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OVERALL QUALITY EFFECTIVENESS (OQE): A HOLISTIC QUALITY METRIC IN MANUFACTURING

The famous asset utilisation metric – Overall Equipment Effectiveness (OEE) has regained significant traction amongst the industry leaders with the accelerating Industry-4.0 (I4.0) in the last decade. CEOs look for OEE trends during the manufacturing plant performance review process. Its application is justified not only for its simplicity but also for the reason of high capital investment and stretched Return on Investment (ROI) targets in the technology-driven I4.0. It requires tracking of the overall utilisation of the equipment. OEE has three simple elements: Availability of the equipment, Performance of the asset in terms of production output, and Quality of the product produced. The OEE measure is arrived at by the product of the three metrics. The higher the value (close to 100%), the better the performance with benchmarks of > 95% in the current smart factories. The current technology-driven digital shop floor proactively ensures the uptime of equipment. Furthermore, automation and AI facilitate near-perfect output performance. Quality standards continue to target error-free six-sigma levels.

A continuously improving Quality culture continues to be on the radar of CEOs. Therefore, the objective is to develop a simple and holistic quality metric to measure and track improvement trends and facilitate bridging gap areas in smart manufacturing. The manufacturing ecosystem can be categorised into three broad quality buckets – the customer bucket, the manufacturing process bucket, and the design bucket. The customer bucket spells out the customer's expectation of conformance through error-

free products. The manufacturing process bucket comes from the adherence to the manufacturing process/ system parameters, like speed, temperature, pressures tooling, jigs, fixtures, preconditions, operator cares, and many other preconditions. The design bucket consists of a robust design with zero changes after a comprehensive design tool application in the design stage.

The three quality buckets together provide the overall quality status of the industry. The customer is delighted by using an error-free product that conforms to the robust manufacturing process and robust design. A product with poor design will be of low quality even after quality control/ assurance success. Hence, all three elements together will create a healthy quality culture. Improvement in each quality bucket shall improve the overall quality culture. This results in the development of a simple index- Overall Quality Effectiveness (OQE) which can be computed as

OQE = Product-quality X Process-quality X Design-quality
= Fraction of error-free products at customer-end
X Fraction of conforming manufacturing processes
X (1- Fraction of design changes on designs reviewed)

The multiplier impact of the three elements, like in OEE, is also severe on the OQE value. Even with high values of 98%, 97%, and 100% of the three elements, the OQE is only 95%. However, in the current technology-driven smart factories the benchmark OQE will hover around 1.

In smart factories which are supported by the state-of-the-art building blocks- Industrial internet of things (IIOT), Additive manufacturing processes, Autonomous robotics, Artificial intelligence (AI), Big data analytics, Radio frequency identification (RFID), Cloud computing, Lean systems, Cyber-physical space (CPS), and System digitisation, the high value of each of the three elements of OQE is imperative. The low intervention of human factors in routine activities, interactions between machines, processes & material, human-like intelligent decision-making by machines/ equipment, large data capturing and quick simulation for decision making, application of sensors & actuators, use of optical sensors for quality assessment, and visibility of product condition through the industry 4.0 application is expected to take quality to the next higher level and make it a non-issue.

In traditional manufacturing factory quality issues emanate from human errors from fatigue, malfunctioning of machines/ equipment, error-prone manually handled set-up changes, faulty material movements, reactive manual response to process changes, scalability issues, weak design for manufacturing, and many more. The I4.0 technologies of IIOT, Robotics, AI, RFID, Lean, and many more are creating a very positive impact on product quality.

In summary, the OQE index can serve as an effective metric for industry leaders to track the progress of the quality culture. The analyses of the scores of the three buckets would make a significant improvement in the quality culture. Further, a drill-down of the causes for the low-value scores by the three sub-indices will expose issues for auctioning for improvement. During the transition from traditional manufacturing to the technology-driven industry this set of indices will be a useful facilitator. Such indices are computed by the formal routine audit system by the Quality assurance department.