

Industry Challenges for Capstone Edition-II

Industry Challenge No. 1

Image Processing of Casting Products

Sector- Image Processing/Machine Vision/Manufacturing/Industry 4.0

Background

In casting industries, ensuring dimensional accuracy and surface integrity of components is critical for product performance and customer satisfaction. Conventional inspection methods primarily rely on manual visual checks and basic measuring instruments. These methods are time-consuming, operator-dependent and prone to inconsistencies and human error. With increasing production volumes, maintaining uniform quality through manual inspection becomes challenging. Adoption of image processing and computer vision technologies offers a modern, reliable, and efficient approach to automated quality inspection.

Industry Problem Description:

The company seeks to implement an advanced image processing-based defect detection system capable of identifying flaws at their point of origin in the production line. By integrating high-resolution cameras, machine vision algorithms and real-time data analytics, the system will continuously monitor product surfaces and identify deviations from quality standards such as cracks, discoloration, shape inconsistencies, or surface irregularities. Industry want a ready-to-deploy solution that accurately identifies and segregates defective products based on the part specification provided in the drawing.

Industry Challenge No. 2

Stoving Alkyd Amino and TSA paints to be standardized.

Sector- Paints/Coating/Chemical

Background:

Paint manufacturing industries face multiple formulation and processing challenges that directly impact product performance and durability. Consistency in viscosity, film formation, storage stability and UV resistance are key quality parameters that determine the reliability of industrial and decorative paints. In alkyd- and amino-based systems, these challenges become more prominent due to complex resin interactions, solvent evaporation behaviour and pigment dispersion characteristics.

For stoving industrial paints (alkyd-amino systems), viscosity pick-up during storage or baking often leads to application inconsistency and poor surface finish. In TSA systems, sagging after baking causes uneven coating thickness and aesthetic defects. Synthetic enamel paints face issues like hard settling within a short storage period, making re-dispersion difficult and resulting in material wastage. Additionally, limited UV resistance in synthetic enamel paints leads to colour fading and surface degradation during prolonged exposure. Maintaining storage stability in alkyd-amino systems remains a concern, as variations in temperature and chemical compatibility of ingredients can alter the formulation balance over time.

Industry Problem Description:

The industry is facing several interrelated formulation and performance issues in its paint products. It seeks effective measures to control viscosity pick-up in stoving industrial paints (alkyd-amino systems), minimize sagging in TSA systems after baking and prevent hard settling in synthetic enamel paints within two months of packing. Additionally, the industry aims to enhance the UV resistance of synthetic enamel paints to improve their outdoor durability and to improve the overall storage stability of alkyd-amino systems. Addressing these issues will help achieve consistent paint performance, longer shelf life and superior surface quality in the final applications.

Industry Challenge No. 3

Reusability of FOM & LFOM - Fermented Organic Manure

Sector- Bioenergy/Organic Waste Management

Background:

The industry is engaged in the production of Compressed Bio-Gas (CBG) and Fermented Organic Manure (FOM) and Liquid Fermented Organic Manure (LFOM) are generated as by-products during this process. Both FOM and LFOM are currently seasonal products, with sales largely confined to specific months of the year. FOM is mainly sold between April and June, with smaller quantities in February and March, while LFOM is sold primarily from February to mid-June.

Despite daily production, the limited sales window leads to stock accumulation, storage challenges, and underutilization of production capacity. This seasonal demand pattern affects cash flow stability and limits overall profitability, even though production continues uninterrupted. There is therefore a strong need to explore strategies, product variants, or application markets that can support round-the-year sales and ensure sustained profitability, while efficiently utilizing the by-products from CBG production.

Industry Problem Description:

The industry seeks to develop and market economically viable, feasible, and market-acceptable products derived from FOM and LFOM that can be sold throughout the year. The moisture content in FOM is 77%, and in LFOM is 97%, which impacts storage, handling, and formulation. The objective is to maintain continuous production, expand market reach, and explore product diversification, formulation improvements, or new end-use applications that align with market requirements. This initiative aims to convert the by-products of CBG production into value-added products, reduce wastage, and ensure consistent revenue generation beyond the current seasonal constraints.

Industry Challenge No. 4

Automation of Pre-Shaping of Butyl Rubber Green Tubes Prior to Mould Curing

Sector- Automation/Rubber Processing/Industry 4.0

Background:

Butyl rubber green tubes are produced through an extrusion process in which hollow cylindrical tubes are continuously formed. These extruded tubes are cut into specific lengths and converted into circular form by joining their ends through a splicing operation. The spliced tubes are then manually mounted onto a shaper ring by operators and inflated with air to achieve a preliminary shape and to check for leakage. After pre-shaping, the tubes are removed from the shaper and placed into moulds for final curing. The current pre-shaping operation is entirely manual and heavily dependent on operator skill and physical effort.

Description:

The manual mounting and inflation of green tubes on the shaper ring requires significant physical exertion, leading to operator fatigue and ergonomic concerns. Additionally, manual handling introduces variability in tube positioning, inflation level, and shaping quality, which can result in defects and rejections during curing. The industry requires automated or semi-automated system for placing, holding and inflating spliced green tubes on the shaper ring in a consistent and controlled manner. Automation of this stage is expected to reduce operator fatigue, minimize process variations, improve dimensional consistency of green tubes, and enhance overall productivity and product quality.

Industry Challenge No. 5

Live Monitoring of Machines

Sector- IoT/Automation/Industry 4.0

Background:

In modern manufacturing environments, achieving high productivity and minimizing machine downtime are critical to maintaining competitiveness. Traditional monitoring methods often rely on manual data collection and delayed reporting, which limits the ability to respond quickly to equipment issues. With the advancement of Industry 4.0 technologies, real-time machine monitoring systems have emerged as a powerful tool to enhance operational transparency and efficiency. By integrating sensors and IoT-enabled devices, industries can continuously track machine health, performance and utilization through a centralized dashboard.

Industry Problem Description:

The industry intends to upgrade its existing machines by implementing a real-time machine monitoring system that provides instant visibility of operational performance through a centralized digital dashboard accessible via web and mobile devices. Currently, machine status and production data are monitored directly from individual PLC screens, and production records are maintained manually, which limits real-time oversight, data accuracy, and traceability. The proposed solution should enable online viewing of PLC running status on mobile devices, centralized storage of production data for review and analysis and live monitoring of machine progress. By leveraging real-time data acquisition and analytics, the system will facilitate early detection of anomalies, support proactive maintenance, reduce unplanned downtime, enhance overall equipment effectiveness (OEE) and streamline production workflows, ultimately improving efficiency and lowering operational costs.

Industry Challenge No. 6

Die resurfacing /surface analysis for life improvement

Sector- Manufacturing/Coating/Surface Engineering

Background:

SAE 2714 steel dies are being resurfaced by welding and machining, but the current practice yields poor die life. The alloy's high hardenability promotes martensitic microstructures and substantial internal stresses during thermal cycles. When resurfacing filler metals do not closely match the base-metal properties, or when post-weld heat treatment (PWHT) is inadequate, the welded zone develops high residual stresses and brittle phases that accelerate cracking and premature failure. Additionally, filler-metal compositions are not always disclosed by suppliers, making it difficult to select compatible consumables without testing.

Industry Problem Description:

Resurfaced SAE 2714 dies are failing prematurely due to filler-to-base metal mismatch and elevated residual stresses from welding and service thermomechanical cycles. The

uncertainties in filler composition and improper PWHT are producing martensitic structures and stress concentrations that reduce die life. The industry needs a systematic approach to (a) identify or verify filler compositions (e.g., supplier engagement, spectrometer or EDS-SEM analysis), (b) select fillers with closely matched mechanical and thermal properties and (c) develop optimized PWHT and welding procedures to minimize residual stresses and brittle microstructures thereby significantly improving resurfaced-die performance and service life.

Industry Challenge No. 7

Fatigue and failure analysis of Camshafts

Sector- Fatigue & Failure Analysis/FEM

Background:

Camshafts are critical rotating components in internal combustion engines, directly influencing valve timing and overall engine performance. Due to their continuous operation, camshafts are subjected to cyclic stresses and contact wear over billions of cycles. Fatigue failure or excessive wear can lead to engine inefficiency, breakdowns and costly maintenance. As such, ensuring long-term durability through validated fatigue performance and tribological properties is essential for product reliability and competitiveness in the market.

Industry Problem Description:

The industry aims to certify the fatigue life and wear resistance of its camshafts to guarantee performance over billions of operational cycles. Achieving this certification would not only enhance product reliability but also serve as a key marketing advantage over competitors. The company requires accurate testing, analysis and validation methods to demonstrate that its camshafts can withstand long-term cyclic loading while maintaining minimal wear under operational conditions.

Industry Challenge No. 8

Compact Air Pollution Control Devices

Sector- Air Pollution Devices/Cleaner Technologies/Emission Control

Background:

Industrial air pollution control systems are critical for maintaining environmental compliance and workplace safety. Traditional devices, however, often require large installation spaces and substantial structural support, limiting their applicability in facilities with space or height

constraints. There is growing demand for compact, high-performance air pollution control solutions that can deliver the same filtration and purification efficiency while occupying significantly less space. Advances in materials, design optimization and process engineering provide opportunities to miniaturize these systems without sacrificing performance, enabling broader adoption across various industries.

Industry Problem Description:

The company aims to develop compact air pollution control devices that maintain efficiency and functionality while significantly reducing their physical footprint. The goal is to optimize design, materials and process engineering so that these systems can be installed in industries with space or height limitations without compromising performance. This miniaturization will improve feasibility, adaptability and operational efficiency, facilitating easy integration into existing setups, especially where conventional large-scale systems are impractical.

Industry Challenge No. 9

Development of Cost-Competitive Indigenous Technologies for Recycling Post-Consumer Garments into New Textile Fibres

Sector- Textile Recycling/Circular Economy

Background:

The textile industry generates substantial volumes of post-consumer garment waste, creating significant environmental and resource-efficiency challenges. In response, several advanced textile-to-textile recycling technologies both mechanical and chemical are emerging globally. While these technologies demonstrate technical feasibility, they are often capital-intensive, energy-heavy and economically viable only with subsidies or premium pricing. As a result, recycled fibres remain significantly more expensive than virgin fibres, limiting large-scale adoption.

For circularity to be mainstreamed, the industry requires indigenous recycling technologies that are not only environmentally sustainable but also commercially viable at scale. Producing recycled fibres that can economically compete with virgin fibres is essential for widespread industry acceptance and long-term impact.

Industry Problem Description:

The industry seeks to develop indigenous, scalable, and resource-efficient recycling technologies that can convert post-consumer garments into high-quality fibres suitable for new textile manufacturing, at a cost that is price-neutral or near price-neutral to virgin fibres. The proposed solution must recover fibres with adequate length, strength, and consistency for spinning and fabric formation. It should be compatible with existing textile

manufacturing infrastructure. It must also be capable of efficiently processing blended and contaminated post-consumer garments, minimizing energy, water and chemical consumption throughout the recycling process. Importantly, the technology should achieve economic viability comparable to virgin fibre production, without dependence on long-term subsidies.

The objective is to enable true textile-to-textile recycling by transforming post-consumer waste into a dependable, competitively priced fibre feedstock. This initiative aims to reduce dependence on virgin raw materials, strengthen domestic technological capability, and accelerate the transition to a circular textile economy.

Industry Challenge No. 10

Involvement of Image processing in Quality process.

Sector- Images Processing/Industry 4.0

Background:

In the automotive and manufacturing sectors, Noise, Vibration and Harshness (NVH) testing plays a critical role in ensuring product quality and performance. Conventional NVH evaluation methods primarily depend on sensor-based data acquisition and analysis to identify mechanical or acoustic irregularities. However, several NVH-related issues often originate from visual or physical defects such as surface irregularities, improper component alignment and assembly inconsistencies, which may not be fully captured by sensors alone. Integrating image processing and computer vision techniques into NVH testing can provide a complementary, objective and real-time layer of quality assurance. This approach can strengthen defect detection accuracy, reduce human dependency in inspections and enhance the overall precision of quality control systems.

Industry Problem Description:

The company aims to integrate image processing technologies into its NVH quality assurance workflow to improve defect detection and process control. The challenge involves capturing, analyzing and interpreting visual data to identify surface anomalies, misalignments, or assembly inconsistencies that may contribute to NVH performance deviations. By combining visual inspection with traditional sensor-based testing, the company seeks to enhance product reliability, minimize subjective assessments and create a more data-driven, automated quality assurance system.

Industry Challenge No. 11

Experimental verification of the Eigen Mode data generated during FEA

Sector- Finite Element Modelling (FEM)/ Simulation/Computer-Aided Engineering (CAE)

Background:

In the field of Noise, Vibration and Harshness (NVH) engineering, Finite Element Analysis (FEA) is widely used to predict the dynamic behavior of components and assemblies during the design stage. These simulations provide valuable insights into natural frequencies, mode shapes and potential resonance conditions that influence product performance. However, simulation accuracy depends heavily on model assumptions, material properties and boundary conditions. To ensure that FEA predictions accurately reflect real-world behavior, experimental validation through physical testing such as modal analysis is essential. Such correlation between simulated and measured data strengthens confidence in the digital models and enables more effective design optimization for vibration and noise control.

Industry Problem Description:

The company aims to experimentally validate the eigen mode data generated through Finite Element Analysis (FEA) as part of its ongoing NVH investigations. This validation process involves confirming the accuracy of predicted natural frequencies and mode shapes using modal testing and related experimental techniques. The objective is to ensure that simulation results reliably represent actual dynamic behavior under real operating conditions. Successful validation will enable the company to refine its FEA models, enhance simulation reliability and achieve improved product design and NVH performance.