

Postanschrift:
Fachhochschule Bonn-Rhein-Sieg, 53754 Sankt Augustin

Tomaš Bat'a University
Faculty of Technology
Department of Science and Research
Nám TGM 275
762 72 Zlín
Czech Republic

Abteilung Rheinbach
von-Liebig-Str. 20
53359 Rheinbach
Tel. 02241/865-531
Fax 02241/865-8531
Email bernhard.moeginger@fh-rhein-sieg.de

February 16th, 2024

Report on
Martin Novák's thesis
entitled
Powder Injection Molding: Feedstock Tailoring and Process Optimization

by

Prof. Dr.-Ing. Bernhard Möginger,
Hochschule Bonn-Rhein-Sieg (University of Applied Sciences)
Rheinbach, Germany

Martin Novák's PhD thesis addresses important aspects of current developments in the field of Powder Injection Molding (PIM). The major goals of his research work were

- Developing more environment friendly feed stocks allowing for also a more energy efficient processing, and
- Making the feed stocks usable for Additive Manufacturing (AM) techniques.

To pursuit these goals, he structurized his scientific approach using the method of DoE, thus, providing relevant results with a minimum number of experiments. The results of Martin Novák's research work are represented in a PhD thesis having 106 pages. It provides a good overview over the state of research of PIM with remarkable width and depth shown by 163 citations. Furthermore, important research outcomes were presented in five publications submitted to well-known journals and presented on 5 conferences.

Martin Novák has chosen 2 stainless steel powders compounded with 7 multi-component binder systems. This allows for a thorough investigation of the processing behavior of the corresponding feed stocks both in PIM and AM.

As key results of Martin Novák's investigation can be considered:

The acrawax/paraffin wax/polyethylene glycol (AW/PW/PEG)-based binder is a very promising binder system. Its feed stocks can be processed at temperatures below 100°C, and debinding can be done in water at 50°C (1st step) with subsequent thermal debinding (2nd step). Both contribute significantly to a more sustainable manufacturing process of PIM parts. Furthermore, the surface properties in terms of roughness turned out to be also good. Its application to both PIM and AM showed that there are similarities with respect to processing but the surface properties of the AM parts were worse, in particular, the surface roughness of AM was twice that of PIM. The use of PLA in binders caused a lot of problems in processing and debinding, thus, PLA based binder systems require a much different approach.

From my point of view, the following aspects should be pointed out and clarified in a more precise manner in the discussion of the final exam:

- In the figures 27 and 28 thermogravimetric curves are shown with the explanation that a gentle and gradual thermal debinding is preferable. Please, explain the reasons behind the "step-by-step" design you used.
- What exactly is the deformation induced martensite you described in your work (Figure 32), and how may its presence affect the mechanical properties?
- You processed feedstocks with the Arburg plastic freeformer and found that processing was discontinued by problems such as wear and flow instabilities. Please expand on this issue.
- The sintering model developed by Pokluda was mentioned concerning sintering time. Please show and explain this model and explain the basic physical principles behind sintering.

To summarize it can be said: Martin Novák presents in his PhD thesis an interesting approach to improve the energy efficiency of PIM and the environmental friendliness of PIM feed stocks. Furthermore, in his PhD theses he made first steps to make PIM feed stocks applicable to AM. Congratulation to this interesting PhD thesis which I recommend to be accepted.

Prof. Dr.-Ing. Bernhard Möglinger