

Heterogeneous tests for (visco)plasticity

Vform-xSteels - WP3

Design of a novel test using an integrated topology-shape optimisation methodology and a thermomechanical indicator

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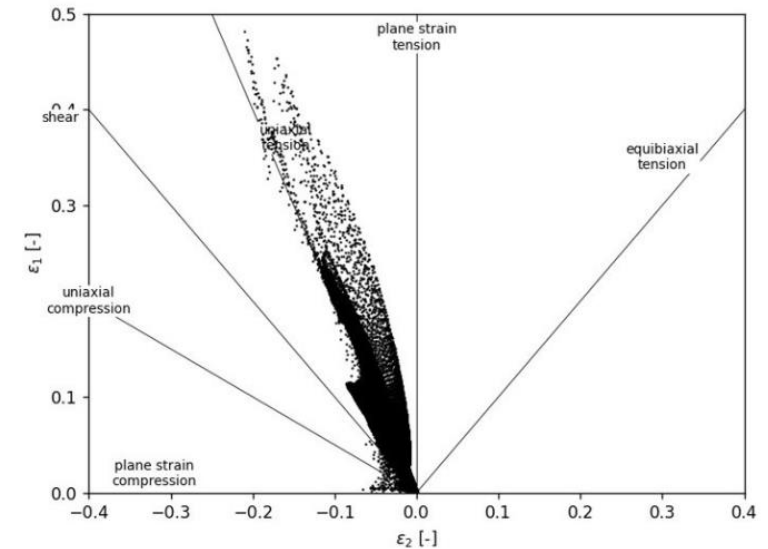
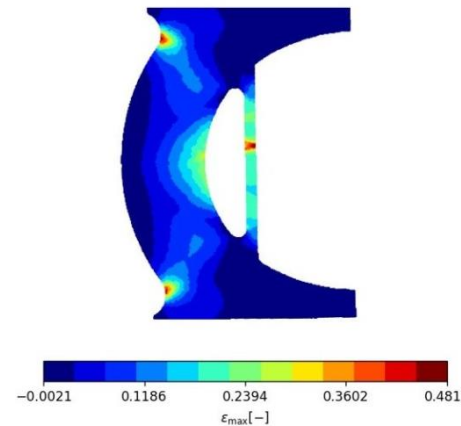
- Empirical knowledge: it is necessary to consider a certain diversity of stress and strain states for material parameter identification to ensure a reliable virtual forming

- Big database: one material, around 60 quasi-homogeneous tests (room temperature, strain rate independence)

1.5 person.month for mechanical characterisation, 0.5 person.month for calibration

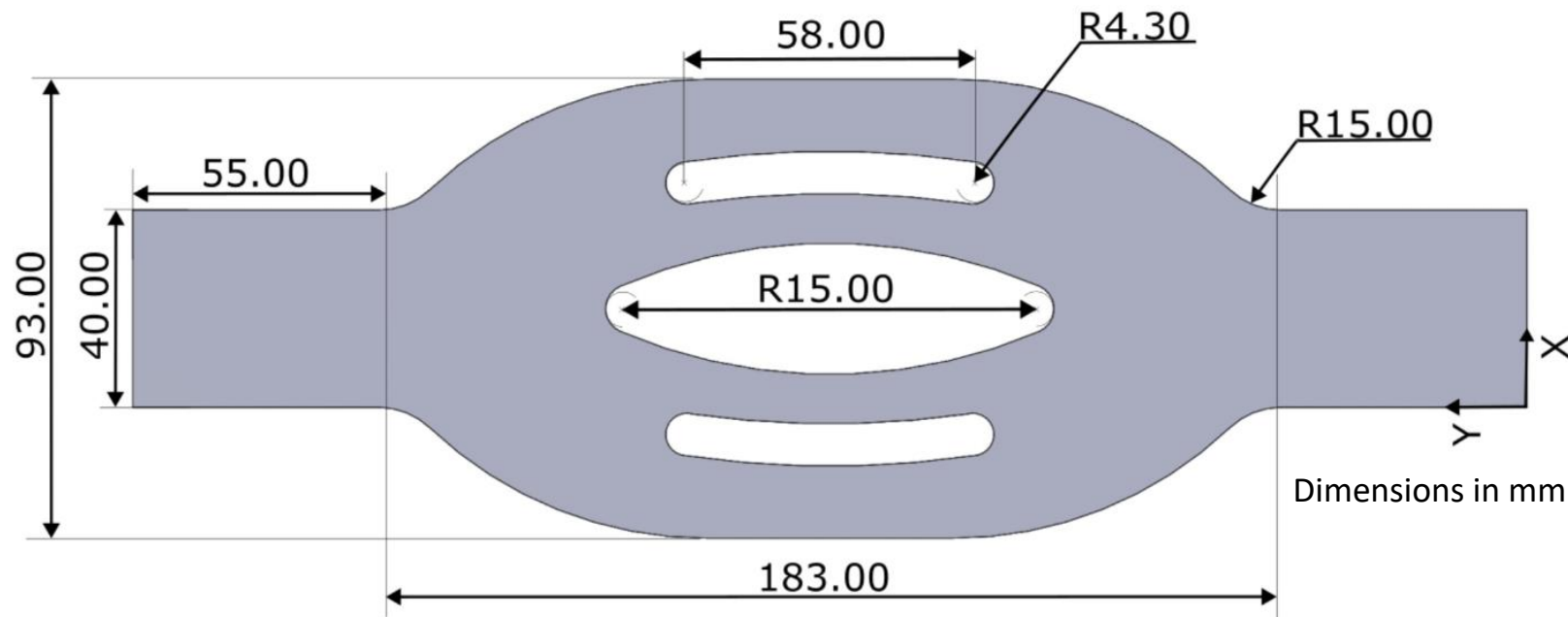
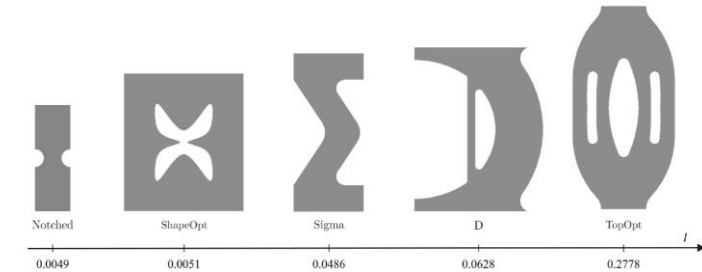
→ automatized testings (ETH Zürich, ... Lorient in some time)

- Smart database → heterogeneous tests



Mafalda Gonçalves, Design of a novel heterogeneous mechanical test using topology optimisation for sheet metal characterization, PhD Univeresidade de Aveiro (to be defended on 19 December 2024)

- Since the late 1990s, still in a state of creativity
- One contribution of Vform-xSteels project: TopOpt specimen



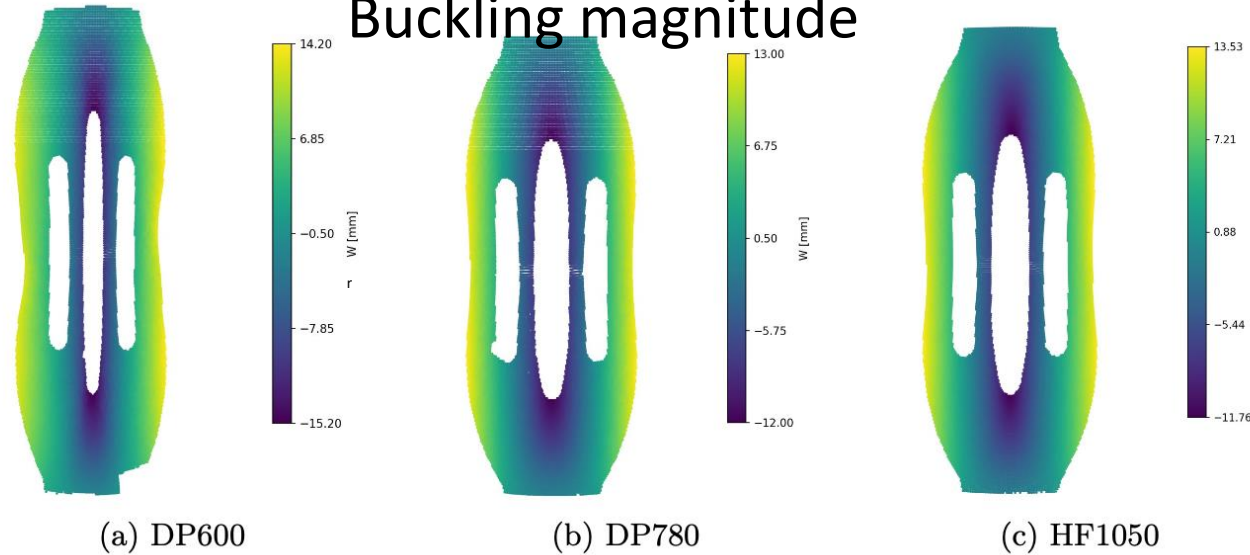
Mafalda Gonçalves, Design of a novel heterogeneous mechanical test using topology optimization for sheet metal characterization, PhD Universidade de Aveiro (to be defended on 19 December 2024)

An experimental database for 3 high strength steels DP600 (0.8 mm), DP780 (1.5 mm), HF1050 (1 mm)

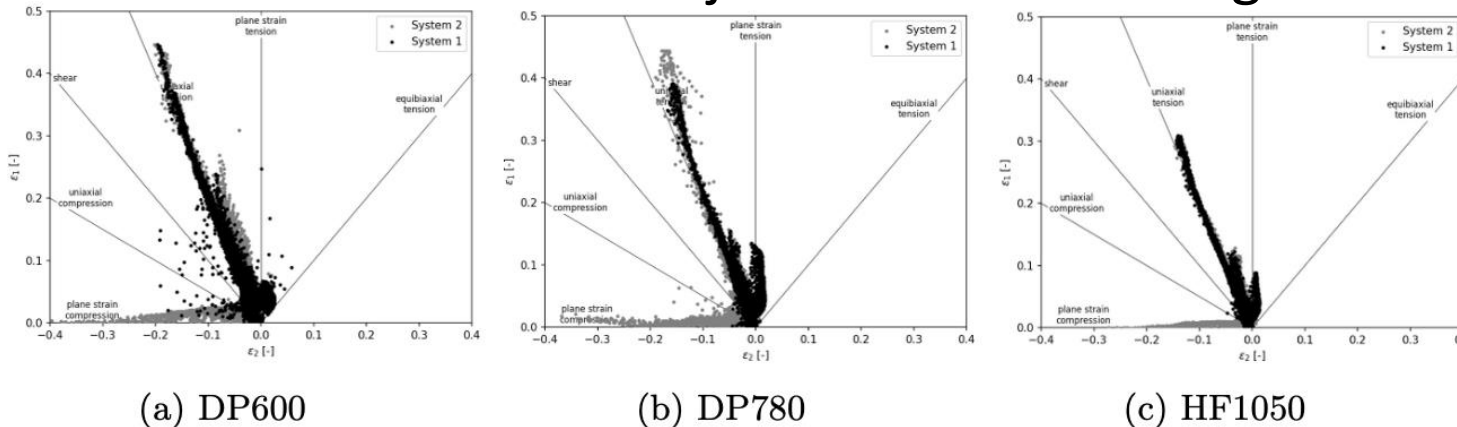
| Material | $R_{p0.2\%}$ (MPa) | R_m (MPa) | \bar{r} | Δr |
|----------|--------------------|-------------|-----------|------------|
| DP600 | 354.5 | 648.8 | 0.999 | 0.085 |
| DP780 | 499.6 | 787.0 | 0.906 | 0.048 |
| HF1050 | 785.6 | 1124.8 | 0.912 | 0.069 |

- TopOpt for the 3 materials: repeatability, robustness

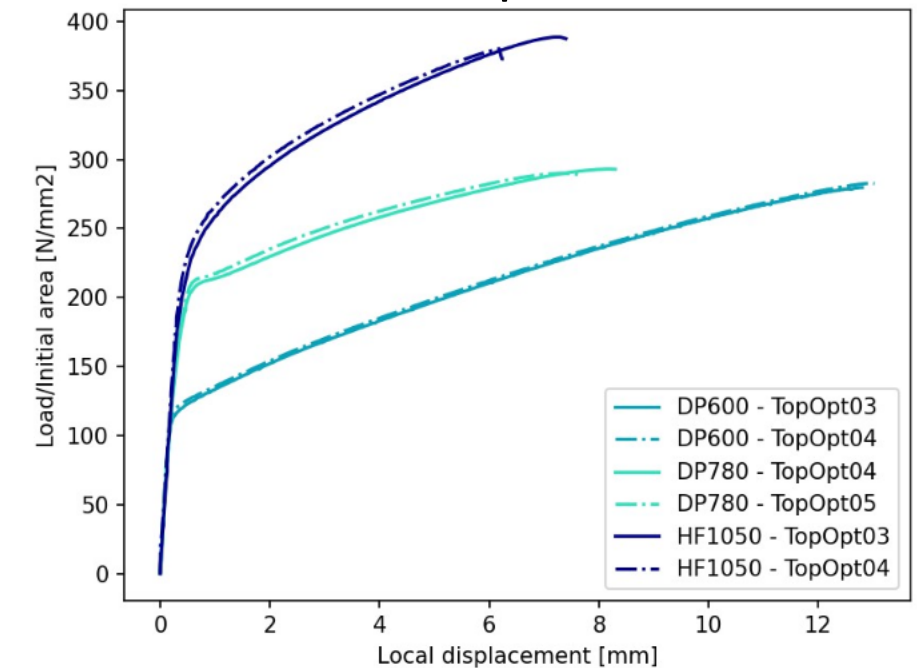
Buckling magnitude



Strain state in major-minor strains diagram

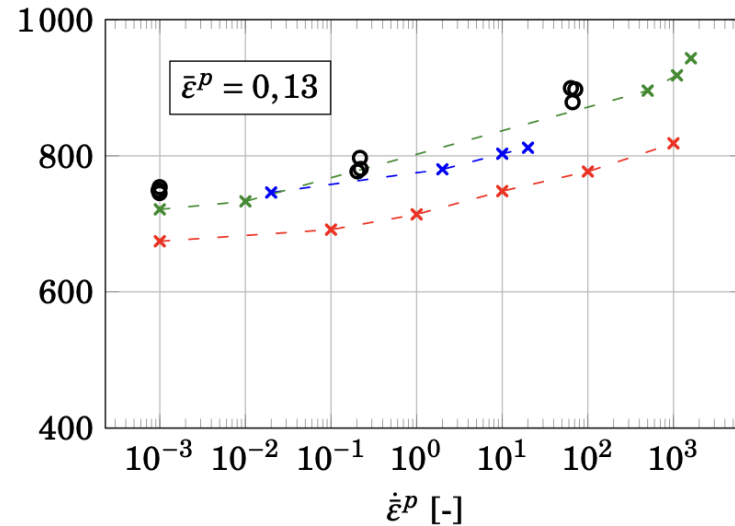
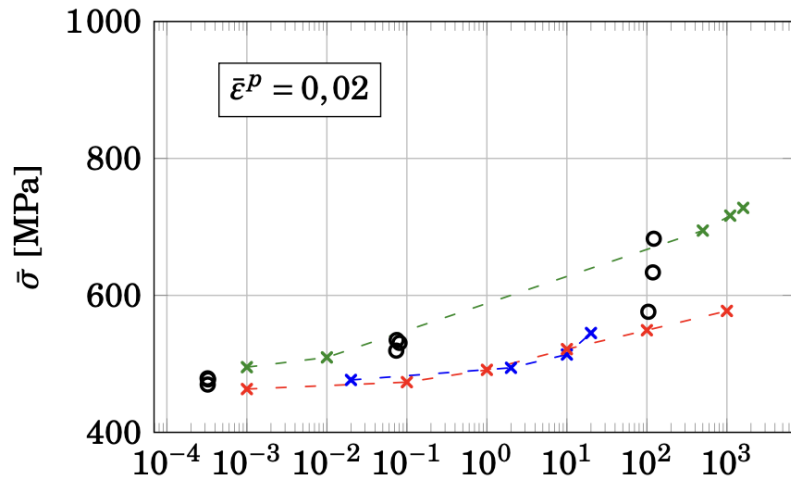


Load-local displacement

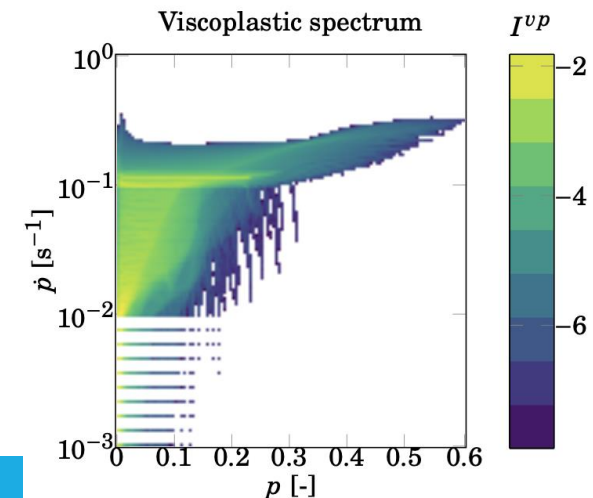
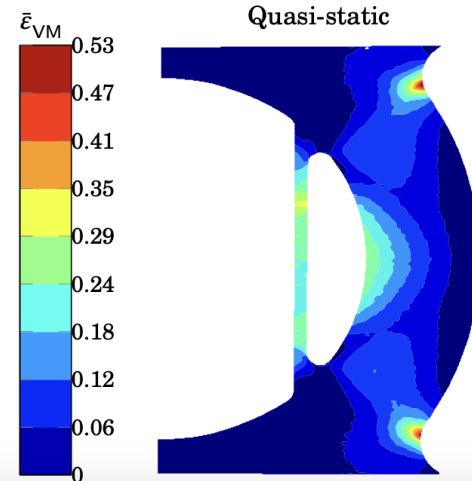


Mafalda Gonçalves et al., Assessing the potential of heterogeneous mechanical tests for sheet metals through experimentally measured full-fields, submitted in Exp. Mech. 2024

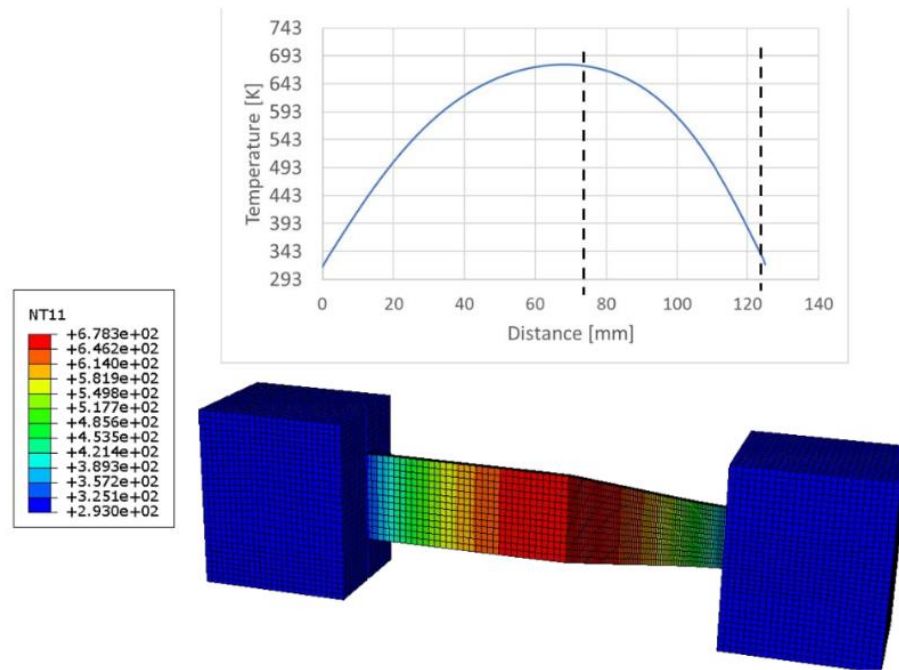
- Strain rate sensitivity of DP600 at room temperature: hydraulic bulge tests to investigate the strain rate range up to 80 s^{-1}



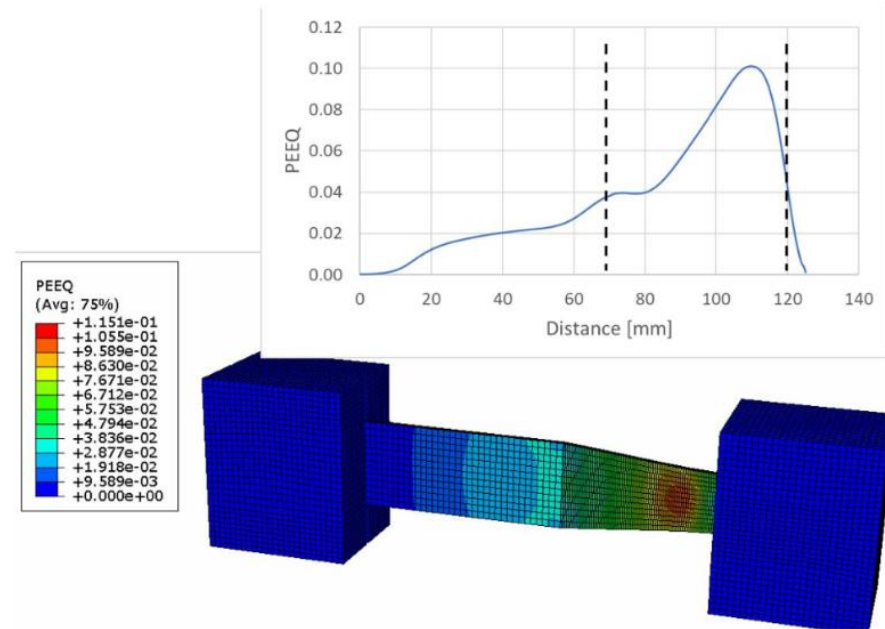
- D-shape specimen (Jones et al., 2018)



- Heterogeneous temperature and strain fields, with a tapered specimen



(a) Temperature field for the tapered specimen



(b) Strain field for the tapered specimen

MaRco Rossi et al., Thermomechanical characterization of high strength steel through inverse methods, SEM, 2024

Research products generated by WP3



- A paper published in the conference proceedings and presented at the international conference ESAFORM 2021, related to the mechanical design of heterogeneous interior notched specimens [5]
- Two papers published in the conference proceedings and presented at the international conference ESAFORM 2022. They are related to the topology-based optimisation to design a novel heterogeneous test using a linear elastic mechanical behavior [6] and to the calibration of a hardening law using an optimum-designed interior notched specimen [7].
- A paper published in the conference proceedings and presented at the international conference IDDRG 2022. It is related to the topology-based optimisation to design a novel heterogeneous test using a non-linear mechanical behavior [8]
- A paper published in the conference proceedings and presented at the international conference IDDRG 2022. It is related to inverse identification methods for plasticity [9]
- A paper published in the conference proceedings and presented at the international conference ESAFORM 2023. It is related to a comparison of the performance of several heterogeneous tests, based on key performance indicators [10]
- A journal paper related to topology optimization for mechanical test design [11]
- A journal paper related to the ranking of several heterogeneous tests based on numerical simulations using DP600 material [12]
- A paper published in the conference proceedings and presented at the international conference ESAFORM 2024. It is related to the experimental characterization of DP600 using the specimen geometry designed in the VForm-xSteels project [13]
- M. Gonçalves, S. Thuillier and A. Andrade-Campos, Assessing the potential of heterogeneous mechanical tests for sheet metals through experimentally measured full-fields, a journal paper submitted for publication in Experimental Mechanics (August 2024)
- A poster presentation related to the characterisation of the strain rate sensitivity of DP600 using hydraulic bulge tests [14]
- An oral presentation (with a 2 page abstract) on the experimental characterisation of the strain rate dependence of DP600 using a heterogeneous test [15]
- A paper published in the conference proceedings and presented at the international conference SEM 2024. It is related to a comparison of specimen geometry to be used for thermo-mechanical loading [16]
- 3 specimen geometries, subject to a uniaxial loading, were mechanically designed as part of the VForm-xSteels project, cf. Fig. [7]

- More model calibration with heterogeneous testing
- Validation and application to virtual forming

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Many thanks

- To Dr Antonio Andrade-Campos, leader of Vform-xSteels project
- To Drs Sam Coppieters and Seven Cooreman for today's organisation