Tire Building Machine
Reduce Design Time and Improve TCO for Tire Manufacturers

This paper takes a closer look at the automation and information solutions available for tire building machine builders.
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Executive Summary

As a machine builder, you are challenged to differentiate yourself amidst global competition and rapidly evolving technology. Tire manufacturing demands machines that combine high production output, consistent reliability and product quality with low manpower requirements and low maintenance costs. Alongside high-speed production, flawless product quality is also a priority. The machines also need to be flexible enough to adapt to trends like larger tire dimensions and more sophisticated designs.

Whether measured from a business, commercial or technical perspective, Rockwell Automation can help improve your tire building machine performance with solutions and services to lower the Total Cost to Design, Develop, and Deliver℠ machines and meet your customers’ requirement.

At Rockwell Automation, we strive for a holistic approach that focuses on your machine and business performance. What may start out as an “order-by-order” relationship, can eventually develop into a mutually beneficial business relationship. Rockwell Automation will work with you to develop solutions that will give you a competitive advantage throughout your machine’s life cycle.
Introduction

The tire industry is reportedly the largest consumer of rubber in the world and has an average industrial revenue of $17.6 billion annually where 21% of sales are contributed by OEMs and 79% of sales are replacement tires.

In today’s highly competitive tire and rubber manufacturing, businesses across the globe face unprecedented and volatile changes. Manufacturers, material suppliers, and machine builders (OEMs), are affected by shifting customer demands, globalization, industry consolidation, technology innovations, safety requirements, government regulations and the demand for lower customer prices.

Tire manufacturers must reap the most productivity from every stage of their manufacturing process. At the same time, they must ensure the tires produced meet their customers’ specifications and overall quality standards.

A Sample Production Flow Chart for Tire Manufacturers
(Source: Internet)
Tire Building Machine (TBM)

TBM is the one of key machines in tire manufacturing and is widely used to produce green tires.

The TBM assembles all semi-manufactured goods such as: tread, sidewall, inner liner, body ply, bead, and cord body together to build green tires according to industry standards.

The machine cycle is programmed to carry out the various operations automatically and simultaneously, to give a balanced and single operator building cycle.

All sequences are controlled by a PLC system.

TBM Situation

Multiple machine parts need to be coordinated from and to:

- Drums
- Conveyors
- Rollers
- Jointless Belt Array
- Unwinding
- Cutter
- Laser Mark
- Correction System
- Pneumatic Valves

Complicated sequencing and logic linking with:

- Motion Control
- Drive Control
- Safety Interlock

Human Machine Interface (HMI) requirements including:

- Recipe
- Alarm
- Diagnostic
- Operation

Communication interface with multiple 3rd party devices
Categories of General TBM
(Corresponding to the relevant machine)

<table>
<thead>
<tr>
<th>By Vehicle</th>
<th>Categories of Radial TBM</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC</td>
<td>Passenger Car Tire</td>
</tr>
<tr>
<td>LT</td>
<td>Light Truck Tire</td>
</tr>
<tr>
<td>TB</td>
<td>Truck &amp; Bus Tire</td>
</tr>
<tr>
<td>AG</td>
<td>Agriculture Tire</td>
</tr>
<tr>
<td>OTR</td>
<td>Off The Road</td>
</tr>
<tr>
<td>ID</td>
<td>Industrial Truck Tire</td>
</tr>
<tr>
<td>AC</td>
<td>Aircraft Carrier Tire</td>
</tr>
<tr>
<td>MC</td>
<td>Motorcycle Tire</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>By Structure</th>
<th>Categories of Radial TBM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bias Tire</td>
<td></td>
</tr>
<tr>
<td>Radial Tire</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>By Size</th>
<th>Categories of Radial TBM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Giant Tire</td>
<td>&gt;= 17in</td>
</tr>
<tr>
<td>Large Scale</td>
<td>&gt;= 10in and &lt; 17in</td>
</tr>
</tbody>
</table>

Categories of Radial TBM

<table>
<thead>
<tr>
<th>Building Methods by Tire Types</th>
<th>Uni-Stage</th>
<th>Two Stages</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Steel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 drums</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>3 drums</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>4 drums</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>Half Steel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 drums</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>3 drums</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
A Typical Tire Building Machine

Half Steel Uni-Stage 2 Drums TBM

Machine Basic Parts
Challenges
For the tire manufacturer, the tire building machine should be:

- **Productive**: Optimize period per phase as short as possible; short changeover time by complex recipe management; shorten recovery time, and maximize throughput with highest quality
- **Safe**: Meet safety compliance standards to ensure the safety of staff and equipment
- **Flexible**: Match different tire types and building processes, including the size of the green tire and different types of components
- **Easy to use**: Easy maintenance despite complexity of the machine
- **I.T. Integrated**: Provide enterprise level connectivity with standard Ethernet access, MES platform and ERP support;

For the machine builder/designer the machine should be:

- **Modular**: Mix and match tire machine functions that are ideally suited for specific customer applications; customize functions to develop a new machine that is localized to market demands
- **Standard**: Develop and document mechanisms common to complex tire machines that can be easily redeployed with minimum modifications, despite different machine sections/conditions that result in more complicated sequencing and interlocking;
- **Cost-effective**: Machine integration, mechanical and electrical optimization and wiring start up time costs are reduced

Why TBM automation is so critical
Synchronization of machine sections, including let-off, feed cutter, splicer, and wind-up

- Achieve tension and edge control
- Slip correction between belts and tire building material
- Higher accuracy of cut-to-length, independent of machine speed
- Jointless Belt (JLB) and wind; Cam Profile to optimize the motion through a highly automated machine
- Regular tracking to keep abreast of technology to save manpower and ensure product quality
- Ability to make adjustments such as tire dimensions and advanced fault diagnosis system
Proposed Solutions

Solution 1: Rockwell Automation Integrated Architecture™ with Integrated Safety Function

When safety protection is applied in the machine, hazards are reduced which results in manufacturers achieving EN/ISO 13849-1. This solution is primarily focused on overall machine performance, including safety, efficiency, design and productivity. It helps machine builders to deliver flexible high performance machines in the competitive TBM industry.

Integrated Safety Solutions

Accelerating Value with Integrated Safety increases productivity, efficiency levels, intelligence and overall competitiveness.

Optimizing Functional Safety beyond compliance improves functional operation of the machine while reducing waste. Scope of safety control can be expanded.

Designing Powerful Integrated Solutions increases competitiveness to capture global opportunity, reduces risk, improves service, and improves MTTR and diagnostics.

Delivering Scalable Safety Technology that combines Control, Network, Motion, Drive, Safety and I/O. Standard and safety control systems share assets so costs for hardware and software development and support are minimized.

Maximizing results while keeping machine downtime to a minimum. No need to bypass system to save time. Solution helps increase flexibility and maintenance procedures are carried out efficiently.

Reducing Acquisition Cost by using a common platform and programming tools for safety and standard control and visualization. Also reduce switches (safety relays) and cabinet space.

Safety Programming offers flexibility with easy-to-use programming and provides open and integrated control that will help to achieve machine safety and protect your current control investments.
Solution 2: Rockwell Automation Integrated Architecture™ and Safety Components

The main objective for the Tire manufacturer and builder is to have one controller to achieve distributed control. This solution also includes open networks, integrated motion, and a full range of safety components. The result is ONE set of spare parts, ONE Maintenance Department, and ONE system to manage, therefore reducing total cost,

Integrated Architecture™ Solution

Allen-Bradley® CompactLogix™ PAC uses a common control engine with a common development environment to provide mid-range application control. This provides a cost-effective machine or safety application integration into a plant-wide control system, combining safety, motion, discrete and drives capabilities in a single controller

Allen-Bradley® Kinetix® 350 and 6500 servo drives with MP-Series Low Inertia (MPL) servo motors provide smooth acceleration and deceleration, fewer wiring connections, and a common software platform

Broad industry adoption of EtherNet/IP (trademark of ODVA - NOT owned by Rockwell Automation), leveraging CIP motion, CIP safety, CIP Sync, and DLR technology, allows for easier TBM integration with IT environment. So more on-site information can be collected

Allen-Bradley® PanelView™ Plus human machine interface (HMI) provides a window into the machine status and alerts operators to faults. Also allows easy tracking and adjustments of machine recipe.

Full range of Allen-Bradley® safety components to add safety controls
Manufacturing Performance and OEE

Performance metrics, like equipment and material use, and overall equipment effectiveness (OEE) can provide critical insight into how well a production operation is being managed.

**Standard reports and dashboard sets** provide a mechanism to help machine builders and manufacturers achieve higher efficiencies such as:

- Reduced downtime
- Reduced cycle time variation
- Reduced unit costs
- Reduced overtime
- Improved quality

This can be achieved by considering:

- OEE (overall equipment effectiveness) Analysis
- Machine Monitoring
- Downtime Tracking
- Process Improvement
Rockwell Software FactoryTalk® Metrics monitors plant-floor equipment and provides accurate, timely, granular, and specific information both on current machine performance, as well as providing detailed work cell/line/area/site historical data for long-term analysis. This data is the basis for understanding the real causes of inefficiency, waste, and lost capacity, and empowers plant personnel to make informed decisions around optimizing assets within a production facility or across a manufacturing enterprise.

As an example, a tire manufacturer may want to create a reporting system that collects data such as downtime, quality, and material waste in order to improve performance. Key data collection and reporting could include:

- Production Counts
- Scrap Production
- Material Consumption
- Downtime events – automatic and manual
- Yield calculations
- KPI Calculations
  - Performance
  - Quality
  - % Machine Efficiency
  - % Material Efficiency
  - % Operator Efficiency
  - % Uptime Efficiency
  - % OEE
- Collection and reporting of data by additional values:
  - SKU (Part Number)
  - Operator
  - Shift (Crew)
  - Run #
- Changeover Times
  - Let off change
  - Windup change
  - Gum applier
- Quality checks: Angle, Width, Treatment, Gum strip
- Changeover scrap capturing
- Web-based reporting for visualization of data
- Supervisory HMI Solution
  - Operator Quality Checks
  - Manual Scrap Production Entry

### Start of Shift Quality Checks

<table>
<thead>
<tr>
<th>Spec</th>
<th>Actual</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Width - SS</td>
<td></td>
<td>Width - NS</td>
</tr>
<tr>
<td>Gumstrip - SS</td>
<td></td>
<td>Gumstrip - NS</td>
</tr>
<tr>
<td>Spool - SS</td>
<td></td>
<td>Spool - NS</td>
</tr>
<tr>
<td>OIL Scribe - SS</td>
<td></td>
<td>OIL Scribe - NS</td>
</tr>
</tbody>
</table>

### 1st 10 Min Quality Checks

<table>
<thead>
<tr>
<th>Are open splice detectors working at the splicer?</th>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are open splice detectors working before sizer?</td>
<td>Yes</td>
<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td>Are the bolt up detectors working at the sizer?</td>
<td>Yes</td>
<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td>Are poly detectors working?</td>
<td>Yes</td>
<td>No</td>
<td>N/A</td>
</tr>
</tbody>
</table>

### Product Run Quality Checks

<table>
<thead>
<tr>
<th>SS</th>
<th>NS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enter Angle</td>
<td>Enter Gumstrip Value</td>
</tr>
<tr>
<td>Enter Width Value</td>
<td>Submit</td>
</tr>
<tr>
<td>Enter Treatment Value</td>
<td>Submit</td>
</tr>
</tbody>
</table>

Sample screens
Development Tools

**Power Programming** is suitable for any Logix controller, including small memory sizes, and is useful for simple to moderately complex applications.

Modular programming technique with ready-to-use predefined templates and faceplates that are reusable results in shorter engineering time across machine portfolio.

Flexible production allows existing assets to be adapted to new product requirements with minimal time and capital investment. Ease of modular implementations to test software objects reduces development time (typically $\geq 50\%$).

Significantly less chance that new software modules or modification to existing software modules will adversely affect other unmodified modules. This encourages and facilitates continuous improvements while reducing the risk that changes can present.

Example of Power Programming on TBM
Faceplate/AOI sets bring the power of the Integrated Architecture™ to your system quickly and easily.

- Add a device, like a PowerFlex® drive, into a Logix controller project with ready-to-use tags.
- Utilize these tags with your controller code and HMI graphics via configuration following the downloading instruction.
- By implementing pre-programmed, pre-tested Faceplate/AOI sets for devices such as drives, networks, and I/O modules, you can configure, commission, and operate devices without the need to write a single line of code.
- Many diagnostic functions are included to assist with maintenance and troubleshooting of your system.

Mechatronics Tools and Electronic CAMs optimize servo-system hardware and motion cam profiles.

Motion Analyzer Virtual Design Tool links mechanics with controls. Analyze, optimize, simulate, and select in a virtual environment before committing to a final machine design.

Smooth and efficient profiles (optimized electronic CAMs) for axes movements

Motion Axis Complex Move - quickly generates absolute or incremental complex motion profiles from a given move distance and move time. Get Modified Trapezoidal, ModSine, Simple Harmonic Move (SHM), Cycloidal, Parabolic, and 5th Order Polynomial by using just one instruction.

Multi Servo-Loop Configuration - online update for servo loop configuration and provides: Position servo, Velocity servo, Torque servo, Dual feedback servo, Auxfeedback servo and Dual Command servo.
Summary

Tire manufacturing is a complex process. A misstep or improper procedure at any of these stages can threaten the structural integrity of the tire. Often times it is during the manufacturing process that issues occur, causing the tire recalls prevalent in today’s news.

By integrating control and information along with finite capacity scheduling, manufacturers can streamline their operations.

Significant financial savings can be realized, including achieving increased manufacturing throughput as well as benefits from greater visibility, tracking and control of operations.

Let Rockwell Automation be your solution experts in tire manufacturing. Helping your business succeed and grow is what we do best, with power, control and information services designed to give you a competitive advantage.

Our in-depth understanding of the policies and requirements affecting you can help you reduce business risk, improve operational efficiency and achieve faster time to market.

Let Rockwell Automation be your answer today!

Global Solutions – Locally Delivered

Whether you’re around the corner or around the world, our Services & Support network can provide the skills and resources you need to optimize performance and utilization of your automation equipment, helping you meet your business objectives.

- Global emergency support 24/7
- Offices and agents in more than 80 countries
- 35,000 distributors and agents
- 1000 service engineers, consultants and project managers worldwide
Customer Case Study

RRR Development Reduces its Machine Wiring Time by 20%, while Helping Tire Manufacturers Reduce their Maintenance Woes

RRR Development is one of the major contributors to the more than one billion tires manufactured annually. It designs and builds single, multi-stage and specialty tire machines for 34 tire plants across the globe.

After some failed attempts on various wiring methods that could help them assemble, disassemble and install their machinery faster, RRR Development approached Rockwell Automation to implement a distributed I/O architecture.

Results of Implementing a Rockwell Automation Solution

Reduced Designed Time

Architecture shortens build time by 4.8 days, enabling RRR Development to produce ten more machines per year, which equates to a USD $2.5 million sales increase annually. Plug-and-play wiring system minimizes wiring errors, as there are fewer points of failure.

Improved TCO for Tire Manufacturer

On-machine controls reduced junction box footprint by 25% by replacing bulky terminal blocks with pre-configured wire assemblies.

The modular wiring technique speeds troubleshooting to less than a minute, significantly reducing the risk of impacting the production schedule.

“We need the flexibility to build our machines in stages, as well as the ability to quickly assemble and disassemble it for shipping…”

RRD Development

With the Rockwell Automation On-Machine™ wiring technique, RRD Development was able to reduce:

- The wiring process from seventeen steps to six simple steps
- Machine build time by nearly five days, resulting in production of ten more machines per year, equivalent to $2.5 million increase in sales annually

RRR Development designed a revolutionary new machine the company refers to as the RRR First-Stage Tire Building Machine (TBM)
Customer Case Study

VMI Increases Speed, Precision and Safety with Servo and Linear Technology

VMI is the world’s leading supplier of machinery and services to tire manufacturers in radial passenger, light truck, all steel radial truck, bus tires and off-the-road (OTR) tires specializing in the technical rubber industry, tire industry, and tire retreading industry sectors.

After spending two years developing mechatronic machine concept, VMI introduced a new line of production machines named “MAXX” to double speed and gain multiple performance benefits.

The Rockwell Automation solution includes robotisation for component handling, such as removal of finished product; 22 servo drives for high precision positioning of the drums, cutting tools and conveyors; drives for tension control of the cap strip; and Allen-Bradley® GuardLogix controller for safety and motion control.

Results of Implementing a Rockwell Automation Solution

Reduced Cycle Time to 38 Seconds per Tire and More Than 80% Possible for OEE

From a cycle time of 50 to 60 seconds per tire, the new MAXX TBM does it in 38 seconds. The use of servo drives speed up the cycle time by controlling linear movement of the drums over the track. The combination of a short cycle time and the increase of Overall Equipment Effectiveness (OEE) results in a high output.

Fully Automatic with Balance of Productivity, Safety and Ergonomics

Robotisation takes over a portion of operator's tasks. Pre-assembly and body piles are applied automatically in a single, continuous motion. Many important parameters are recipe controlled, so the accuracy and repeatability are very good. Safety products and solutions were incorporated to ensure the safety of operators handling the machines.

Application Speed for Cap Strip Increased From 6 to 8m/s

For the Capstrip Tension Controller, the speed is doubled from 4m/s to 6m/s and in the new machine a speed of 8m/s has been achieved.

Winner of “Award for Innovation and Excellence”

MAXX machine not only helped VMI to attain an award at the Tire Tech 2009 trade fair in Hamburg, it also strengthens VMI’s top position in the market.
Resources

Call a Rockwell Automation sales office or an authorized distributor today or visit us online at: www.rockwellautomation/solutions/oem