Comparison of numerical models for investigating deep drawing of thin-walled steel cups

Peter Auer[1], Tobias Lohinger[1], Markus Unterrainer[2], Andreas Burböck[2], Christof Sommitsch[1], Josef Domitner[1]

[1] Institute of Materials Science, Joining and Forming (IMAT), Graz University of Technology, 8010 Graz, Austria.
[2] MARK Metallwarenfabrik GmbH, Gleinkerau 23, 4528 Spital am Pyhrn, Austria.

INTRODUCTION

In recent years, numerical simulations have become indispensable for designing and optimizing sheet metal forming processes. Simplifying "real" processes in numerical models aims for reducing the computational expenses; however, simplifications may considerably influence the quality of the numerical results. For this reason, the present work investigates and compares different simplified models of an industrial deep drawing process for producing thin-walled steel cups in two serial forming steps.

MATERIALS AND METHODS

The axisymmetric models of forming steps I and II are shown in Figure 1. Both models were built using the DEFORM 2D finite element (FE) software package. The tools (punch and die) were modeled as rigid or as elastic, whereas the steel blank (step I) and the steel cup (step II) were modeled as plastic or as elastoplastic. The wall thickness calculated using the 2D FE models was compared with the actual wall thickness of "real" deep-drawn cups captured using an optical 3D geometry measuring system. Finally, the influence of different model simplifications on the results of the simulations were compared and quantified.

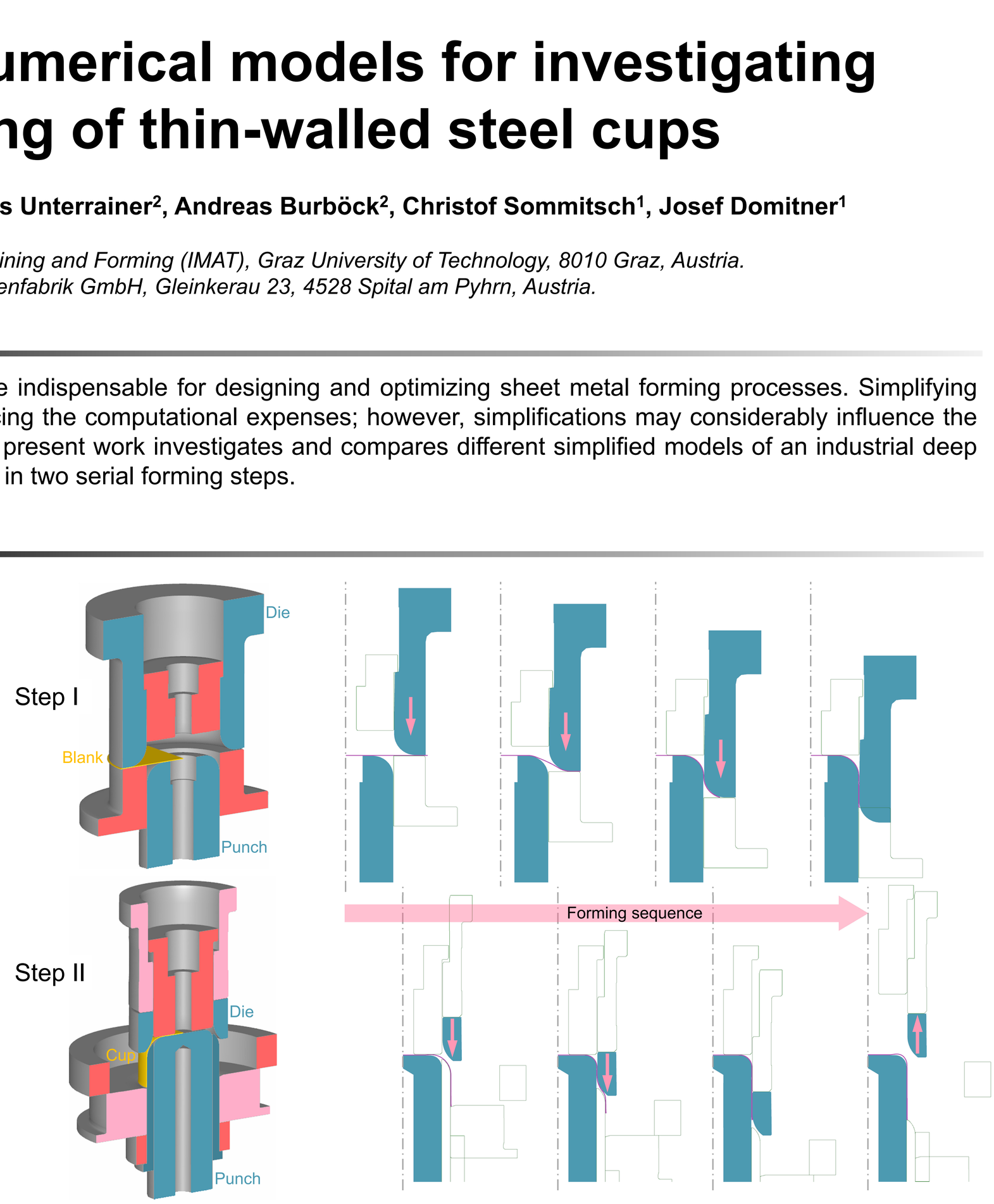
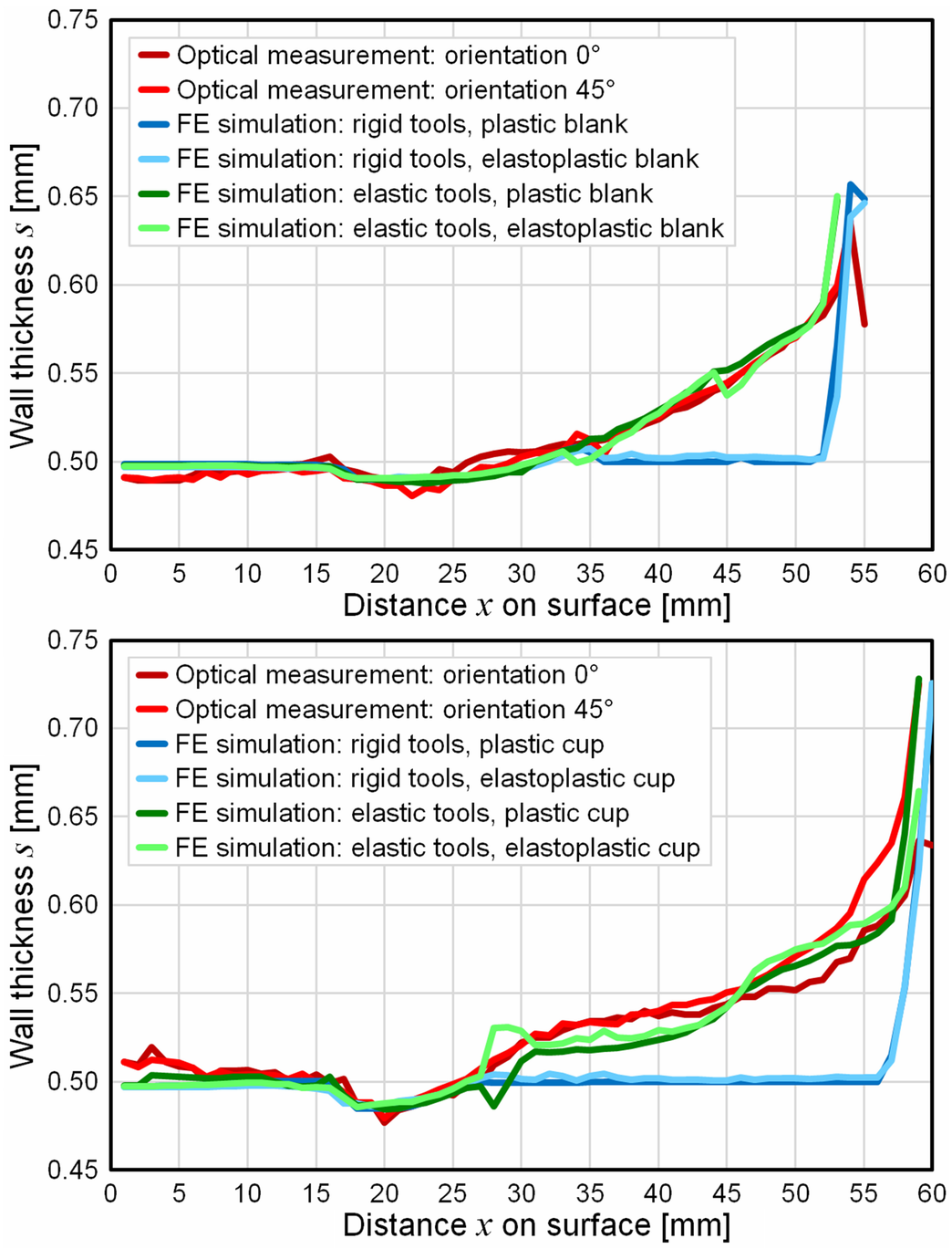


Figure 1: Visualization (3D) and axisymmetric models (2D) of forming steps I and II. The cup which is produced in step I is subsequently used as input for step II.

RESULTS

Figure 2 compares the measured wall thickness profiles with profiles calculated using different FE models for both, forming steps I and II. Significant improvement of the numerical results, i.e., best agreement between the wall thickness profiles of simulations and experiments, was obtained if the tools were modeled as elastic. In particular, deformation of the die was identified as key factor that influences the wall thickness of the cups. Modeling the blank (step I) or the cup (step II) either as plastic or as elastoplastic did not reveal big differences in the thickness profiles. Hence, in order to reduce the calculation time in 2D FE modeling of deep drawing processes, (i) simplifying the tools as rigid is only feasible for rough estimation of the wall thickness of the parts, and (ii) neglecting the elastic properties of the blank can be an option if detailed calculation of springback is not required.



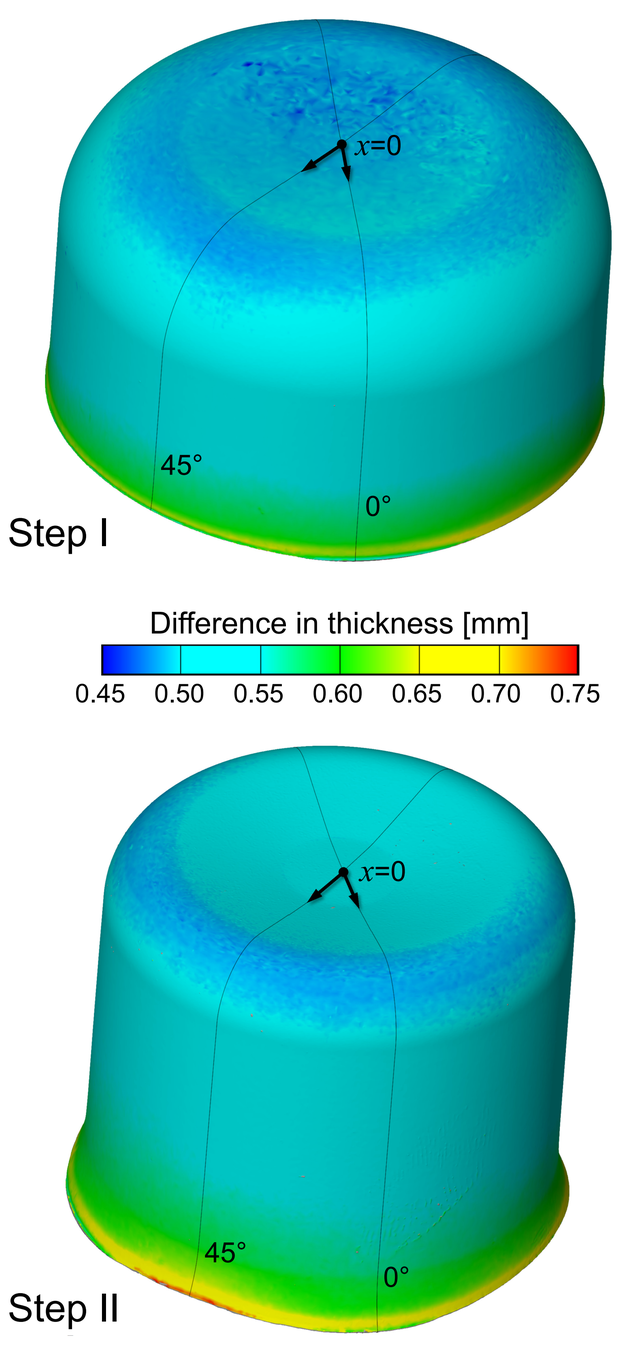


Figure 2: Comparison between measured and calculated wall thickness profiles and cup geometries for forming steps I and II.