

Integrating Stamping Tool Temperature Effects into Early-Stage Process Design: Insights from an Industrial Benchmark

Lide Insausti^{1,4}, Alexander Barlo¹, Mats Sigvant^{1,2}, Johan Pilthammar^{1,3}, Eneko Saenz de Argandoña⁴, and Joseba Mendiguren^{4*}

¹Dept. of Mechanical Engineering, Blekinge Institute of Technology, Karlskrona, Sweden

²AutoForm Engineering Sweden AB, Olofström, Sweden

³Volvo Cars Dept. 81153 Concept Engineering, Olofström, Sweden

⁴Mondragon Unibertsitatea, Faculty of Engineering, Mechanics and Industrial Production, Loramendi 4, Mondragon 20500, Gipuzkoa, Spain

Abstract. Reducing the CO2 footprint has become a key objective in the manufacturing sector, with the automotive industry being no exception. A significant portion of a car body consists of stamped components, making the reduction of CO2 emissions in stamping lines a critical focus. One major contributor to emissions is the high material usage, partially derived from the scrap generation. Additionally, production ramp-ups in critical components, such as side door-inners and wheel housings, often lead to increased defect rates, further exacerbating waste. This work investigates the influence of stamping tool temperature increases during production and its consideration in the early stages of process design. Using a Volvo side door inner as an industrial benchmark, various numerical solutions were explored using AutoForm software. The technical note presents the advantages, limitations, and challenges of these approaches, while highlighting the potential of numerical tools to drive CO2 footprint reduction in stamping processes from an early design stage.

Keywords: deep drawing, stamping, CO2 reduction, simulation

1 Introduction

In contemporary stamping and deep drawing processes, die temperature elevation during large-scale production can significantly modify the boundary conditions of the forming operation [1]. Such thermal accumulation is recognized to alter material flow and deformation attributes, frequently resulting in flawed components [2]. Conventional mitigation approaches consist of either incorporating cooling channels within the dies, an alternative that, while effective in preserving temperature consistency, escalates cost, complexity, and die maintenance, or halting production to facilitate die cooling, thus diminishing throughput [3].

The principal aim of this research is to assess and delineate a methodology that integrates the thermal influences encountered during manufacturing into simulation models. By incorporating actual production data of a Volvo side door inner, including temperature profiles, material characteristics, lubrication conditions, and component geometries, we strive to forecast the effect of die temperature fluctuations on stamping and deep drawing operations. Ultimately, the intention is to recommend process enhancements that diminish defect rates without resorting to costly die alterations or production interruptions.

2 Methodology

Utilizing a Volvo Cars side door-inner industry benchmark, we gathered comprehensive production data to describe the temperature escalation in dies during stamping activities. The research approach included the following phases:

- *Data Collection:* Temperature fluctuations, material properties, lubrication methods, and geometric specifications were documented from the production schedule. Fig. 1 shows the stamping die working phases in where the contact with the sheet is defined as simple contact, forming phase and after forming contact.
- *Numerical Simulation:* Various modelling techniques were devised using AutoForm software. These techniques evaluated various options within the software to represent the production dynamic, i.e., blank feeding, die closing, opening, part output, as close as reality as possible. Fig. 2 shows the different numerical strategies evaluated in this study compared to the real manufacturing cycle dynamics, i.e. Quick opening, accurate opening and waiting time change method.

* Corresponding author: jmendiguren@mondragon.edu

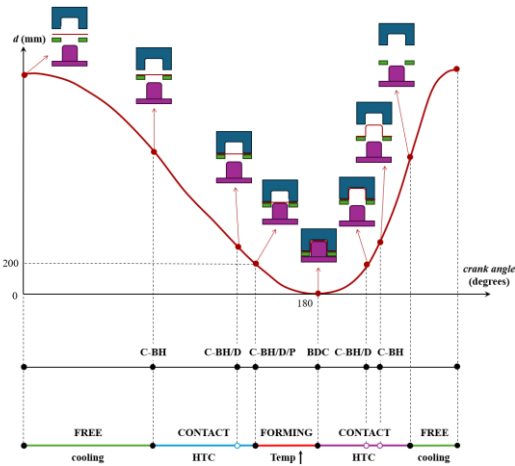


Fig. 1. Stamping die working phases in where the contact with the sheet is defined as simple contact, forming phase and after forming contact.

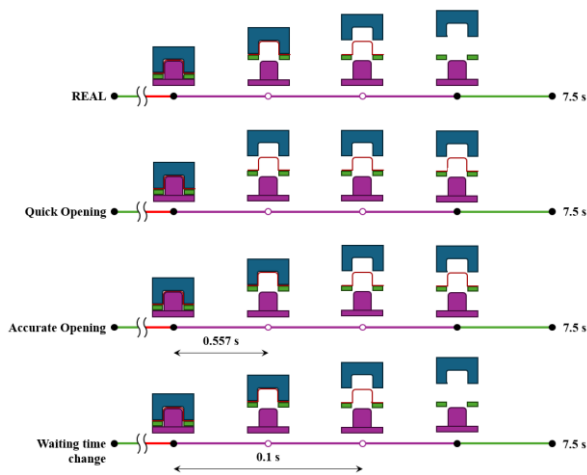


Fig. 2. Different numerical strategies and their impact on the opening phase.

- *Validation and Evaluation:* Simulation results were contrasted with actual production results to authenticate the models. Different techniques were evaluated to determine which most accurately forecasted the influence of temperature on the forming procedure. Fig. 3 shows the summary of the impact of each numerical strategy on the numerical contact (and therefore heat transfer) time.

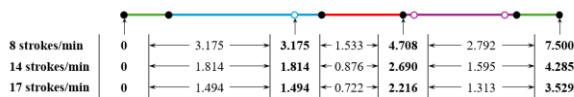


Fig. 3. Influence of the production velocity on forming and cooling times.

- *Suggestions:* Based on simulation comparisons and sensitivity assessments, we recommended possible enhancements to both the simulation methodology and the production workflow. Fig. 4 shows the impact of the simulation when considering different processing speeds.

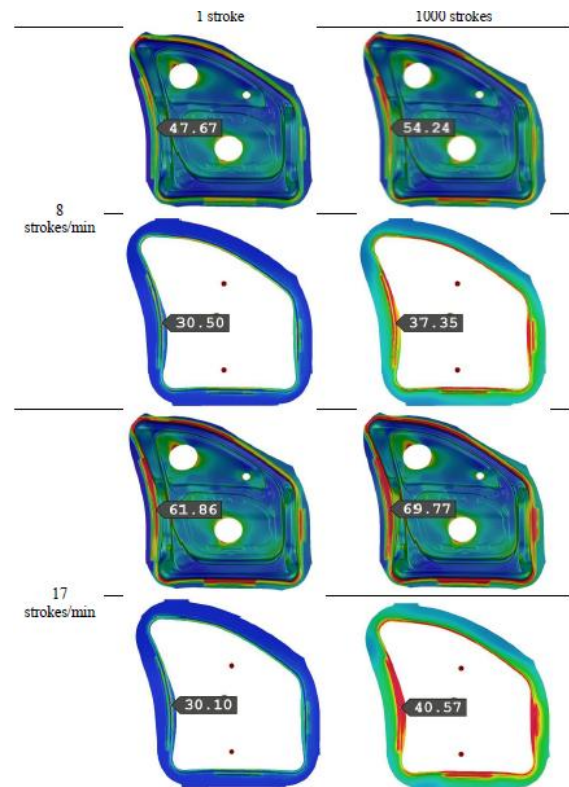


Fig. 4. Impact of the production velocity on the temperature increase between the first and 1000s stroke. The temperature field is shown in a scale between 20 °C and 100 °C.

3 Conclusions

The following bullets summarize the main conclusions of this study:

- Numerical simulations can predict the run-up heating of the dies. But, the selected numerical strategy has a critical impact on the temperature development.
- The main factor for impacting formability is tribological related.
- A deeper study is needed in the die-set dynamics and blank positioning and part removal times to accurate prediction.

With all this in mind, a further model refinement as well as new numerical tools towards accurately simulating the die opening are necessary to increase the prediction accuracy.

References

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