# THE OAP® OUTPUT ACCEPTED PROCESS AS A BASIS FOR OPTIMAL CERAMIC PROCESS CONTROL

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## ABSTRACT

*In the competitive ceramic market minimal costs, maximum quality and efficiency and flexibility determine the competitive edge. This requires knowledge based, integral process control. To achieve this process analysis techniques as Failure Modes & Effect Analysis (FMEA) and the principles of statistical process control have been tailored to be implemented in the ceramic production process. To support this the FGK has developed a process scan methodology, the Output Accepted Process OAP® scan, with which direct actions can be defined and undertaken to optimize existing production processes, based on the incorporation of company knowledge to achieve an optimal process control. The approach is based on a strong cooperation with the factory staff to define and control targets, to define relevant improvement actions and to support transfer of the results into the production practice.*

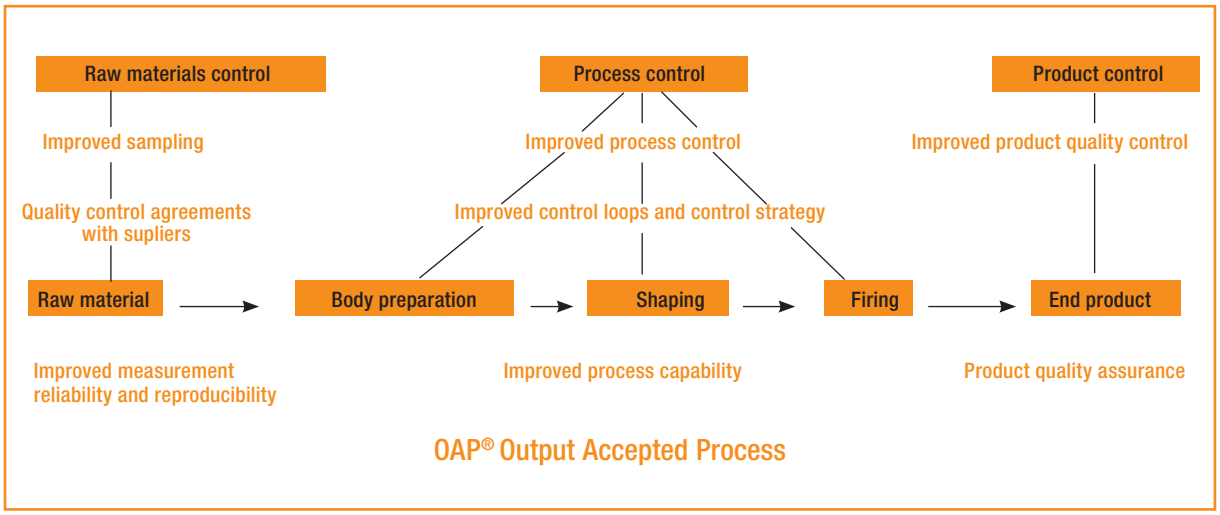


*Figure 1. The OAP® Output Accepted Process*

*Starting from the raw material control up to the quality control of the end product critical parameters, bottle necks are specified and process improvement possibilities for the ceramic production process are defined and can be directly implemented to enhance process capability to let each process perform to its highest potential. Innovative measuring methods and new equipment can so be quickly embedded in the ceramic production to achieve the targeted yields. In the following the results and developed tools from different projects are described.*

## 1. METHOD

The tools, which have been used, are:

- Process Inventory using the Phase Model for the Production (PMP)
- Reproducibility & Reliability (R&R) Analysis of the measuring methods
- FMEA Risk Analysis of defects and process parameters
- Statistical variation analysis and correlation Analysis
- Design of Experiments DoE
- Design of control loops

These tools are tailored to meet the requirements of small up to large sized enterprises, to achieve clearly defined cost reductions by higher quality rates, energy savings and improved production stability. The tools are implemented in an approach, in which the cooperation with the production personnel is crucial, to enhance the support of knowledge management and the embedding of the personal experience of the operators.

In figure 2 the approach is illustrated.

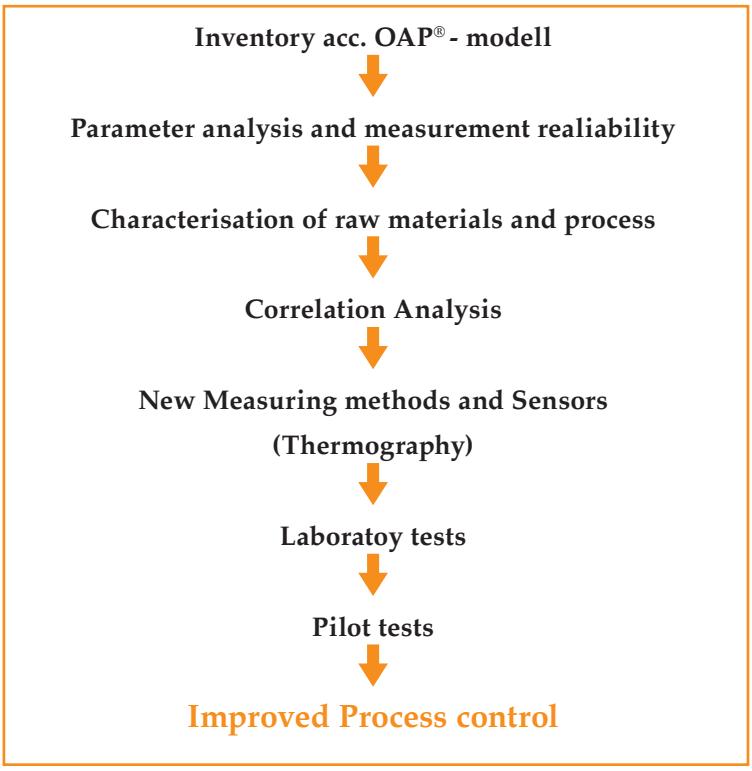


*Figure 2. The OAP® approach*

After a thorough inventory of the production, the OAP® team evaluates the risks of the different defined parameters regarding their impact, the possibility of variations, the ease which with they can be detected, and the possibility to control these parameters. This leads to a definition of bottlenecks, which define the actions, to be taken during an intensive monitoring of the production, in which new measuring methods and sensors can be applied to generate necessary knowledge. The necessity for the improvement of the applied measurements can be derived from figure 3, which illustrates the effect of measurements which contribute to the process variation.

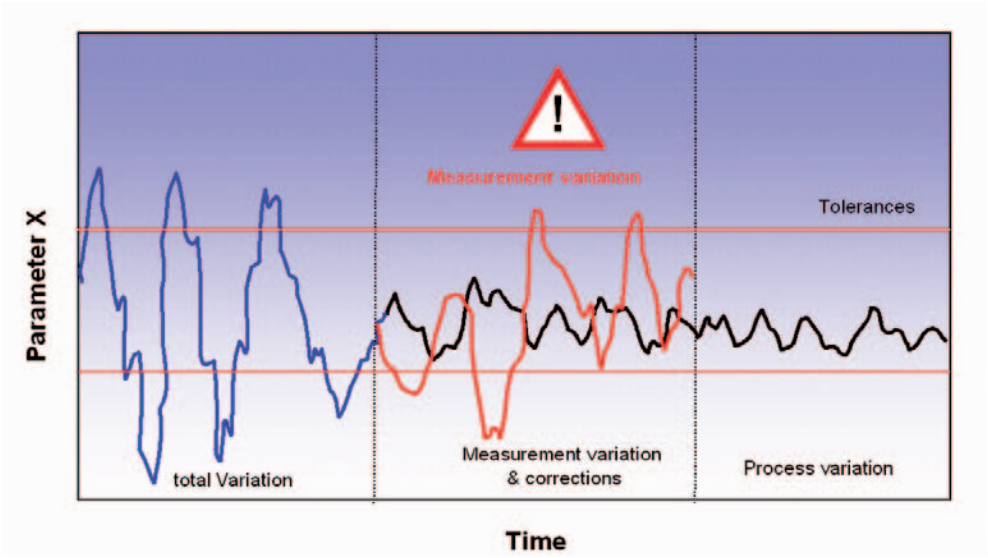


*Figure 3. The influence of measurement variations*

The improvement possibilities, which are defined in a statistical way in the approach, help to reduce these influences. An example of the assessment of improvement possibilities for well known ceramic measurements regarding the influences of the method and the operator are illustrated in figure 4.

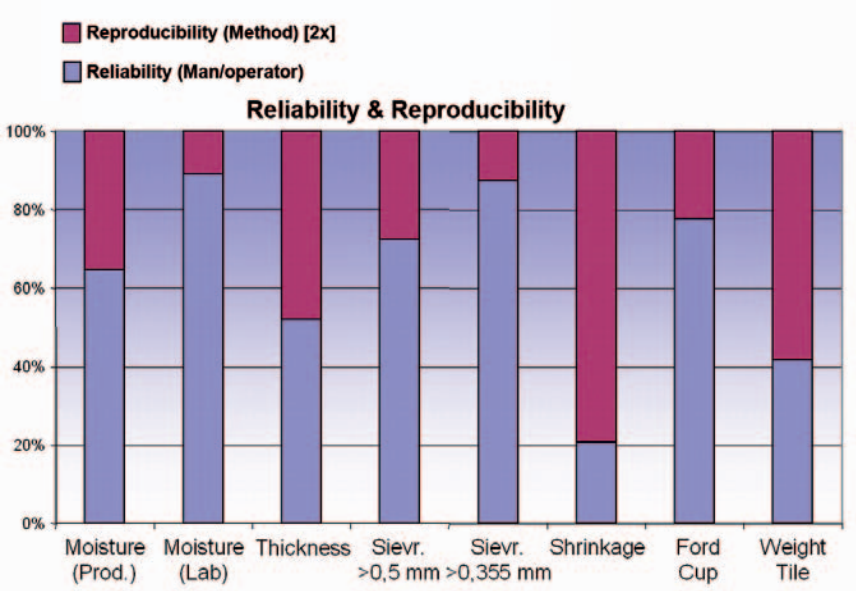


*Figure 4. The influence of the method and the operator on the measurement variation, as defined by the Reproducibility and the reliability Method.*

The following correlation analysis, which is completed by targeted experiments, using also design of experiments techniques, helps to define and implement the finally defined control loops, supported by the resulting control charts.

In figure 5 the possibilities of the approach are illustrated by the improvement of the process capability and the reduction of the scrap rates for the production of extruded tiles.

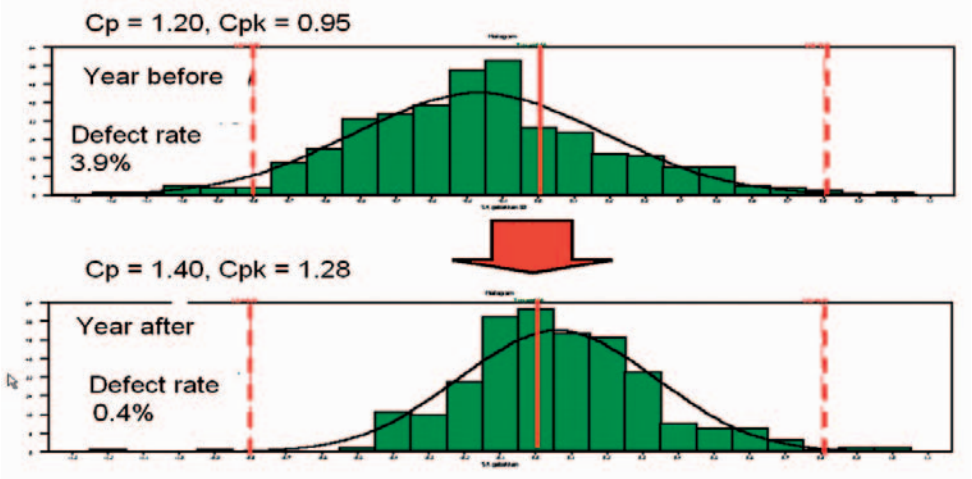


*Figure 5. The impact of improved process control on the process capability and the reject rate for a production line of extruded tiles*

The resulting process control system is based upon closed control loops supported by control charts (figure 6).

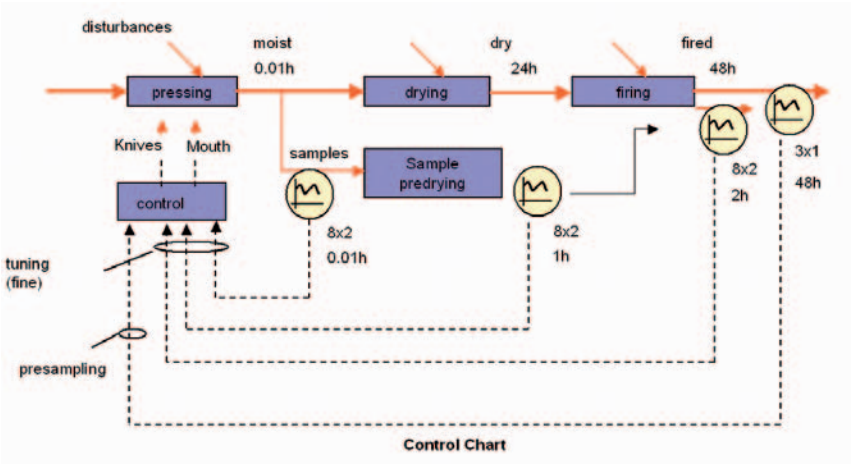


*Figure 6. The improved process control cycle for the production of extruded tiles, based upon closed control loops and new measurements.*

## 2. SUMMARY

The achieved improvements for different ceramic industrial applications, as the improvement potential for existing production like for the production of dry pressed and extruded tiles, split tiles, whitewares, and for technical ceramics industry can be defined by:

- Reduction of scrap rates and rejects
- Reduction of process analysis costs
- Reduction of development costs
- Improvement of sampling for raw materials control
- Definition of quality control agreements with suppliers
- Implementation of adequate and innovative control and measurement methods
- Improvement of the communication and data transfer between production departments
- Improved efficiency of development and project management
- Implementation of statistical process control.

Furthermore the approach is being used as precursor for different new application developments in different projects, as a basic step for direct embedding of new techniques in ceramic production.

## REFERENCES

[1] LINK, S. Uncertainties and influences regarding measurements in ceramic productions, Qualicer 2004, General conferences – communications – posters – panel debate volume I, p. 237 - 246