PQA® PRODUCT QUALITY ANALYZER – DIGITAL ROAD TO SUPERIOR QUALITY FOR LATIN AMERICA *

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Abstract
The high competition scenario pushes the steel producers business. Zero defect requirements from customers force the operators for additional efforts in process control and quality management. PQA® has been developed as an advanced process and quality management assurance solution. It is focusing on the analysis of process data, equipment information, inline quality measurement devices and trend analysis. The paper describes the structure of the advanced process and quality management assurance solution PQA®; it gives insights on the expert know-how, process and quality evaluation and points out the benefits like cost reduction, improvement yield and customer satisfaction increase.
Keywords: PQA®; quality management; product quality; expert know-how; production planning; plant condition; data warehouse; big data analysis; artificial intelligence.

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1 INTRODUCTION

A competitive landscape pressurizes the steel producers business. Zero defect requirements from customers force the operators for additional efforts in process control and quality management. The so called quality related costs, which include cost for downgrading, rework and customer claims is already a remarkable lever in a plants profitability breakdown. Beyond that, the introduction of advanced state-of-the-art grades in the product portfolio requires already a budgeting for the expenses for R&D and quality management.

PQA® has been developed as an advanced process and quality management assurance solution. It is focusing on the analysis of process data, equipment information, inline quality measurement devices and trend analysis. It obtains and answers, whether the process is running according to definition and expectation and whether the intermediate or final product is fit for further processing or can be shipped as prime material to the end costumer.

The core elements of the PQA® are the quality and proactive expert rules based on expert know-how defining process and quality fundamentals. Advanced analytics which are linked to these rules identifies deficiencies along the entire process chain. An intelligent, state-of-the-art rating system evaluates tolerable deviations.

The rules are executed by a modular software platform, including the data configurator and collector from the different sources in the production process and units. A powerful Product Data Warehouse structures all plant data in a smart way for further analytics. Easy to use reporting tools complete the software platform. Finally by the utilization of AI-(Artificial Intelligence) modules big data analytics are used for a self-adaptation of quality and proactive expert rules.

The paper describes the structure of the advanced process and quality management assurance solution PQA®; it gives insights on the expert know-how, process and quality evaluation and points out the benefits like cost reduction, improvement yield and customer satisfaction increase.

2 THE SMART STEEL PLANT

2.1 Challenges

Customers are facing 3 main challenges linked to their business performance:

- Flexible production planning with varying up to single batch size order with adherence to delivery dates
- Maximum operational plant performance with a minimum of maintenance effort and lowest net working capital.
- Continuous achievement of best product quality with highest yield

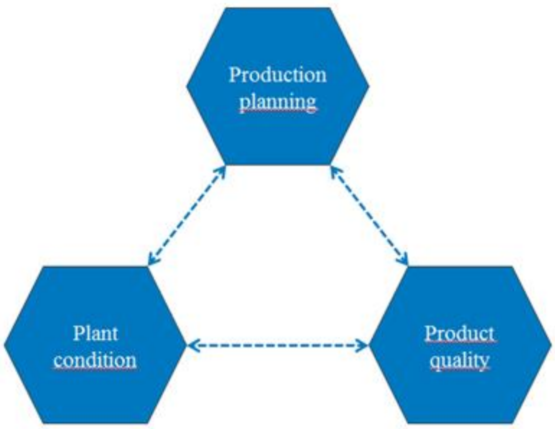

Figure 1. Smart Plant Triangle

Business results and profitability next to EBITDA depend on KPIs which are known as:

- Yield;
- Product Quality;
- Delivery reliability.

Every steel maker is measured by these KPI´s which are depending on a number of different parameters.

The production planning needs up-to-date information on production targets regarding quality and output, the plant condition and the achieved product quality to comply with the contract condition. Production planning, Plant condition and Product quality are forming the Smart Plant triangle (Figure 1).

Information on plant condition includes information on equipment and components but can be also interpreted by process parameters.

The product quality has continuously to be reproducible with the current condition of the plant. The actual product quality has to be assessed, documented and adjusted with the product planning requirements. Instant rescheduling must be possible at any time and at short notice. The effects on the sequence of production order and other important KPI have to be specifically evaluated and predicted.

For the supervision of product quality in a smart steel plant product quality relevant information along the complete production process needs to be aggregated and assessed automatically by a multi-stage adjustment comparison of the achieved product quality with the order specification by certain quality rules (Figure 2). In the ideal case this is done in real time communication with production and plant planning.

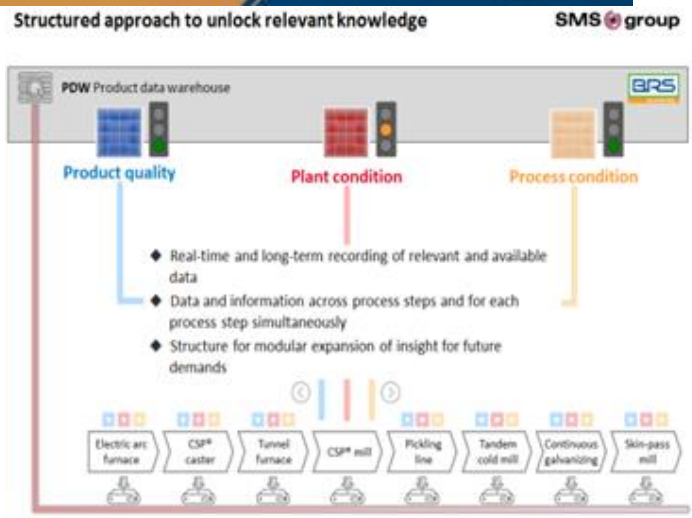

Figure 2. Digital solution along the complete process chain

3 PQA® - SOFTWARE BASED QUALITY MANAGEMENT

Zero defect requirements from customers force the operators for additional efforts in process control and quality management. The so called quality related costs, which include cost for downgrading, rework and customer claims is already a remarkable lever in a plants profitability breakdown.

Beyond that, the introduction of advanced state-of-the-art grades in the product portfolio requires already a budgeting for the expenses for R&D and quality management.

PQA® has been developed as an advanced process and quality management assurance solution. It is focusing on the analysis of process data, equipment information, inline quality measurement devices and trend analysis. It obtains and answers, whether the process is running according to definition and expectation and whether the intermediate or final product is fit for further processing or can be shipped as prime material to the end costumer.

With the help of PQA® prime KIPs the quality cost at a steel plant can be significantly reduced. How is PQA® doing this?

Step 0: Integration of all automation levels into PQA®
Step 1: Creating Transparency throughout the process chain
Step 2: Intelligent rule based analysis
Step 3: Integration of Expert Know How
Step 4: Pattern recognition analyses
Step 5: Root cause identification or prediction of problems
Step 6: Intelligent long-term storage of process and product parameter
Step 7: Correlation of big data for identification of new relationships of parameters
Step 8: Definitions of optimized process parameter and tolerances
Step 9: Application of artificial intelligence for the adoption of new self-learning rules and process parameters and transforming operation to an autonomous plant (final target in the future!)

It can be stated that the intelligent steel plant optimizes auto-adaptively its operation and production process from raw material input to finished product as a part of an integrated supply chain with physical and data driven models.

3.1. Economic benefits of PQA® for steel makers

Steel makers are facing a tough competition on the domestic and international steel market and constantly decreasing tolerance for defects of their customers.

Various attempts were made to reach zero defects but the steel making process itself is prone to take up defects and by producing coils as a final product, zero defects will remain a magic number in the near future.

When producing steel in an integrated steel mill or a lean mini mill at each process step value is added to the product and makes a detection of defect extremely expensive (Figure 3) when process related defects make the final product not suitable anymore for its final application.

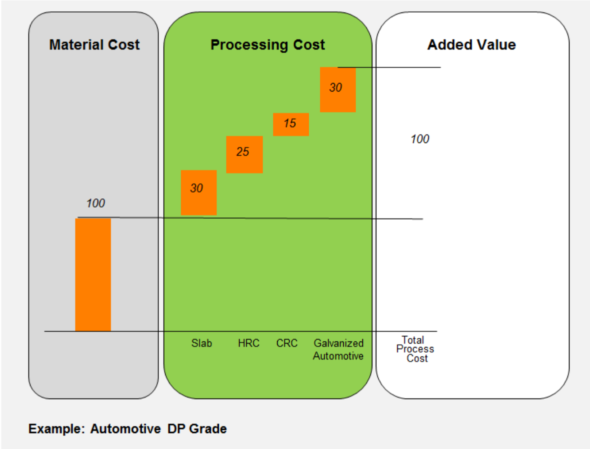

Figure 3. Processing Cost

PQA® is improving the quality in two different ways:

1. Significant increase of probability for detection of deviations from product specification (defects) which in turn will at first increase the downgrade and rework rate. But by doing this at each process step from the very first process less non-compliant material reaches the final process step where maximum of value has been already added to the product. Detection of short comings at an early stage increases the yield in the final process step significantly in the long term.

2. Proactive supervision rules which compare the current process parameter with product requirements of planned material in front of the respective process line create a learning curve of the operator who will prevent non-compliant material from being produced by taking corresponding countermeasures proposed by PQA®.

* Technical contribution to the 11th International Rolling Conference, part of the ABM Week 2019, October 1st-3rd, 2019, São Paulo, SP, Brazil.

3.2. Payback time through PQA®:

PQA® becomes obviously beneficial when looking at the processing cost from slab to CGL with the tonnage of down grade at each process step from two perspectives:

1. Downgrading material at the CGL (as last process step) including defects from upstream units without PQA® :
2. Downgrading material directly at originator by increasing the quality control with the help of PQA®

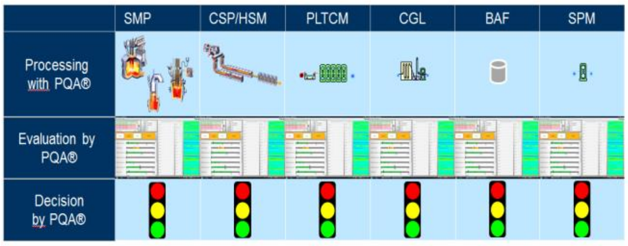

Figure 4. Quality control by PQA®

When reducing the defects from upstream units by filtering the defects already at the originating process unit by applying PQA® with respective to lower accumulated added processing cost to the product, significant savings are already possible, even if CGL defects would stay at the same level(which they will not do!).

The following example may describe the potential savings: A Hot strip coil, which according to the planning should become an exposed automotive coil but actually is contaminated by laminations will bring more profit if sold as prime Hot Strip Coil then being rolled down to a 0.6 mm zinc coated coil but finally downgraded to scrap subprime.

Certainly it is not that easy to solve all quality issues at processing lines but filtering the non-compliant material at each process is easier as a first step, although this is depending on the level of supervision, automation and sensors in the line. PQA® permits by application of quality rules an improved and more severe quality control which identifies non-compliant material more efficiently, also be creating greater transparency between each process step. Adding know-how based rules to the PQA® additional savings can be expected.

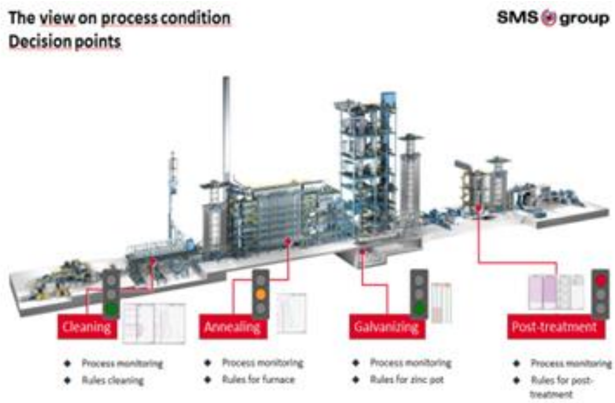

Figure 1. Process condition monitoring

Know-How based rules do not simply compare actual product and process parameter of a processed coil when it has left the exit section but does also look forward to the to be processed coils waiting in line before the processing unit.

The comparison of Level 1 and Level 2 data from the actual coil in the line with the requirements of the coils to be processed may unveil deficiencies. PQA® delivers custom-made expert advice how to cope with this situation (seeFigure 6) and by corrective actions or making proposals how to reshuffle the sequencing of coils in front of the processing line.

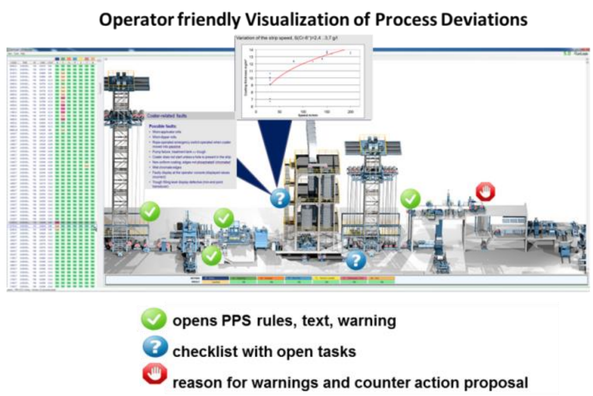

Figure 6. Example of PPS

A typical example is the roughness on automotive strip. Requirements on roughness can differ from OEM to OEM. Work roll roughness applied 'print' a defined roughness on to the strip. The roughness of work rolls declines with the strip length processed and if not taken notice by the operator higher requirements for roughness for the coils programmed to the CGL may not be encountered by new work rolls prepared or even already inserted into the skin pass mill.

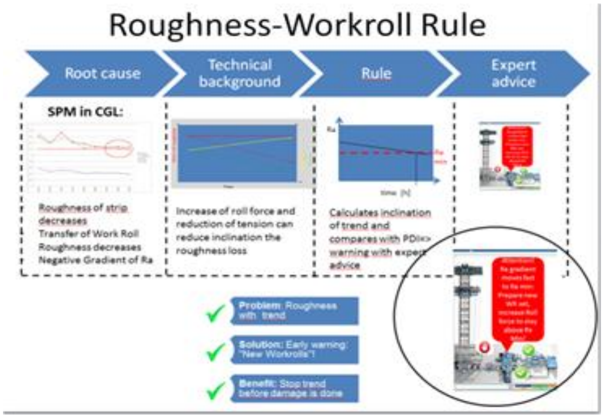

Figure 7. Roughness rule

This know-how rule to be programmed into PQA® to remind the operator by an expert advice to prepare new work rolls for the new requirements since latest measurements of roughness show the trend of declining roughness below the new requirement.

The key to quality improvement is the view into production planning and comparison to the line status. This can be done on different levels like for each process step or already on plant scale with more sophisticated tools.

3.3. Calculation of Return of Invest

Before investing into a new device or software the potential return of invest is frequently asked by CEOs of steel plants in order to decide when or even whether the investment is paying off. MET/Con is currently developing a model how calculating the potential savings at a plant by a scientific approach and also based on empirical data taken from before and after PQA® quality data.

Figure 8. PQA® Major Customer Projects WW

Target of this model is to identify the most important factors on product quality and the potential influence of PQA® on these parameters. No doubt that these are multiple factors but to name a few the portfolio of the steel maker, yearly tonnage of the plant, level of automation, final application of the product (automotive or commodity), level of skills of operator and also the quality situation at each process step in terms of down grade, rework and claim rate play a major role.

Further, some defects are certainly easy to be resolved with the help of PQA® others need more complicated and sophisticated rules to be developed.

Running projects of major steel makers on 3 continents already seem to prove the profitability of PQA® (see Figure 8) but tighter market prices and competition cannot leave the calculation of the ROI to speculation or at best assumption.

4. REFERENCES: CURRENT STATUS AT BRS

Looking at BRS, PQA® is meanwhile an integrated quality tool at BRS. BRS is 100% relying on PQA® and was able to fend off all claims of their customer. Almost no unnecessary further processing of faulty pre-products and it is the undisputed target of BRS to run future quality management completely by PQA® system without human intervention.

But currently the situation for quality work is described in the figure 10 below, where data from different information bases are reviewed by the metallurgist who does within X-Pact® MES 4.0 the dispositioning of PQA® decision into quality categories like:

- Release of coil and send certificate to ERP/L4
- Re-apply
- Secondary
- Scrap

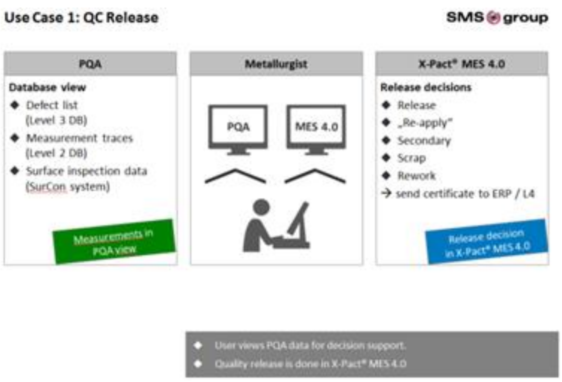

Figure 9. QC Release at BRS

5. OUTLOOK TO THE DIGITAL FUTURE AT A STEEL PLANT

Using all levels of data for Quality condition, Plant condition and Process condition is the bottom line for PQA®. But requirement for long-term storage of real time data in high resolution and later correlations of big data and Artificial Intelligence make storage solutions necessary which need to take many aspects into account like:

- Generic data feed & storage resulting in uniform data access patterns (JSON based; independent of special ETL tools; scalar values, 1d, 2d, events);
- Meta data management (attribute descriptions, measurement units, limits and other semantic information);
- Product genealogy (modeling of production plant in terms of material flow among plant's facilities; PDW global unique product identification);
- Historization of multiple identical key/time range/position data (data modifications in the source are stored in PDW);
- Pre-calculation/Aggregation of data (Segmentation of measurement data; time to position recalculation);
- Long term storage (5-10 years) incl. storage volume reduction (efficient lossless compression & decompression).

The implementation activities of PDW by SMS at the CSP line at BRS are a show case of how a PDW-system can work in the near future. Data from different automation levels are stored within the PDW like:

- Process data from L1
- SIS-Data,
- Plant condition data from equipment
- Aggregated data Level 2

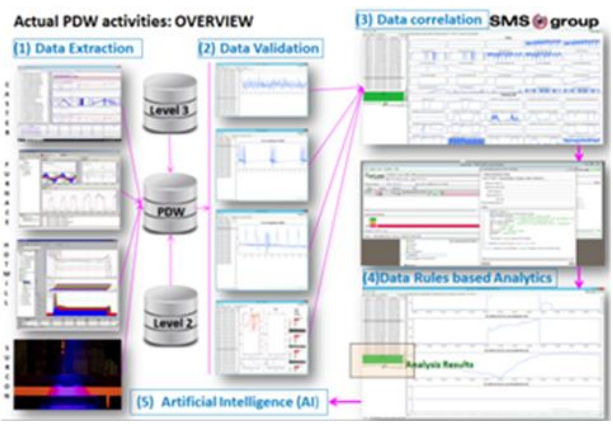

Figure 10. PDW – Production Data Warehouse

This massive information is stored in a smart way which makes fast Data Correlations possible. And data based rules will pave the road for future Artificial Intelligence to create self-learning systems as the final target.

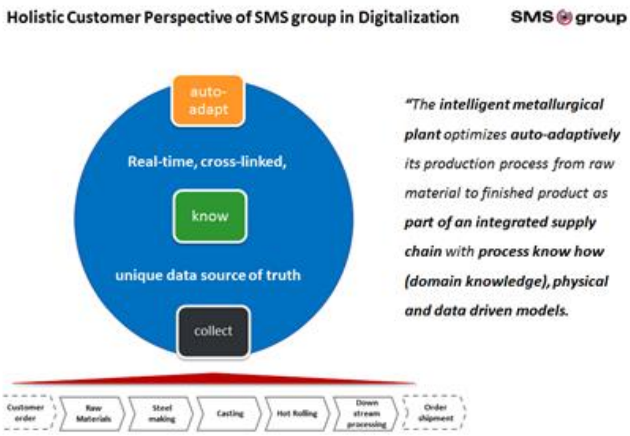

Figure 11. Digitalization approach

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