8th. World Congress on Computational Mechanics (WCCM8)
5th European Congress on Computational Methods in Applied Sciences and Engineeering (ECCOMAS 2008)
June 30 –July 5, 2008
Venice, Italy

FINITE ELEMENT MODELLING OF PROCESS INTEGRATED POWDER COATING

*** J. Frischkorn[1], S. Reese[2]**

[1] TU Braunschweig
Insitute of Solid Mechanics
Schleinitzstrasse 20
38106 Braunschweig
Germany
j.frischkorn@tu-bs.de
www.tu-braunschweig.de/fm

[2] TU Braunschweig
Insitute of Solid Mechanics
Schleinitzstrasse 20
38106 Braunschweig
Germany
s.reese@tu-bs.de
www.tu-braunschweig.de/fm

Key Words: *FE method, powder compaction, sintering, ring rolling.*

ABSTRACT

The process integrated powder coating by radial axial rolling of rings is expected to provide a new hybrid production technique to apply different kinds of powder metallurgical functional surfaces to ring-shaped work pieces. Main advantages compared with conventional manufacturing processes in this field can be found in lower costs, shorter process cycles and larger work pieces. In order to meet the requirements for an industrial application of this new process it is important to proof its capability particularly with regard to reproducibility and to investigate its boundaries. A reliable process simulation will provide a deeper insight into the governing parameters and reduce the money and time consuming experimental tests. Considering a numerical simulation using the FE method two challenges can be named. First one requires a material model to describe the compaction of metal powder at different elevated temperatures. As second the simulation of the ring rolling process itself is still very time consuming. A fine spatial discretization due to large deformations in the rolling gap and contact interaction between workpiece and rollers are the most prevailing factors in this context.
The talk summarizes the basic equations of a continuum based material model which is used to describe the compaction and sintering behaviour of metal powder. The model is formulated in the large strain regime to cover the geometric nonlinearities which usually occur during a rolling process and is derived from the entropy balance in form of the Clausisus-Duhem inequality. The material density is treated as an additional internal variable. Inelastic deformations as well as compaction of the material are gained from a pressure sensitive yield potential by using an associated flow rule. The existence of a so called sintering stress is important to describe free sintering effects. Free sintering is highly temperature driven. It represents the effort to reduce the free surface energy of the metal powder due to porosity by diffusion effects and is accompanied by an increase of the density. The sintering stress is obtained by making an assumption about the shape of the pores which is adopted from [1].

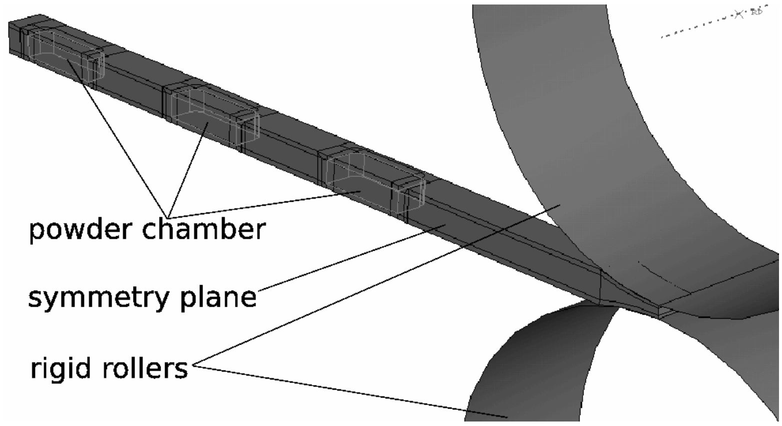

Figure 1: Geometry of a longitudinal rolling experiment including powder chambers

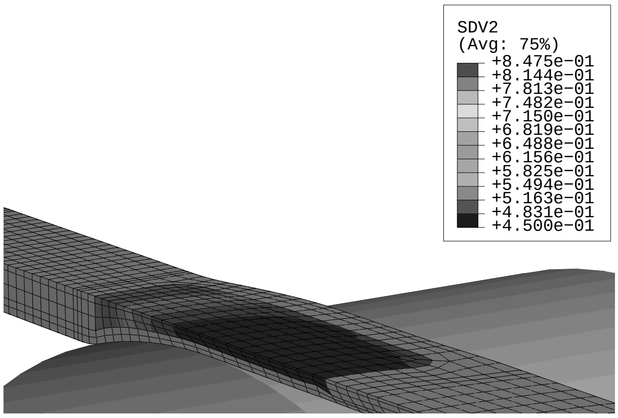

Figure 2: Distribution of the relative density within the powder chamber

Longitudinal rolling experiments with encapsulated and pre-sintered metal powder are used as a starting point for the validation of the model. The talk will give an overview of the essential information concerning the model validation and knowledge obtained from the simulation of these experiments. Especially the influence of several process and material parameters on the densification behaviour of the powder and how far the model is able to predict them is an important aspect of the simulation. To illustrate the longitudinal rolling experiment Figure 1 shows one half of a specimen including chambers with encapsulated pre-sintered metal powder. In Figure 2 the distribution of the relative density (ratio of the actual density to the solid materials' density) within the metal powder is depicted for a quarter of the specimen.

Paying attention to the fact that the simulation of ring rolling experiments is still very time consuming the portability of the knowledge from longitudinal rolling experiments to ring rolling is a further aspect under numerical investigation. The talk will close with simulation results of the ring rolling process and an evaluation of its capability compared to experimental results.

REFERENCES

[1] L. Mähler and K. Runesson. "Constitutive modelling of cold compaction and sintering of hardmetal". *Engeneering Materials and Technology*, Vol. **125**, 191-199, 2003.