CONTOUR MEASUREMENT OF RUBBER TREAD USING 3D PROFILOMETRY

Prepared by
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INTRO:

Like all materials, rubber’s coefficient of friction is related in part to its surface roughness. In vehicle tire applications traction with the road is very important, and surface roughness as well as the tire’s treads both play a role in this. In this study, the rubber surface and the treads are analyzed for roughness and precise dimensions.

IMPORTANCE OF 3D NON CONTACT PROFILOMETER FOR RUBBER STUDY

Unlike other techniques such as touch probes or interferometry, the 3D Non Contact Profilometer using axial chromatism can measure nearly any surface. Sample sizes can vary widely due to open staging, and there is no sample preparation needed. Nano through macro range is obtained during surface profile measurement with zero influence from sample reflectivity or absorption, has advanced ability to measure high surface angles and there is no software manipulation of results. Easily measure any material: transparent, opaque, specular, diffusive, polished, rough etc. The technique of the Non Contact Profilometer provides an ideal, broad and user friendly capability to maximize surface studies when pitting analysis will be needed; along with the benefits of combined 2D & 3D capability.

MEASUREMENT OBJECTIVE

In this application the Nanovea ST400 Profilometer is used to measure the surface and treads of a rubber tire. The surface area measured was selected at random, and was large enough that it could be extrapolated to make assumptions about a much larger surface. Contour dimensions, depth, surface roughness, and developed area will be used here to quantify the rubber’s characteristics.
RESULTS:

Rubber Tread

The 3D View and False Color View of the treads show the value of mapping 3D surface designs. It provides users a straightforward tool to directly observe the size and shape of the treads from different angles. The Advanced Contour Analysis and Step Height Analysis are both extremely powerful tools for measuring precise dimensions of sample shapes and designs.
## Advanced Contour Analysis

### Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Unit</th>
<th>Step 1</th>
<th>Step 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum height</td>
<td>mm</td>
<td>3.228</td>
<td>3.235</td>
</tr>
<tr>
<td>Mean height</td>
<td>mm</td>
<td>3.182</td>
<td>3.206</td>
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Rubber Surface

The rubber surface can be quantified in numerous ways using built-in software tools as shown in the following figures as examples. It can be observed that the surface roughness is 2.688 μm, and the developed area vs. projected area is 9.410 mm² vs. 8.997 mm². This information allows us to examine the relationship between surface finish and the traction of different rubber formulations or even rubber with varying degrees of surface wear.
CONCLUSION:

In this application, we have shown how the Nanovea 3D Non Contact Profilometer can precisely characterize the surface roughness and tread dimensions of rubber. The data shows a surface roughness of 2.69 μm and a developed area of 9.41 mm² with a projected area of 9 mm². Various dimensions and radii of the rubber treads were measured as well. This information could be used to compare the performance of rubbers with different tread designs, different formulations, or varying degrees of wear. The data shown here represents only a portion of the calculations available in the analysis software.

Learn more about the Nanovea Profilometer or Lab Services
MEASUREMENT PRINCIPLE:

The Chromatic Confocal technique uses a white light source, where light passes through an objective lens with a high degree of chromatic aberration. The refractive index of the objective lens will vary in relation to the wavelength of the light. In effect, each separate wavelength of the incident white light will re-focus at a different distance from the lens (different height). When the measured sample is within the range of possible heights, a single monochromatic point will be focalized to form the image. Due to the confocal configuration of the system, only the focused wavelength will pass through the spatial filter with high efficiency, thus causing all other wavelengths to be out of focus. The spectral analysis is done using a diffraction grating. This technique deviates each wavelength at a different position, intercepting a line of CCD, which in turn indicates the position of the maximum intensity and allows direct correspondence to the Z height position.

Unlike the errors caused by probe contact or the manipulative Interferometry technique, Chromatic Confocal technology measures height directly from the detection of the wavelength that hits the surface of the sample in focus. It is a direct measurement with no mathematical software manipulation. This provides unmatched accuracy on the surface measured because a data point is either measured accurately without software interpretation or not at all. The software completes the unmeasured point but the user is fully aware of it and can have confidence that there are no hidden artifacts created by software guessing.

Nanovea optical pens have zero influence from sample reflectivity or absorption. Variations require no sample preparation and have advanced ability to measure high surface angles. Capable of large Z measurement ranges. Measure any material: transparent or opaque, specular or diffusive, polished or rough. Measurement includes: Profile Dimension, Roughness Finish Texture, Shape Form Topography, Flatness Warpage Planarity, Volume Area, Step-Height Depth Thickness and many others.
## Definition of Height Parameters

<table>
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| **Sa** Arithmetical Mean Height | Mean surface roughness.  
\[ Sa = \frac{1}{A} \iiint_A |z(x, y)| \, dx \, dy \] |
| **Sq** Root Mean Square Height | Standard deviation of the height distribution, or RMS surface roughness.  
\[ Sq = \sqrt{\frac{1}{A} \iiint_A z^2(x, y) \, dx \, dy} \]  
Computes the standard deviation for the amplitudes of the surface (RMS). |
| **Sp** Maximum Peak Height | Height between the highest peak and the mean plane. |
| **Sv** Maximum Pit Height | Depth between the mean plane and the deepest valley. |
| **Sz** Maximum Height | Height between the highest peak and the deepest valley. |
| **Ssk** Skewness | Skewness of the height distribution.  
\[ Ssk = \frac{1}{Sq^3} \left[ \frac{1}{A} \iiint_A z^3(x, y) \, dx \, dy \right] \]  
Skewness qualifies the symmetry of the height distribution. A negative Ssk indicates that the surface is composed of mainly one plateau and deep and fine valleys. In this case, the distribution is sloping to the top. A positive Ssk indicates a surface with a lot of peaks on a plane. Therefore, the distribution is sloping to the bottom.  
Due to the large exponent used, this parameter is very sensitive to the sampling and noise of the measurement. |
| **Sku** Kurtosis | Kurtosis of the height distribution.  
\[ Sku = \frac{1}{Sq^4} \left[ \frac{1}{A} \iiint_A z^4(x, y) \, dx \, dy \right] \]  
Kurtosis qualifies the flatness of the height distribution.  
Due to the large exponent used, this parameter is very sensitive to the sampling and noise of the measurement. |
| **Spar** Projected Area | Projected surface area. |
| **Sdar** Developed Area | Developed surface area. |