OPTIMISED PROCESS CONTROL FOR THE TILE EXTRUSION PROCESS

M. Engels, R. Diedel

FGK Forschungsinstitut für Anorganische Werkstoffe -Glas/Keramik- GmbH,
Hoehr-Grenzhausen, Germany

ABSTRACT

The extrusion process has a large potential regarding the development of new process and product technology for traditional and technical ceramic applications. To use this potential, key figures and critical parameters of the material have to be known to support the present equipment technology, and an optimal process control based upon knowledge of processing and material parameters is needed.

In the framework of a national co-operative research project with industrial manufactures of extruded and split tiles research was performed on the use of new characterisation and measurement methods, focused on the material properties. As technical target the reduction of the deviation of rectangularity of the tiles was defined, by implementing a stable process control based on the developed measurements. New material parameters have been studied in relation to production measurements, to define control parameters, which can be used to develop short term and long-term control loops.

1. EXPERIMENTAL

In addition to traditional production measurements like Pfefferkorn plasticity and online data acquisition of process variables like rotation speed of the auger, extrusion velocity and electrical consumption of the press, new techniques like thermography of the material during processing, moisture measurement on the strand and rheological measurements have been used to define meaningful material parameters and their relevant correlations.

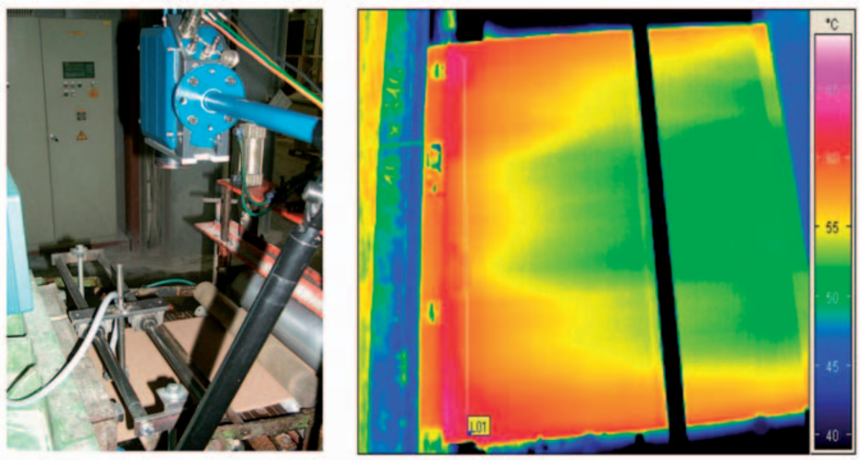

Figure 1. The experimental setup for the thermography measurement and the measured temperature profile

In production tests the validity of the online temperature measurement as a process control parameter has been evaluated, using different thermographic techniques. Using a line scan camera over an elongated period of time while monitoring the product properties, showed that the surface temperature and temperature distribution can be directly correlated to the rectangularity of the products, depending on the pressing conditions and the moisture content of the body. This correlation has been used to develop a concept control loop, based on feed backward control based on the temperature, and moisture measurements of the body composition. Requirements regarding the use of respective sensors have been defined and are described.

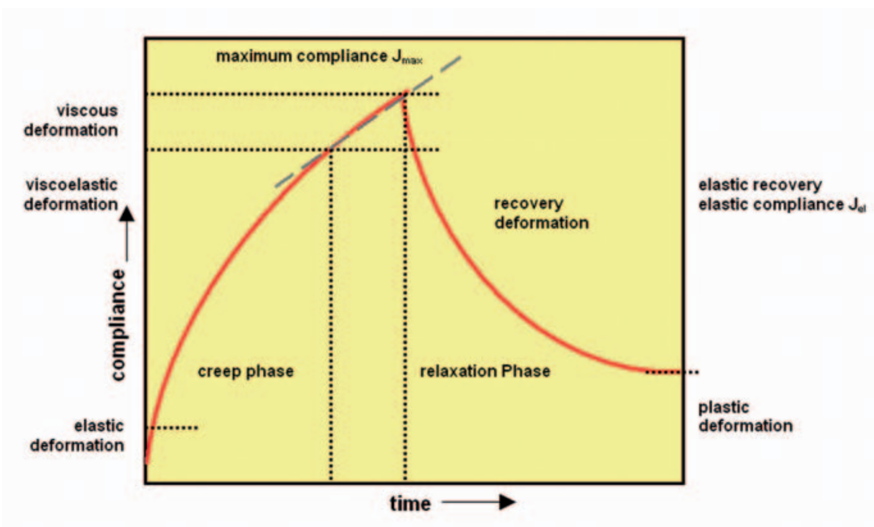

Figure 2. The creep compliance test

A rheological test using a laboratory rotational viscosimeter equipped with a plate-plate system to establish creep behaviour has been adapted and tested to characterise the ceramic raw clay material composition as well as the extruded products, to yield results regarding the plastic and elastic deformation of the material. The behaviour of the material is expressed by describing the compliance, being the deformation divided by the applied load. In this case a constant load was applied during the creep phase. The creep test method including the evaluation of the recovery phase has shown good results in characterising the differences between the body compositions of the industrial partners as well as the influence of moisture on the elastic deformation of the plastic body compositions.

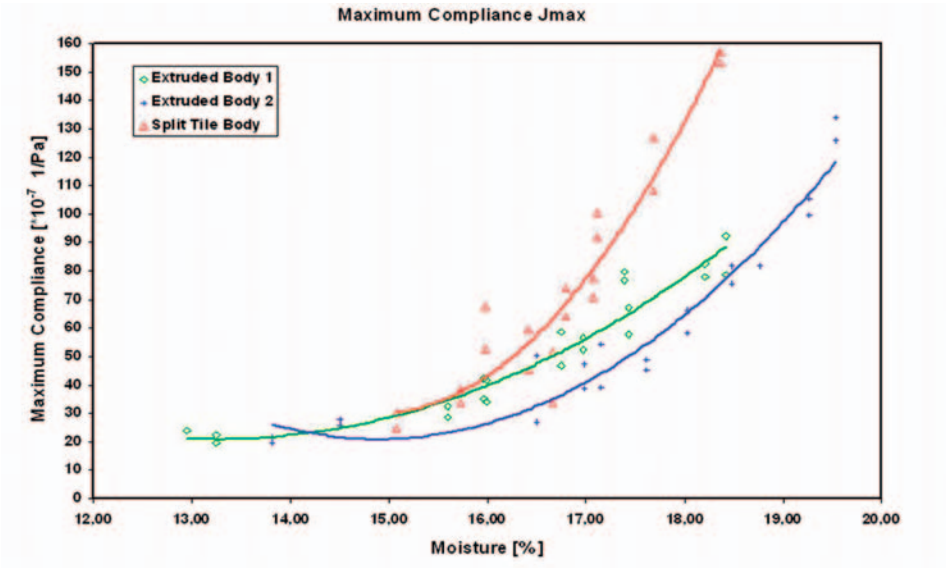

Figure 3. Comparison of the maximum compliance for three different production bodies, derived from the rheological creep test.

The reproducibility and repeatability of the method has been determined to define its criteria of use, showing that the method can be used to define the influences of mineralogical composition and particle size distribution on the extrusion properties and the product characteristics. Differences in sensibility to moisture and deformability of the material can be defined and correlated to observations in production.

Figure 4. The vacuum laboratory press as used in the project

To further evaluate and simulate the correlations of the material characteristics and the process variables as function of the moisture, prepared samples as well as production samples have been tested and evaluated using a small scale vacuum laboratory press with the possibility to control the rotational speed of the auger and the temperature of the cylinder, with the possibility to measure vacuum pressure, to measure online the radial pressure in the head, the temperature in the cylinder and the electrical consumption of the press.

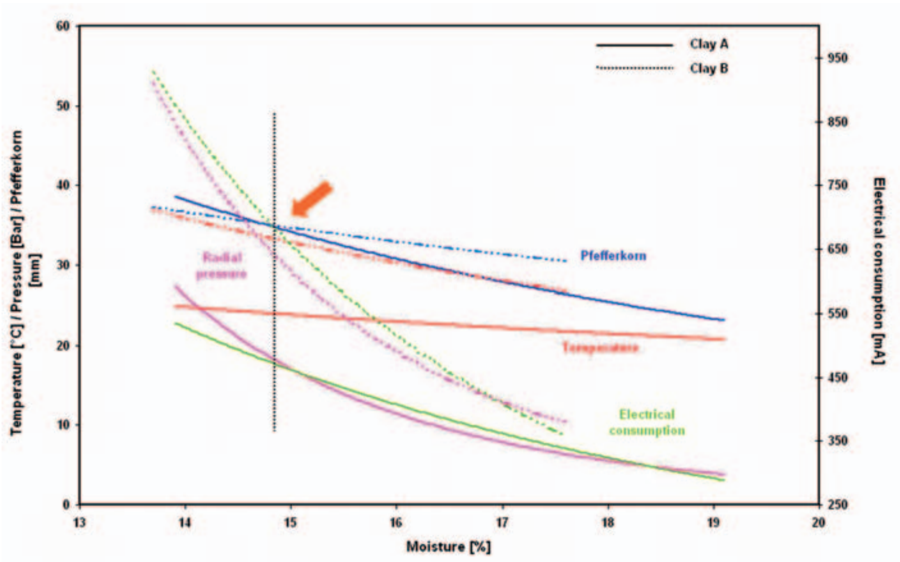

Figure 5. Comparison of two different clay mixtures used in bodies for extruded tiles using the laboratory press.

In figure 5 a comparison of two different clay mixtures used in bodies for extruded tiles production is illustrated. The higher energy consumption and the higher pressure for the pressing of clay B are evident. It has to be noted that at the indicated crossing point of the Pfefferkorn values, the difference in radial pressure as well as the differences in the electric consumption indicate a significantly different performance of both clays in production.

2. CONCLUSIONS

The results have been used to design a control system for the extrusion process based upon predictive and feed backward control, which can be implemented to achieve optimal process control. The possibilities of the new characterisation methods have been translated into developing new body compositions according to the processing requirements of the existing as well as new equipment, taking into account the possibilities to reduce development time, adjustments after product change in production and defect rates.

3. ACKNOWLEDGEMENTS

The authors wish to thank the Ministerium für Wissenschaft, Verkehr Landwirtschaft und Weinbau of Rhineland Palatinate Germany for the financial support of this project in the framework of the Förderung der wirtschaftsnahen Forschung – WinaFo Rheinland-Pfalz.