Engagement central to the adoption of AI technolgies

Rockwell expert explains the processes and steps involved in implementation projects

Introducing artificial intelligence & machine learning (AI & ML) technologies at tire plants requires close engagement with everyone from process experts to plant managers, according to Mithun Nagabhairava, senior manager, data science & AI, Rockwell Automation.

As a major player in industrial automation & digital transformation for tire plants, Rockwell has gained a "deep understanding" of the industry and its manufacturing processes: establishing solid relationships with operators and managers at facilities worldwide.

Such collaboration, operational knowledge and experience is of the "utmost importance," believes Nagabhairava, noting the unique challenges presented by processes such as mixing, extrusion, calendaring, tire-building, curing, and final inspection.

For instance, he said, "hundreds of material compositions, intricate compound interactions, rheological properties of rubber, and dynamic production conditions can lead to inconsistencies in tire quality."

"Everything really starts with plants having to meet certain targets: whether it's reducing scrap, meeting production targets, achieving the right first-time quality, or addressing process challenges" Nagabhairava explained in an interview with *ERJ*.

Typically, he said, AI/ML projects focus on achieving optimal Mooney viscosity at mixing, consistent weight measurements closer to the setpoint at extrusion, reducing out-of-tolerance events on tire building machines, optimal vulcanisation properties at curing and automated defect detection at final inspection.

"So, we start with specific areas of the plant of greatest importance to customers, knowing that every bottleneck in every plant is slightly different," said Nagabhairava.

Projects usually begin with a Rockwell team going into the tire plant to gain an in-depth understanding of specific "pain points", existing OT-IT infrastructure, baseline performance, and target goals.

"We talk to the operators, to the process experts, as it all has to begin with engagement and gaining a thorough understanding of the current state."

The process typically involves workshops with the plant teams over several days: discussing the challenges they face and learning about the plant infrastructure and data capabilities.

"We involve experts from every area of the plant – mixing, extrusion, tire-building, curing, inspection etc – because we want to understand the equipment and how they operate," said Nagabhairava. "Then we engage topic-by-topic with specific experts to accurately define the problems we are trying to solve."

A key aim of this collaborative exercise is to decide on which areas to target, taking into account, for instance, the current maturity of OT-IT infrastructure, data availability, and constraints.

"Towards the end of the process, we identify priorities in terms of production challenges, taking into account factors ranging from data availability to the business value of applying AI/ML to particular processes," said the Rockwell expert.

When finalising our approach

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Machine vision

Traditional inspections relied on manual methods and sampling techniques to monitor product and material flow in extrusion, calendering, TBMs and final inspection.

Solution

Combination of 2D/3D cameras & sensing strategy was employed to capture product characteristics in real-time. Convolutional neural network models were trained in the Cloud and deployed for inference at the edge to detect defects accurately & faster than human inspections. Further augmented with closed-loop strategies to minimise defects.

Results

Automatic detection of defects, tire markings and DOT codes with >95% accuracy, resulting in a 50% reduction in inspection time.

High accuracies with determining the precise product characteristics and surface defects with extrusion, and detecting fabric wrinkles, skewness, perforations and joint lengths at TBMs.

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to deploying AI/ML capabilities, he added, "we create a use-case prioritisation matrix showing which projects we should do now for quick-wins, and which to target next, building out a multi-year execution roadmap, showing the targeted results."

Project buy-in

When it comes to getting buy-in from managers and operators on the shopfloor, the Rockwell manager said attitudes can range from being highly positive to sceptical, adding: "We equally respect both, because sometimes the sceptics are the people we have to learn from and earn respect from."

And, according to the Rockwell manager, when "you show you can solve problems and deliver tangible results "that gets the excitement going. That's a beautiful part of the journey because people then see how something real is being deployed and creating value for them."

So, once good results are demonstrated in the production environment, Rockwell translates that information into the language of the operators and experts for easier adoption and enables the plant teams to maintain the deployed solution.

According to Nagabhairava, the Rockwell team prides itself on showcasing results on the production floor, within a 12-to-16-week timeframe, depending on the scope.

"That way, everyone can fully understand the benefits of AI/ML, build trust with the technology in action and be an integral part of the journey," he said.

Asked about concerns over job losses, Nagabhairava said that rather than replace people, AI/ML supports them in the work they do. Operators often have an overwhelming number of tasks, from setting up the machines and materials to determining how to stabilise processes and maximise throughput.

Many organisations are focused on aggregating and showing the data on a dashboard. This, in turn, puts the onus on people to figure out what's happening, and then go fix any problems.

"Instead, AI/ML capabilities help to elevate the role of an operator from making repetitive manipulations to managing the performance of the machines, which they highly appreciate.

"So, they appreciate finding a partner who understands tires and tire machinery and can also introduce data science in a way that can be expressed in their language and equip them to achieve results at plant- and organisational-level."

According to Nagabhairava, the tire industry is now entering an "acceleration and scale-up phase" with the adoption of AI/ML technologies.

Some companies, he said, "are taking aggressive bets on advancing this quite rapidly, as these capabilities are truly adding value at tire plants. Certainly, today the top manufacturers are making AI mainstream in their plants and taking advantage of it."

And, concluded Nagabhairava, "there is an immense opportunity here for every tire manufacturer. The opportunity exists for everyone who's able to grasp the opportunities and are willing to collaborate and look really seriously into applying AI at plant and enterprise levels."

Extrusion complexity

Extrusion processes are inherently complex with repeated challenges to consistently achieve the target weight and width. This resulted in significant scrap during startups, and variations in product quality impacting downstream processes and tire uniformity metrics.

Solution

Designed & developed AI/ML capabilities using process knowledge to predict expected weight ahead of inline measurements.

Deployed the AI-enabled industrial control solution with adaptive control capabilities, which made real-time adjustments to line speeds, proactively correcting for weight and dimensional accuracy.

Results

Scrap reduction by over 50%-70% across various tire codes and mixes.

Enhanced uniformity evidenced 50% reduction in standard deviation, and thereby improving the strength and performance characteristics of the overall tire quality.

1 DISCOVER	2 DEVELOP	3 SCALE	4 SUSTAIN
Goal: Derive insights and models to determine technical feasibility and economic viability.	**Goal:** Develop robust adaptive control methods that can adjust the process autonomously in realtime.	**Goal:** Scale the capabilities to similar machines across all plants while supporting competency development.	**Goal:** Provide support for the maintenance of capabilities for continued best performances.
4-6 weeks	8-12 weeks	Rapid scale	Cost-effective
Key activities: • Project kick off and workshops • Exploratory data analysis • Preliminary predictive modeling • Defining the business value	**Key activities:** • Internal environment for development • Finalising the predictive model • Prescriptive model development • Supervising management capabilities	**Key activities:** • Stakeholder alignment • Rapid and collaborative rollout • Customising capabilities specific to each asset • Knowledge transfer and training	**Key activities:** • Model upkeep • Optimisation algorithm upgrades • Supporting plant teams for the most efficient operations

Recipe optimisation

In tire manufacturing, achieving the desired end-product characteristics relies heavily on recipe control setpoint values managed within the MES. Traditionally developed through labour-intensive trial-and-error methods and operator experience, these recipes often lacked adaptability and overlooked accumulated knowledge from runtime adjustments in production runs.

Solution

Utilised advanced control techniques to establish initial recipe values within the MES system, providing a reliable starting point for production while accommodating unknown systematic variations.

Developed golden recipes by enhancing existing set points and previously unadjusted control variables, considering the intricate relationships between equipment, product, and their recipes.

Results

Continuously adapted and improved recipes for the key equipment, materials, and products in the plant, led to significant contributions to intellectual property, enhanced product quality & operational efficiency.