Hot Blister Detection and Measurement in Cured Tires

Hot Blister Detection and Measurement in Cured Tires

INTRODUCTION

A Hot Blister is defined as a bulge in the surface of a cured tire that is caused by entrapped gasses or steam. Such blisters can be observed in the hot tires when they exit curing. Blisters will often shrink as the gasses migrate outward, or are absorbed into the tire materials. There is concern however that the entrapped steam and gasses present during curing can weaken the laminate structure of the tire.

Air entrapment has been frequently observed by the author during capability studies conducted on Tire Building Machines. This paper presents cases showing entrapped air between the inner liner and body ply in a typical green tire carcass construction. Such air pockets can remain between the layers and migrate outward during tire curing to produce blisters. Air can also be absorbed into the tire structure. Steam and gasses can also be introduced into the tire structure during curing, and emerge as blisters after curing.

This paper presents a method to detect blisters after curing, and to detect entrapped air pockets during the tire building stage. Scans of both cases are presented. These cases demonstrate that automatic monitoring systems can be implemented to detect these conditions.

The method uses high-speed line laser sensors to digitize the sidewall and/or tread of the un-inflated tire. The data set is rendered as a 3D model. The data is post-processed and searched for blisters. This same sensor technology is employed to scan tire sidewalls for bulges and depressions.

PART 1 – LINE LASER SENSOR TECHNOLOGY REVIEW

LASER TRIANGULATION

Laser triangulation is a method of distance measurement. As shown in Figure 1, a laser light source projects a point of light onto the measurement surface at distance D1. The laser light is reflected at angle *α* through a lens and onto a detector at position d1. When the measurement surface is positioned closer to the laser source at D0, the reflected light falls on the detector at position d0. When the measurement surface is positioned farther from the source at D2, the reflected light falls on the detector at position d2. The range of the D2-D0 can be scaled to the range across the detector d2-d0 so that the detector output correlates to the actual distance between the sensor and the measured surface.

Early laser triangulation sensors used analog devices such as gallium arsenide to detect the change in position of the reflected laser light. These came to market in the 1970's and were referred to as Position Sensitive Detectors (PSD). PSD's output a varying voltage or current proportional to the position of the light on the detector. Charge Coupled Devices (CCD's) are now in wide use as detectors. CCD's are light sensitive microchips of the type used in digital cameras. A CCD detector may contain, for example, 1,024 pixels that result in a detector resolution of 1,024 parts across the measurement range.

Profile Triangulation

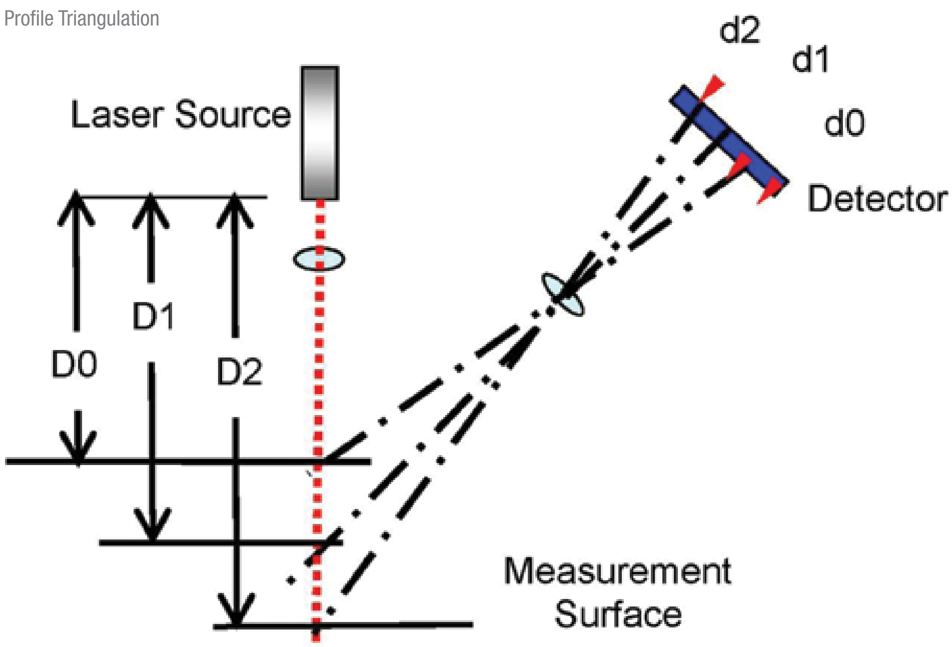

Figure 1 - Laser Triangulation Method

In the mid-1990's, Bytewise Measurement Systems and others developed profile triangulation sensors that substituted a laser line source for the laser point source, and substituted a 2-dimensional CCD or CMOS array in place of the single-axis pixel array. This is illustrated in Figure 2. A line laser sensor using a one and one-half megapixel detector (1,500 x 1,000) could now acquire data comparable to 1,500 fixed-point laser triangulation These high-speed line laser triangulation sensors are employed in many applications in tire manufacturing, including measurement for cured-tire sidewall bulges and depressions, green tire radial and lateral runout measurement, and automatic tire identification using DOT Code and other molded-in information.

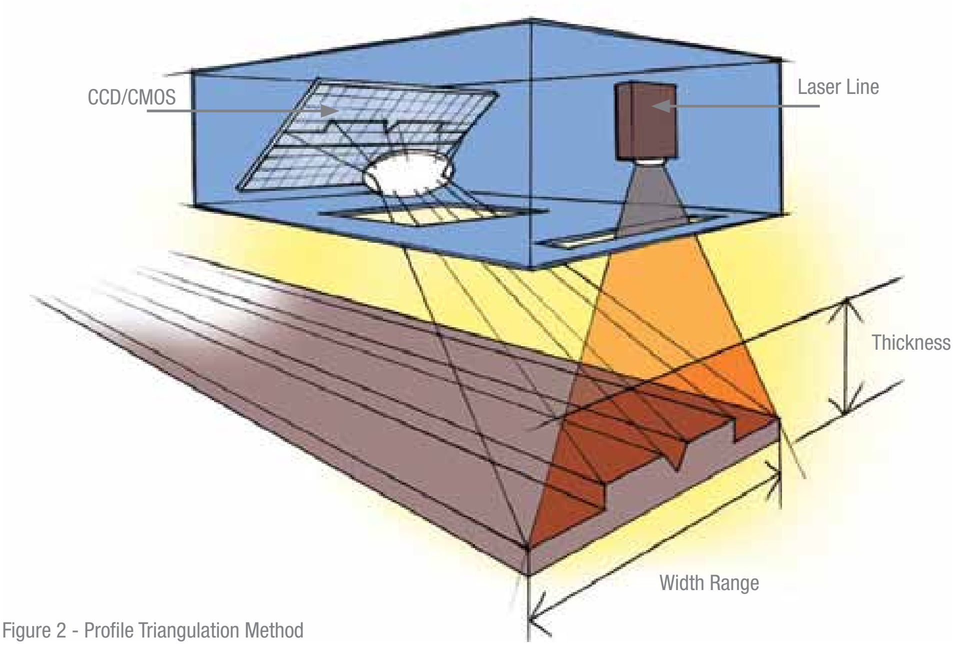

Figure 2 - Profile Triangulation Method

PART 2 – HOT BLISTER SCAN RESULTS

A test was done to scan cured tires with simulated hot blisters. Blisters were simulated using modeling clay applied to the tire sidewall. Blisters were modeled in sizes about 10mm, 20mm, and 30mm in diameter.

Tires were scanned by rotating them under a fixed line laser sensor. The sensor frequency was set at 1,000 Hz. The sensor size was 100mm in line width. This sensor resolution was 70µm in the lateral axis, 50 µm in the radial axis, and 1mm in the circumferential axis. Scan time was approximately 1 second.

Figure 3 shows the overall scan of the cured tire. Data is rendered as topographical color map, with 16 color gradients over a 2 mm range. The red gradient indicates a high point (bulge) and the blue gradient indicates a low point (depression). The simulated blisters are observed as the dark red circles.

Figure 3 - Scan of the Simulated Hot Blisters

The data set in Figure 3 is comprised of 1,500 rows of data, with 2,000 points per row. Figure 4 shows a waveform for one of the rows through the set of simulated blisters.

Figure 4 - Waveform through the Hot Blisters

Drag and drop caliper tools can be configured to automatically find and measure bulges. Figure 5 shows a measurement caliper applied to detect the height and angular location of the simulated blister. The label is displayed in red to indicate the blister exceeds the allowable limit.

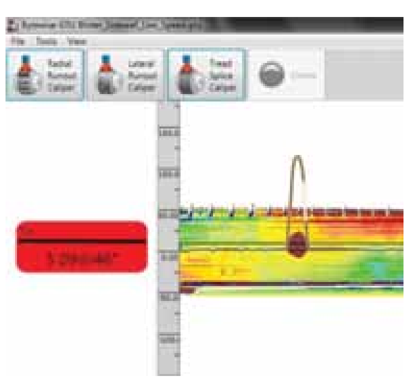

Figure 5 - Caliper Measurement Method

A waveform analysis tool can be applied to display and export waveform data sets for any of the 1,500 rows or 2,000 columns of data. Figure 6 shows a single blister scan along with its corresponding radial and lateral waveforms.

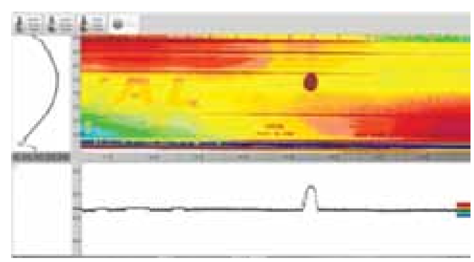

Figure 6 - Radial and Lateral Waveforms

PART 3 – GREEN TIRE CARCASS SCAN RESULTS

Scans were made of green tires after application of the body ply. In this set-up, tires were scanned by a tripod-mounted line laser sensor for one rotation of the carcass drum. The sensor frequency was set at 1,000 Hz. The sensor size was 400mm in line width. This sensor resolution was 270 µm in the lateral axis, 100 µm in the radial axis, and 1 mm in the circumferential axis. Scan time was approximately 1 second.

Figure 7 shows a 360 degree scan around a carcass drum after application of the first body ply. Air pockets are observed as the dark red blobs along the center of the carcass. The waveform below shows irregularity in the bulge contour.

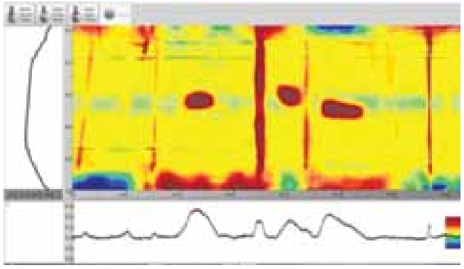

Figure 7- Entrapped Air Pockets between Inner Liner and Body Ply

Data can be rendered in a 3D model, as shown in Figure 8.

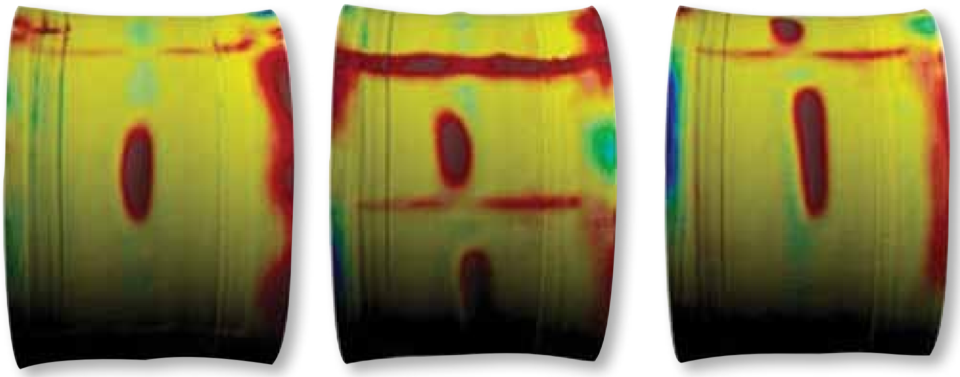

Figure 8- 3D Model Visualizations Showing Air Pockets between Inner Liner and Body Ply

PART 4 – CONCLUSIONS

High-Speed Laser Line Sensor Technology easily demonstrated the ability to reliably capture the dimensional parameters of the simulated blisters. Cycle time and resolution are comparable to other applications in the tire industry where these sensors are broadly used.

The same sensor technology, when applied to the first stage carcass building operation, demonstrated the ability to reliably capture the dimensional parameters of actual air pockets between the inner liner and body ply.

We conclude from this study that the technology supports 100% monitoring at the first stage TBM drum for the root-cause of air entrapment, and 100% monitoring after curing for any hot blisters that may be produced.

The same scan data can be analyzed to automatically find the DOT Code or mold serial number, as shown in Figure 9.

Figure 9 - Automatic DOT Code Regonition using the same data set.

ABOUT STARRETT-BYTEWISE

Starrett-Bytewise Measurement Systems produces laser measurement solutions specialized for profile manufacturing industries, with a special emphasis in tire manufacturing measurement systems. Starrett-Bytewise is a complete solutions provider manufacturing line laser sensors, multi-sensor systems, application software, and turnkey measurement solutions. Products are found around the world among the largest global manufacturers as well as the smallest privately-owned companies. For these companies, Starrett-Bytewise technology is a core component of their quality and production management standards.

Starrett-Bytewise is a Division of The L.S. Starrett Company of Athol, Massachusetts, USA – a leader in metrology since 1880. Starrett is a manufacturing company with businesses in precision metrology tools, instruments, gages, optical comparators, vision systems, laser measurement systems, saw blades, granite plates, and lubricants. Starrett has five US manufacturing locations and three international manufacturing facilities located in the UK, China, and Brazil. The L.S. Starrett Company is listed on the New York Stock Exchange under the symbol SCX.

FOR MORE INFORMATION ABOUT THIS PAPER, CONTACT:

Dennis Reynolds
Vice President Sales and Marketing
+1.330.633.2253
dreynolds@starrett.com

HOW TO ORDER

To order your Laser Measurement System contact us:
Starrett-Bytewise
1150 Brookstone Centre Pkwy.
Columbus, GA 31904-USA
Tel: 706-323-5142
www.starrett.com

FOLLOW US