RESEARCH CENTRE IN SHEET METAL FORMING-CERTETA

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Acronym	**CERTETA**	
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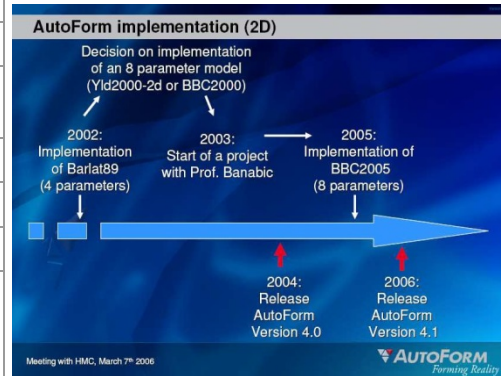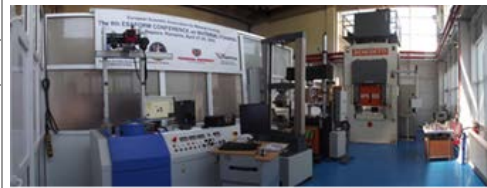
Areas of expertise

The main areas of our scientific interest and activity are:
1. Modelling of the material behavior
2. Formability of metallic materials
3. Simulation of the sheet and tube metal forming processes
4. Virtual fabrication in metal forming

Team

Prof. Dorel Banabic, Reader Dan-Sorin Comșa, Lecturer Lucian Lăzărescu

Representative projects

VIF, **"Virtual Intelligent Forging"**, European FP6 Project, (2004-2008)
"Sheet metal formability for special metal forming processes", Humboldt Foundation (Joint Research Project), (2005-2008)
"Improvement of performances of formability models for sheet metals using new constitutive laws", Swiss National Science Foundation (Joint Research Project), (2005-2008)
VIRFAB, **"Integrated platform for the simulation of forming processes in virtual manufacturing"**, CEEX, (2006-2008)
"From micro to macro - continuum scale modelling of advanced materials in virtual fabrication", PNII, (2009-2013)
"Holistic, extensible, scalable and standard Virtual Factory Framework", European FP7 Project, (2009-2013)

Significant results

Books and contribution to books:
1. D. Banabic, "Sheet Metal Forming Processes", in *Springer, Heidelberg-Berlin*, 2010
2. L. Felice, D. Banabic, "Formability and damage", in (Eds.: L. Laperrière, G. Reinhart, Encyclopedia of Production Engineering), *Springer, Heidelberg-Berlin*, 2013
3. A. Brosius, D. Banabic, Anisotropy, in (Eds.: L. Laperrière, G. Reinhart, Encyclopedia of Production Engineering), Springer, *Springer, Heidelberg-Berlin*, 2013
4. D. Banabic, Fliessortkriteria, in (Ed: K.Siegert, Blechumformtechnik), *Springer, Heidelberg-Berlin*, 2014
5. Banabic D., Comsa D.S., BBC2005 yield criterion used in the numerical simulation of sheet metal forming processes, In: (Ed.:Tekkaya E.A.), 60 Excellent Inventions in Metal Forming), *Springer, Heidelberg Berlin*, 2015

6. Banabic D., Lazarescu L., Comsa D.S., An innovative procedure for the experimental determination of the Forming Limit Curves, In: (Ed.:Tekkaya E.A.), 60 Excellent Inventions in Metal Forming), *Springer, Heidelberg Berlin*, 2015
7. D. Banabic, "Sheet Metal Forming Processes", in *Science Press*, Beijing, 2015

The most representative publications of the past 5 years:
1. D. Banabic, M. Sester, "Influence of material models on the accuracy of the sheet forming simulation", in *Materials and Manufacturing Processes*, vol. 27, 2012, pp. 304-308
2. R. Jafari Nedoushan, M. Farzin, M. Mashayekhi, D. Banabic, "A Micro-Structure Based Constitutive Model for Superplastic Forming", in *Materials and Metallurgical Transactions, A,* vol. 43A, 2012, pp. 4266-4280
3. L. Lazarescu, D. S. Comsa, I. Nicodim, I. Ciobanu, D. Banabic, "Characterization of plastic behaviour of sheet metals by using the hydraulic bulge test", in *Trans. Nonferrous Met. Soc. China*, vol. 22, 2012, pp. 275-279
4. D. Banabic, L. Lazarescu, L. Paraianu, I. Ciobanu, I. Nicodim, D. S. Comsa, "Development of a new procedure for the experimental determination of the Forming Limit Curves", in *Annales of CIRP*, 2013, pp. 255-258
5. M. Vrh, M. Halilovič, B. Starman, B. Štok, D. S. Comsa, D. Banabic, "Capability of the BBC2008 yield criterion in predicting the earing profile in cup deep drawing simulations", in *European J. of Mechs.*, vol. 45, 2014, pp. 59-74
6. S. Bruschi, T. Altan, D. Banabic, P. F. Bariani, A. Brosius, J. Cao, A. Ghiotti, M. Khraisheh, M. Merklein, E. Tekkaya, "Testing and Modeling of Material Behavior and Formability in Sheet Metal Forming Processes", in *Annales of CIRP*, vol. 63, 2014, pp. 727-749
7. A. Kami, B. M. Dariani, A. S. Vanini, D.S. Comsa, D. Banabic, "Application of a GTN Damage Model to Predict the Fracture of Metallic Sheets Subjected to Deep-Drawing", in *Proc. Rom. Acad.*, vol. 15, 2014, pp. 300-309
8. Nedoushan R.J., Farzin M., Banabic D., "Simulation of Hot Forming Processes Using Cost Effective Micro-Structural Constitutive Models", in *Int. J. Mechanical Sciences*, vol. 85, 2014, pp.196–204
9. A. Kami, B. M. Dariani, A. S. Vanini, D.S. Comsa, D. Banabic, Numerical determination of the forming limit curves of anisotropic sheet metals using GTN damage model, in *J. Materials Proc. Technol.*, 216 (2015) 472–483
10. J. Gawad, D. Banabic, A. v.Bael, D. S. Comsa, M. Gologanu, P. Eyckens, P. v. Houtte, D. Roose, "An evolving plane stress yield criterion based on crystal plasticity virtual experiments", in *Int. J. Plasticity*, vol. 75, 2015, pp.141-169

Significant solutions:
The members of the CERTETA Centre developed a yield criterion for anisotropic metallic materials called BBC2005. Its mathematical formulation has been implemented in the commercial finite element code AutoForm in order to simulate the sheet metal forming processes. One may notice the fact that the AutoForm program is used by 95% of the world's leading manufacturers of automobiles and airplanes, which assures a global scale application of the model BBC2005. This means that the model is applicable at the global scale and CERTETA Centre is visible in automotive and airplane production industries (according to the AutoForm official site www.AutoForm.com, over 2500 users from 500 companies located in 40 countries). The Material Modelling Committee of the Japan Association for Nonlinear CAE (JANCAE) has recently developed a unified user-subroutine (called UMMDp, Unified Material Model Driver for Plasticity), which couple different hardening rules and yield functions, including BBC 2005 and BBC2008 models developed by the CERTETA team. This subroutine can be used within any commercial FE software (Abaqus, LsDyna, ANSYS, MSC Marc, Radioss) by using the unified interface routine.

Other remarkable results consist in the fact that CERTETA developed a program for the calculation the forming limit curves, called FORM-CERT. This program is used by several automotive companies (Daimler, Audi, etc.).

The third major achievement consists in the development of a model for the prediction of Forming Limit Bands. In this research field, CERTETA is a pioneering laboratory at international level.

Products and technologies:
The yield criteria developed in order to describe the plastic anisotropic behavior of the metallic sheets. The BBC2005 yield criterion has been implemented in the AutoForm FE commercial code and in the UMMPd user subroutine.
Hierarchical Multi-Scale (HMS) model coupled with BBC2008 yield criterion.
FORM-CERT commercial program for the determination the forming limit curves.
Technology and expertise to determine the mechanical parameters of the metallic sheets
Technology and expertise to determine the formability of the metallic sheets

The offer addressed to the economic environment

Research & development	CERTETA currently develops constitutive models for anisotropic metallic materials, with special emphasis on cold-rolled sheet metals. The theoretical prediction of the forming limits is also an important domain of research. The models are developed with the aim of being implemented in the programmes used for the numerical simulation of the forming processes and computer-aided design of the forming tools. The members of the CERTETA are also involved in the development of experimental methods for the determination of the mechanical parameters and limit strains of metallic sheets.
Consulting	The research centre provides consulting services in the field of materials testing, numerical simulation of the sheet metal forming processes, and computer-aided design of forming tools.
Training	The research centre offers training courses in the field of numerical simulation of the metal forming processes using finite element programmes. The members of team have also a sound expertise in the field of metal forming procedures and their implementation in industry.