



Five Ways to Improve Tire Uniformity at the Tire Building Machine



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INTRODUCTION

Tire Uniformity refers to the dynamic mechanical properties of pneumatic tires as strictly defined by a set of measurement standards and test conditions accepted by global tire and car makers. These measurement standards include the parameters of:

- Radial Force Variation
- Lateral Force Variation
- Conicity
- Plysteer
- Radial Runout
- Lateral Runout
- Sidewall Bulge
- Static Imbalance
- Couple Imbalance

Tire makers worldwide employ tire uniformity measurement as a way to identify poorly performing tires so they are not sold to the marketplace. Both tire and vehicle manufacturers seek to improve tire uniformity in order to improve vehicle ride comfort.

Poor tire uniformity can be explained, in part, by geometry variations introduced at the tire building machine (TBM) as components are built-up on the drums. These can be generally characterized according to their placement accuracy and splice accuracy. Additional variations can be introduced by the bead placement and turn-up operations.

The Green Tire Uniformity System (GTU) is a sensor and software package used to scan green tires at any stage of production to measure the key geometry features that affect cured tire uniformity and imbalance performance. This provides a way to thoroughly study the carcass, belt/tread package, and final shaped green tire for radial and lateral runout, and splice quality. The fix-mounted version provides

a means to perform 100% inspection at any drum for any parameter. This is useful for understanding the population characteristics of green tire runouts and to alarm when limits are exceeded.

This paper presents five easy ways to quickly improve the uniformity of your TBM operations using the GTU System.

#1 - FINAL STAGE LATERAL RUNOUT

Objective - Reduce cured-tire Lateral Runout (LRO), Lateral Force Variation (LRV), Conicity (CONY) and Couple Imbalance (CPI).

Approach - Check green tires on each TBM after final shaping and stitching to understand the LRO (snaking) of the tread die groove.

Method - Use GTU to scan several tires on each TBM. Use the LRO caliper to assess the snaking of the center die groove. High first harmonic values indicate tread snaking that correlates to LRO, LFV, conicity, and potentially CPI.

Action - Improve alignment and setup of tread servicers to reduce tread snaking.

- Note - Since a green tire can be scanned in one rotation at 60 RPM a comprehensive study of all your TBM's can be done in less than a day.

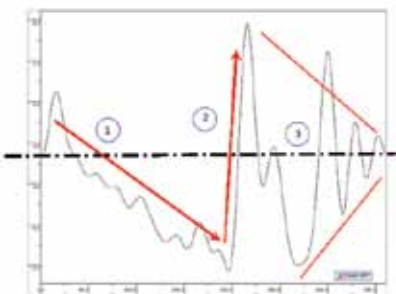


Figure 1 - This is the LRO waveform of the die groove for a green tire after shaping. It indicates tread snaking due to bad servicer dynamics.

Zone 1 – Tread abruptly jogs left 1mm then drifts right 2mm over 200 degrees

Zone 2 – Tread shifts left abruptly 3mm over 20 degrees and returns to center

Zone 3 – Tread oscillates left to right with starting magnitude of 3mm and settling back down on center after 5 cycles

- This suggests that the tread servicer drifts right, shifts quickly left, then vibrates back and forth until it settles out at the end of the rotation

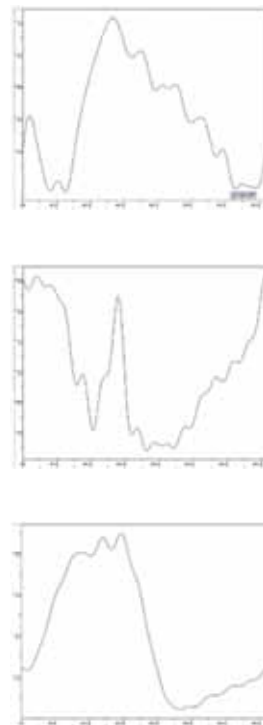


Figure 2 - These examples show green tires with different tread snaking conditions.

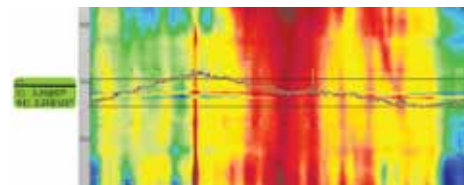


Figure 3 - In this scan red indicates high RRO and blue indicates low RRO. The waveform is the die groove LRO. The LRO caliper indicates a peak-to-peak LRO magnitude of 3.29mm with a peak at the tread splice, and a first harmonic LRO of 2.23mm.

#2 - FINAL STAGE RADIAL RUNOUT

Objective - Reduce cured-tire Radial Runout (RRO), Radial Force Variation (RRV), and Static Imbalance (STI).

Approach - Check green tires on each TBM after final shaping and stitching to understand the RRO, especially by comparing right side and left side RRO magnitudes and angles.

Method - Use GTU to scan several tires on each TBM. Set up RRO calipers for the right and left sides of the green tire. Phase angle differences for RRO1H indicate a non-symmetry in the material distribution that correlates to couple imbalance.

Action - Reassess the component splice orientations and other sources of RRO, specifically belt splices.

- Note - This analysis can be done using the same data sets obtained in Test #1.

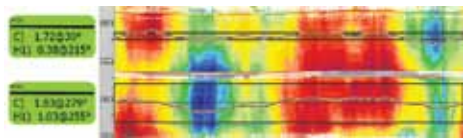


Figure 4 - Left and right RRO calipers expose a 40 degree phase angle difference in the RRO1H, which is indicative of a couple imbalance problem.

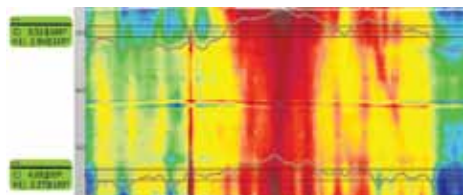


Figure 5 - The low RRO areas at 340 degrees shown in blue are indicative of heavy sidewall splices that increase the spring rate and reduce the expandability of the carcass at final shaping.

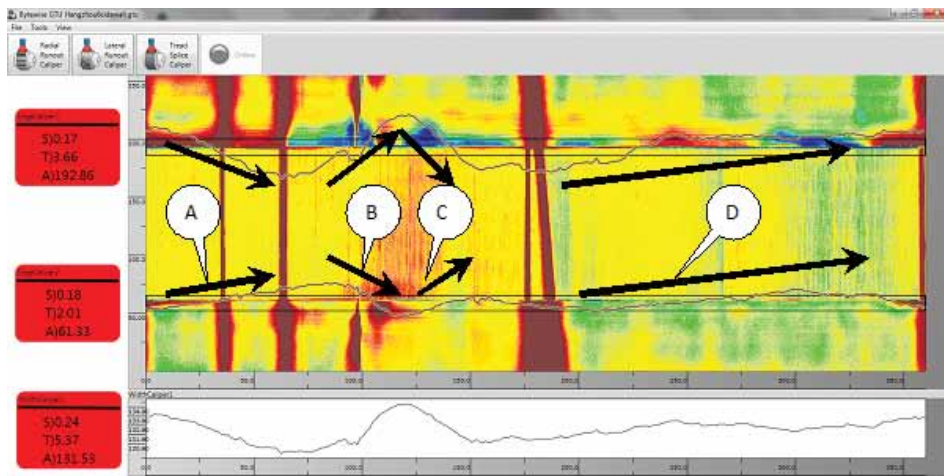


Figure 7 - This carcass scan shows areas related to RFV and LFV.

#3 - CARCASS STAGE TURN-UP SNAKING

Objective - Reduce cured-tire LRO, LRV, CONY, CPI, RRO, RFV, and STI.

Approach - Check carcasses on each TBM after ply turn-up to understand the LRO of the turn-up edges.

Method - Use GTU to scan several carcasses on each TBM. Use the Edge Calipers to assess the snaking of each side of the turn-up. High, in-phase, lateral movement of the edges indicates snaking that correlates to LRO, LFV, conicity, and potentially, CPI. High, out-of-phase movement of the turn-up edges indicates a condition that correlates to RRO, RFV, and STI.

Action - Improve alignment and setup of turn-up mechanics to reduce turn-up edge variation.

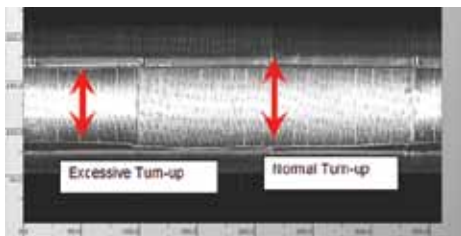


Figure 6 - This gray-scale image of carcass after turn-up exposes non-uniformity.

Above, edge calipers track the turn-up edges for lateral variation. In the region A, the edges move toward the center. We would expect the area around the 60 degree mark to exhibit lower RRO due to the higher spring constant associated with the larger turn-up and the double-thickness ply splice. In the region B the edges move away from the center. We would expect the area around the 120 degree mark to exhibit higher RRO due to the lower spring constant associated with the smaller turn-up and the absence of splices. In region C they move away from the center. In region D they snake upward. We would expect this condition to contribute to LRO in the cured tire.

Parameter T is the total lateral variation for each side. The left edge (upper) varies by 3.66mm over 360 degrees. The right edge (lower) varies by 2.01mm. Parameter S is the lateral variation over a user defined window, and is used to characterize the dog-ear splice value.

Parameter A is the average position of the edge along the width scale at left.

The bottom window shows the width between the turn-up edges.

#4 - DRUM SEGMENT MISALIGNMENT

Objective - Reduce runouts induced by poorly-aligned drum segments.

Approach - Check carcass and belt drums for poor segment alignment.

Method - Use GTU to scan several tires on each TBM. Use the visual display to observe segment alignment. High misalignments can induce runouts that can change the mass distribution in the final shaping stage.

Action - Repair drums.

- Note - Drum segments are usually in great alignment when initially set up, but can drift out of alignment during use. This test should be done after several hours of use.

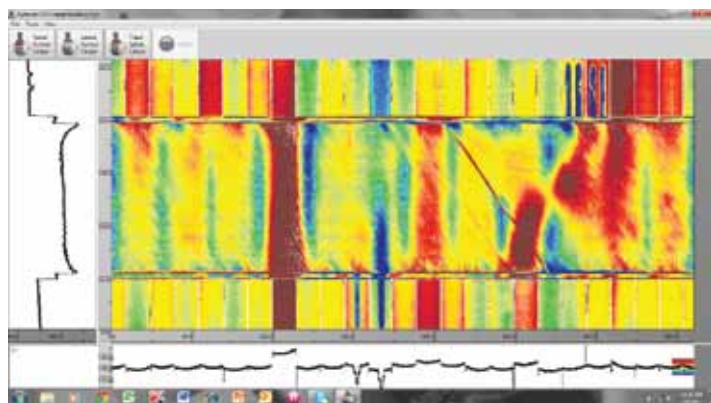


Figure 8 - The waveform below shows badly aligned drum segments on this belt/tread drum. Will the corresponding high RRO of the belt/tread package associated with this segment transfer to the shaping drum?

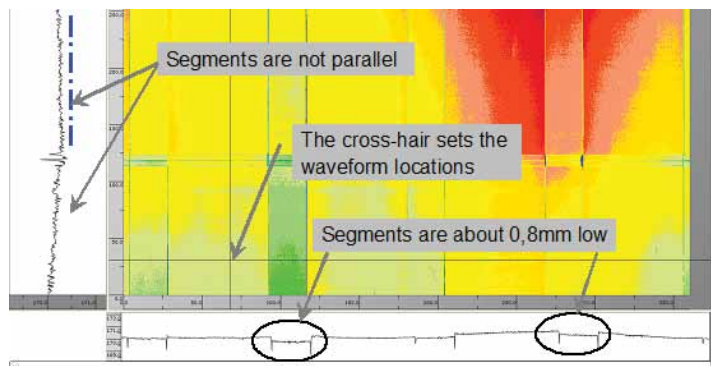


Figure 9 - The waveform below shows badly aligned drum segments on this carcass drum.

#5 - LARGE POPULATION STUDIES

Objective - Improve the overall quality of green tire production.

Approach - Establish a benchmark of the machine capability for one or more TBM's.

Method - Use GTU to scan 100% of the green tires produced on one machine for a one week period using a fix-mounted GTU System. Measure and record RRO and LRO from the shaping stage, and produce a plot of the results. Analyze the range, mean, standard deviation, and skewness of the curve. Compare the population statistics to typical cured-time uniformity statistics. Repeat the test on several other machines. Check for values exceeding 3Sigma above the mean. Check to see if the plots vary significantly from machine to machine.

Action- Improve those machines with the worst performance. Determine whether a 100% checking can identify the worst-behaving green tires - green tires that we expect to have strong correlations to the worst-behaving cured-tires.

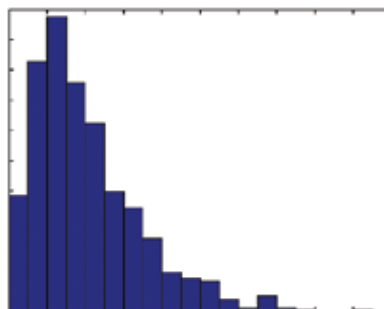


Figure 10 - An example of a typical population distribution curve for green tire and cured tire uniformity parameters. The vast majority of tires are good ones - the goal is to reduce those at the tail end of the curve.

HOW TO ORDER

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Starrett-Bytewise
 1150 Brookstone Centre Pkwy.
 Columbus, GA 31904-USA
 Tel: (706) 323-5142
www.starrett.com

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