/ Perfect Welding / Solar Energy / Perfect Charging

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QUALITY ASSURANCE IN ARC WELDING TECHNOLOGY - NEW POSSIBILITIES DUE TO DIGITALIZATION

AGENDA

/ **Motivation.** Why is Fronius dealing with this rather old topic?

/ **Quality.** What is quality and quality assurance all about?

/ **Digitalization.** What is the nature and driving force of this ongoing process?

/ New **possibilities**. How can digitalization support quality assurance?

/ **Conclusions.** Summing up all results.

Motivation.

Why is Fronius dealing with this rather old topic?

MOTIVATION

/ **Joining technology.** The **quality of a joint** has always been associated with the **joining process**. In this respect, the quality of arc welded joints and the corresponding quality assurance will **always be a driving force in Fronius product developments**.

/ **Misunderstandings.** In cooperation with our customers, however, it has become apparent that **unclear definitions of quality and quality assurance** have often led to **false expectations**.

/ **Digitalization.** Nowadays digitalization is an **extremely frequently used buzzword**. The **reason why** this process offers new possibilities is often not indicated.

Quality.

What is quality and quality assurance all about?

DEFINITIONS – EN-ISO9000:2005

German	English
Qualität: Grad, in dem ein Satz inhärenter Merkmale (3.5.1) Anforderungen (3.1.2) erfüllt	quality: degree to which a set of inherent characteristics (3.5.1) fulfils requirements (3.1.2)
Qualitätssicherung: Teil des Qualitätsmanagements (3.2.8), der auf das Erzeugen von Vertrauen darauf gerichtet ist, dass Qualitätsanforderungen erfüllt werden	quality assurance: part of quality management (3.2.8) focused on providing confidence that quality requirements will be fulfilled

/ These very general definitions, in my opinion, explain the many different understandings of QA in welding technology!

NOW WHAT IS QUALITY?

/ What does “**quality: degree to which a set of inherent characteristics fulfils requirements**” really mean?

/ **Characteristics** = A recognizable feature.

/ **Inherent characteristics** = These are understood to mean

the **system**, the **process**, the **product**

immanent, recognizable features.

/ It should be noted here that **immanent** only makes sense if system, process or product **boundaries** have been well defined.

NOW WHAT IS QUALITY?

- Examples of possible **system, process or product boundaries**.
  - **Products:** blanks, welded component, ...
  - **Processes:** welding process, seam preparation process, ...
  - **Systems:** welding system, calibration system, robot system, ...

- Degree **of fulfillment**.
  This can only be specified if a feature can be **measured** and consequently also **compared**.
  Finally the **degree of fulfillment** of requirements results from the comparison of a **measured feature** with its **target values**.

WHAT IS QUALITY IN WELDING TECHNOLOGY?

- Consequently we at Fronius make the following **distinction** when it comes to **quality assurance in welding technology**:
  - Quality of the **welded joint**
  - Quality of the **welding process**
  - Quality of the **welding system**

- It is essential to note that before quality assurance in welding technology can be used, it is necessary to define **which quality** (of which system, process or joint) should be assured.

EXAMPLES FOR INHERENT CHARACTERISTICS?

- **Welding system:** measurement accuracy (voltage, current, wire speed), condition of inner-liner, contact tip, wire-feeder, machine cooling, hose-pack compensation, dynamic controller accuracy (current, shielding gas, …) …

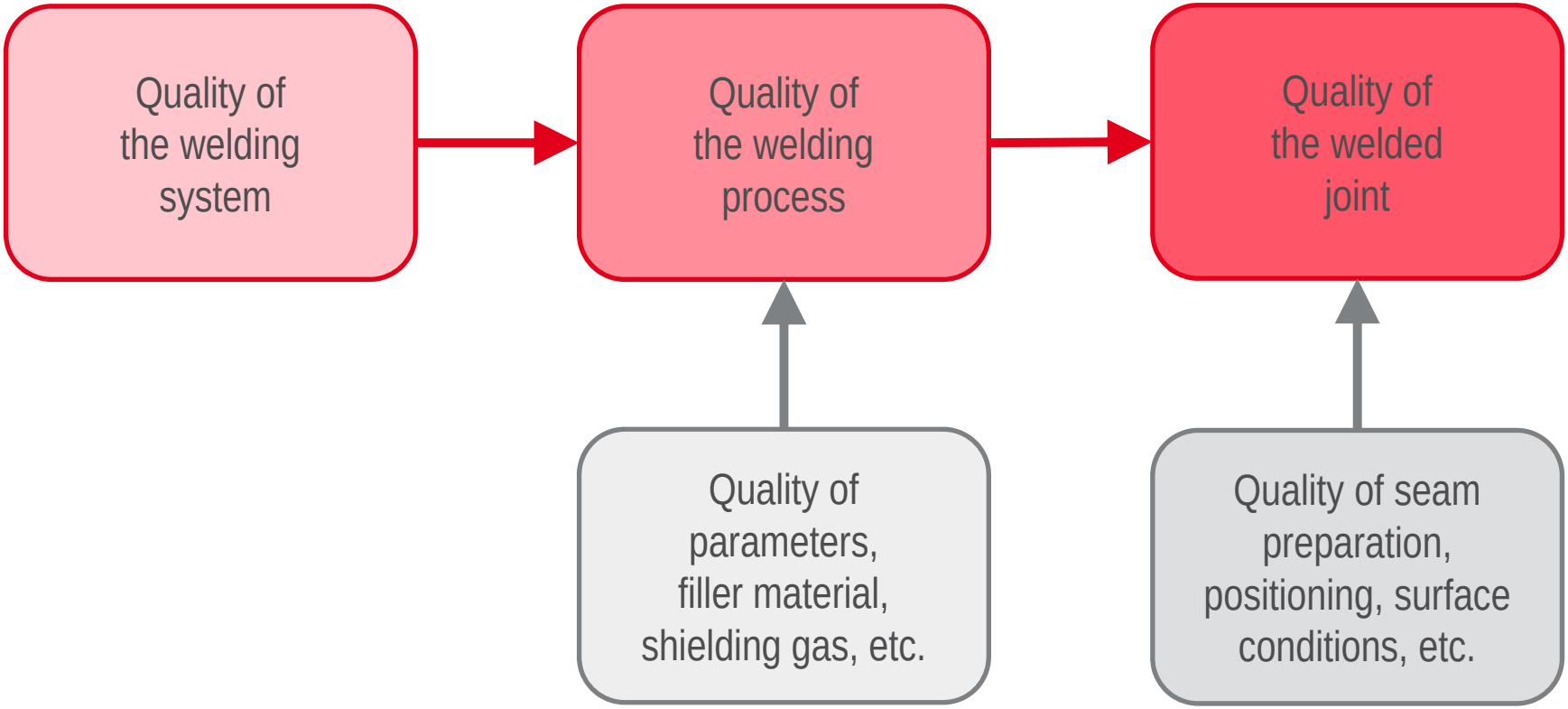
- **Welding process:** welding speed, welding angles, contact-tip-to-workpiece-distance, process parameters (define nominal values for voltage, current, wire-feed-speed), shielding gas purity, welding wire parameters, …

- **Welded joint:** surface geometry of the seam (undercut, throat thickness, …) , penetration, strength, leakproofness, porosity, …

→ It is obvious, that all **these quality characteristics** are **linked** and thus **cannot be treated independently**.

HOW ARE THESE QUALITIES COUPLED?

/ With respect to **welding systems** we can define the following relation:



WHAT IS QUALITY ASSURANCE?

/ Every **measure** that is providing somehow

"confidence that quality requirements will be fulfilled"

can be considered as **quality assurance**.

/ Consequently quality assurance cannot **guarantee** that quality requirements will be fulfilled **under every circumstance**.

/ Quality management in welding technology requires **coordinated quality assurance** measures on the **welding system**, the **welding process** and the **part**.
Thus the **system and process manufacturer** and the end user (part manufacturer) have to **work closely together** in order to obtain an optimal result.

Digitalization.

What is the nature and driving force of this ongoing process?

NATURE OF DIGITALIZATION

analog object
or
analog procedure

digitalization →

digital object $\in \mathbb{N}_0$

live vocals, record	cd, mp3, stream
bank visit	online banking
Hotel booking via telephone	Booking portal

NATURE OF DIGITALIZATION

properties of digital objects (i.e. natural numbers)

- / practically **no basic physical laws** apply
- / have different **physical representations**
- / allow **lossless duplication** (the copy is equal to the original)
- / allow **lossless transmission**

DRIVING FORCES OF DIGITALIZATION

From my point of view the current wave of **digitalization activities** is mainly driven by the two properties of **digital objects**:

/ **lossless duplication** (the copy is equal to the original)

/ lossless transmission

These **driving forces** will also be addressed in the next chapter of this talk – **they are opening up new possibilities**.

New possibilities

How can digitalization support quality assurance?

CONTINUAL IMPROVEMENT - ISO - 9001

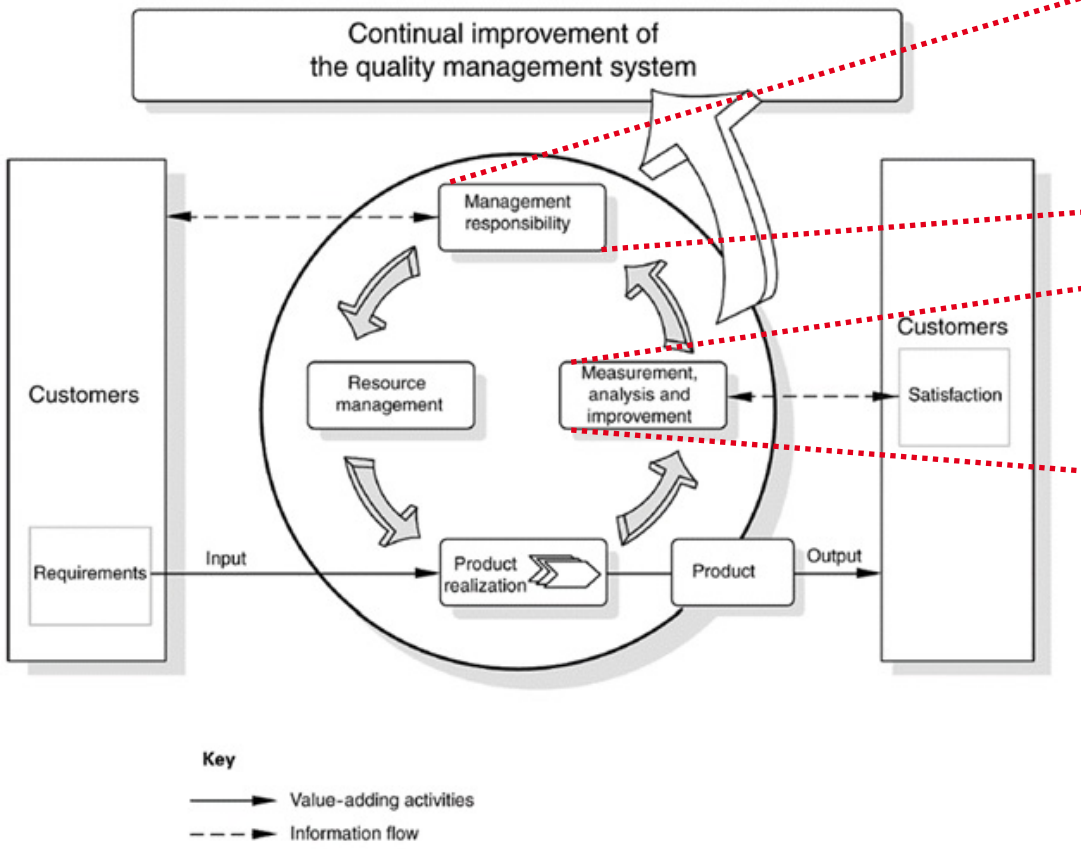


Figure 1 — Model of a process-based quality management system

Management responsibility

Measurement, analysis and improvement

This circle of improvement also applies to all different qualities that influence an arc welding production line.

New possibilities in measurement.

MEASUREMENTS

- System calibration.
  - Voltage
  - Current
  - Wire feed speed
  - ...
- Condition monitoring.
  - Inner liner
  - Contact tip
  - Wire feeder
  - ...

- Limit monitoring.
  - Process signals
  - ...
- Visual monitoring.
  - Weld pool
  - Arc
  - ...
- Thermal conditions.
  - Cooling of the seam
  - ...

- Non destructive tests.
  - Surface geometry.
  - Ultra sonic
  - X-ray
  - ...
- Destructive tests.
  - Mechanical properties
  - Corrosion
  - ...

NEW POSSIBILITIES IN MEASUREMENTS

- **Digitalization of measurement results.** This process enables the **distribution** of digital measurement results **over all involved systems, processes and products.**

- Examples.
  - For every **welded part** the information of the **calibration status** of all involved welding systems is available.
  - Every **welded part** is delivered to the customer with the information of all **welding process signals.**
  - Every **welding system** has the results of the **non-destructive** and **destructive tests** of the welded joints, it has generated, available.
  - Every welding system has a **documentation of service activities, system modification, parameter changes available.**
  - …

New possibilities in analytics.

ANALYTICS

- Examples for impact analysis
  - Conditions of the welding system → limits of process signals
  - Limits of process signals → surface geometry
  - Weld pool parameters → mechanical properties of the joint
  - Process parameters → X-Ray results
  - …
- Examples for condition relation
  - Wire feeder <> inner liner
  - Process voltage <> wire motion
  - …

New possibilities in improvement.

POSSIBLE IMPROVEMENTS

- Preventive maintenance.
  - Optimal intervals
  - ...
- Predictive maintenance.
  - No unplanned standstill
  - ...

- Adaptive Limit monitoring.
- Visual, thermal monitoring.
  - Automatic feature detection – what's essential
  - ...

- inspections taking into account
  - Process and system characteristics
  - ...
- Optimal first yield
- Minimal operating costs

Conclusions.

Summing up all results.

CONCLUSIONS

/ **Digitalization.** Enables the **lossless interchange of information**. Applying this feature at the **shop floor level** provides all systems and processes with the **all data they need** (a central idea of industry 4.0).

/ **Quality of a welded part.** This is not only the result of **quality assurance** measures at the **welding systems** and the **welding processes**. In addition **all other influential systems** and **processes** have to be optimized.

/ **Cooperation.** Classical **system boundaries vanish** and thus standard **supplier<>customer business models** will loose their importance. Cooperative models, that **incorporate all different suppliers and the end customer**, will dominate the market.
→
Not the fastest, but the one with the **best understanding of the overall system will win**.


Let's get
connected.
PERFECT WELDING