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Quality 4.0 and Welding in Digital Era

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Abstract

Today, the time has come, when we are totally tied with digital world and our lifestyle is mostly dependent on it, and Quality is no exception. Over the last 50 years, welding technology has undergone a phenomenal change because of efforts made in global exchange of information and research. Quality Management in welding also changing from its conventional method to Quality 4.0. During last 100 years or so, Quality has changed from Inspection concept to today's smart manufacturing. Quality 4.0 is referenced the future of quality and organisational excellence within the context of Industry 4.0, hence emphasized on digitisation and machine learning etc., where Artificial Intelligence has a major and vital role. The innovation of Industry 4.0 revolves around the cyber physical systems, creating the smart factories, where modern technologies are used in smart production, smart services, and smart energy. The final arbiter of weld quality is no longer just the eye of the welder or weld engineer overseeing the process. We can have total digital control over welding, and it can be controlled from anywhere through software, sitting far away from the actual workplace . We can now be able to produce top quality products, controlling every hold points properly through digital aids. The data feedback assures that the weld conforms to the established WPS. In this Quality 4.0, Inspection and Quality Control to be done mainly through automated visual inspection system, in process gauges and Artificial Intelligence based evaluation. Remote inspection also will be very much helpful to avoid in person contacts.

Key words: Quality 4.0, Quality Management, Inspection, digital control, smart factory, Artificial Intelligence.

1.0 PREFACE

Today, the time has come, when we are totally tied with digital world and our lifestyle is mostly dependent on it. Quality is no exception, be it quality control or quality assurance, we must go hand in hand with digital world, which is Quality 4.0. Before entering deep into Quality 4.0, let us start with the basics.

Each and every organization must have some goal, which is the Vision. Again, every organization must have some strategy to achieve that goal, which is the Mission. To execute this strategy is quite impossible without managing the Quality. This 'Quality' is the ultimate goal our life today, and welding is no different from this.

2.0 RADICAL SHIFTING OF WELDING LANDSCAPE

Over the last 50 years, welding technology has undergone a phenomenal change because of efforts made in global exchange of information and research. These changes have led to adoption of higher productivity processes with consistent quality, safety and improvements of work environment and have also contributed to raising welding technology to a level where it is today.

Several new processes have been developed or the erstwhile processes have been upgraded. Simultaneously, welding power sources have been upgraded and modified for specific purposes and advantages.

Quality Management in welding also changing from its conventional method to Quality 4.0.

3.0 WHAT IS QUALITY?

The definition of quality as per ISO 9000 is - Degree to which a set of inherent characteristics of an object fulfils requirements. Which is the totality of features and characteristics of a product or service that bears its ability to satisfy stated or implied needs. It is about meeting the needs and expectations of customers.

3.1 Why Quality?

- Conformance to specifications
- Fitness for use / purpose
- Value for price paid
- Support services
- Etc., etc...

Image courtesy: Hodgson Sealant

And finally, the Customer Satisfaction.

3.2 Quality Control in Welding

To ensure the proper quality of welded product and to optimize manufacturing cost, the whole welding process must be controlled from the very start. To take all welding quality affecting aspects into consideration, the welding shop is recommended to implement a quality assurance system. The standard ISO 3834 sets out requirement for manufacturers to meet, in order to apply good practice to their welding operations.

There are several steps in a Welding Quality Assurance; to make sure the welding shop has competent welders, there are standardized ways to test them through written welding instructions and/or so-called Welding Procedure Specifications (WPS), in order to increase the possibility of consistent quality. The WPS must be qualified, i.e., the WPS has to be based on a PQR or WPQR, Welding Procedure Qualification Record. The WPQR explains that, if you follow the WPS, you will have a good chance to weld a joint with the expected properties.

3.3 Cost of Quality (CoQ)

Cost of quality is divided into two parts - Cost of conformance and cost of nonconformance.

Again, cost of conformance includes Preventive costs (to build a quality product) and Appraisal costs (to assess the quality); which are -

Preventive costs:

a. Training
b. Document processes
c. Equipment
d. Time to do it right

Appraisal costs:

a. Testing
b. Destructive testing loss
c. Inspection

3.4 Prevention over Inspection

It is evident that we have to take care of quality and the cost of quality should be within the cost of conformance; this is possible only when we can think of prevention over the inspection.

Image courtesy: Pngwing

Quality should be planned, designed, and built into — not inspected into the project's management or the project's deliverables.

The cost of preventing mistakes is generally much less than the cost of correcting mistakes when they are found by inspection or during usage.

3.5 Evolution of Quality

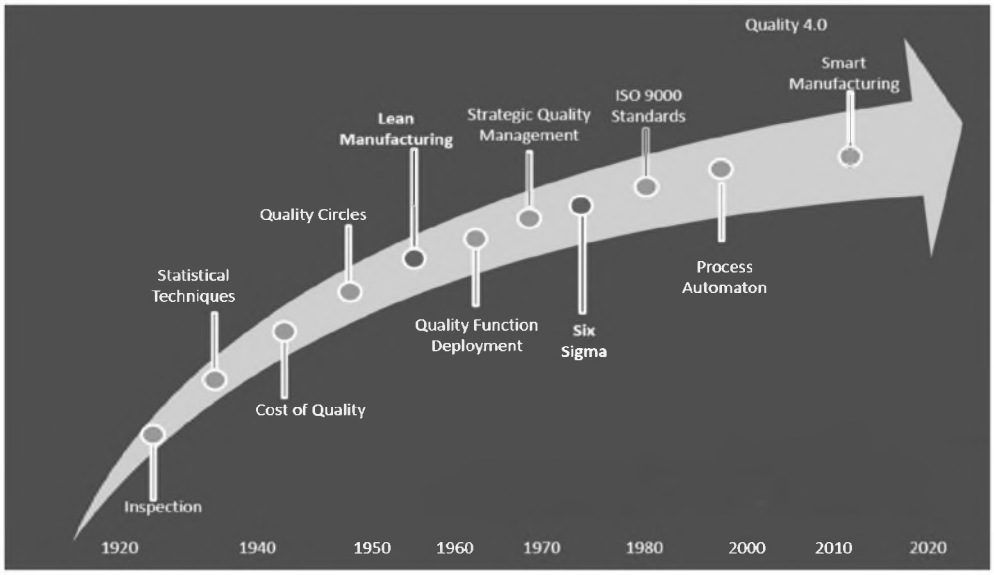

Image courtesy: Sameer Kumar, Trainer, Quality Council of India

The real evolution of quality has started around 100 years back with the implementation of inspection in early 1920s. Then introduced statistical quality control, lean management etc. step by step till 1987, when ISO 9000 introduced for Quality Management Systems for the first time. It was based on the BS 5750 series of standards from BSI that were proposed to ISO in 1979. Now we are in the digital era with smart manufacturing, and also in the era of Quality 4.0.

3.6 Quality Concepts

Quality 1.0:

- Quality is assured through measurement and inspection
- Production volume is emphasized rather than quality

Quality 2.0:

- Maximize productivity is the primary focus
- Adhere to standards just to meet the minimum quality level

Quality 3.0:

- Quality is business imperative
- Customer satisfaction is emphasized
- Continuous / continual improvement
- Stabilizing highly efficient processes
- Standardization like ISO 9001

Quality 4.0:

"Quality 4.0" is a term that references the future of quality and organizational excellence within the context of Industry 4.0.

Concepts of Quality 4.0:

- Digitization is used to optimize signal feedback and process adjustment
- Shifts control-oriented focus from process operators to process designers
- Machines learn how to self-regulate and manage own productivity and quality
- Human performance shifts from productivity to system design and integration with business system

In short, Quality 4.0 is Connectedness, Intelligence and Automation - for discovering insights into performance.

3.7 Eco system of Quality 4.0 Tools

The Quality 4.0 tools below should be leveraged to alleviate challenges when implementing and deploying systems to support digital transformation:

- **Artificial intelligence:** Computer vision, language processing, chatbots, personal assistants, navigation, robotics.
- **Big data:** Managing and analyzing large data sets without having to use supercomputers, MapReduce, Hadoop, Hive and NoSQL databases.
- **Blockchain:** Increasing transparency and auditability of transactions (for assets and information), monitoring conditions so transactions don't occur unless quality objectives are met.
- **Deep learning:** Image classification, complex pattern recognition, time series forecasting, text generation, creating sound and art, creating fictitious video from real video, adjusting images based on heuristics.
- **Enabling technologies:** Affordable sensors and actuators, cloud computing, open-source software, augmented reality (AR), mixed reality, virtual reality (VR), 5G networks, IoT.
- **Machine learning:** Text analysis, recommendation systems, email spam filters, fraud detection, classifying objects into groups, forecasting.
- **Data science:** The practice of bringing together heterogeneous data sets for making predictions, performing classifications, finding patterns in large data sets, reducing large sets of observations to most significant predictors, applying sound traditional techniques (such as visualization, inference and simulation) to generate viable models and solutions.

4.0 WELDING PROCESS: SMART FACTORIES & SMART FACTORS

The innovation of industry 4.0 revolves around the cyber physical systems (CPS), i.e., systems that can connect the digital world with the physical one optimizing results, thanks to continuous data analysis.

The economic outlook is one made of smart factories where modern technologies are used in:

- **Smart production** - people and tools work together
- **Smart services** - digitization improves connections between companies, suppliers and customers
- **Smart energy** - less consumption and greater care for the environment

The software applied to 4.0 welding machines are designed to increase welding efficiency, whether it is done by a robot, or a human operator.

The concept of synergy is very clear when we think of a welding machine helping an operator identify the best settings for MIG or TIG welding.

The automation of work processes and the smart management of orders and materials enable creating made-to-order products for the customer.

5.0 MANUFACTURING INTELLIGENCE SOLUTION (MIS)

Manufacturing Intelligence Solutions are supporting the industry through -

A. Performance Management:

- Plant equipment OEE (Overall Equipment Effectiveness)
- Real-time manufacturing plant information
- Measure and improve performance
- Increased Production capacity
- Decreased manufacturing & overhead costs
- Deferred capital expenditures
- Empowered continuous improvement
- Improved Time to Trend

B. Notifications & Reports

- Connect & View to any plant floor device or system
- E-mail & Mobile alerts
- Ease to Create and publish data

C. Maintenance Management

D. Remote Diagnostics

E. Energy Management

F. Asset Management

Image courtesy: Hugo Britt, Thomas

6.0 DIGITAL CONTROL IN WELDING

- Power sources are controlled by microprocessor
- All welding characteristics are created in programs
- The capability lies with the software
- Continual adjustment from real data & command data
- Perfectly synchronized communication system between power source & peripherals

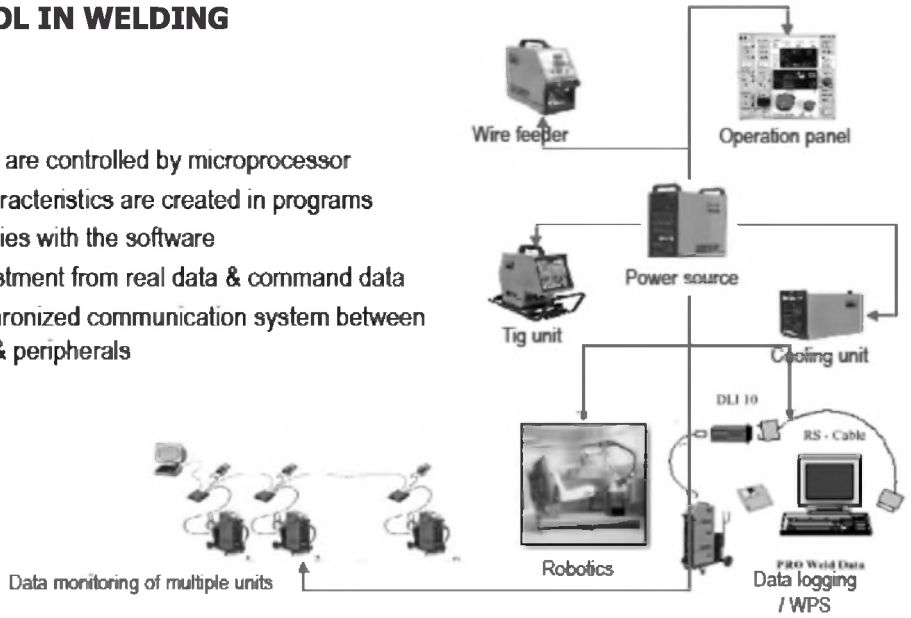

Image curtesy: Devasis Paul, Nextgen Plasma Pvt. Ltd.

6.1 Wireless Data Gathering System (schematic diagram)

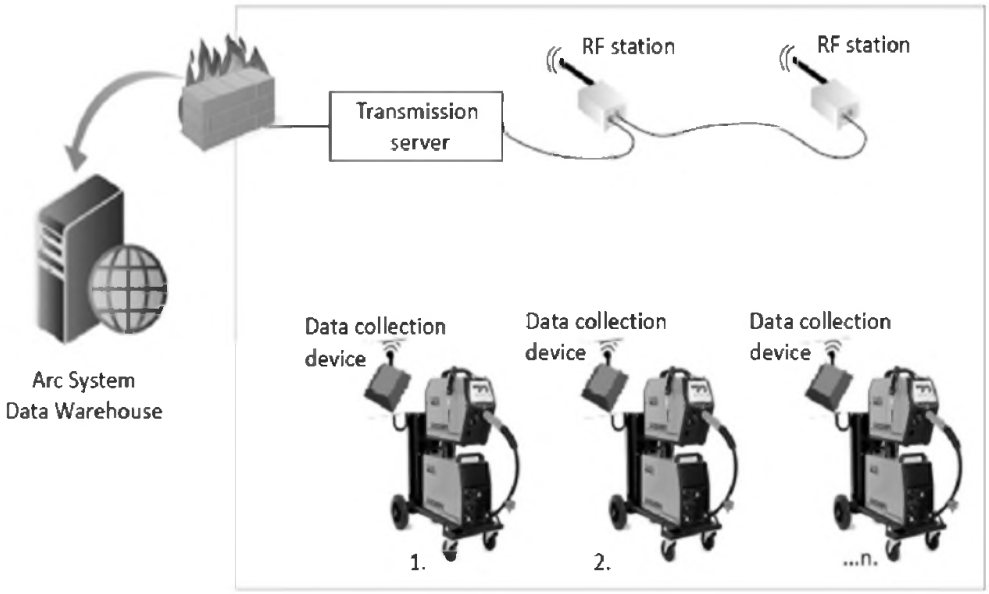

Image curtesy: Kemppi Oy, Finland

6.2 Digital Data Processing for Welding (schematic diagram)

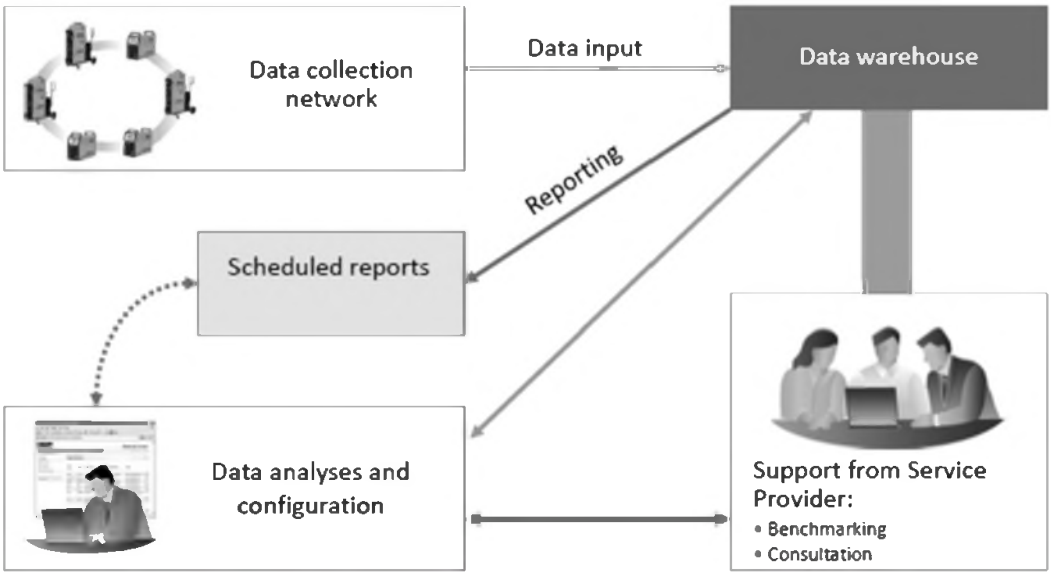

Image curtesy: Kemppi Oy, Finland

7.0 QUALITY 4.0 VALUE PROPOSITIONS

New technology should always be introduced with a clear articulation of the desired benefits it will deliver and, sometimes, how it will happen. Value propositions for Quality 4.0 initiatives fall into six categories, listed in order of significance:

i) Augment (or improve upon) human intelligence.
ii) Increase speed and enhance the quality of decision making.
iii) Anticipate changes, reveal biases and adapt to new circumstances and knowledge.
iv) Learn how to learn by cultivating self-awareness and other awareness as skills.
v) Reveal opportunities for continuous improvement.
vi) Improve transparency, traceability, and auditability.

7.1 Journey towards Implementing Quality 4.0

- Look at your pain points — where are you having issues in your processes and procedures?
- Ideate opportunities around these pain points and then prioritize them — where do you think you are going to get the most value with some of these new technologies?
- Define and implement on a small scale — at head-quarters via dashboards, at a pilot plant, etc.
- See if you get proof of concept and return of investment.
- If yes, take your detailed roadmap and go to scale, implementing the initiative across the entire organization.

7.2 Welding in Industry 4.0 World

The monitoring software continuously keeps tabs on the welding process and records the prescribed welding parameters as the joint is created for each job on every shift — at least for a designated time period.

The final arbiter of weld quality is no longer just the eye of the welder or weld engineer overseeing the process. Now a fabricator has the data that gives it the feedback to confirm or reject a joint, not just the thumbs-up from an experienced welding expert that likes the look and feel of the joint. This feedback is assurance that the weld conforms to the established WPS.

8.0 BIG DATA: AN INTEGRAL PART OF WELDING PROCESSES

Today, no welding process or welding technology can be viewed in isolation from the other. Collecting the data, processing, and analyzing it helps the end-users detect the imperfections and errors in the processes from various units of production. This will help the companies make their machines, systems, and even their entire production lines more powerful and efficient.

A failure to invest in advanced welding technology could quickly become a failure to invest in the future of your business. After all, as the saying goes, "You can't do today's job with yesterday's methods and expect to be in business tomorrow".

9.0 INSPECTION IN QUALITY 4.0 ERA

Inspection and Quality Control to be done mainly through:

- Automated visual inspection system
- In process gauges
- Artificial Intelligence (AI) based inspection

Remote inspection is very much helpful during any pandemic situation, and this is the future!

Image courtesy: Oceaneering

Let us go Digital !!!

ACKNOWLEDGEMENT

1. American Society for Quality (ASQ.org)
2. 'The Quality 4.0 Revolution: Reveal hidden insights now with Data Science and Machine Learning' by Nicole M. Radziwiii (Intelex)
3. 'Quality 4.0: Future of quality and performance excellence (Quality in the age of Industry 4.0)' by Sameer Kumar, Trainer, Quality Council of India
4. Study materials of Institute for Advanced Welding Training & Research, Jadavpur University
5. 'Welding skills in the times of Industry 4.0' by Sahitya Karra (National Skills Network)
6. 'Welding 4.0: The future of industry' by Geoff Crittenden (Manufacturers' Monthly)
7. Project Management Book of Knowledge
8. Thefabricator.com
9. CEAWELD.com
10. Various articles through internet

IMAGE COURTESY

1. Hodgson Sealant
2. Pngwing
3. Sameer Kumar, Trainer, Quality Council of India
4. Hugo Britt, Thomas
5. Devasis Paul, Nextgen Plasma Pvt. Ltd.
6. Kemppi Oy, Finland
7. Oceaneering

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