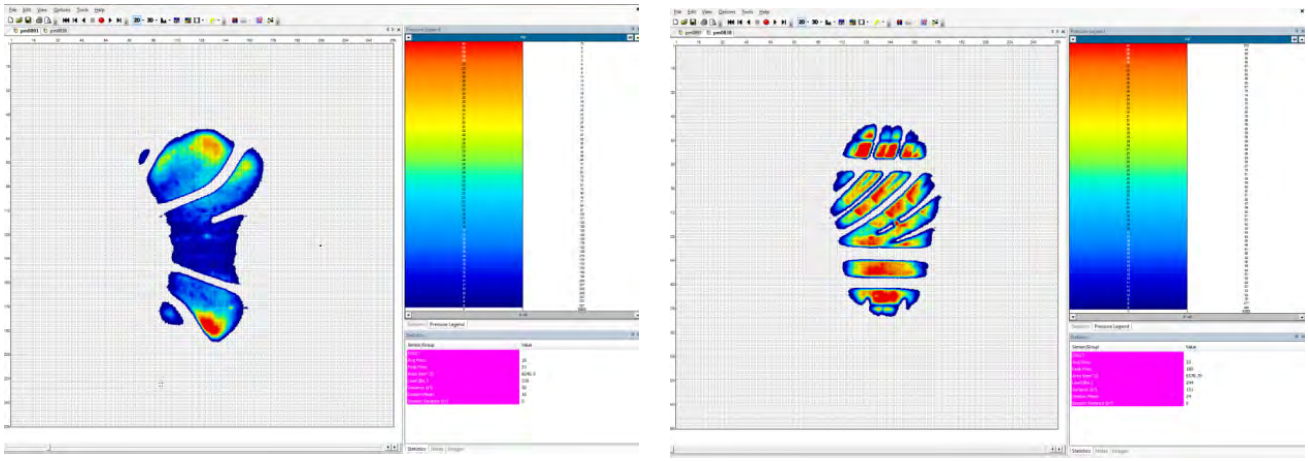

Figure 1. Comparison of contact patch for a semi slick and treaded tyre

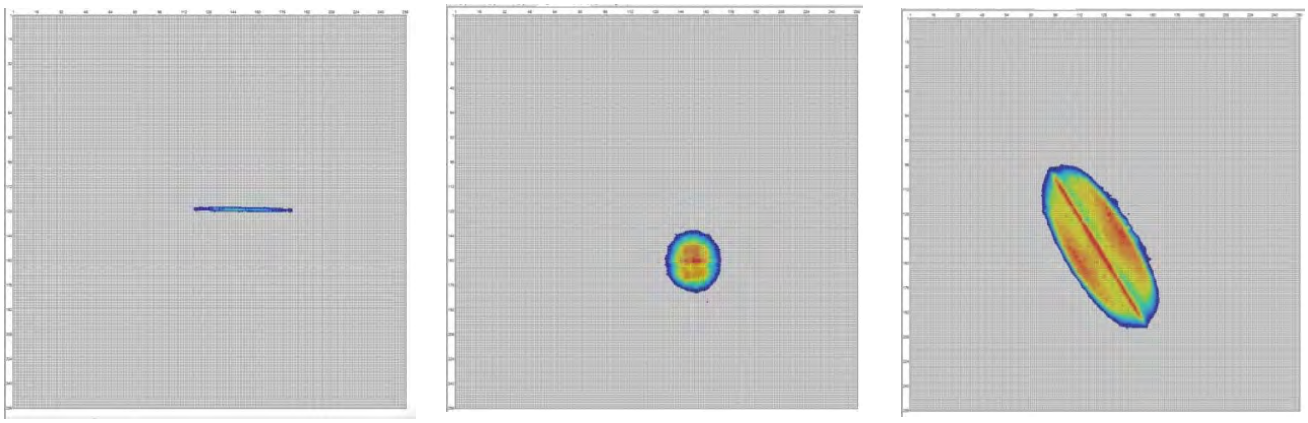

Figure 2. Comparison of static contact patch for the three most common devices used in the UK (left to right the devices are pendulum tester, GripTester and SCRIM)

The second question asks how the devices used to measure grip interact with a smooth surface and whether their interaction is similar to a vehicle tyre? There are about 20 devices in use around Europe. Although they all measure skid resistance, the actual measurements can differ widely for the same road surface. The three most common devices used in the UK are the pendulum tester, GripTester and SCRIM. The pendulum tester is similar to a person sliding their foot along a surface to get a feel of its grip. The pendulum tester replaces the calibrated foot with a piece of spring-loaded standard rubber attached to the end of a pendulum arm. The GripTester is a longitudinal friction device in the form of 3 wheel towed trailer that measures skid resistance by simulating the interaction of a fixed slip tyre with the road surface in a longitudinal direction. The SCRIM is a transverse friction-measuring device that simulates interaction between a braked tyre and the road surface as an angled tyre turns into a corner. Figure 2 shows the contact patch for each device measured on a smooth surface. This shows their contact patch is not comparable to a vehicle tyre.

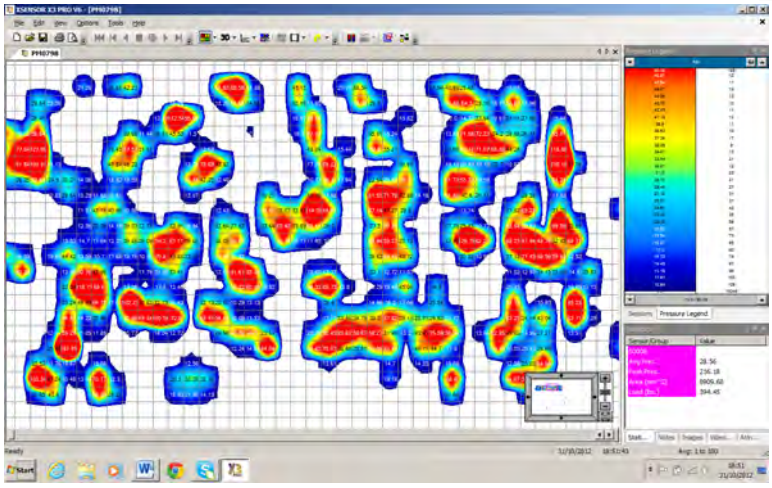

Figure 3. Contact patch for a UK motorway asphalt showing how a GripTester contacts its surface texture under slow speed conditions

The third question considers the interface between the smooth GripTester friction measuring tyre and a typical English motorway surface material. Figure 3 shows a pressure map contact patch image measured at slow speed free rolling conditions. The image illustrates the distribution of contact stress corresponding to the road surface texture. This technique can be used to quantify the contact area for different types of surface materials, their contact pressure distributions and how these parameters change with time as the surface is trafficked.

The fourth question considers how a tyre deforms as it moves over a surface. The example chosen relates to the laboratory method of measuring aggregate skid resistance. Figure 4 shows a test specimen that has been painted and then subjected to accelerated polishing involving interaction between the aggregate particles, solid tyre, abrasive and water. The test specimen was photographed and filters used to highlight where contact took place. Three dimensional modelling was used to determine the depth of tyre interaction into the test specimen surface texture. The example shows that only the top 1.17 mm of the aggregate particle has been subjected to accelerated testing at this interface. Should this continue to be used as a method of aggregate selection?

This short paper has considered 4 simple questions relating to understanding of the tyre surface interface from the perspective of the road. Space does not allow proper explanation of the examples given other than to highlight that these are issues that involve not only roads but other sectors relating to vehicles and tyres.

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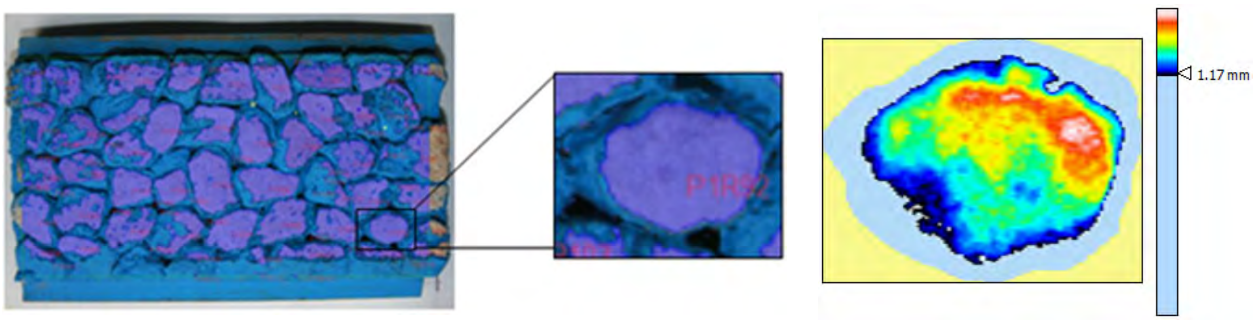


Figure 4. Aggregate / test tyre interaction during laboratory testing