Digimat for Advanced Materials Characterization & Efficient Design of Components

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Who are we...?

- Software & Engineering company 100% focused on advanced material modeling.
- Founded in 2003
- Acquired by MSC Software in Sept 2012
- Team of ~35 persons
- Material experts
  - Micromechanics
- It's all about...

COMPOSITES
Global trends in the industry

∞ Economy
  ✓ Reduce costs

∞ Maintain leadership
  ✓ Sustainability
  ✓ Reduce time-to-market

∞ Environment
  ✓ Lightweighting

∞ Politics
  ✓ Meet gouvernemntal regulations (CAFE, ...)

∞ ...

MATERIAL
Challenges for lightweight materials

Availability & Sustainability
- Grades, quality, costs
- CO2 – footprint, ...

Development, Optimization & Integration of new materials
- Accurate modeling of (composite) materials, parts & systems
  - Heterogeneity, Nonlinearity, Anisotropy

Optimization of parts & systems
- Right material at the right place
- Reduce safety factor, stop over-designing
- The Material(s) as a design parameter to innovate
- The optimal manufacturing process
Digimat users community today

∞ Material Suppliers
  ✓ Plastics
  ✓ Composites
  ✓ Other: Rubber, Metals, Ceramics,

∞ Automotive
  ✓ OEMs
  ✓ Tier 1

∞ Aerospace
  ✓ Aero Structures (OEMs)
  ✓ Aero Engines

∞ Electric & Electronic
  ✓ Electronic Appliances: Mobile Phones, Cameras,…
  ✓ Electric: Connectors, transformers, …

∞ Defense
Material engineers

✓ To Understand & Optimize Material Behavior
  • How to design/select the optimal material?

✓ To Reduce Material Testing (Time & Cost)
  • How to optimally process the material?

✓ To Promote Material Usage and Support the Internal and External Users of the Materials
Digimat for Material Suppliers

Huntsman

Solvay

EMS-Grivory

Mitsubishi

Ube

Dupont

Hexcel

Arkema

DSM

Borealis

Toray

Ticona

Sumitomo Chemical

CEMCAT

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Digimat for Material Users

Material “Users” (i.e. OEMs & Suppliers)

- Understand & Optimize Structural Behavior
  - How to design the optimal component?

- Reduce Component and System Testing (Time & Cost)
  - How to optimally process the part to meet the requirements?

- Meet regulations and increasing constraints

- Maintain leadership and reduce time-to-market
Some Digimat users in the automotive

- GM
- Honda
- Renault
- Autoliv
- Ford
- PSA Peugeot Citroën
- Delphi
- HYUNDAI
- Faurecia
- Dräxlmaier
- montaplast
- Bosch
- TRW
- Hutchinson Worldwide
- Kolbenschmidt Pierburg
- Calsonic Kansei
- Takata
- Goodyear
- L&L Products Europe
- Brose
- Mann + Hummel
- Plastic Omnium
- Trelleborg
Some Digimat users in the aerospace market
But basically... WE ARE IN ALL MARKETS!!
Digimat, The nonlinear multi-scale modeling platform

Digimat-MF to predict the nonlinear constitutive behavior of multi-phase material.

Digimat-FE to perform Finite Element modeling of realistic Representative Volume Elements (RVE).

Digimat-MX platform to reverse engineer, store, retrieve and securely exchange DIGIMAT material models.

Digimat-CAE Interfaces to all major injection molding and structural FEA software codes.

Digimat-MAP Shell and 3D mapping software.

Micross to design honeycomb or foam core composite sandwich panels based on FE analyses.
Digimat to model the behavior of material

- Virtual lab
- Material database to store & exchange data
- Reverse engineering tool to characterize the Digimat material model
**Digimat: Prediction of material behavior**

- **Fast & efficient prediction of composite material properties**
  - (Thermo-)Mechanical
  - Electric
  - Thermal

<table>
<thead>
<tr>
<th>MATERIALS</th>
<th>MICROSTRUCTURE</th>
<th>PROCESSING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matrix</td>
<td>Inclusion</td>
<td>Setup</td>
</tr>
<tr>
<td>Fibers</td>
<td>Orientation</td>
<td></td>
</tr>
</tbody>
</table>

**Short fibers**
- Thermoplat
- Glass (Carbon)
- Straight
- Random
- Skin/core

**Long Fibers**
- Thermoplat
- Glass
- Straight
- Random
- Complex Layers
- Injection molding
- Compression molding

**Continuous Fibers**
- Thermoset (Thermoplast)
- Glass Carbon
- Straight
- Fixed
- Stacked
- Draping

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Digimat to predict the behavior of component

- Mapping technology
- Interface to FE, Manufacturing & Fatigue software
- Bending and in plane shear tests of sandwich panels
Digimat, to bridge the gap between process and FEA

Input

Interfaces

Result

Strain

Stress & Stiffness Matrix

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SOME APPLICATIONS
Some applications in the automotive industry
**Front End – Stiffness & Vibrational Analysis**

**Coupling to injection molding**

- Static load
- Material
  - PP (LGF)
- Digimat gives good prediction of stiffness

**Test Stiffness** vs. **Digimat Computed Stiffness**

-3.75%  + 8.07%

-6.97%

**Courtesy of:**

[RENAULT]

**displacement**
Coupling to injection molding

- Vibrational analysis
- Digimat gives excellent prediction compared to test data

<table>
<thead>
<tr>
<th>Mode Number</th>
<th>Test</th>
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</thead>
<tbody>
<tr>
<td>7</td>
<td>1.68%</td>
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<tr>
<td>8</td>
<td>0.96%</td>
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<tr>
<td>9</td>
<td>-3.66%</td>
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<td>18</td>
<td>2.21%</td>
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Mode Number

Test

MDA Predictions

Courtesy of: [RENAULT]
Coupling to injection molding

- Quantitative Results
  - Static Load Case
Coupling to injection molding

Application to engine mounting system
- Cascading mass saving to engine mounting system: FIAPLAST program launched in 2007

Loading conditions:
- Static
- Fatigue
- Crash

Conclusion - Outlook
- An industrial FEA procedure accounting non linearity and anisotropy of PA6.6 GF reinforced is available.
- Good correlation FEA/test achieved for static and fatigue
- Part available for mass production

Mass: 710 g
Cost: -15%
Start of production 2012

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Multi-Scale Modeling of an Over-Molded Beam

Overmolded Beam

Short fiber reinforced plastics
Injection molding
HYBRID solution

Woven composite
Draping
MICRO solution
Overmolded Beam

- Coupled analysis

- Injection molded vs. Over molded beam

Force response
Global

Injection molded SFRP

Over molded Woven + SFRP

Displacement (mm)
Some applications in the automotive industry
Simulation Strategy

Bottom → Up

Ply
Composite

Phase
Matrix

Phase
Fibers

Coupon
Performance

Part
Performance

Laminate
Properties

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Deflection of a Wing Panel

Influence of processing Draping vs. Fiber placement

✓ Amplitude of displacement
Bird strike on aeroplane underbelly fairing

Micro & Macro results

- **Composite stress** ($\sigma_{11}$)
- Failure

- **Macro**
- **Matrix**
- **Fibers** ($0^\circ$)
Digimat-CAE Modeling of Open Hole Coupon

- Digimat-CAE/Nastran (SOL400)

IN

FEA Model

W = 1.5 in  D = 0.25 in

L = 12.0 in

INTERFACE

Digimat-CAE/Nastran

Global results
Local results

Ply Composite

Digimat Material

OUT

Composite

Matrix Fibers

IN

OUT

Coupon Composite

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Local Response in the Specimen

- Ply level
  - Macroscopic properties in each ply
    - Max. Princ. Stress [ksi]
    - Influence of the hole on local behavior

Laminate 1
10/30/60

Laminate 2
60/30/10

Laminate 3
10/40/50
CONCLUSION
SUMMARY: DIGIMAT EMPOWERS TO MODEL:

- Material
  - Plastics
  - Composites
  - Rubber
  - Other (multi-phase)?

- Industry
  - Chemical (Material Suppliers)
  - Automotive (OEM & Suppliers)
  - Aerospace (OEM & Suppliers)
  - E&E (OEM & Suppliers)

- Application
  - Compound: Plastics, rubber, ...
  - Auto Interior: IP, Airbag
  - Auto Powertrain: Oil pan, Engine Cover, ...
  - Aero: Engine, Body, ...

- Performance
  - Stiffness, Vibration
  - Crash/Failure
  - Creep
  - Fatigue

- Technology
  - Nastran, Marc
  - Abaqus, Ansys, ...
  - Ls-Dyna, Radioss,
  - Moldflow, Moldex,

*e-Xstream is the “Composite” Design & Manufacturing of Composite Products*
What's new in Digimat 4.4.1?

- New interface to MSC Nastran SOL400
- Marc Mentat plug-in
- Advanced woven capability
- Support of new processing simulation such as (injection-)compression molding & MuCell®
- Fatigue of continuous fiber composites
- And many more...