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Developing a Strategy for Automated Chain Inspection

BorgWarner Inc., an $8.4 billion company headquartered in Auburn Hills, Michigan, is a global automotive industry components and parts supplier with sales of $9.8 billion in 2017.

A leading supplier in the transmission and powertrain segment, BorgWarner has an international presence, with more than 29,000 employees at 62 manufacturing facilities in 17 countries.

It is primarily known for its powertrain products, which include manual and automatic transmissions and transmission components, such as engine timing applications, electro-hydraulic control components, transmission control units, friction materials and one-way clutches, along with turbochargers and four-wheel drive system components. The company is divided into two groups, Engine and Drivetrain.

BorgWarner Morse Systems, also known as Morse TEC, is part of the Engine Group, which is responsible for research and development of the company's internal combustion engine-related components, along with operational effi ciency, including fuel consumption, emissions and performance.

A global technology leader for more than 130 years, BorgWarner Morse Systems delivers broad expertise and customized solutions for variable camshaft valve timing, chain-driven engine timing systems, and HY-VO drivetrain chains for front-wheel drive transmission and transfer case applications. With best-in-class simulation, testing and manufacturing capabilities, it partners with engine manufacturers and automakers to provide advanced technologies and award-winning innovations to improve fuel economy and reduce emissions, enhance performance and deliver integrated systems solutions.

BorgWarner Morse Systems has more than 2,800 employees globally and operates in 13 locations in seven countries. About 70 percent of the vehicles on the road have a Morse Systems product in them.

Morse Systems Arcore (MSA-Italy) manufactures timing system chains for the automotive market.

Above, L to R: Marco Sacchetti, Morse Systems Arcore; Anab Waris Rathore, MBA; Len Middleton, Ross School of Business; Austin Friedant, EGL: BSE & MSE-Mechanical Engineering; Fred Terry, College of Engineering; Stephanie Ewart, Morse Systems Arcore; Marco Miatto, Morse Systems Arcore

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"At the end of the automatic manufacturing assembly process there is a visual inspection of all chains performed by direct workers," said Marco Sacchetti, MSA manufacturing assembly supervisor. "This final inspection does not assure 100 percent the overall quality of the chain produced.

"Our business unit was trying to reduce the direct manpower applied to visual inspection due to three different reasons: cost reduction, low quality assurance given this human operation, and the high cost risk related to operational carpal tunnel disease.

"The visual inspection applied to chains can give some operators this disease due to repeated movements. In the last two years we had an increasing number of people that cannot do that operation anymore, or can only do it for a few hours a day. This can cause a lot of problems in terms of organization, costs, and overall standard quality."

Fred Terry
College of Engineering

Len Middleton
Ross School of Business

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In developing a strategy to eliminate this step in order to improve product quality, decrease inspection costs, and reduce ergonomic risk, BorgWarner Morse Systems brought in a student team from the Tauber Institute for Global Operations at the University of Michigan, consisting of **Austin Friedant**, a member of the Engineering Global Leadership Honors (EGL) Program, which leads to BSE and MSE in Mechanical Engineering degrees, and **Anab Waris Rathore**, pursuing a Master of Business Administration degree.

"The purpose of the project was to perform a feasibility analysis and provide a technical evaluation of automated inspection systems applied to timing chains in order to improve product quality through reducing visual inspection related claims, the ergonomic risk for operators in visual inspection, and the cost of the visual inspection process," said Sacchetti.

The Tauber team conducted a technological assessment of proposed solutions that could detect all defects currently found in visual inspection. Defect types were categorized based on the technologies capable of detecting them, and pilot studies of these technologies were completed. This included validating eddy current sensing to detect missing components and a feasibility study for Artificial Intelligence (AI) in chain inspection.

"MSA built a bench to perform all tests related to innovative technologies, and all economic evaluations and benchmarking were done by the Tauber team," said Sacchetti. "This bench was built to make chains run under different camera and lighting systems, take pictures and store them, and make chains run through an eddy current device to check for missing components. The eddy current system feasibility test was conducted 100 percent in house by the Tauber team, and this trial lasted one week."

According to Sacchetti, the most technically innovative aspect of the project was to prove the feasibility of AI applied to the final quality checks.

"AI technology is not applied in all Borg Warner groups and Morse Systems Italy was the first business unit to apply this tool" said Sacchetti. "Our customers always ask us to apply technology to our internal process to reduce quality issues, and developing an AI device to answer that question could give us a competitive advantage.

"AI can give a real benefit in terms of overall quality for our customers and internal manufacturing costs. AI was conducted in collaboration with a professor at the University of Pavia. The Tauber team performed all the necessary data sets to conduct the study, and the professor set the AI parameters to perform the trial and tests, and prove feasibility. This trial lasted more than two months."

Alongside technical development, an attribute study was conducted to establish the current effectiveness of visual inspection. These studies informed a recommendation around the system design of a future state, fully automated chain inspection system.

A comprehensive cost benefit analysis was conducted for a pilot assembly line, providing a robust decision-making tool for expanding automated inspection to other chain assembly lines. The cost analysis tool built in the possibility for an imperfect technical system to demonstrate the financial impact under different scenarios.

"This strategy was reduction cost driven," said Sacchetti. "The costs to be reduced were related to customer claims, head count and scrap rate reduction. The second strategy we are going to use is pre-sorting components by automatic equipment. This can reduce the cost of scrap from one finished chain to one single link."

In addition to financial considerations, a strategic approach was taken toward managing key stakeholders in the project. Outputs included a stakeholder map and

risk assessment capturing the concerns of key stakeholders. From this analysis, an engagement strategy was developed to manage high-priority risks.

Upon conclusion of the project, the Tauber team developed a roadmap for continued technical development in pursuit of fully automated inspection.

"The proposed solutions were testing new technologies applied to automatic final quality controls, such as eddy current devices and AI applied to chain images; using a consolidated solution integrated in the final process phase; and sorting parts before processing them," said Sacchetti.

In the immediate term, recommendations provided by the Tauber team can decrease inspection times by 33 percent, improve customer quality, and reduce ergonomic risk for visual inspectors. Furthermore, a strategy of process control recommended by the team can limit defective production and reduce scrap costs.

This project could potentially be expanded to seven additional global facilities. Moving from the single pilot line, the team provided recommendations for expanding automated inspection within MSA and to other global Morse Systems facilities.

"Once we are able to manage this new technology to check and sort images, we could expand this application to other manufacturing processes or start learning to use this concept to tune "live" some operating parameters to increase stability in mass production," said Sacchetti.

"We proved the feasibility of the new automated inspection system. In 2019 there will be the first chain assembly line ready to test the entire system in real mass production on a bushing timing chain. After results are consolidated, it will be extended to other chain assembly equipment and business units."

BorgWarner Project Team

Student Team
Austin Friedant–EGL (BSE/MSE Mechanical Engineering)

Anab Waris Rathore–Master of Business Administration

Project Sponsors
Ivan Meloni–Morse Manufacturing System Global Engineer

Marco Miatto–Manufacturing Engineer, Morse Systems Arcore

Francesco Rossato–Director of Operations, Morse Systems Arcore

Marco Sacchetti–Manufacturing Assembly Supervisor, Morse Systems Arcore

Faculty Advisors
Len Middleton–Ross School of Business

Fred Terry–College of Engineering

About Tauber Team Projects

Tauber 2018 Team Projects resulted in $564.4 million in savings according to sponsoring company calculations, an average of $28 million per project over 3 years. Each two to three person Tauber Team consists of graduate engineering and/or graduate business students. Along with receiving high-level corporate support from the sponsoring company, each team is advised by a College of Engineering and a Ross School of Business faculty member and overseen by a Tauber Institute Co-Director. The projects begin on-site in May and continue for 14 weeks. Students present the results of their projects and compete for over $40,000 in scholarships at the U-M Tauber Institute's annual *Spotlight!* event, held each September in Ann Arbor, Michigan. *Spotlight!* provides outstanding opportunities for students and corporate partners to establish relationships while exploring innovations in operations and manufacturing.

To learn more about the Tauber Institute for Global Operations, visit tauber.umich.edu or contact us at 734-647-1333.

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