cover story

It's all about 5 star quality

Todd O'Neal and Jay Park, TMEIC Corporation, USA, provide a Japanese view of lean manufacturing methods, and explain how excellence in manufacturing can assure reliability.

LNG facilities are among the largest and most complex facilities requiring hundreds of thousands of small and large components, systems, processes, and controls that must work flawlessly, simultaneously to achieve the necessary efficiencies for profitable operation. Additionally, each component and system must operate without failure for many thousands of hours or even years. Piping, compressors, pumps, electrical equipment, controls, heat transfer systems, safety/environmental systems, and all other operational systems must function as designed, or the process slows or comes to an abrupt halt. In the worst case, far less than desirable and extremely unsafe 'rapid unplanned disassembly' may occur. How can we be assured large systems will run reliably and not 'disassemble?' We cannot. That is, not as a single machine. Instead, we commonly deconstruct the composite machine and then consider the reliability of individual systems and components. A component-level




individual parts are closely looked at, then the machine is reconstructed statistically to arrive at the expected behaviour of the overall system. The individual systems and components operating without failure combine to form a successful assembly. When designed and manufactured precisely in conformance with a well co-ordinated process, these individual systems and components provide the greatest potential for total system success. Through long-term incorporation of quality processes during the design and manufacturing phases, engineers can achieve this component and subsequent recombined equipment level success. In a deconstruction and reconstruction method similar to FMEA for the calculation of reliability, techniques in manufacturing focus on the individual steps of manufacturing at the component and assembly level such that equipment designed to be reliable actually ends up… reliable. Total quality management or lean manufacturing is the common path forward to manufacturing excellence.

The fundamentals of quality management

Quality management is far older than one may think and has evolved over many centuries. As far back as medieval times, craftsmen developed rules for making better common products or weapons. The craftsmen would affix their mark to a product indicating they had completed their work and were satisfied with the quality. The feedback process was not as immediate then, but in time the message would get back to the part's maker, and improvements could be made. Later, inspection by dedicated individuals was added as a process during the industrial age. In this period, a few workers with great experience and ability in their craft would inspect the work of many. Any anomalies were addressed directly between the craftsperson and the inspector, but the process was less than formal, and documentation was generally lacking. Dividing labour into individual crafts and then subdividing the craft groups into smaller efforts further enhanced product quality in the workforce. Specialisation of labour provided a greater level of skill at each task, furthering each product's quality.

Figure 1. Clean, ordered assembly area.

In the late 1930s and 1940s, the quality effort became a critical component of the war effort. It marked the first time organisations worked with their suppliers and sub-suppliers to support quality at the sub-system and component level. Following World War II, quality pioneers such as Deming and Juran introduced total quality systems in which inspection was combined with process improvement and focused training to rapidly improve manufacturing precision and expertise. This total quality approach also resulted in reduced cost of manufacturing. Process changes were not rapidly adopted, nor were requests passively accepted, yet finally, cultural changes came about. Eventually, statistical methods and analysis were combined with the focus on the entire organisation. In the 1950s this became known as total quality management (TQM) and companywide quality control (CQC) or quality management system (QMS). Today, these systems form the backbone of modern global quality systems. Systems such as ISO 9000 are now the basis of acceptance for most industrial users. Nowadays, the ISO system is generally accepted as the gold standard for quality certifications. The general mantra for ISO is "say what you do, do what you say." Each ISO-certified company must document and implement their own quality programmes and require sub-suppliers to maintain quality programmes of their own. This way, manufacturers can be assured components received can be assembled into a product worthy of branding. ISO and other certifications are often combined with assessments, audits, and actual experience to arrive at an overall product assessment.

In the 1940s, decimated by the war in the Pacific, Japanese manufacturing was at an all-time low with respect to output and quality. Japan would have had great difficulty recovering quickly by itself. Japanese and US leadership both understood that to recover more efficiently, Japan needed to embrace a new paradigm. The new paradigm was total quality. With the additions of total quality systems, and the consulting support of quality innovators such as W. Edwards Demming, Japanese manufacturing rallied to recover quickly. Soon, US manufacturers found themselves looking to Japanese companies for guidance in processes that were best in class in quality and manufacturing expertise. By embracing the process of total quality, Japanese manufacturers developed and improved upon the innovative post-war quality philosophy and excelled. Japanese manufacturing came to define quality – a reputation that continues to this day.

Excellence in manufacturing

TMEIC is a Japanese company and a global manufacturer of high-power electric motors and power electronics, including variable frequency drives and utility scale inverters for solar power producers and world-class industrial automation systems for a variety of industries. The company utilises total quality management and adds additional Japanese concepts to arrive at its own form of total quality management. This system is used throughout the company to achieve manufacturing excellence. The company recently opened one of the newest manufacturing centres in the US, in Katy, Texas. TMEIC understands that quality is best achieved by closely combining technological innovation and continuous improvement philosophies.

The local quality team in conjunction with headquarters in Tokyo, Japan makes sure the quality systems are both consistent and relevant. The operations and quality teams work daily to ensure the company processes are on par with best in class standards. Luis Padilla is Operations Director at the company's Texas facility. Luis claims TMEIC's focus on quality is not just a local goal. "We train on and share our quality programmes and methods with our companion facilities in Japan and India and around the world." TMEIC uses a variety of well-developed process tools to ensure excellence in manufacturing. Many of these methods have been modified to incorporate a distinctly Japanese flavour.

Continuous improvement

TMEIC practices Kaizen. Kaizen is a Japanese term meaning continuous improvement. The word is formed from two words, 'kai' meaning change and 'zen' meaning good. Kaizen is a statistical process introduced by the Toyota Company in 1980 and is now used around the world. In the Kaizen model, employees are empowered to present ideas when common problems are encountered. The goal is to eliminate the reoccurrence of non-conformances. This concept is the core of the Kaizen strategy. Managers know a highly engaged workforce is one that understands that their opinions matter. Meaningful change is the result. The process of Kaizen is implemented through four primary actions of the team; plan, do, check, and act. Objectives are planned, and methods are defined. Much effort is placed on this planning phase. No work is started before the plan is complete and understood by all. Strategies are implemented based on the plan. Deviations are not acceptable. Results are then evaluated for improvement and adjustments are made as needed. This feedback step is paramount. Employees participate in the quality control process and receive feedback on how they are contributing to improve the quality of the company's products. Assemblers have different levels of skills, from level one to five, specific to a particular assembly line and are assigned accordingly. Employees receive periodic training and the company requires assemblers to pass national skills tests to move up to the next level. Quality and reliability are improved by a motivated and highly skilled workforce. The result is reduced processing time, inventory, waste, unnecessary motion, excess transportation, and product defects. Kaizen is the purposeful path to high-quality, highly reliable products. Additionally, all Texas based manufacturing managers at the company are required to make multiple extended trips to Japan to train in quality practices including Kaizen.

Another tool used by the company is termed the 5S's. The 5S's of manufacturing are taught to all employees and followed each day. The 5S's are: sorting, setting, shining, standardising, and sustaining. These 5S's are fundamental to efficiency and repeatability in manufacturing operations.

- S1: (Seiri) Workers sort necessary items from unnecessary items and dispose of the unnecessary pieces immediately. A designated person is responsible for determining the items to be disposed of.
- S2: (Seiton) Items are clearly marked and placed in order of installation. The items are then installed in this order every time. All parts, tools, and cleaning equipment have fixed locations. Once a task is complete, the tools are replaced to their designated locations before the next step is initiated.
- S3: (Seiso) Work areas are cleaned continuously. All cleaning equipment is provided, and mandatory cleaning points are defined in the workflow.
- S4: (Seiketsu) Standardise and maintain the first three S's. Time for evaluation by supervisors is established. If non-conformances are discovered, they are addressed immediately.
- S5: (Shitsuke) Observe and follow the rules. All employees are expected to practice mutual attention to detail.

The purpose of the 5S's is to reduce waste, injuries, failures, defects, complaints, and delays.

Waste is a tightly monitored and evaluated quantity. Waste is created when there is an instance of careless or extravagant use or use without purpose. There are a variety of categories of waste, all of which can be placed into seven groups in lean manufacturing. The waste categories are processing, inventory, over-production, waiting, motion, transportation, and defects. Unchecked, the seven wastes will occur increasingly if the process is not controlled. However, the seven waste categories are reduced greatly using the concept of Muri, Muda, and Mura. These concepts are interrelated with each affecting the other. Muri (unreasonable workload) are wastes that can be remediated by the elimination of excessive or strenuous movement or thought. Muda (loss of time and effort) are wastes reduced by eliminating movement of parts, waiting, and searching. Mura (inconsistent work) is waste decreased by eliminating or reducing sudden changes to workflow or instructions.

Quality from the start

Reliable components, built with excellence in manufacturing, using TQM or lean manufacturing techniques, are the direct path to reliable machines for highly complex systems such as LNG facilities or other industrial complex. The lack of high quality, high precision, highly planned processes in manufacturing will lead to failure of components. Failure is intolerable and highly detrimental to the availability of the facility overall. Furthermore, the quality process and the process of continuous improvement are fundamental to success in manufacturing. Does the use of a total quality process necessarily dictate a zero-defect product? No, it does not. But, minimisation of random and systemic non-conformances in the engineered processes will minimise defects at the component level and will benefit the greater system.

Quality in manufacturing cannot be left to chance. Quality is not something that can simply be hoped for. Total quality management works well and provides the greatest impact in companies with a long-term vision. Feedback and adjustments are always necessary, and the expertise gained in each iteration adds to organisational wisdom.

In the end, the component or equipment manufacturing organisation is not the only beneficiary. The end user will also derive significant benefit when all of the associated component and equipment manufacturers implement well-considered quality management systems. LNG