Finding the Right Balance: Capability, Capacity, and Durability

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In the world of machine making, common trade-offs occur between speed vs. weight, weight vs. durability, and speed vs. overall capability. Accomplishing a balancing act among these characteristics is, in fact, much of what forms the machine's value. And each tire manufacturer, as the customer, may have a different idea of tire testing machine value based on the importance of variables that relate to their own unique products. For example:

1) A company that manufactures product sold as Original Equipment for fitment on a high-end automobile may place a high value on a very low 1-sigma standard deviation (capability).

2) A company that manufactures tires sold into a lower cost market area may only want to test tires to screen for truly defective product. A company in this position may place a higher value on throughput (capacity).

3) A company that manufactures larger product sold in the Light Truck and SUV market may have the greatest need for a testing machine that has high availability and very large Mean Time Between Failure (durability).

In reality, the overall value that most companies attribute to a tire testing machine is typically based on 1) their perception of how well the testing machine supplier has achieved balance among the variables of capability, capacity, and durability, and 2) how well that balance fits tire testing requirements associated with the products they produce.

While a variety of tire testing machines exist to satisfy particular capability, capacity, and durability requirements, the question arises:

Is it possible for a single machine to dynamically manage these process and production variables, and within the normal testing process? Fortunately, the answer is yes!

The proper combination of controls and mechanical design make it possible for a tire testing machine to very accurately and repeatably measure one tire, then measure the next tire more quickly with a lesser (but controlled) degree of accuracy and repeatability. This achievement greatly enhances the value of the testing machine, because now a single machine has the flexibility to automatically balance capability and capacity through the shifting of variables related to a tire manufacturer's product mix.

To better understand the value of such a tire testing machine, consider these requirements related to capability, capacity, and durability.

Capability

It is accepted throughout tire manufacturing that every testing machine supplier is going to sell a piece of equipment that provides industry standard measurements. In fact they must provide those measurements to be useful. So what additional machine capabilities should a tire maker consider?

1) The degree of repeatability of the measurement.

2) The flexibility of the machine to process products of differing sizes (rim diameter and bead/tread width) and measurement requirements (Radial and Lateral Force Uniformity, Radial and Lateral Run Out, Sidewall Geometry, Appearance, Surface Velocity, etc.)

3) Advanced communications that allow automated setup, testing variations and storage of production parameters and testing results.

4) The ability to provide and manage varying degrees of accuracy and measurement speed with a very high degree of substitution, combination and flexibility.

Some in the industry would refer to this list as defining lot size one, others as flexible manufacturing, and yet others as simply "that is what I need" for production tire testing in the Final Finish Area. In any case it is clear that disciplines and processes from machine building and Information Technology (IT), as well as advanced concepts derived from high and low speed tire testing, are now integrated within a new, homogeneous requirement set.

Given this requirement set, consider these "Best of Best" (BoB) parameters for measuring the capability of a tire testing machine:

1) Measurement of uniformity and geometry with a repeatability of 1 sigma standard deviation. For example, a machine running a 5x5 qualification test of a 225/75 R15 set of tires with a spring rate of 17.95 DaN/M (1025 LBS/Inch) can produce measurements to these specifications:

- Radial force 0.13 DaN (0.3 LBS)
- Lateral force/Conicity 0.11 DaN (0.25 LBS)
- Lateral and Radial Runout 0.05 mm (0.002 inch) with a spot laser
- Sidewall bulge and depression 0.05 mm (0.002 inch) witha spot laser
- Lateral and Radial Runout 0.02 mm (0.0008 inch) with a line laser
- Sidewall bulge and depression 0.02 mm (0.0008 inch) with a line laser

2) Measurement of surface velocity/angular velocity/instantaneous radius.

3) Use of collected geometry data to locate various molding-related appearance defects.

4) Capability to act upon the bar code identity of a tire to:

- Obtain tire testing recipe (testing requirements and grading limits) from an upper level computer system
- Transmit test results to an upper level computer system
- Transmit measurement waveforms to an upper level computer system
- Manage machine cycling to interchange, as needed, high measurement repeatability with a faster cycle time/higherthroughput
- Align measurements to a registration mark on the tire (usually a bar code) to provide the data needed for signature analysis (determine influences undesirable to uniformity such as component placement during tire assembly)

5) Provision of various advanced measurement algorithms and procedures such as:

- **Waveform validation.** This process analyzes other data source waveforms collected during the same time as the measurement data to provide an indication of overall quality of the measurements (i.e., determine if they are acceptable for use in grading the tire).
- **Measurement correction.** This process, which is the natural outcome of waveform validation, looks for certain subtle variables in the corresponding waveforms to see if the measurement waveform can be modified (along its length) to minimize an unwanted influence.
- **Measurement enhancement.** The goal of this additional process is to provide more precise and repeatable measurements. It will increase cycle time; however it is very valuable in the measurement of low profile or high spring rate tires, or for a machine that has a minimal or unknown electrical or mechanical deficiency.
- **Machine characterization.** This process determines various repeating machine effects and then uses this information (subsequent to the measurement process) to minimize unwanted affects.

Capacity

Generally, consideration given to tire testing machine capacity falls into these main categories:

1) What size of product can this machine test (process capacity)

2) How many products can be processed in a given time frame (production capacity).

Obviously, the size of the machine directly influences the limits for the first category (and to some extent the second). With most equipment in the tire industry, whether small or large, there is an almost one-to-one correspondence between machine manufacturer/model and production capacity. Unfortunately, that relationship can severely limit production capacity.

To minimize this limitation and move beyond industry norms, consider possible improvements to capacity based on a combination of various mechanical improvements, better machine capability (previously described) and information technology. For example:

- One direction testing is one of the best and least used ways to increase production capacity. This method requires tire conicity to be calculated from the forward direction of lateral shift, along with the average plysteer for the tire type/construction. However, it is easily accomplished with a reasonably good and statistically valid estimate of the average plysteer available from a results data base on an upper level computer system.
- Waveform validation and measurement correction allows testing to begin without waiting a set amount of time for tire and machine stabilization (warm-up), thereby decreasing the total cycle time and increasing production capacity.
- Test cycle selection based on bar code identity allows the degree of measurement repeatability and test cycle speed to be adjusted and/or interchanged to the benefit of increased production capacity.
- Multi-diameter test rims and an automatically adjustable rim width chucking (AAWC) system allow a greater variety of tire types to be tested, without tooling changes, at a single machine. This flexibility

greatly increases production capacity while reducing product flow bottlenecks that cause tires to be recirculated in an automated material handling system or removed from the process flow and stock-piled.
- In a facility that has a small number of machines and no automated material handling system, the use of an automated rim changing system further increases production capacity as it lessens the amount of time machines are out of service for rim size changes.

Consider these "Best of Best" parameters as you compare production capacity among testing machine suppliers: For a machine cycle that produces a radial force uniformity repeatability 1 sigma standard deviation of 0.19 DaN (0.43 LBS) for a 5x5 qualification test of a 225/75 R15 set of tires with a spring rate of 17.95 DaN/M (1025 LBS/Inch):

- One direction uniformity and geometry test for Passenger Car Radial (PCR) or Light Truck Radial (LTR) tires in 14.5 seconds. With 85 percent combined availability and utilization this cycle time allows 5,000 tires to be tested in a day.
- Two direction uniformity and geometry test for MTR tires in 48 seconds. With 85 percent combined availability and utilization this cycle time allows 1,500 tires to be tested in a day.

For the PCR/LTR machines, recent advances in the tire chucking system show an improvement in production capacity by as much as 8.1 percent can be obtained.

Durability

With all large tire production equipment, the expectation of most customers is that the equipment will not experience a structural failure during the life time of the machine. Unfortunately, on the road to producing lower cost and faster tire testing machines this "no failure" expectation is often not met.

Further, the idea of costly routine maintenance is something that is often not considered. For example, the cost to procure the parts needed for yearly maintenance can often be in the double digit range of the testing machine's original cost.

Generally, premature structural failure and high yearly maintenance costs can be attributed to an overall lower quality of components, along with a design philosophy slanted toward lighter structural systems in an attempt to achieve faster machine movement.

What is the "Best of Best" for machine durability? Consider these parameters when you look at the long term cost of owning tire testing equipment:

1) No structural failure during the lifetime of the equipment

2) No major (greater than 5 percent of machine cost) single item reoccurring maintenance cost per 2 million cycles

3) Yearly maintenance parts procurement cost of less than 5 percent of machine's original cost.

Poling Group companies produce equipment for production and endurance tire testing and provide computer systems and controls used throughout modern tire manufacturing facilities worldwide. At the Poling Group, we call what we do for tire manufacturing the Poling Group difference. And that difference is the integration of machine building, advanced controls and Information Technology.

The machine Capability, Capacity, and Durability described in this document can be found in our X line of production tire testing machines and complementary upper level computer systems.

Ask us how we balance the variables of capability, capacity, and durability to exceed the expectations you have for your tire testing requirements.

Together we can make a big difference in your company's overall performance!

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