Precision Tread Measurement

CTWIST™ System Delivers Fast and Accurate Tread Wear and Uniformity Measurements

By Michael Harris, CEO Bytewise Measurement Systems

Introduction

Laser-triangulation based tread measurement systems have been in use since the early 1990's by a number of tire and automobile manufacturers. Most of these systems have been developed "in-house" and have not had the opportunity to flourish and mature as market-driven products. In 1995, Bridgestone Firestone licensed their patented CTWIST™ system (**C**ircumferential **T**read **W**ear **I**maging **S**ystem version **T**wo) to Bytewise Measurement Systems for commercialization and enhancement. After being selected by Ford Motor Company as their standard tread wear measurement platform, CTWIST™ is emerging as a fast, automated, and truly standardized tread wear measurement system, supported by an independent company, and evolving to meet market requirements.

Figure 1. The CTWIST™ Physical System.

Objectives of Tread Measurement

The traditional tread measurements have been depth measurements, taken with mechanical depth gauges. The objectives of these measurements have been varied, depending upon the testing organization. Tire manufacturers require accurate wear information of prototype tires in order to refine and improve designs. Automobile manufacturers require comparative measurements to select the best tires for their new vehicle models. Independent firms perform tests for a variety of consumer and government organizations.

As an extension of traditional tread depth measurements, laser based measurements can provide a complete wear profile of the tire, as well as quantifications of irregular wear. This is important for road noise implications, as well as identifying local wear phenomena such as heel / toe wear, recessed lugs, diagonal wear, shoulder wipe, center wear, etc.

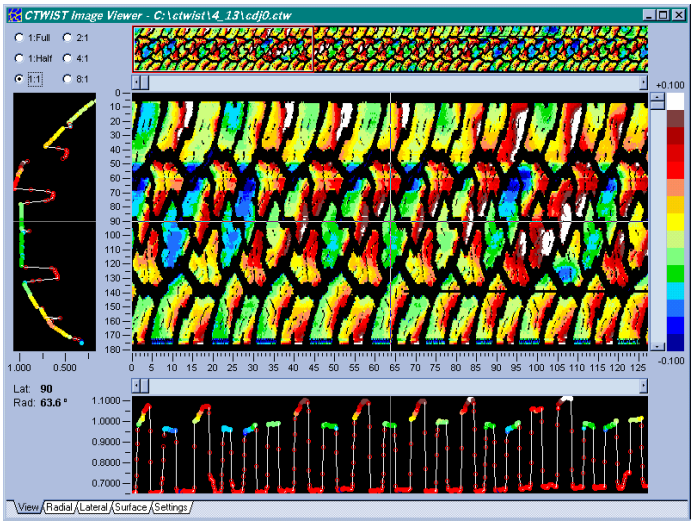

Figure 2. Example of severe Heel/Toe and diagonal wear.

Laser based tread measurement can also be effectively used to diagnose manufacturing problems, with lateral and radial run-out displacements clearly visible from high precision surface measurements of a new tire.

Measurement Technique

The CTWIST™ system is based on the tire mounting system of a Coats™ dynamic balancer. The tire/wheel assembly is rotated at an adjustable speed, (120 RPM max) while a precision laser triangulation sensor from Selcom (Selective Electronics) samples the tire at 32 kHz. These samples are continuously averaged between encoder pulses, providing bandwidth optimized displacement measurements at a rate of 4096

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measurements per revolution. The Selcom laser is utilized because of the high speed and accuracy of the sensor and the years of experience Selcom has in the difficult-to-measure rubber applications. The accuracy of the measurements is better than .025mm (.001").

A typical tire measurement consists of 100 to 200 circumferential "scan-lines," each consisting of 4096 measure points. This provides a measurement "grid" for the tire of approximately .5mm circumferentially by 1mm laterally. The time required to collect this measure is approximately 3 minutes.

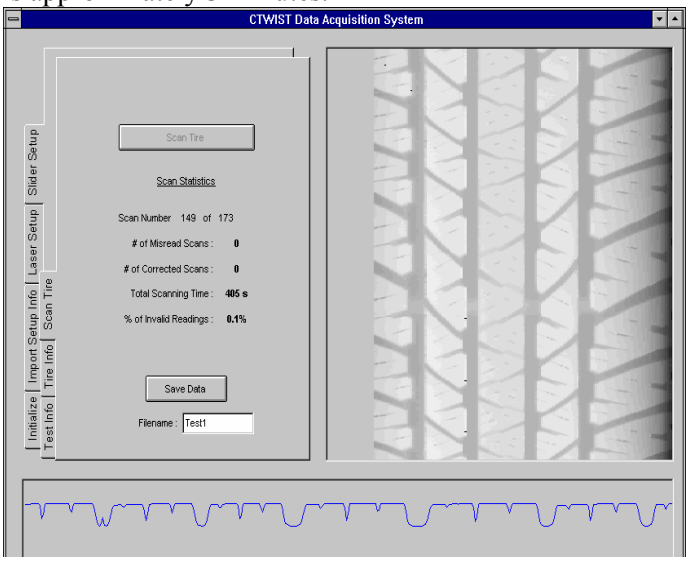

Figure 3. The data collection process.

Data Characterization

To allow effective data analysis, special algorithms classify each measurement point as one of the following:

1. Road Contact Surface (Blue)
2. Lug Side or Sipe (Violet)
3. Tire Base Surface (White)

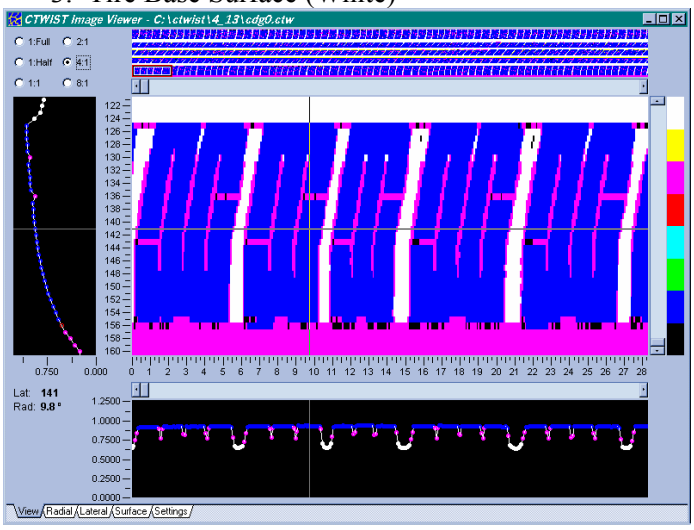

Figure 4. Data Point Characterization

Surface Variations

To visualize variations in the road-contact surface of the tire, the average height of each circumferential scan-line is calculated.

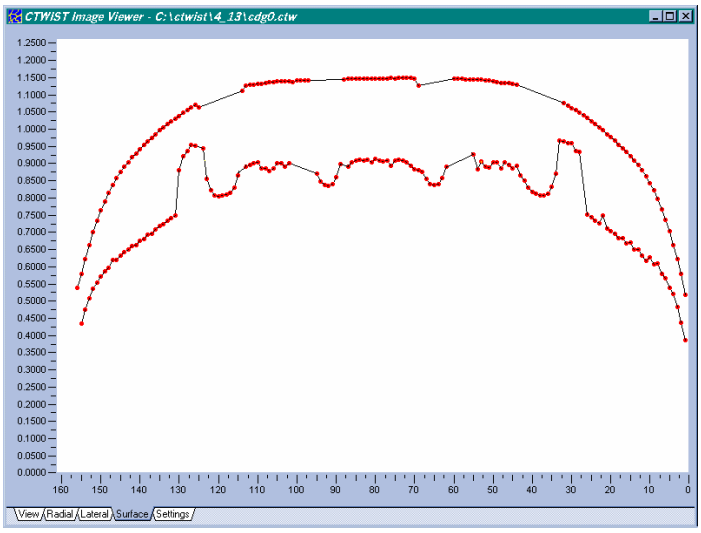

Figure 5. Average Base and Surface Points

The deviation of each surface data point from this "average" surface is then mapped to a defined color scale. This allows variations to be distinguishable as color gradients.

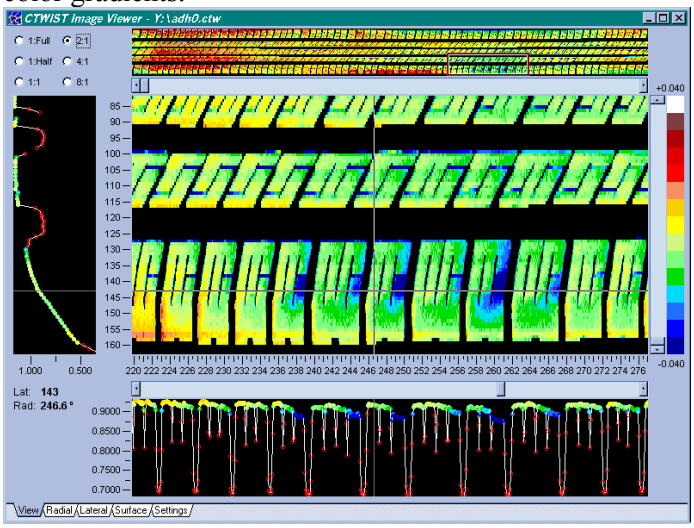

Figure 6. Surface Variation Mapping

Data Viewer

The data examples shown in figures 4, 5, and 6 are presented with the CTWIST data viewer. This tool provides an interactive method of examining a CTWIST measurement. Modes are provided for analyzing the characterization of each data point as well as for viewing the surface deviations.

The main screen consists of several regions. At the top is a condensed full-image of the tire scan. In the center of the screen is the view region, which consists of a

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"zoomed" portion of the image. The "zoomed" portion of the image is marked in the full-image by a box outline.

There is also a cross-hair in the zoomed region, which marks a lateral and circumferential (radial) scan-line. The data points for the lateral scan line are shown on the left of the screen, while the data for the radial scan line is shown at the bottom of the screen. These views can be made full-screen by selecting the lateral or radial tab.

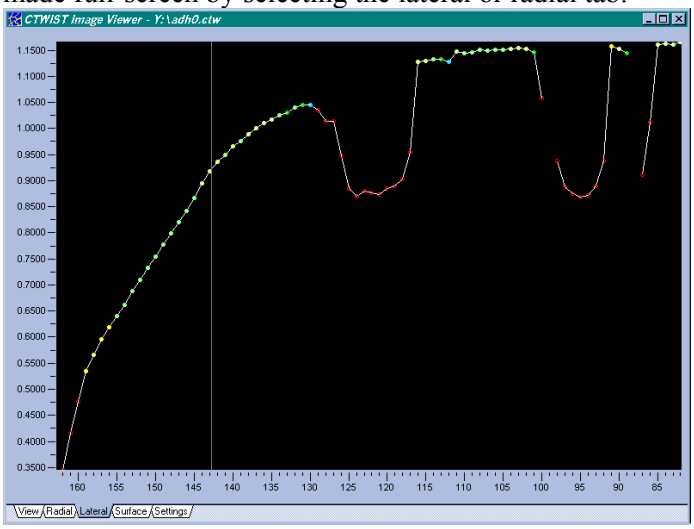

Figure 7. Full-Screen Lateral View

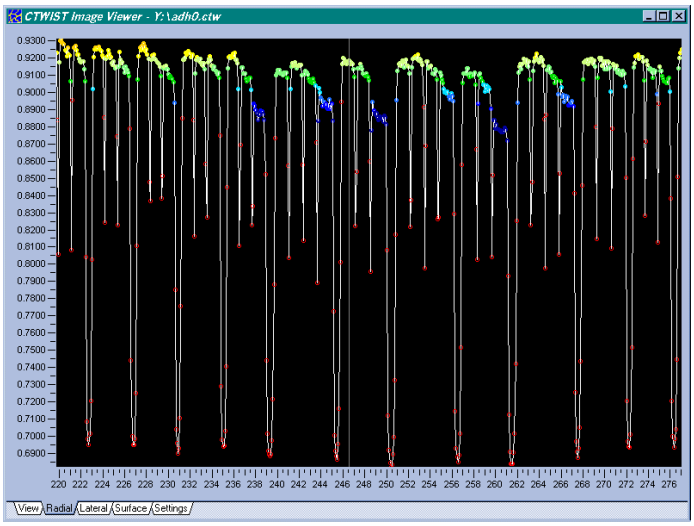

Figure 8. Full-Screen radial view.

The Data Viewer can be used to analyze a single tire, or to analyze the differences between new and worn tires.

Wear Reporting

The CTWIST system can be linked to a data management system to provide various wear index measurements. To evaluate tread wear with CTWIST, Ford Motor Company uses indices constructed from various parameter measurements and their variations. Of interest are Heel / Toe wear, irregular rib wear, irregular tread wear, and projected mileage. These wear indices can be customized for the system application.

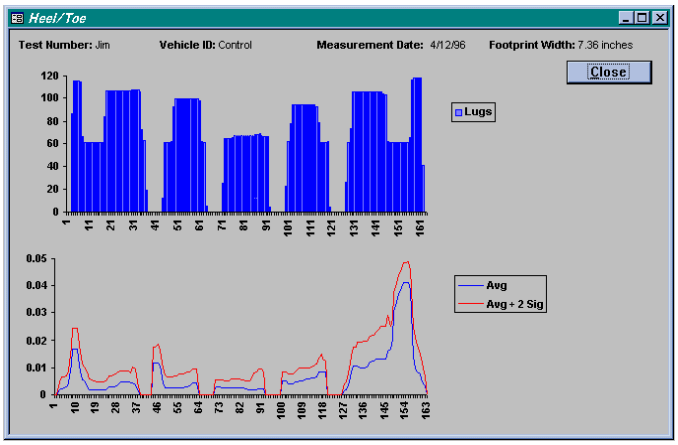

Figure 9. Heel / Toe wear report

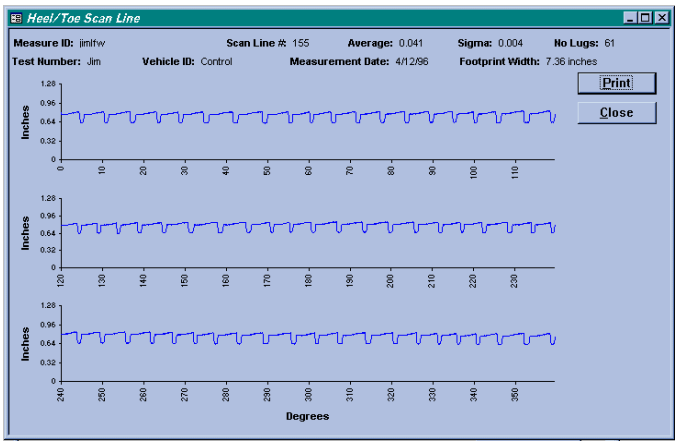

Figure 10. Heel / Toe scan-line report

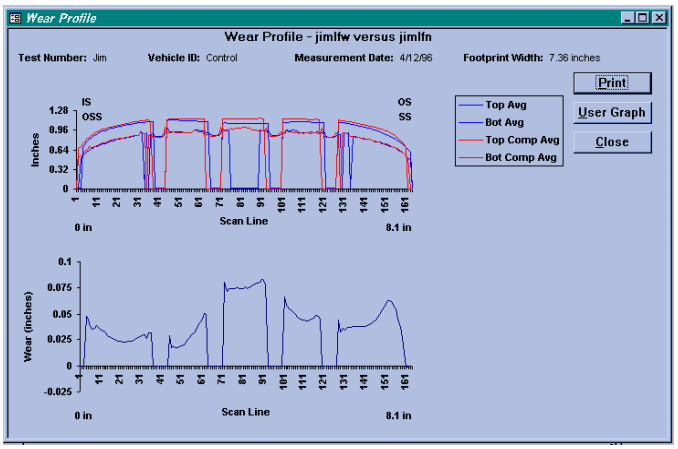

Figure 11. Tread Wear Report

Manufacturing Applications

CTWIST also has applications in manufacturing diagnostics, for the analysis of radial and lateral run-out variations in the finished tire. This can be studied on the tread surface of the tire, or with the appropriate fixturing, on the sidewall of the tire as well. Notice the non-uniformities due to the tread splice and/or mold

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segments in figure 12. Harmonic content of scan-lines can be extracted for further analysis. CTWIST is an excellent tool for the study of tires rejected by Uniformity Force Measurement systems.

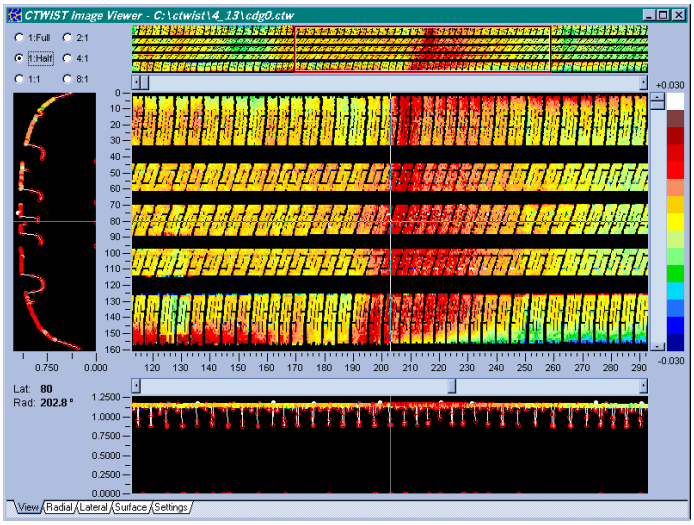

Figure 12. New Tire Diagnosis with CTWIST

Summary

CTWIST is an effective measurement system, benefiting from years of refinement inside Bridgestone/Firestone, and more recently from the market-defined improvements and support offered by Bytewise Measurement Systems. Fast, accurate, operator independent measurements are turning the subjective task of tread wear measurement into a scientific study resulting in longer-lasting, more evenly wearing tires.

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