RESEARCH TOPIC FOR THE PARISTECH/CSC PHD PROGRAM

Field: Materials Science, Mechanics, Fluids

Subfield: Mechanical Engineering, computational mechanics

Title: Prediction of the bendability limits during sheet metal forming processes

ParisTech School: Arts et Métiers Sciences et Technologies

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Lab location: 7 rue Félix Savart F-57070 METZ

(Lab/Advisor website): http://www.lem3.univ-lorraine.fr/

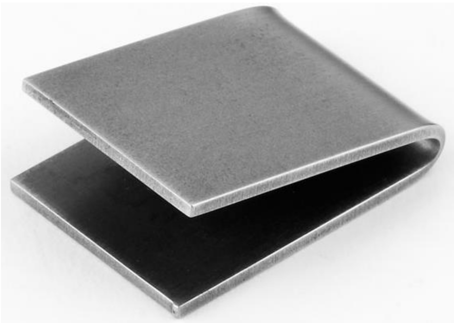
Short description of possible research topics for a PhD:

The vast majority of numerical criteria developed to predict the occurrence of diffuse or localized necking assume that the studied metal sheets remain plane during forming processes. Hence, this conventional assumption does not take into consideration the effect of sheet bending, which seems to be inadequate for analyzing the draw-type operations where sheet metal bends, slides and unbends over a draw radius. The main objective of the current project is to extend the set of numerical tools, that we have developed in our research team for the prediction of diffuse necking (maximum force criterion, …) and localized necking (bifurcation theory, initial imperfection approach…), in order to include the bending effects. The effect of the heterogeneity of the strain through the sheet thickness on the onset of necking will be especially investigated. The mechanical behavior of the bent sheets will be also carefully analyzed by implementing elaborate constitutive models (phenomenological and multiscale models) in our numerical tools. Finite element simulations will be performed to check the accuracy of the developed tools. Once validated, these tools will be used to improve the prediction of the bendability in several industrial and academic applications.

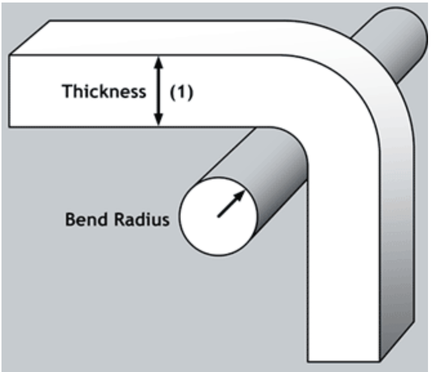
Required background of the student:
- Solid background in solid mechanics and numerical methods;
- Good analytical and programming skills (e.g., Matlab, Mathematica, C/C++, Fortran);
- Experience with Finite Element modeling would be an asset.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. **M. Ben Bettaieb**, **F. Abed-Meraim (2015),** "Investigation of localized necking in substrate-supported metal layers: Comparison of bifurcation and imperfection analyses", *International Journal of Plasticity*, Vol. 65, pp. 168–190.
2. M.Y. Jedidi, **M. Ben Bettaieb**, **F. Abed-Meraim**, A. Bouguecha, M.T. Khabou, M. Haddar **(2019),** "Prediction of necking in HCP sheet metals using a two-surface plasticity model", *International Journal of Plasticity,* doi.org/10.1016/j.ijplas.2019.102641.
3. **M. Ben Bettaieb**, **F. Abed-Meraim**, X. Lemoine **(2019),** "Numerical investigation of the combined effects of curvature and normal stress on sheet metal formability", *International Journal of Material Forming,* Vol. 12, Issue 2, 211–221.
4. J. Paux, **M. Ben Bettaieb**, **F. Abed-Meraim**, H. Badreddine, C. Labergere, K. Saanouni **(2020),** "An elasto-plastic self-consistent model for damaged polycrystalline materials: Theoretical formulation and numerical implementation", *Computer Methods in Applied Mechanics and Engineering,* doi.org/10.1016/j.cma.2020.113138.
5. J.C. Zhu, **M. Ben Bettaieb**, **F. Abed-Meraim (2020),** "Investigation of the competition between void coalescence and macroscopic strain localization using the periodic homogenization multiscale scheme", *Journal of the Mechanics and Physics of Solids*, doi.org/10.1016/j.jmps.2020.104042.



Bendability of nanosteels



Bending of thick sheet