(PPCK, 2006)

Hemp fibre reinforced bio-polymers
- concepts and future trends -

Jörg Müssig
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Fourth International Conference of the

EIHA European Industrial Hemp Association

November, 21st-22nd 2006
EuroMedia Hotel in Hürth, Germany

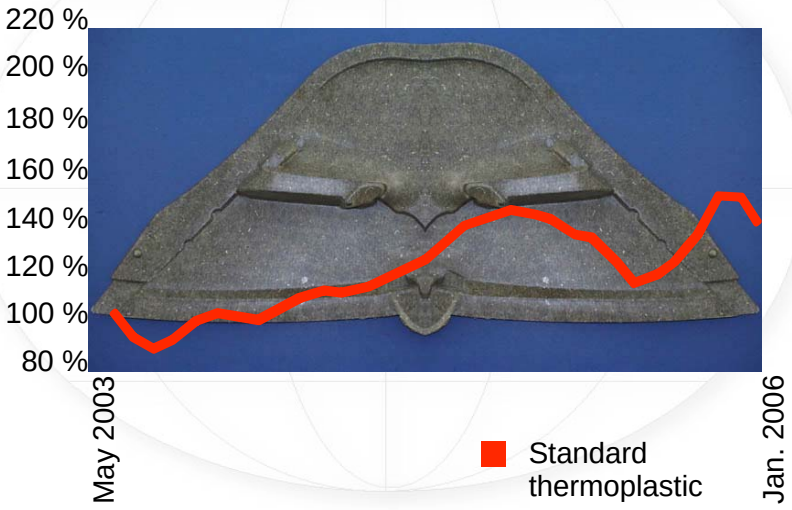
Overview

- Introduction
  - Motivation to use fibres & polymers based on renewables
  - Scenario & Price
  - From Corn to PLA fibre / From Oil to PTP
- Material, Methods & Results
  - PLA/Natural fibres & Injection moulding
  - PLA/Natural fibres & Compression moulding
  - PTP/Natural fibres & Press flow-moulding
- Summary and Outlook

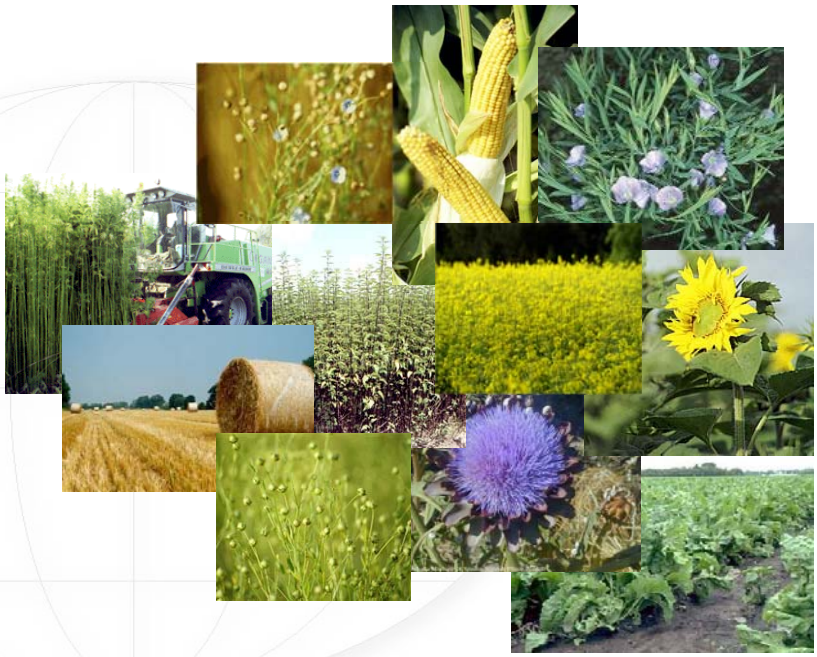
Price stability of materials

Scenario:

- Price calculation of a virtual car part / start of production: 200X
- Product cycle: X years
- Price reduction per year: X %



Crude oil or Alternatives?



Glucose as a raw material / PLA

(GABI, 2004)

→ Based on starchy raw materials:

Corn, Wheat, Potatoes, Rye etc.

→ Based on sugary raw materials:

Sugar beets (Sugar cane)

From corn to granules

Sugar (Glucose)

Fermentation

Lactid acid

Monomer production

Lactide

Polymer Production

PLA

Polymer Conversion

NatureWorks PLA

(Nature Works, 2005 .- adapted presentation)

PLA - and it works in bottles too

Composting

✓ industrial conditions

Recycling

✓ mechanical

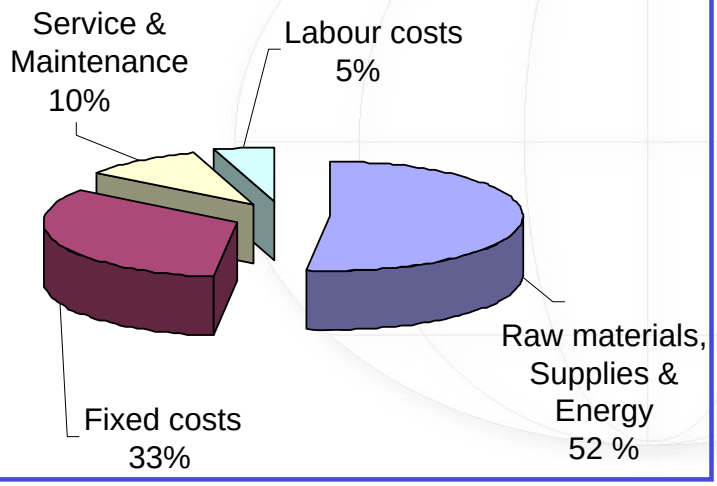
✓ chemical

(Nature Works, 2005)

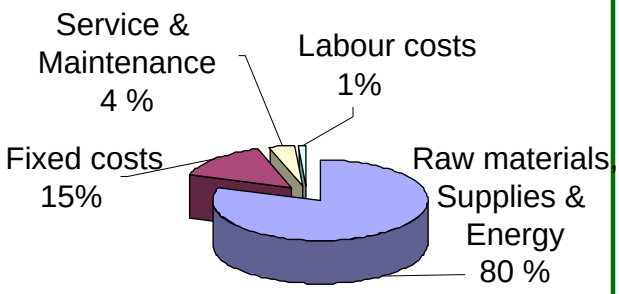
Exemplary account / PLA production

(European Bioplastics, 2006)

Capacity: 10,000 t/a
2.10 €/kg PLA

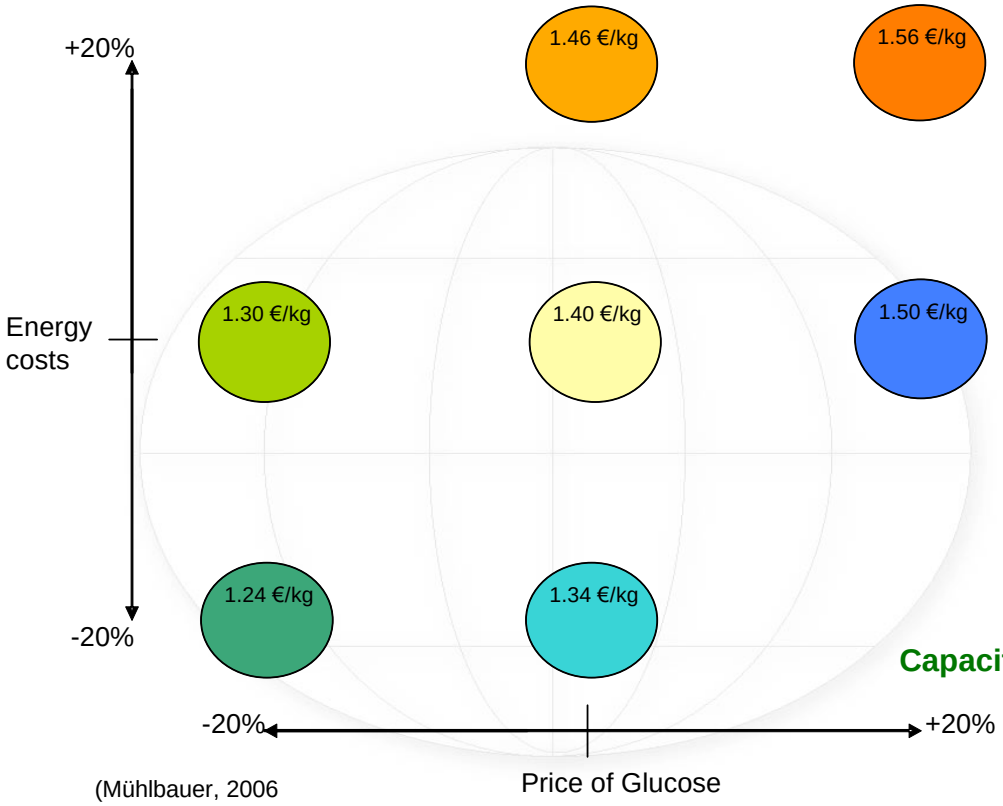


Capacity: 100,000 t/a
1.40 €/kg PLA



(Mühlbauer, 2006
.- adapted presentation)

PLA / Production costs



Capacity: 100,000 t/a

(Mühlbauer, 2006
.- adapted presentation)

PTP® reaction resin

Resources for the resin component

plant oil

Resources for the hardener component

fermented ethanol

fermented carboxylic acid

epoxy-enhanced triglyceride

polycarbon acid anhydrides

initiator

Polymer material made of **T**riglycerides and **P**olycarbon acid anhydrides
PTP

PLA/Kenaf „mobile phone“

(IBAW, 2005)

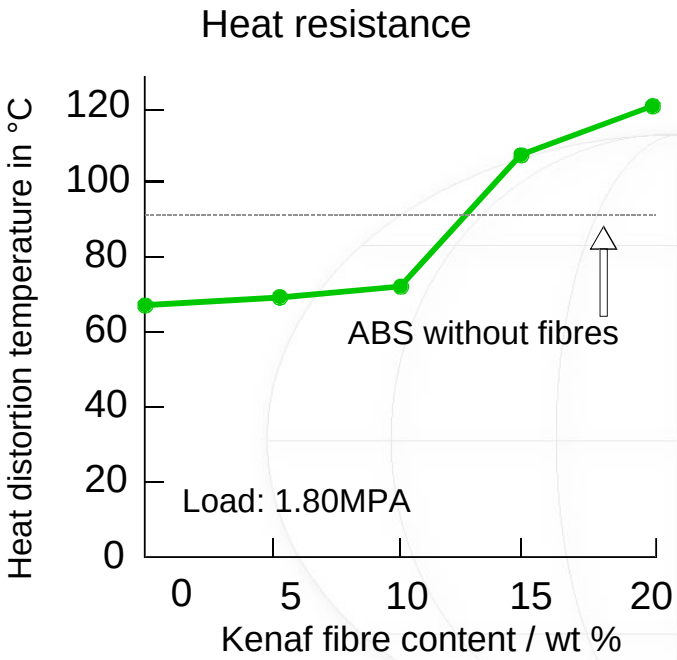
(NEC, 2006)

(anonym, 2006)

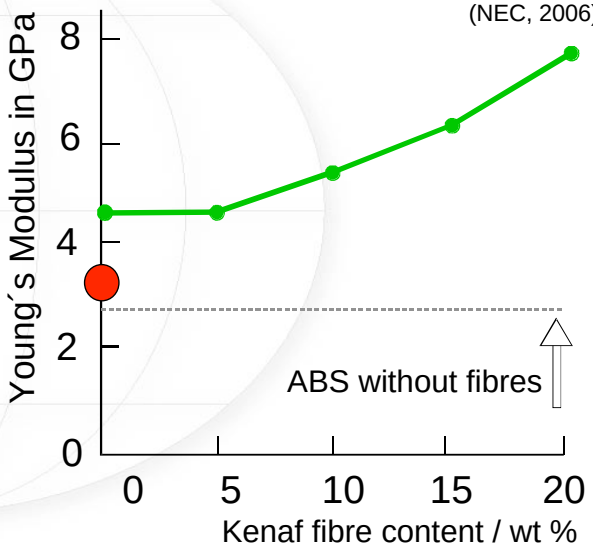
NEC & UNITIKA

Mobile phone / Properties

(NEC, 2006)



(anonym, 2006
.- adapted presentation)



From corn to fibres

Sugar (Glucose) ↔ Fermentation

Fermentation → Lactid acid

Monomer production

Monomer production → Lactide

Polymer Production

Polymer Production → PLA

PLA → Polymer Conversion

NatureWorks PLA

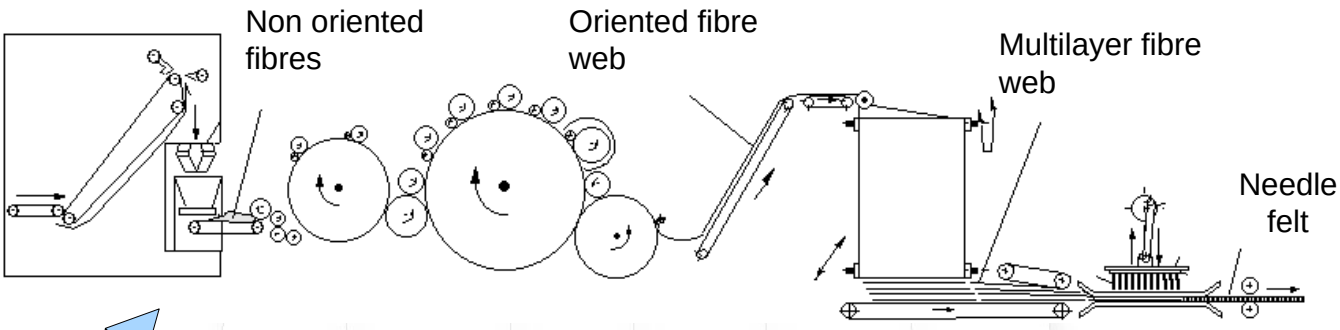
Polymer Conversion → NatureWorks PLA

Polymer Conversion → Ingeo Fasern

(Nature Works, 2005 .-
adapted presentation)

Needle felt production

NAFGO GmbH



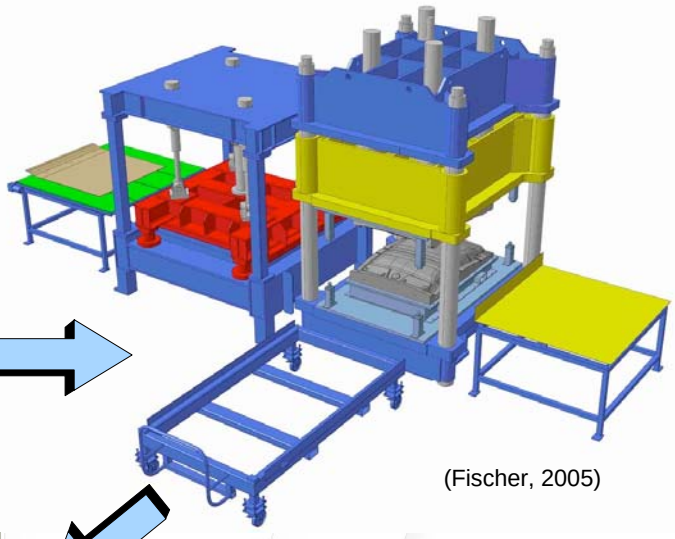
PLA & Hemp fibres

Roller card

Needle felt machine

(Müssig, 2001)

Compression moulding



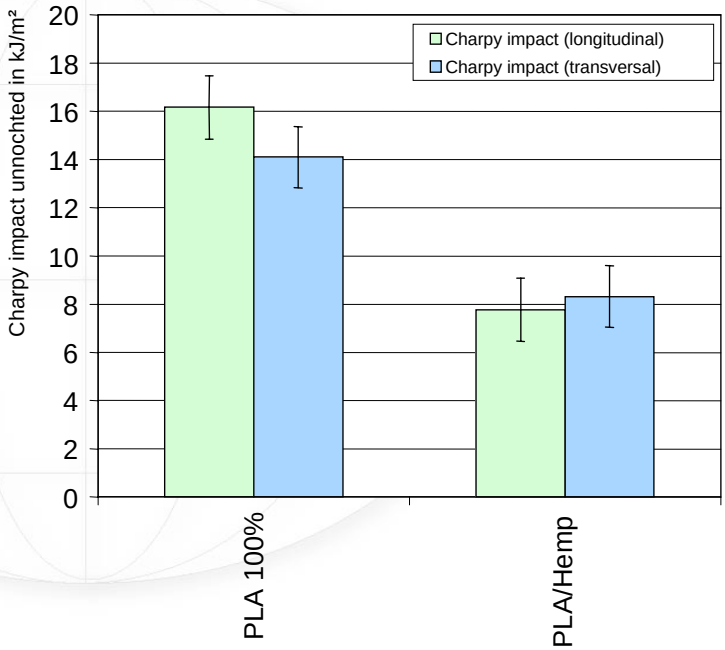
(Fischer, 2005)

PLA/Hemp – Impact

- Felt: 100 % PLA
- Felt: 40 % Hemp / 60 % PLA

Impact
DIN EN ISO 179

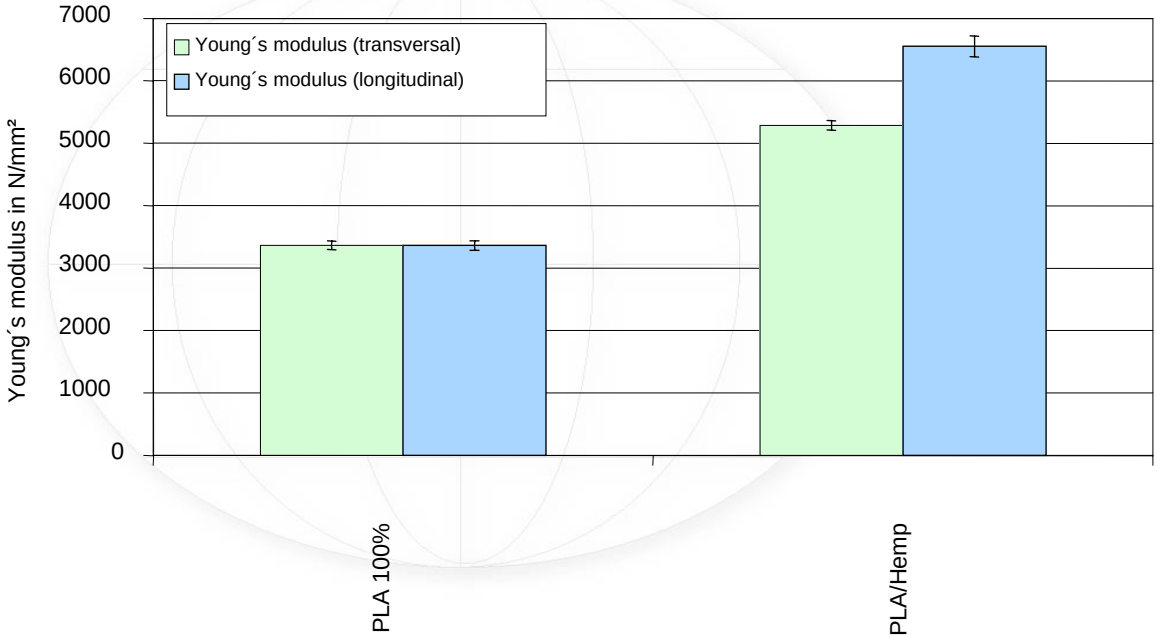
Hydraulic Press:
Rucks Maschinenbau GmbH, Glauchau,
(1000 kN; 600x600 mm²)



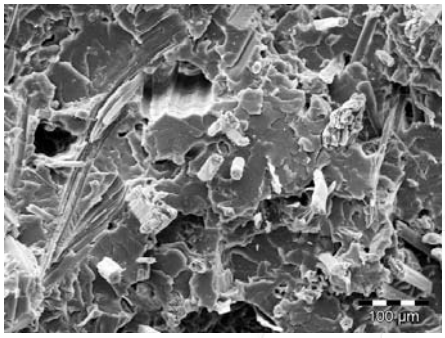
PLA/Hemp – Young´s modulus

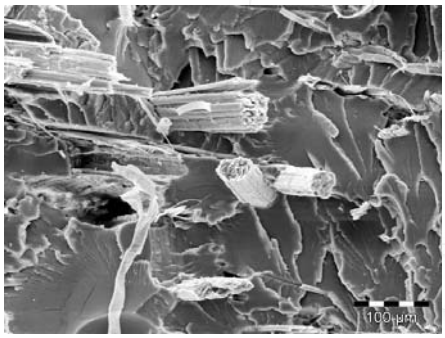
Tensile test
DIN EN 61
Type 1

- Felt: 100 % PLA
- Felt: 40 % Hemp / 60 % PLA



PLA/Hemp – Tensile strength





- Felt: 100 % PLA
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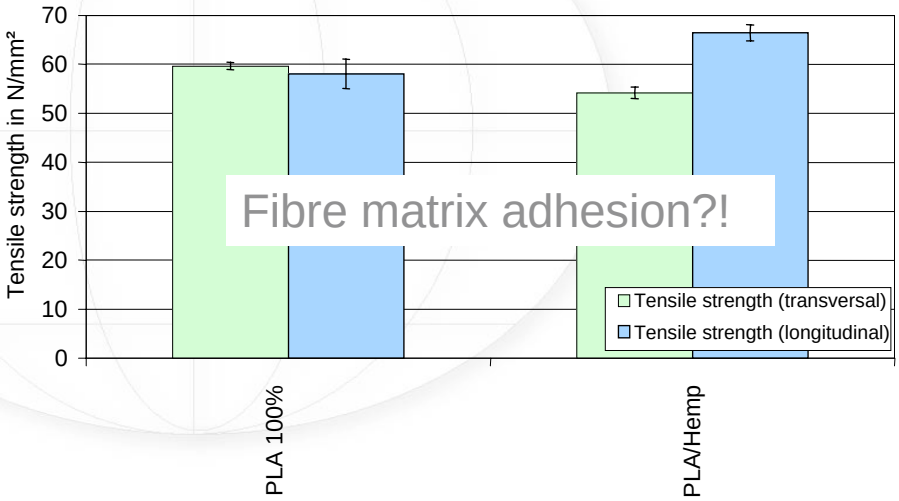
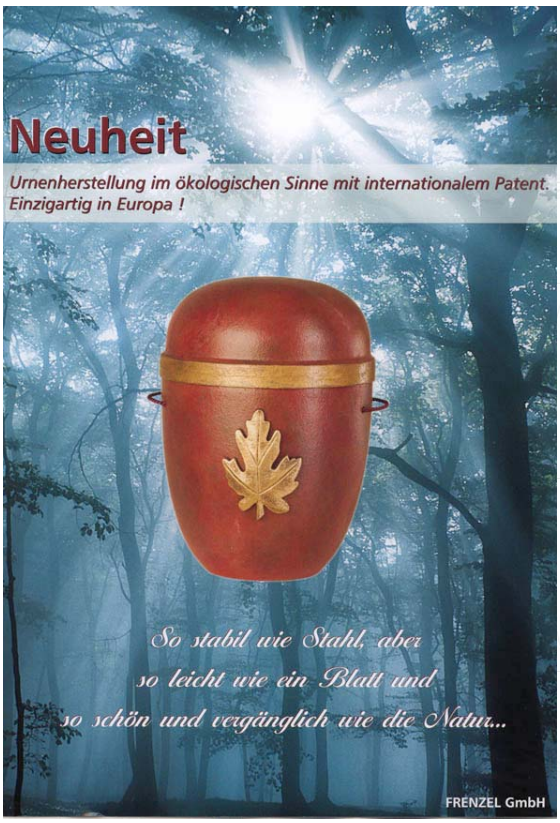
Type 1



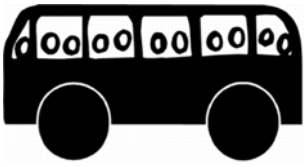
First PLA-Hemp Product



(Frenzel, 2006)

So beautiful, yet so temporary – like nature.

NFK-NR / Idea & Team



Glass/Polyester

versus

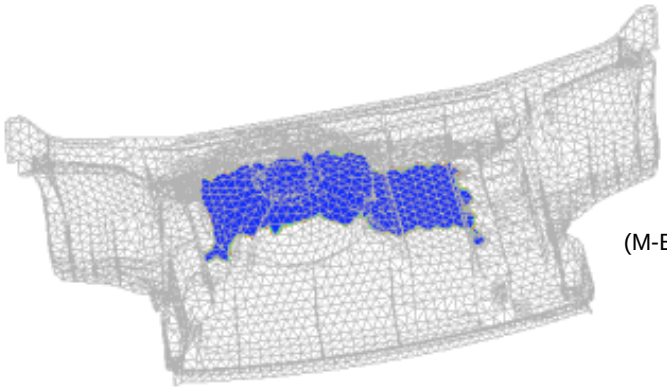
Hemp/PTP

IGLU

AGRO-Dienst

FIBRE

BKT



(M-Base, 2004)

TU Braunschweig ***B.A.M.***

SMC / Innovation

September 2005: AVK-TV Innovation Award 2005

- Award of German composites federation "AVK-TV" (category environment / 2nd Award)

Mid of December 2005: On-road Test

(Müssig et al., 2006)

- SMC bus component mounted on a bus
- On the road in the City Braunschweig (Bus of the Braunschweiger Verkehrs-AG)

Summary & Outlook

- Choice of moulding technology depends on production numbers
  - Compression moulding well established.
  - Compression flow moulding will be important for exterior components.
  - Injection moulding with natural fibres now entering serial production (not only for automotive applications).
- The price calculation of petrochemical plastics and composites will be more complicated in the future because of rising crude oil prices.
- Polymers based on renewable resources will become more important in the future.
- First commercial products with hemp fibres & PLA are available.
- Hemp fibres in combination with thermosets based on plant oil are suitable to be introduced in high-tech exterior car parts.

➡ Some further steps are necessary (simulation tools, material data centre, product development, marketing etc.) to introduce these materials into the market.

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