The next generation

of modular tire measurement

An integrated test and measurement system (MTMS) for tire testing is now commercially available, with many innovations being developed to meet tomorrow's tire manufacturer's final finish test and measurement requirements

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Micro-Poise formally introduced the world to its modular tire measurement system, or MTMS, in 2009. It was the first system on the market to integrate all of the tire final finish and testing functions into a single, efficient, highly integrated commercial system. This new type of tire quality testing system provided several advantages over standard independently placed testing machines.

The overriding goal of the MTMS is to provide unsurpassed value in tire testing and measurement. This system is able to achieve the highest throughput on the market, completing tire testing cycles in less than 20 seconds. Because of its highly precise and repeatable measurement capability, the system is also able to reduce the direct costs associated with making the proper decision about a tire's quality and associated grade. The system also reduces lifecycle costs of consumables and maintenance by simplifying operation and removing redundant subsystems, such as marking and tire lubrication devices. By virtue of its simplified configuration, it is able to minimize production floor space requirements by fitting into a smaller and more efficient footprint than previously required by independent testing machines.

The basic MTMS concept and operation represents a very efficient configuration of tire testing equipment and subsystems. The system maintains the orientation of a tire during processing, so angular tire measurements are relatable and much more meaningful. All tire measurements are stored and displayed in one place with coordinated measurement angle information and can be used to evaluate tires in a completely different way. This information can be combined with barcode tire spotting so that angular information can be referenced to the physical tire for all production tires. This provides valuable information to the tire manufacturer to enable a higher level of tire production process control and drive greater product yields.

The MTMS appears as a single entity to the customer's tire handling system in the plant. Only simple handshaking signals are required at the beginning and end of the full system, thus making the integration of the whole measurement process much easier. The system contains tightly integrated controls and data sharing among the separate subsystems as well. The MTMS is easily configurable through modular design to meet any customer's specific tire testing requirements.

Basic system and functionality

The major components of the basic MTMS design are shown in Figure 1. In this configuration, the tire flow is from right to left. At the beginning, a tire handling system is used to center and lubricate the tire in preparation for testing. The first ASTEC station performs a tire uniformity (force variation) test. Immediately following this station is a marking station used to mark the tire according to the uniformity measurement and grade. A drop conveyor is included for easy machine access. Another handling station (minus the tire lubrication system) follows, which will re-center the tire before entering the balance station. This centering station is of the same design as the first component in the line, helping to commonize setup and spare parts. The MTMS's continuous flow design does not require a tire to be relubricated prior to entering the next station. The tire then enters a dynamic balance and tire geometry testing station called the AkroDYNE with TGIS (Tire Geometry Inspection System). The laser-based geometry measurement system is designed into the balancer to aid in cycle time savings. The tire is then transported to a second marking station, which performs tire marking based on balance or geometry measurement and grading. Lastly, the tire enters an automatic sorting station that can sort the tire to the manufacturer's multi-level outgoing tire handling conveyor system.

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Flexibility

The MTMS is designed to accommodate multiple tire sizes in both a batch mode and a flexible (mixed) mode of tire testing. In batch mode, the operator selects the type of tire to be tested as a batch through the system and the system adjusts for the new tire type automatically once set by the operator. In a flex (mixed) mode operation, the MTMS system requires some means of understanding what type of tire is entering the system and will adjust automatically without the intervention of an operator. The available means to identify a tire include a barcode lookup function, a tire sizing station, or some means of tire identification passed to the MTMS by an upstream tire handling system. Once the tire is identified, all information to process (measure) the tire is loaded automatically into the MTMS. The basic system requires a tooling change if tires are to be processed that do not fit the currently loaded tooling, resulting in up to 15 minutes of downtime, depending on tooling change methodology.

As a tire is processed by the MTMS, it is tracked, measured, graded, marked and sorted. Once a tire enters the testing system, it is tracked through the system to ensure proper processing and to collect and connect all relevant measurement data. At the end of the testing line, all measurements have been collected and associated with a specific tire. After all measurements have been taken, the tire is compared to simple screening limits to determine if the tire is above or below the limit and 'graded'. This is done for several relevant tire measurements. A final quality classification or 'tire grade' is assigned to the tire. Based on this quality grade, the tire will be marked and sorted.

Marking and sorting

The final two processes completed during MTMS tire processing are marking and sorting. The tire marking is based upon the tire grade and the desires of the tire customer as to what marks need to be included. Typically, marks are included for balance or uniformity or both. The colors, shapes, and locations of marks are based upon the grade of the tire. Tire sorting is based upon the tire grade as well. Tires are automatically collected or routed to different areas of the plant or warehouse based upon their quality assessment, grade assignment, and associated customer requirements.

Today, the same processes that were performed in the past by various independent machines are now combined into one efficient fully integrated system. This system performs all measurements needed by the tire manufacturer. The integrated system is efficient with respect to production floor space and operator support. Most importantly, the integrated system can make much better final quality decisions with respect to the tire and do so at a high throughput rate.

However, there are several enhancements on the horizon for the next generation of MTMS.

Mark/orient station

One forthcoming improvement to the basic MTMS system is a single-station marking system that will be configurable for balance, uniformity, and geometry marking, eliminating the need for two independent marking stations. This changes the overall layout of the system as reflected in Figure 2. All measurements are known at the time of marking so more advanced arrangements can be created to mark tires based on combined tire grades, not only independent uniformity or balance marking. In addition, this will create only one marking system on which to perform maintenance and results in more efficient use of floor space. It is more cost-effective to have one highly capable and flexible marker with a tire orientation station, than two marker systems for the same capability. This results in greater machine value and direct cost savings.

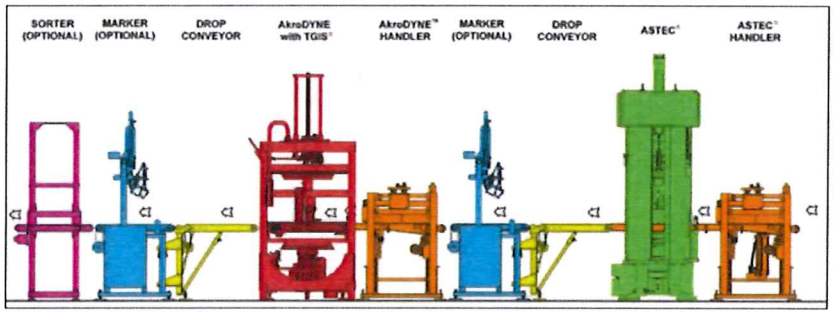

Figure 1: Basic layout of the Modular Tire Measurement System (MTMS), which Micro-Poise introduced in 2009

Automatic rim change

Another development of the next generation MTMS is taking product testing flexibility to a new level. Historically, uniformity measurements are performed using one-step or two-step rims. Dynamic balance measurements are historically performed on three-step rims. With high levels of product mix, a complex and large automatic storage system had to be provided or an excess of floor space was taken up by manually creating batches of tires to be tested by the final finish equipment. This situation leads to frequent and time-consuming rim changes. The latest MTMS system has automatic rim changing capability for both the uniformity and balance subsystems of the integrated testing line. This results in completely automatic changing of tooling to accommodate incoming tire sizes in less than two minutes, creating test flexibility along with greater system uptime without the need of operator intervention.

Data visualization

Another frequently requested capability is local data visualization tools with basic measurement results storage. In today's highly competitive tire market, it is more important than ever to understand what's happening on the production floor immediately. It is critical to have tools available for production support personnel in the plant to monitor general trends or even clearly and immediately see the disposition of a given tire. This requires real-

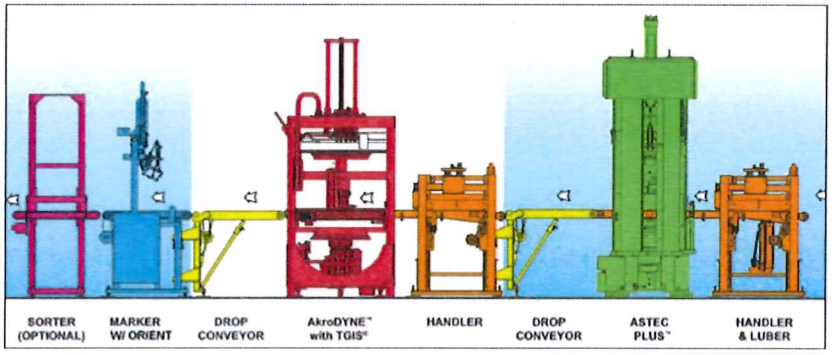

Figure 2: Forthcoming improvements to the MTMS layout include a new layout with a single-station marking system

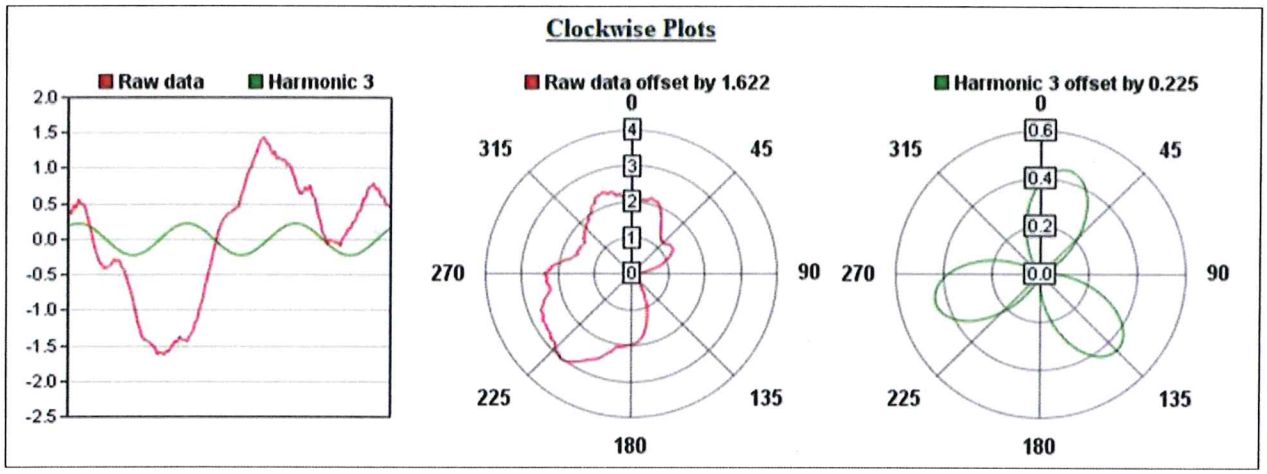

Figure 3: Tire uniformity waveform visualization plots

time measurement data and tools to assist in "seeing what is going on' through the tire manufacturing process. This ranges from visualization of uniformity machine waveforms, to calculating basic statistics on real time production data or machine qualification testing data. An example of this is shown in Figure 3. Many tire manufacturing companies have high-level systems that are great at pulling data together over very long periods of time or from several machines inside a plant. This information is used to create detailed reports and charts, but it is critical to have a tool very close to the production floor to help with making immediate decisions. This enables the manufacturer to be able to react quicker to real-time data and active production trends.

Effective radius measurement

There has been a recent development and commercialization of a new type of measurement for further insight into general tire ride performance called effective radius measurement or ERM. The tire circumference measurement, in the unloaded condition, has been around for a long time in the industry. A better predictor of true rolling performance is a measurement of the loaded radius or what Micro-Poise terms the effective radius measurement (ERM). This measurement is also sometimes referred to as effective rolling radius (ERR) or dynamic rolling radius (DRR). This is directly related to what can be called effective circumference measurement (ECM) where $ECM = 2 \times \pi \times ERM$. It is critical for compliance to American CAFE (corporate average fuel economy) standards and is an extremely useful measurement in race tire applications, ensuring proper tuning of the vehicle on the track. It is also useful as an extra check for a tire manufacturer to ensure a belt has not been omitted from a tire during production.

The ERM measurement is a simple add-on to the tire uniformity machine and can be completed during a normal uniformity measurement cycle. Only a few extra hardware components are added to the machine including, but not limited to, extra encoder-type measurement devices on both the machine spindle and loadwheel, a supplemental instrumentation system, and extra software, which must be added and integrated into the machine. The result is a valuable measurement available for tire grading and storage with the rest of the tire measurement data.

Effective radius variation

Another new measurement driving further insight into high speed ride performance of tires is called the effective radius variation or ERV. While the ERM relates to the average effective radius around the tire, the ERV measurement looks at the instantaneous variation in the effective radius around the circumference of the tire. ERV turns out to be the primary contributor to tangential force variation (TFV) seen at high speeds. Measurement of this parameter, taken during the normal low speed uniformity cycle, can give the tire manufacturer a way to screen-out those tires that may have very high TFV at high speed without the investment in a high speed uniformity machine.

Similar to ERM, the ERV measurement is a simple add-on to the tire uniformity machine and can be completed during a normal uniformity measurement cycle. The same few hardware components are added to the tire uniformity machine to make this measurement available. The ERV measurement is also available for tire grading and storage with the rest of the tire measurement data.

Advanced quality classification and grading algorithms

One additional benefit of the next-generation MTMS, due to the highly integrated nature of the system, is the possibility for the development of new advanced quality classification and grading algorithms. Historical grading techniques include capturing a measurement for
a particular characteristic and performing a simple comparison to a screening limit to determine if that particular characteristic
is above or below the screening limit.

This process is performed on numerous individual characteristics of the tire, all independently. Typically, a uniformity grade is assigned, based upon a comparison between the measured tire data and the lowest order uniformity parameters. Balance and geometry grading is determined in a similar way. Historically, the grading information is not linked or coupled and, for the most part, angular information is ignored in the grading process.

The highly integrated nature of the MTMS and consistent angular measurement capabilities enable customers to develop and implement more complicated methods of grading a tire, which could lead to improved ride performance of tires (a benefit to the automobile maker) and higher production yields (a benefit to the tire manufacturer). The new grading methods can be developed in software and implemented directly into the final quality decision-making algorithms of the system. ***tire***