Closing the loop around tire production

Micro-Poise presents its vision for the future of tire manufacturing along with an overview of its existing test and measurement technologies

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Individual tire components, including the raw rubber, polymer ingredients, and other materials that go into the tire can be identified, tracked, and traced at each step during production. Critical manufacturing data and other in-cell testing data can also be collected, combined, and tracked (e.g. the specific operator who constructed the tire, the specific tire building machine, information on the quality of component splices, the component storage method, etc.). If defects or undesirable characteristics appear in the intermediate or final product, they can be flagged and controlled, immediately minimizing the scrap that is generated. A few of the more established and sophisticated tire manufacturers possess some of this capability, but even in these facilities there is no cohesive system to glue it all together.

One can envision user-friendly visualization tools that can be used to mine this collected data to learn how to improve tire quality and production yields throughout the process. Along with these tools being used by humans to manually discover issues and improvement methods, high-level computer monitoring software can monitor the data, look for trends, predict failing equipment, and determine when something is amiss in the tire manufacturing process. Existing tire manufacturing knowledge can be incorporated into these software monitoring tools, enabling tire manufacturers to focus on productivity and product design while these automatic software tools direct resources where they are needed to address issues along the manufacturing process. In addition to these tools measuring and checking quality along the way and classifying product as good or bad, these systems can provide quantified monitoring data very close to the source, minimizing product created outside of acceptable conditions, and thereby reducing warranty problems and improving quality. Micro-Poise has embraced this vision and set its course on a development path to extend and merge numerous existing and new Micro-Poise technologies in order to make this vision a reality.

Below: Micro-Poise's ATLIS platform combines in a single machine several software-assisted scanning and imaging technologies

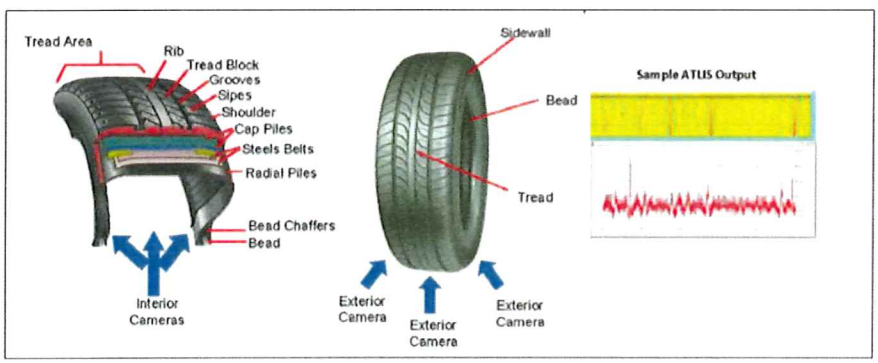
The limited tracking and tracing capability that exists still lacks numerous qualities and capabilities that would provide unsurpassed benefit if realized. Even with all of the automation implemented today, human intervention is still prevalent. For example, humans are still relied upon to perform a final cured tire inspection to ensure the quality of the tire before it is sent to the customer. It is very easy for humans to see and inspect an issue but also very difficult for them to quantify that issue and document it. Little indication is given if manufacturing performance is trending in an undesirable direction. Humans are also inconsistent at times, especially when performing such a repetitive and difficult task. The need is great for automation to reduce this human impact along with a reduction in manufacturing costs and an improvement in consistency and efficiency. The need also exists to pull vital manufacturing data together automatically and quickly in order to develop new tire manufacturing knowledge at a quicker pace. In response to these known conditions, Micro-Poise has undertaken two extensive development programs aimed at providing capabilities non-existent in the tire industry today to address these challenges:

- Micro-Poise Test, Acquire, Upload, Report, Usable, Statistics (TAURUS) product platform;
- Micro-Poise Automated Tire Line Inspection System (ATLIS) product platform.

These two transformational development programs are detailed in the following sections.

Micro-Poise TAURUS

The Micro-Poise TAURUS system is intended to provide a unifying platform for all final and in-cell testing and manufacturing data, which in turn will provide several highly valuable functions. Beginning with uniquely identified tires or tire components using a barcode label or RFID tag, this software system will track tires and raw materials while collecting and storing critical test and manufacturing data along the way. Examples of information stored include which skid of rubber produced the tread components, on which tire building machine the tire was assembled, and in which press cavity the tire was cured. Final finish quality data at the end of the

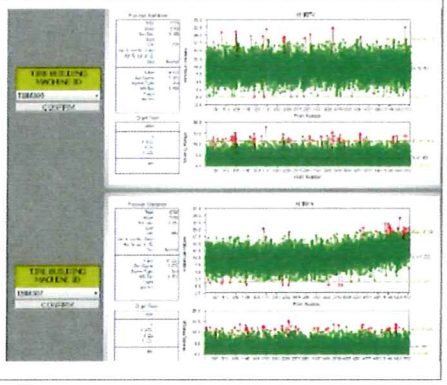


manufacturing line is also stored. This provides a unique foundation for the unification of material, machinery, and process data. In-cell testing data, such as component splicing quality measurements and component gauge control information, can be stored as well. All data can be monitored to determine the current level of process control, and mined for valuable information leading to process improvement and higher product yields and less scrap. This data enables the feeding of statistical process control (SPC) tools, generalized data mining tools, and shift reporting systems.

The TAURUS system also provides a single centralized source for critical tire recipe data and screening specification information for tire production and screening equipment. Recipe or specification limit changes can be made in one place, and all changes synchronized automatically to all of the appropriate local equipment. This minimizes errors in recipe information and dramatically reduces the amount of time needed to maintain recipes. Current practice typically has personnel visit each machine individually in order to make changes to recipes or update specification limits. If several machines of the same type exist on the manufacturing floor, each machine must be updated individually. This new system can also exchange information with higher-level business systems, such as ERP or SCM systems, to provide critical higher-level dashboard data.

Another valuable and available software module performs data visualization and simple data reporting. This easily accessible tool can pull data from the measurement results storage system for the purpose of visualizing what is happening on the floor at that moment, or to see what happened at some time in the past. Typically there are tools on each final finish system that provide immediate on-floor feedback; however, a centralized system can be used for more extensive and plant-wide analysis incorporating data from several machines and machine types. The output can be tailored to a specific audience. Special reports such as production yields and trending, tire quality information, tire uniformity waveform studies, and machine uptime/availability can be instantly visualized for a specific set of production tires as defined by an input data filter.

TAURUS's use of statistical process control – screenshot



There are numerous types of beneficial data available, including but not limited to, quality information and production statistics for production personnel, system availability information for maintenance/production support personnel, quality/yield improvement information for quality personnel, and management dashboard information for plant business management. This tool allows for the immediate ability to see and attack the product variation at the source of variability, and enables the appropriate people to learn which knobs to turn in order to improve the manufacturing process. Attacking variation like this is also key to removing process noise (process variation) and making it even easier to see how to make significant and long-lasting improvement in the manufacturing process.

Pending developments of other in-cell testing/measurement technologies and straightforward interfacing to existing technologies are also planned for this product platform. Existing component gauging and inspection technologies along with tire building and prep splice control systems will be able to interact with this system to contribute useful process control data well upstream from the final finish and test equipment. Other tools not currently available on the market, such as automatic tire building splice optimization and curing press spotting optimization tools, are envisioned for future development on this product. A comprehensive interface to any existing tire sorting and routing equipment is also planned. This interaction will change the way tires are evaluated and routed by enabling the connection to relevant in-process quality data on-the-fly, the making of decisions in a more economically sound fashion, and routing of problematic product out of the system sooner, with less loss in scrap product.

This product platform provides an excellent system for the collection of data, and provisions for a suite of tools used to dramatically improve manufacturing efficiencies. Micro-Poise is striving to also address the remaining human element in tire manufacturing by improving and automating the tire inspection process through its ATLIS product platform. Data from this newly formed ATLIS measurement and inspection technology will be sent to the TAURUS high-level data storage and process improvement system.

Micro-Poise ATLIS

The Micro-Poise ATLIS platform combines in a single machine several software-assisted scanning and imaging technologies that are used together, or each technology may be dispersed throughout the manufacturing process in order to target automatic final tire and component inspection as close to the sources of variation as possible. Historically, the final cured tire inspection process has used production personnel to provide quick visual evaluations of defects in the cured tire, and a judgment on the acceptability of the tire for the customer. There is typically little or no quantification of defects, only a pass/fail evaluation. Consequently, trending or any pattern of pending failure cannot be established. This product platform provides for automated inspection processes and the ability to quantify and trend certain anomalies.

The Micro-Poise ATLIS platform will be comprised of several automatic sensor measurement technologies that can be used to quantify certain defects and trend data. Early detection and prediction of these issues leads to increased and earlier preventative action in the plant. The automation element of this technology enables human resources to be removed from mundane and repetitive visual tire inspection roles and reallocated to implementing financially beneficial production

yield and throughput improvements. The positive financial impact is staggering. The reallocation of these human resources to other more value-added activities, along with a dramatic improvement in the quality and consistency of the inspection process, has a significant impact on cost reduction. Our financial model shows an estimated reduction in tire inspection costs from $0.19 to $0.05 per tire. In addition to monitoring defect-producing trends, tires can be observed to provide preventative maintenance type information such as needed mold cleaning activities or curing bladder replacement, improving the operations within the tire manufacturing plant.

At the heart of this platform are the extensions of primarily two of Micro-Poise's existing technologies, including geometric surface topology scanning (TGIS geometric scanning technology) and x-ray image processing with automatic defect recognition (ADR) technologies. The historical method of inspecting tires has human inspectors checking both the inside and outside of the tire for a given large set of potential defects. Due to the limitations of humans to visually detect small variations in some tire properties, touching the tire (tactile inspection) is currently used for some defects. The embodiment of the ATLIS development platform provides for the automatic sensing of a cured tire with an extensive number of disparate sensor arrays and sensor technologies (e.g. surface topology mapping, visible light or infrared image processing, etc.), and uses newly developed extensions to Micro-Poise's anomaly detection algorithms to detect the desired defects. In many cases, with the extra sensitivity of these sensors, defects can now be quantified and trended where the human inspectors could not provide this capability. This provides very valuable early detection and prediction capability that does not exist in today's most sophisticated tire manufacturing plants.

The benefits of these two primary enabling technologies that make up ATLIS, both geometric surface topology analysis and image analysis, are numerous. They allow for quantification and absolute measurement as close to the source of variation and issue as possible, which minimizes the in-process and final tire scrap during production. These technologies also enable certain preventive maintenance monitoring, leading to more downtime that is planned and less unplanned downtime, therefore enabling operating efficiency gains within the plant. The knowledge created from using this ATLIS inspection technology leads to the development of correction methods for certain issues in the plant. This combination of ATLIS technologies and the continued development of new in-cell sensing technologies and new interfaces to other existing monitoring/testing equipment throughout the tire manufacturing process, along with a continually expanding TAURUS platform, will continue to add more and more value and functionality to this platform for several years.

The next frontier

The long-term evolution of the aforementioned product families will provide foundational capabilities upon which sophisticated higher-level software systems can be integrated to automatically discover and potentially adjust for in-process quality issues. The product families currently under development at Micro-Poise and discussed in the previous sections, can be used independently and under human control to make considerable process improvements. User-initiated trials can be performed and results immediately visualized within the system. Useful production and machine availability data is easily accessed and can be used by plant personnel to devote other resources to a specific area and address current issues.

However, what if the people were not needed in this scenario to discover issues, direct the activities, or create the knowledge? What if high-level software systems that automatically monitor the various sources of data and provided guidance, alarms and, in some cases, actions to begin to correct recognized issues were possible? Some examples include but are not limited to:

- Automatic comparison of tires built on separate building machines, pointing out statistically significant differences and indicating potential causes for difference;
- Automatic comparison of tires cured in separate press cavities, pointing out statistically significant differences and indicating potential causes for difference;
- Inspection measurements indicating a curing bladder in a specific cavity is about to fail and should be scheduled for replacement;
- All tires built from a specific spool of extruded rubber exhibit exceptionally excellent uniformity characteristics and anticipated reasons why this may be the case.

The primary benefits, realized from having a more complete and totally automatic system, result from independent automatic operation and built-in tire processing knowledge and expert systems. Similar systems in existence today can be used to mine this data and perform manual improvement activities, but Micro-Poise is on a path to continually extend the platforms described in this document and develop automatic tools that will help detect and correct quality issues all along the tire manufacturing process. This type of "closing the loop around production" in a tire manufacturing facility would then be realized. The embodiment of this new technology will take the form of advanced software modules that can be added to the TAURUS product that will provide the new and novel capabilities.

The value that such a system could provide for a typical tire manufacturing facility, whether used standalone (open loop) or with automatic software modules guiding improvement activity (closed loop), is staggering. If these types of automated tools can be used to improve product yield in a facility, it could result in over US$3.5 million of cost savings over a given year. A typical tire production facility produces 25,000 tires per day or nearly 9,000,000 tires per year. If a standard cost for a produced tire of US$40 is assumed, and that tire could be sold for an assumed US$80 in the market, then a 1% improvement in product yield will result in US$3.5 million of scrap costs avoided and those tires, in turn, could generate US$7.0 million in revenue. It's easy to see that such a system installed even at a considerable installed cost could quickly return value to the tire manufacturer. This return is even greater when many of these improvements are generated automatically, without the addition of extra skilled human resources in the facility. tire