MatchID

Metrology beyond colors

June 2022

Newsletter 2022/2

Face to face

Finally, we can start interacting in live mode again with our partners, distributors, customers and potential leads. We are delighted to talk again to faces instead of computer screens. Accordingly, we did not dig our heels in and promptly went on site again for a versatility of events.

First, the past few months were very busy by completing dedicated training sessions and talks at customers facilities as e.g. University Clermont Auvergne, University of Delft, OCAS, Onera, University of Bristol and Universidade de Aveiro.

On top, the MatchID team was pleased to be back at expositions and conferences with intense frequented booths at DYFP-Holland, Esaform-Portugal and IDDRG-France. These were specifically selected to present our brand-new anisotropic stress identification capabilities of our VFM engine. A plethora of yield criteria has been integrated in our 2022.2 release. Discover more on the next page!

The wave of enthusiasm and positive feedback received at these events make us excited for the upcoming scheduled occasions. You can find a shortlist at the last page of this newsletter. In particular, we are proud to host our 9th intensive 5-day course on Digital Image Correlation in Ghent. Next year, we will have a teenager!

We also had the opportunity to welcome our Polish (Invenco) and Japanese (JSOL) distributors at our office recently. A healthy mix of business discussions and training sessions guarantee a prosperous collaboration. Both these distributors bring also added value to MatchID: Invenco, being active in the simulation world, will allow to extend our FEA validation capabilities. JSOL, on the other hand, is the ideal partner to gain a growing share in metal plasticity applications. Needless to say that the abovementioned anisotropic add-ons in close connection to our further upgraded turnkey hardware solutions will play a crucial role in these plans.

To conclude, we would like to sincerely thank Erik Jungstedt from the Biocomposites group at KTH-Sweden for his nice illustration of our FEA validation strategy embedded in a closed-loop updating scheme. Enjoy the reading!

-The MatchID Team

In this issue

We recently hosted Hiroshi Fukiharu and Saeko Yoshizawa from JSOL, our Japanese distributor, at our facilities. Thanks to them, MatchID is now also successful in 日本.

MatchID 2022.2 what's new?

MatchID 2022.2 is out now! We are thrilled to present you a range of new features on top of higher performance, flexibility and stability, resulting from 6 months of exciting work.

Ultimate batch procedure

All the post-processing options (stress, kinematics, charting,...) in batch mode, including exporting of the underlying datasets.

Integration of anisotropic plasticity yield criteria

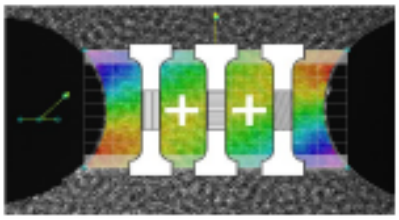
Hill quadratic 1948, Hill 1990, Barlat YLD2000-2D, Barlat YLD2004, Barlat YLD89, Cazacu 2006, Karafillis-Boyce 1993, Hu 2005, Gotoh biquadratic 1978, Vegter, Banabic BBC2005, BBC2008.

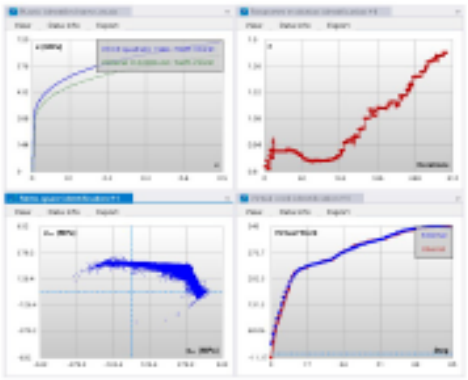
Material orientation

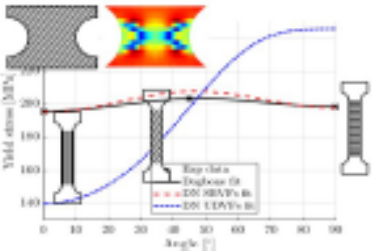
Stress and strain calculation in an assigned material orientation.

Crack module

Strains calculated along the crack path and not overlapping different regions.







The virtual fields module allows to identify anisotropic yield criteria and hardening parameters based on full-field data hereby drastically reducing the amount of test samples required.

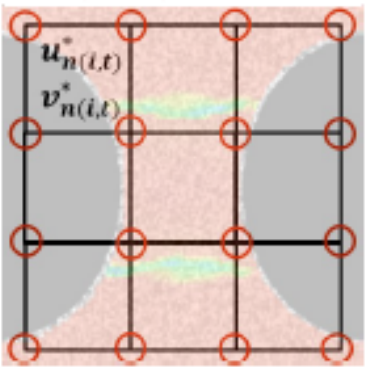
Anisotropic stress reconstruction

The Virtual Fields Method is a semi-analytical approach relying on the principle of virtual work and allows to identify material properties based on full-field data. Accordingly, fewer tests need to be performed since the stress field is allowed to be heterogeneous compared to traditional tensile testing. It has shown to be way faster than typical Finite-Element Model Updating (FEMU) procedures.

$$\left[\int_S\left(\int_0^t \mathbf{M}\,d\tau\right)\cdot\varepsilon^*\,dS-\int_{C_F}\mathbf{T}\cdot u^*\,dl\right]^2=0$$

W_{int} W_{ext}

Measured by DIC at every time t

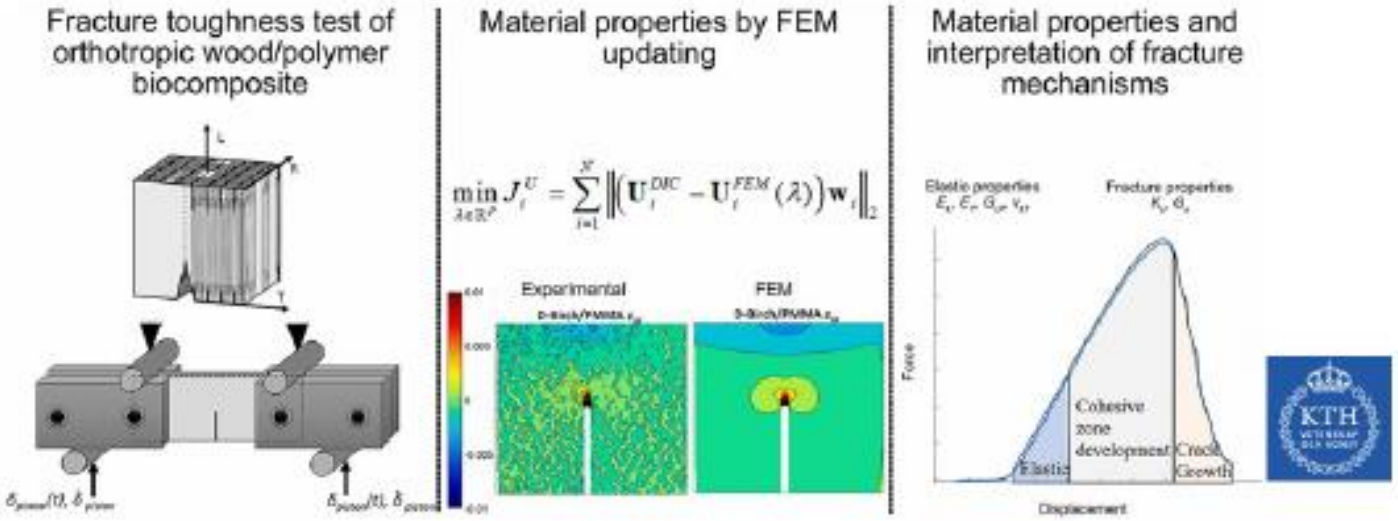


In the MatchID software two types of virtual fields can be adopted: (1) uniform fields giving equal weight to each data point (2) **sensitivity-based** fields that will put more stress on data points with a higher parameter sensitivity and signal-to-noise robustness. To this purpose, a discretization of virtual fields is applied, providing different weighting factors in every element. Secondly, the fields are adjusted in order to allow the usage of the total force measured by the load cell, in contrast to FEMU strategies that generally need a quantification of the force or displacement distribution along the clamping. In MatchID **the virtual fields are automatically determined** based on these principles.

Recently, MatchID has integrated a **large set of anisotropic yield criteria** into its material model portfolio. To validate the procedure, deformation data was obtained during deep-notched tests of cold-rolled sheet of DC04 steel using stereo Digital Image Correlation [1]. By setting cross-polarization specular reflection was minimised which resulted in a grey level histogram spread across most of the dynamic range of the cameras. The analyzed DIC displacement results were seamlessly transferred into the VFM module, A full identification was performed for both Hill48 and YLD2000-2D yield criteria adopting both types of virtual fields. The charts above display the resulting stress strain curves, parameter evolution, stress space and work equilibrium.

When the heterogeneous tests combined with sensitivity-based virtual fields were used to identify Hill48, the material parameters matched the yield stress variation and the loading force well. Hence, 3 homogeneous tests performed at 0, 45 and 90 degrees w.r.t. the rolling direction could be replaced by a single specimen encompassing identical information. The selection of the sample geometry, however, still remains an open problem, and the results could certainly be improved further if the test was richer in terms of load paths. New test configurations will be needed where shape and loading are not constrained by the need for an a priori stress distribution anymore. This was recently coined **"Materials Testing 2.0"** and MatchID has the ambition to play an active part in this process.

[1] A. Marek, F. M. Davis, J.-H. Kim, F. Pierron (2020). Experimental Mechanics 60:639–664



The Research Team of the Biocomposites group at KTH, Sweden, identifies material properties of transparent wood biocomposites by integrating MatchID's FEVAL module into a batch-mode operating Finite-Element-Model Updating scheme.

Application in the picture: Transverse fracture toughness of transparent wood biocomposites by FEM updating

As a reinforcing component in polymer composites, wood is an alternative for sustainable development for lowered global carbon dioxide emissions, with competitive mechanical properties to glass-fiber reinforced polymer composites (GFRP). The Biocomposites group at KTH, Sweden, with Professor Lars A. Berglund, studies wood and cellulose-based biocomposites; one example is transparent wood; an optically transparent, load-bearing, monomer-impregnated wood composite. These composites can be made fully bio-based (https://doi.org/10.1002/advs.202100559), have comparable mechanical properties to GFRP, and offers optical functionalities which are interesting for applications where light transmittance is important, e.g., solar cells (https://doi.org/10.1021/acssuschemeng.8b06248).

For load-bearing composites, elastic and failure properties are essential. However, data for fracture toughness of monomer-impregnated wood composites are scarce, and the fracture mechanisms are not well understood. This study quantifies the deformation and fracture mechanisms by measuring the strain and displacement fields with digital image correlation (DIC) using the MatchID software from a four-point bending fracture test. An inverse updating procedure was used to identify the fracture

"The MatchID FEVAL tool is an important step to validate strain fields of the fracture process zone."

Erik Jungstedt, Sören Östlund, Lars Berglund - KTH, Sweden

toughness and orthotropic elastic properties of wood and transparent wood composites by minimizing the difference in displacement field from DIC analysis and numerical predictions by a finite element model. Material model parameters in the FEM were updated by a Nelder-mead optimisation algorithm until FEM and DIC displacement fields matched. The fracture mechanism was modeled using a cohesive zone, a common model to represent the fracture processes of, e.g., fiber-bridging, a fracture mechanism that impedes crack propagation, often seen in wood materials. The identified properties were validated to experimental force -displacement results, showing a close match. Finally, the deformation and fracture mechanisms could be interpreted by supporting the experimental results with fractography.

The FEM updating (FEMU) routine involved using the FE deformation module (FEDEF) and FE validation module (FEVAL) in MatchID's software package to convert FEM nodal displacements to pixel displacement. These were important steps in the FEMU to compare FEM and DIC results and also helped to validate the strain fields for a quantitatively comparison of the fracture process zone from experiments and the postulated cohesive zone model.

More information: www.kth.se and https://doi.org/10.1016/j.compscitech.2022.109492

Turnkey hardware solutions

MatchID has developed turnkey solutions that facilitate the journey of successful testing. We offer a wide range of hardware products that are customized for a vast amount of applications: from small to large scale, encompassing quasi-static, high-speed, fatigue, vibration, infrared and multi-camera (up to 18!) events.

Our image acquisition software integrates with a broad set of cameras and allows to investigate speckle quality, alignment, calibration, lighting, noise, etc. Synchronisation and data acquisition is ensured via our in-house-made triggerbox.

Apart from synchronisation, the temporal performance of a setup is mainly advocated by an optimised computer configuration. We have created dedicated desktop compositions that allow the invoked hardware to perform at its maximum extent.

Finally, we are pleased to introduce our novel and easy to use Mobile System Rack, tailored to store MatchID equipment.

Have a look at https://www.matchid.eu/en/solutions-overview/hardware to discover our novel solutions!

Meet MatchID at:

- ***T&T sessions:*** *short 20 min sessions to improve your MatchID product knowledge:*
  - ⇒ 20/07/2022 T&T 3 - Batch mode processing.
  - ⇒ 14/12/2022 T&T 4 - High-speed image grabbing.
- ***Webinars:*** *a 45 min-journey to a specific MatchID product illustrating its capacities towards a large range of applications*
  - ⇒ 24/08/2022 Webinar 2 - What's new in release 2022.2?
  - ⇒ 23/11/2022 Webinar 3 - Combining IR and DIC.
- ***Conferences and expositions:***
  - ⇒ SEM Annual Pittsburgh, USA - 13/06/2022
  - ⇒ EMEX22 Oxford, UK - 07/09/2022
  - ⇒ DYMAT 2022 Freiburg, Germany - 11/09/2022
  - ⇒ iDICS Boston, USA - 06/11/2022
  - ⇒ NAFEMS Paris, France - 23/11/2022

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