

Injection moulded hemp fibre-reinforced thermoplastics

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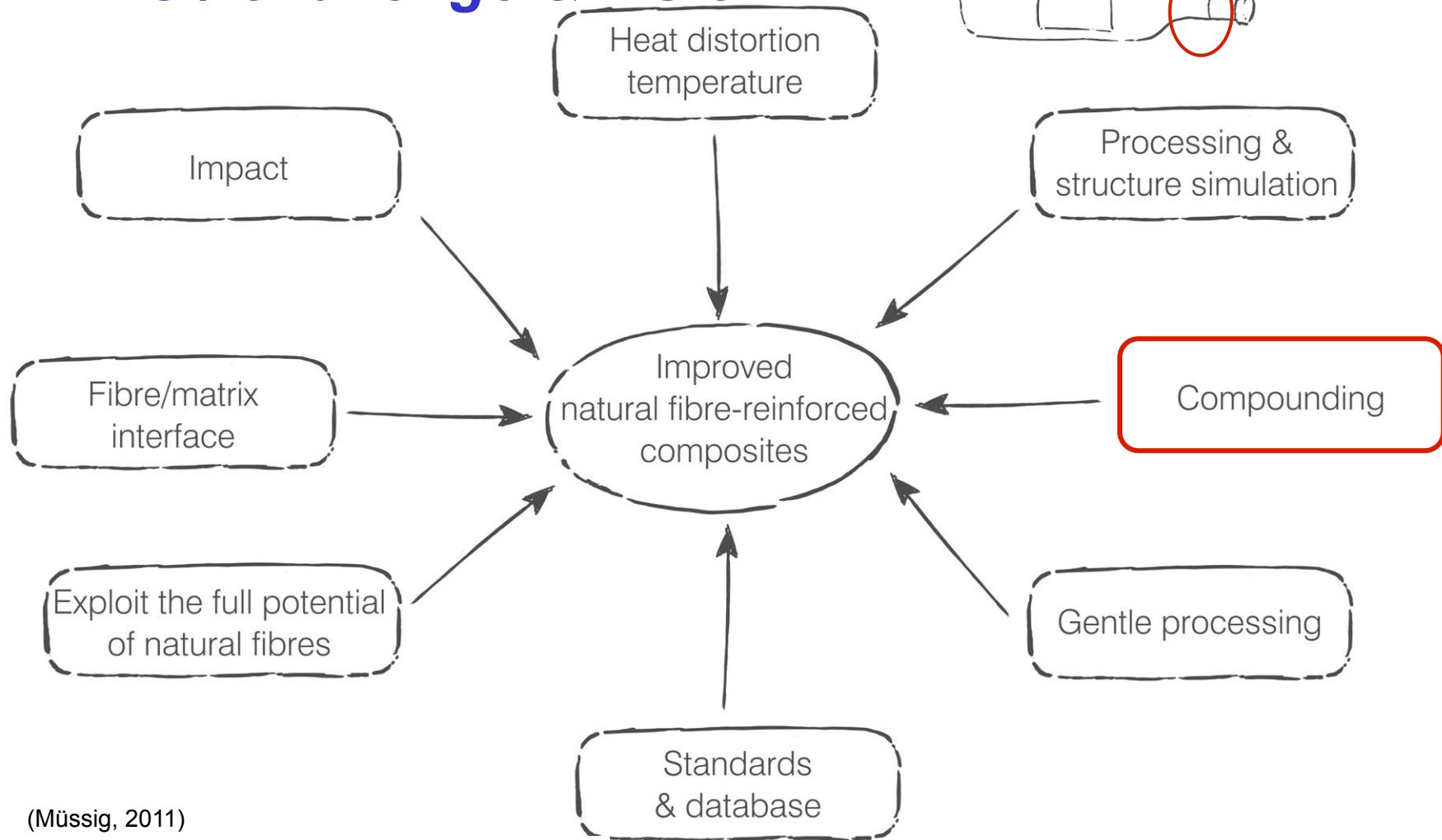
Overview

- ➡ Guiding questions
- ➡ Introduction to different compounding techniques
- ➡ Alternative compounding technique
 - ➡ Material selection
 - ➡ Fibre characteristics
 - ➡ Composite characteristics
- ➡ Conclusion

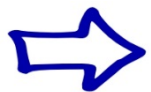
Guiding Questions ?

- Are the existing compounding processes suitable for the production of natural fibre-reinforced thermoplastic granules?
- Is our new concept suitable for the development of optimized natural fibre-reinforced thermoplastic granules (on a 10-kg scale)?
- Is it possible to transfer our new NFRC compounds to production technologies in mass production?

NFRC / challenge & vision

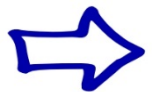
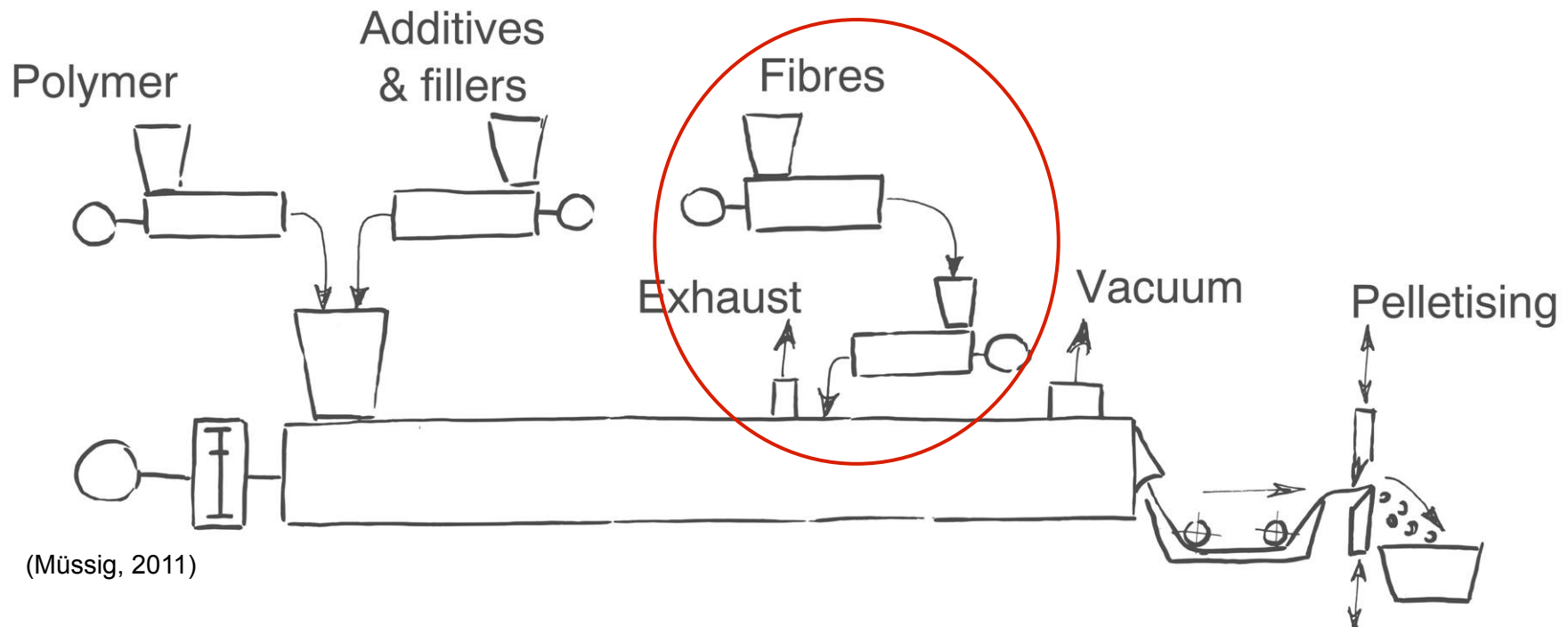


(Müssig, 2011)



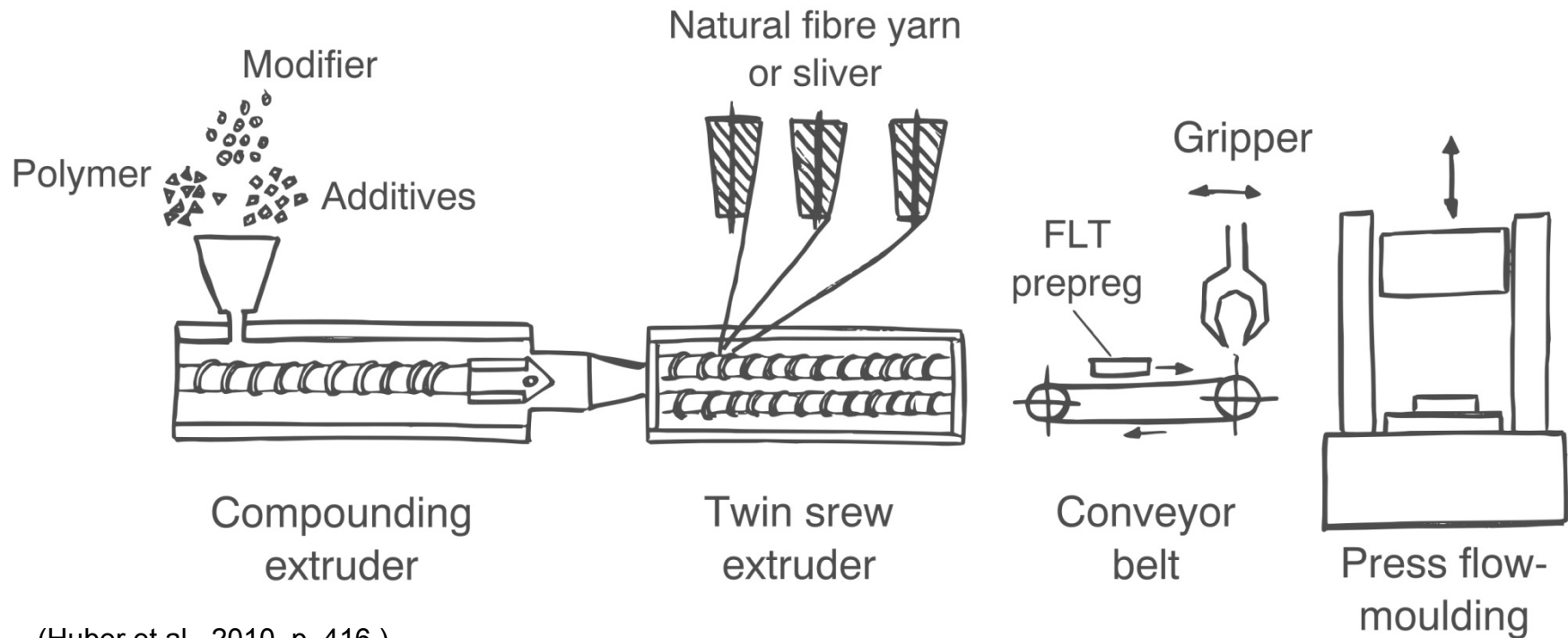
A selection of approaches for the optimisation of natural fibre-reinforced plastics.

Compounding



Process design for the production of natural fibre-reinforced thermoplastics.

Long Fibre Thermoplast Process (LFT) – 1

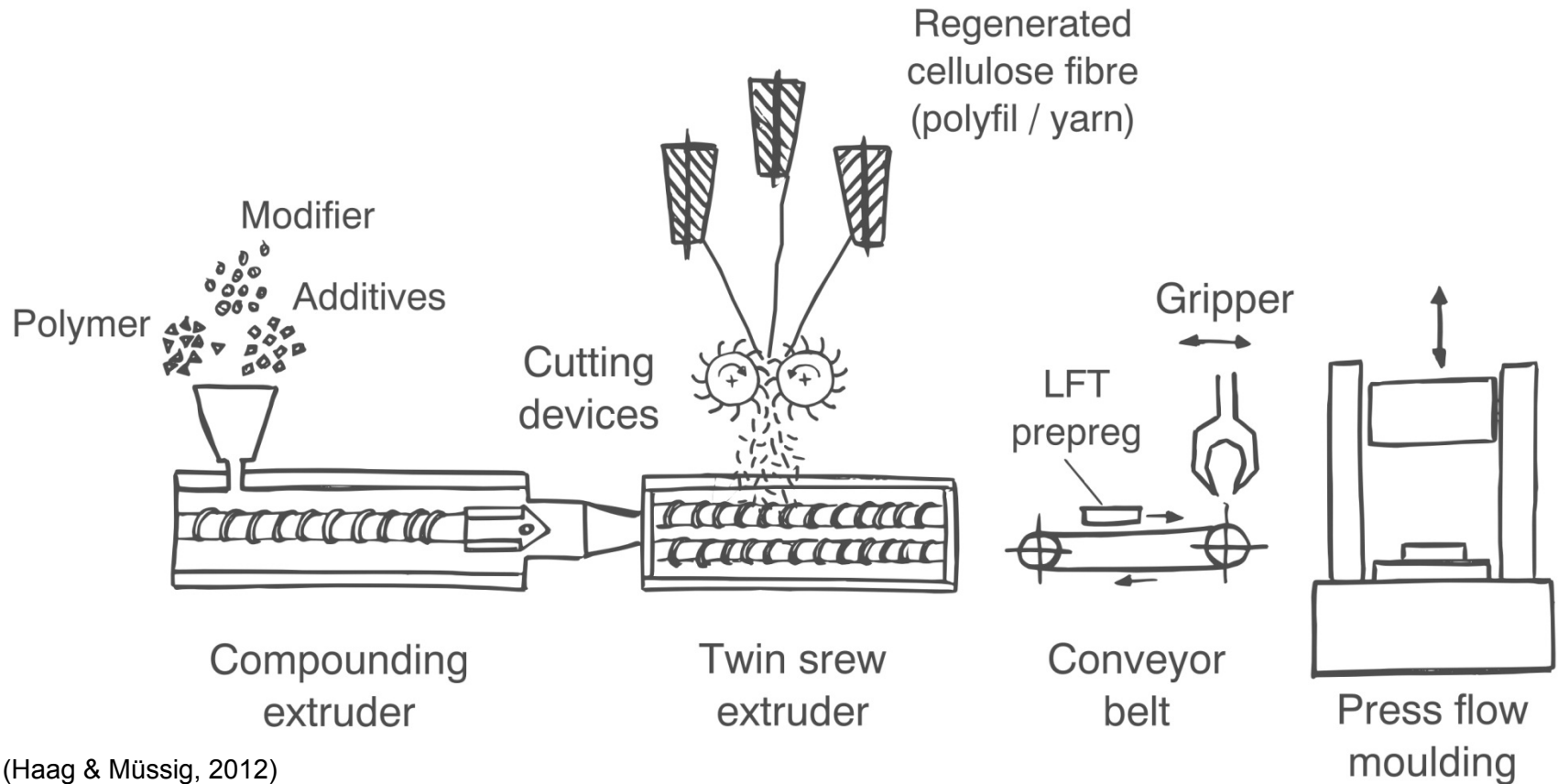


(Huber et al., 2010, p. 416)



Process design for the production of natural fibre-reinforced thermoplastic components (LFT).

Long Fibre Thermoplast Process (LFT) – 2

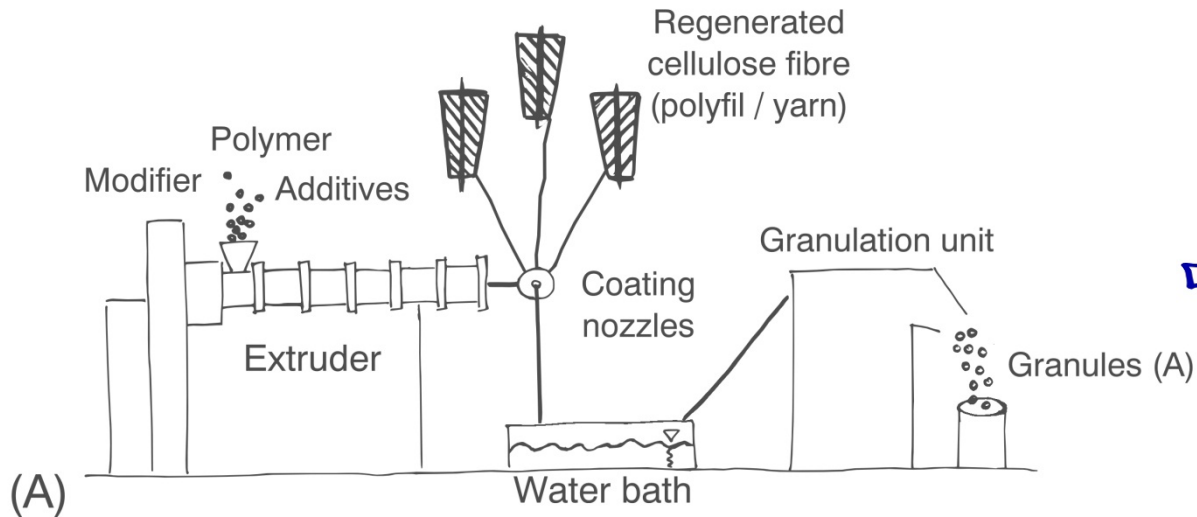


(Haag & Müssig, 2012)

➔ Process design for the production of regenerated cellulose fibre-reinforced thermoplastic components (LFT).

(cf. also the LFT-D process from Fraunhofer ICT)

Two-Step Pultrusion Process



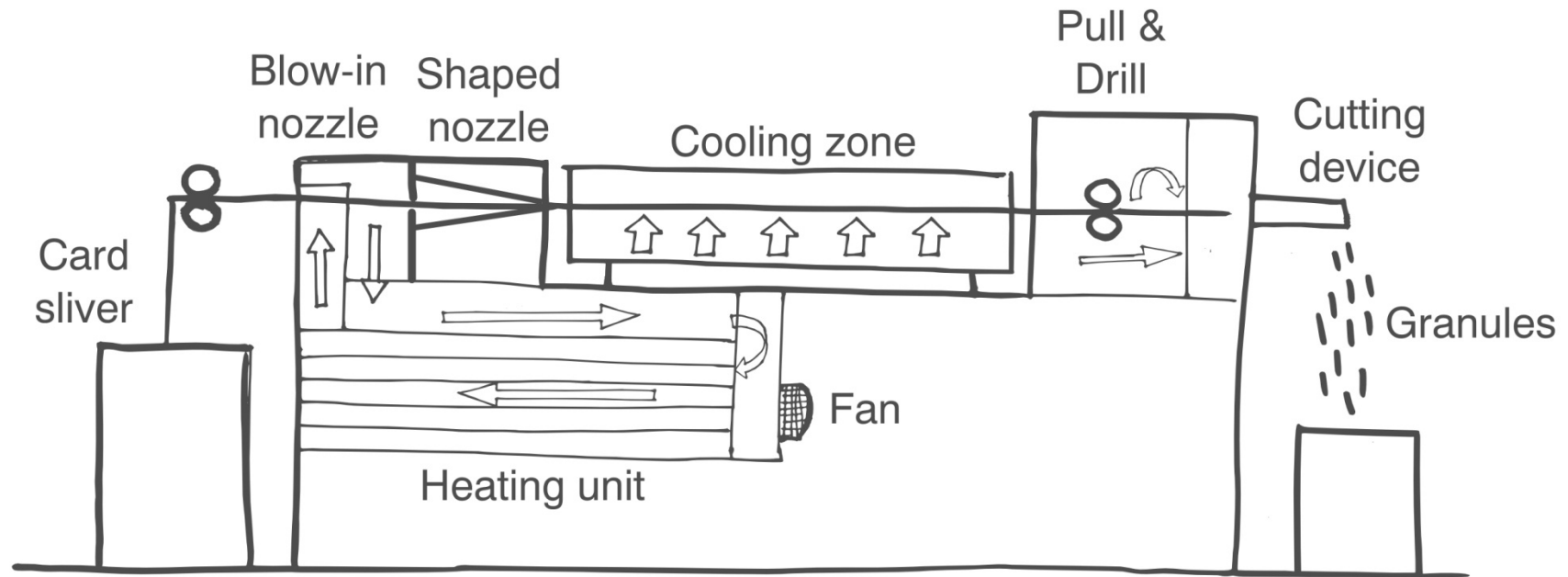
➡ Coating of the polyfil

(Haag & Müssig, 2012)

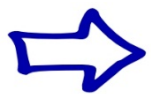
➡ Process design for the production of regenerated cellulose fibre-reinforced thermoplastics (two-step pultrusion).

(cf. also the process from Fraunhofer IAP, Fink et al., 2011)

Pull-Drill Process



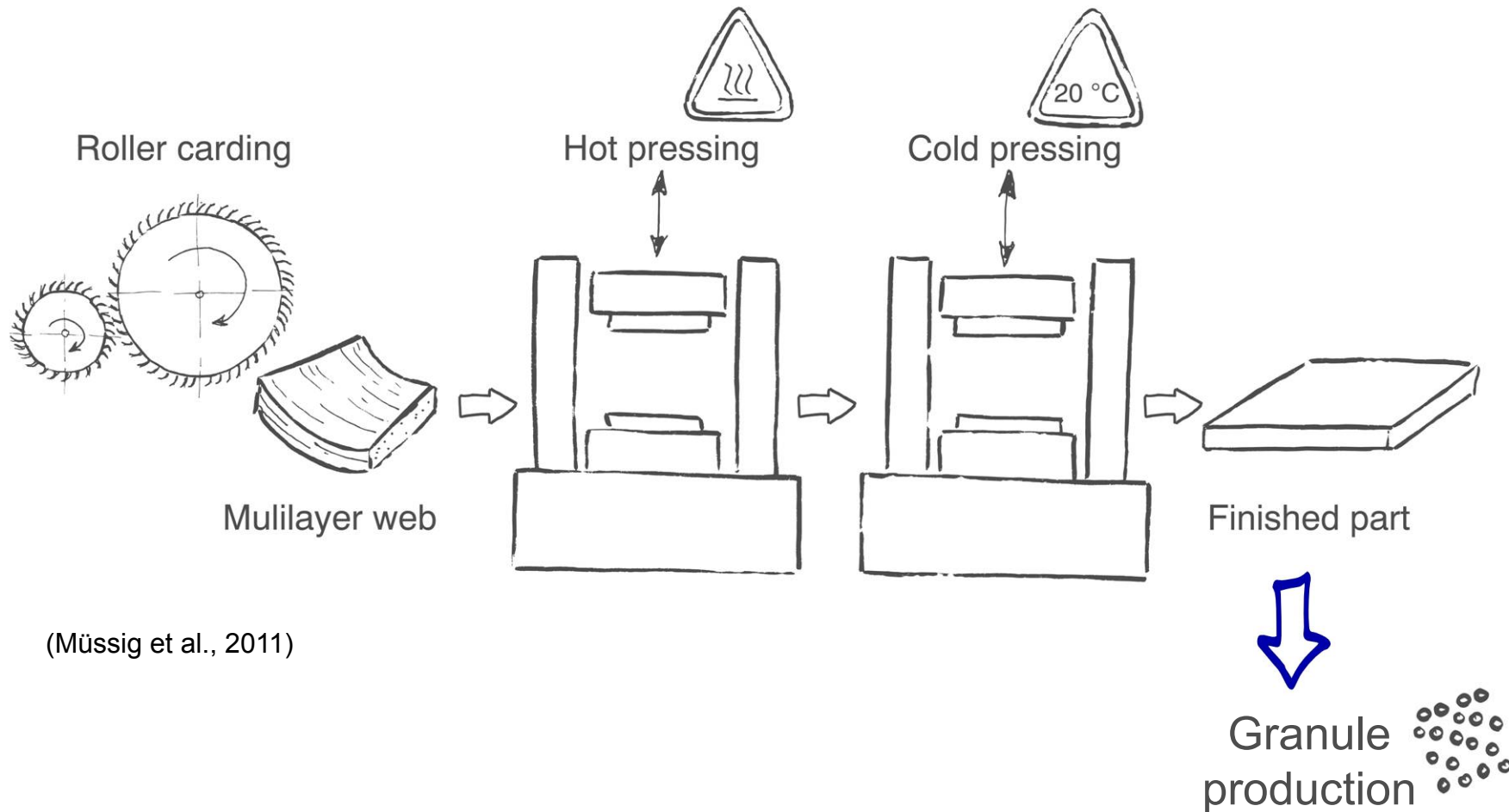
(Haag & Müssig, 2012)



Process design for the production of natural fibre-reinforced thermoplastics (Pull-Drill process).

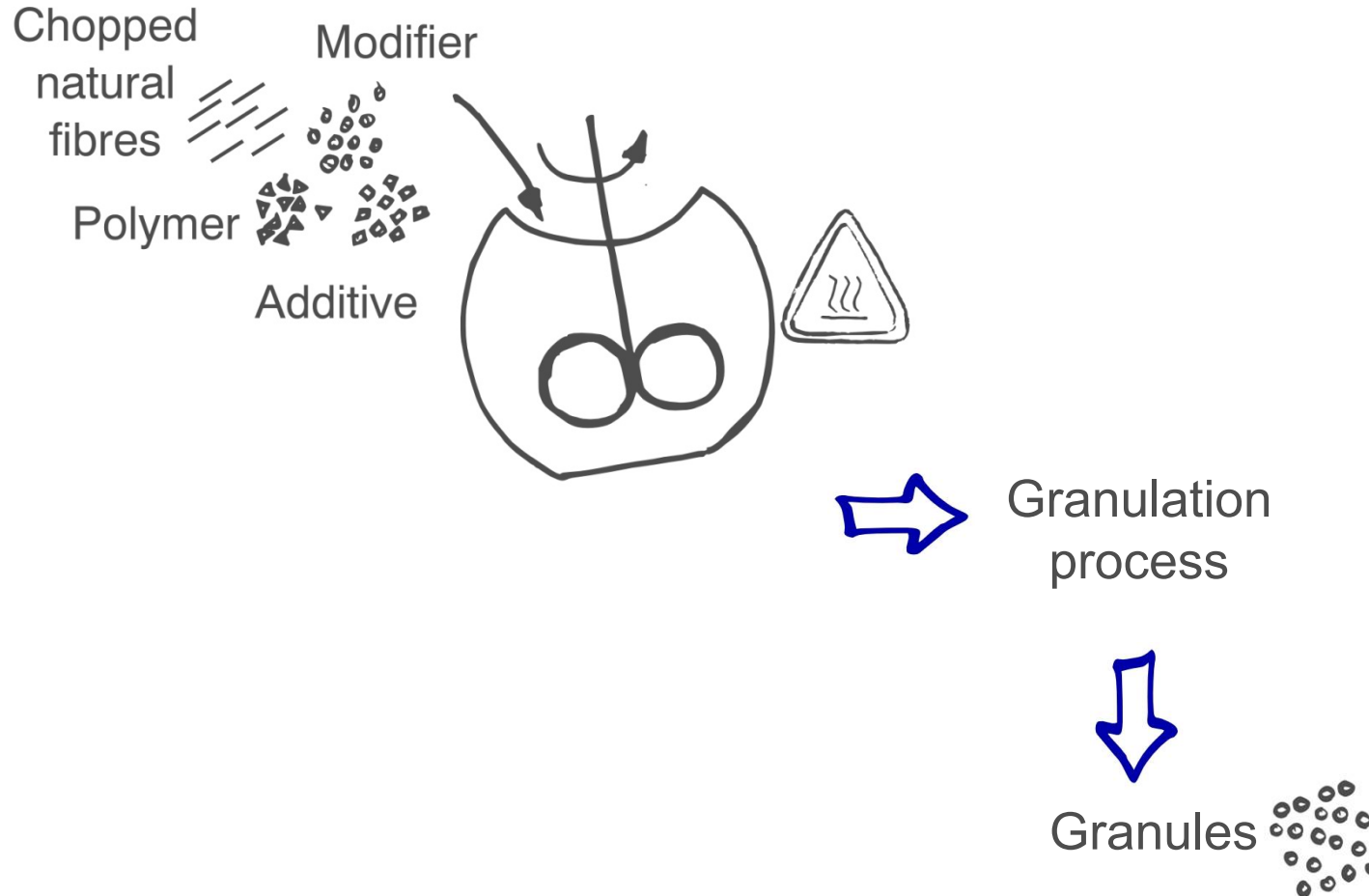
(cf. also the process from TITK, Fink et al., 2011)

Carding, Pressing & Granulation



➔ Roller card to form hemp fibre bundles and PLA fibres to a multilayer web; form pressing of PLA/hemp composites
(cf. also the patent from Beckmann, 2001)

Kinetic Mixing



➔ Process design for the production of natural fibre-reinforced thermoplastics (Kinetic mixing).

Compounding Processes: Analysis

- Free-flowing fibres like chopped sisal with short lengths are suitable to be processed with standard compounding techniques.
- Most problems during compounding of NFRC occur because of the poor feedability of longer natural fibres.
- Some special developments for compounding of NFRC exists but are not economically in all cases.
- Many standard fibre pellets are hard-pressed and can not be separated completely during the compounding process in most cases.

Guiding Questions ?

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Materials

Hemp fibre bundles:

- Hemp (*Cannabis sativa* L.)



Coarse separated hemp KGE02

&

HempAge card sliver

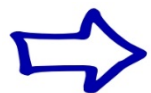


PLA polymer:

- NatureWorks™ PLA Polymer 6202D
(Ingeo fibres)

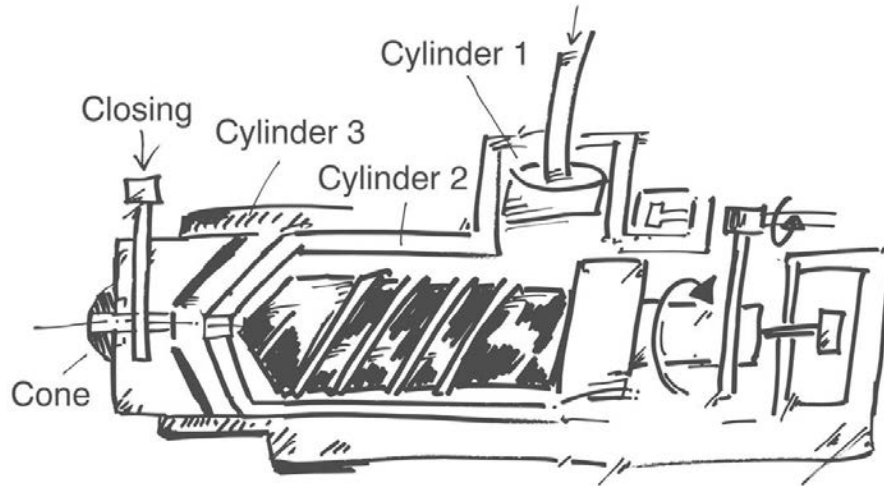


(IBAW, 2005)



Successful compounding of unchopped fibre bundles which are evenly mixed and homogeneously distributed into the matrix. A Fibre mass content up to 40 % was reached.

Injection moulding

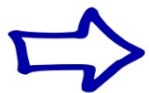


(Huber, Graupner & Müssig, 2010, S. 414)



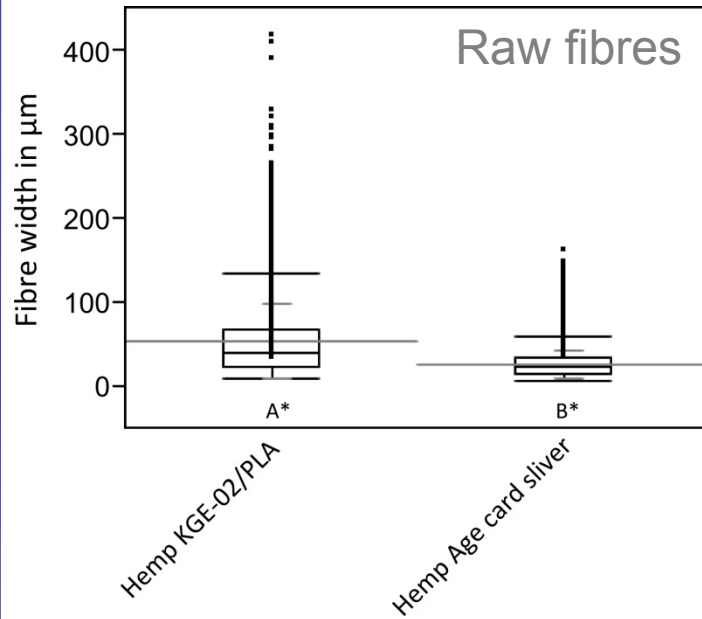
Processing parameters:

- Arburg 320C, Allrounder 600-250 (screw diam. 30 mm)
- Temperature profile in °C: 170-172-175-177-180-180

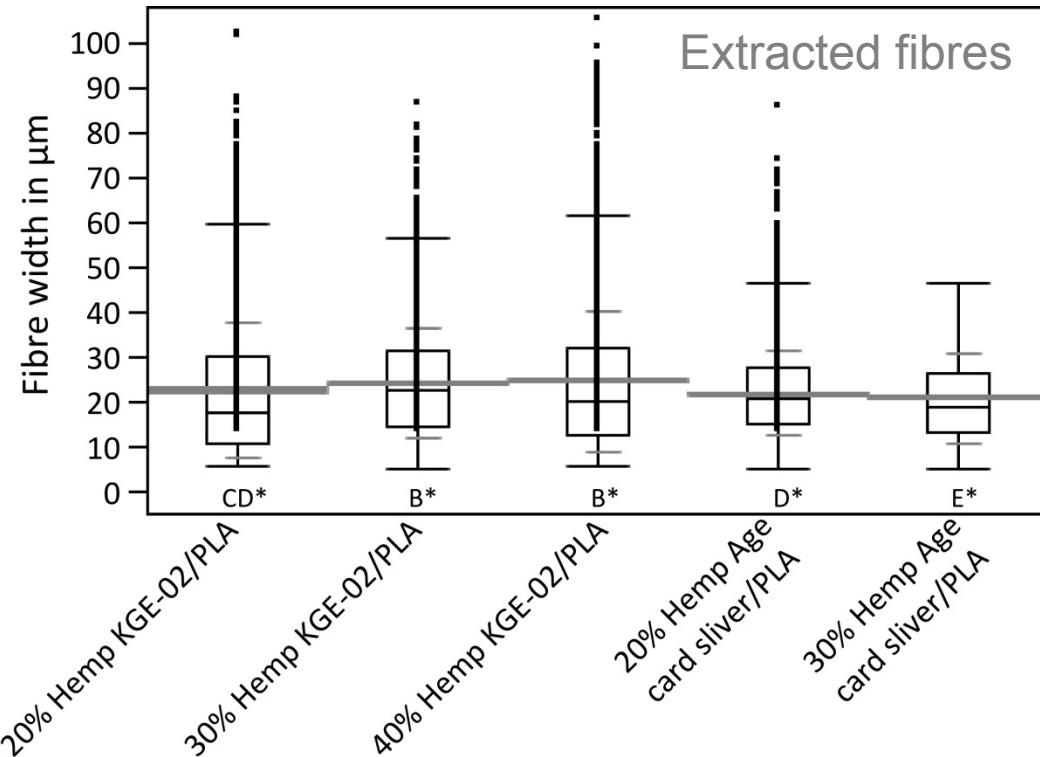


Injection moulding of PLA/hemp samples (20, 30 & 40 mass-% of hemp fibre bundles).

Fibre properties - Width

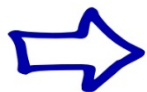


(A)



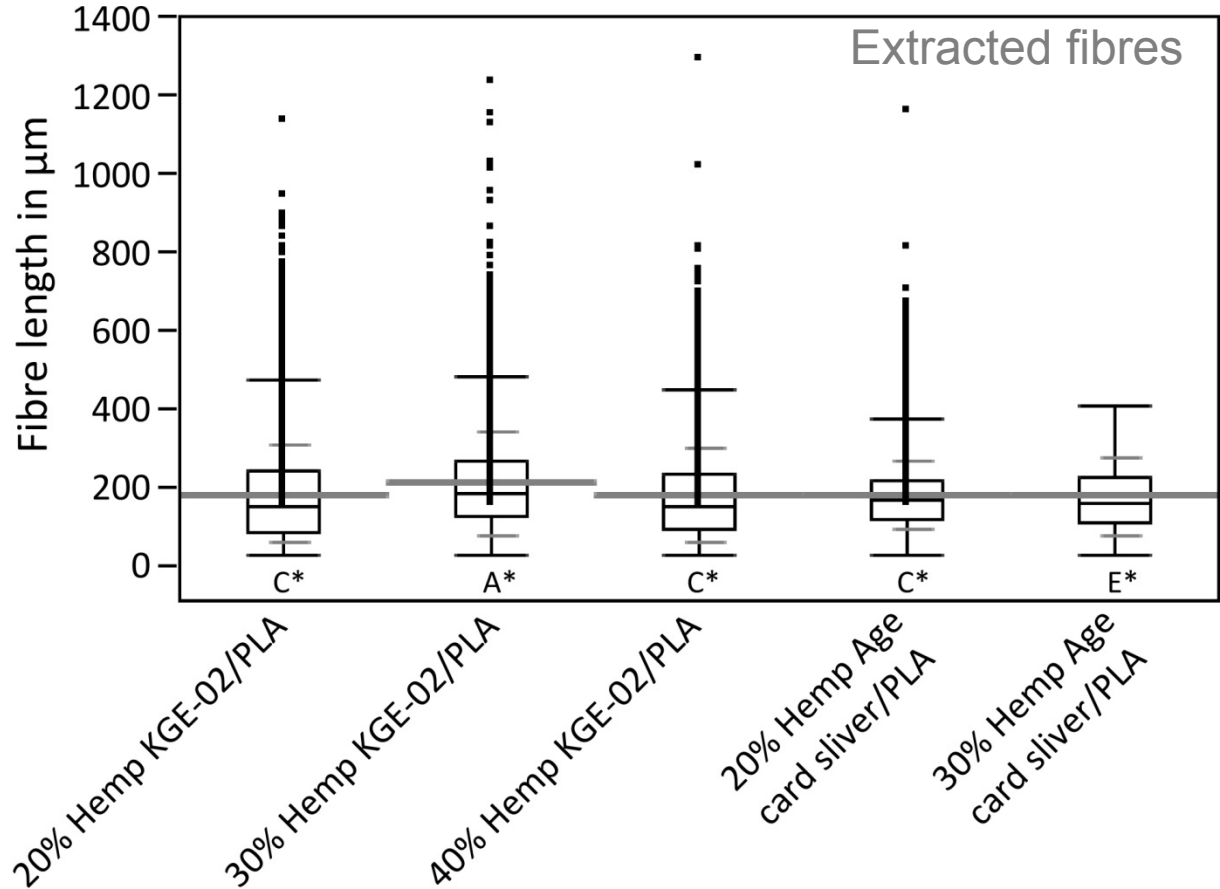
(B)

- Fibre width measurement
- FibreShape, IST AG, CH
- 4000 dpi
- MM: Längen-Breitenmessung_Zoom_4000dpi_NG

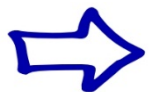


(A) Fibre bundle width of the raw hemp samples. (B) Fibre & fibre bundle width extracted from the injection moulded test specimens.

Fibre Properties - Length

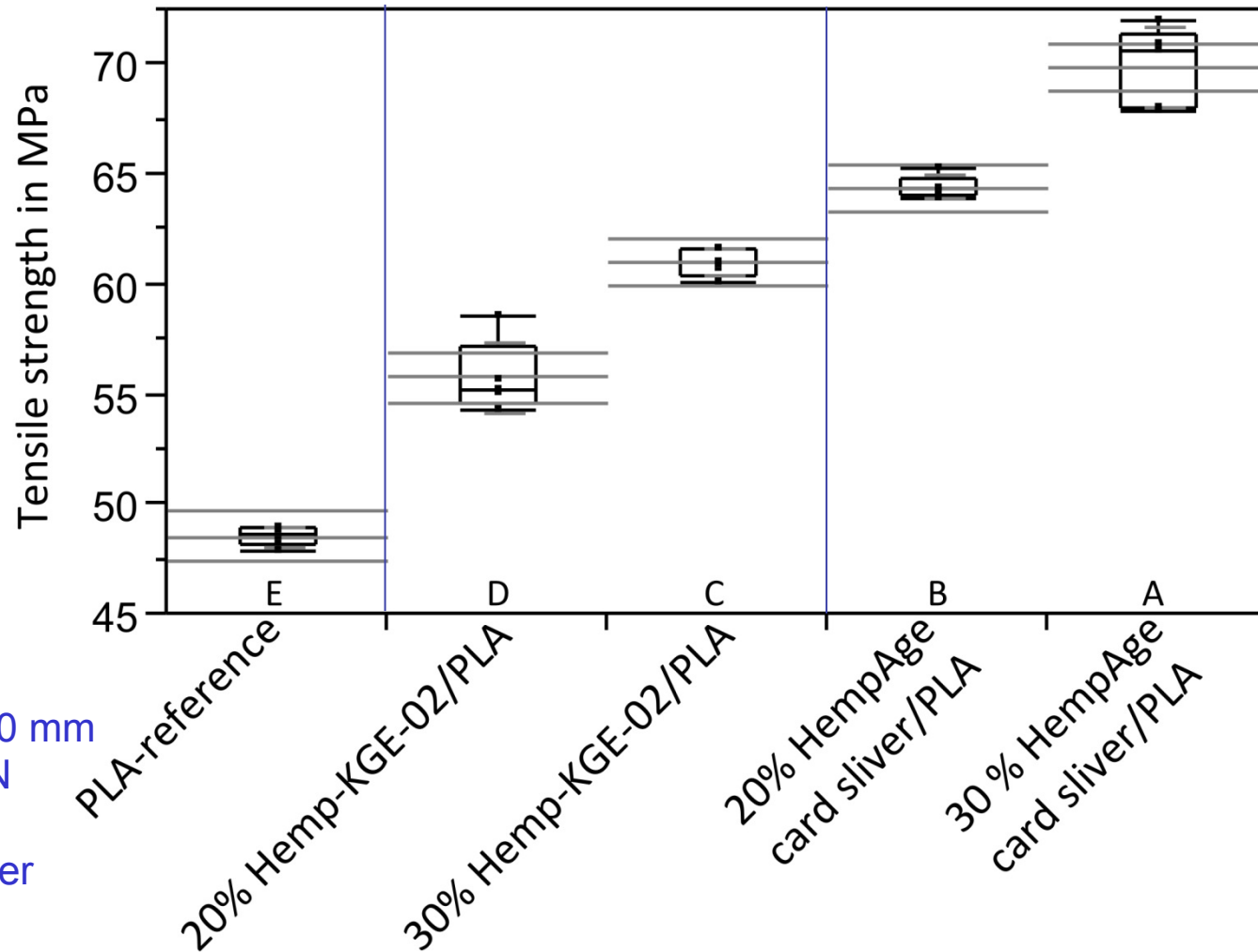


- Fibre length
- FibreShape, IST AG, CH
- 4000 dpi
- MM: Längen-Breitenmessung_Zoom_4000dpi_NG

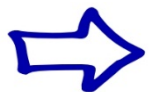


Fibre length of the hemp extracted from the injection moulded test specimens.

Tensile strength of PLA/hemp



- DIN EN ISO 527
- Sample 1A / l = 100 mm
- Zwick Z020 / 20 kN
- 2 mm/min
- Video extensiometer
- 5 samples

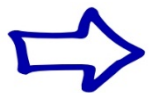


Box-and-whisker diagrams (black): Tensile strength of the injection moulded PLA/hemp composites (mean value & conf. interval in grey).

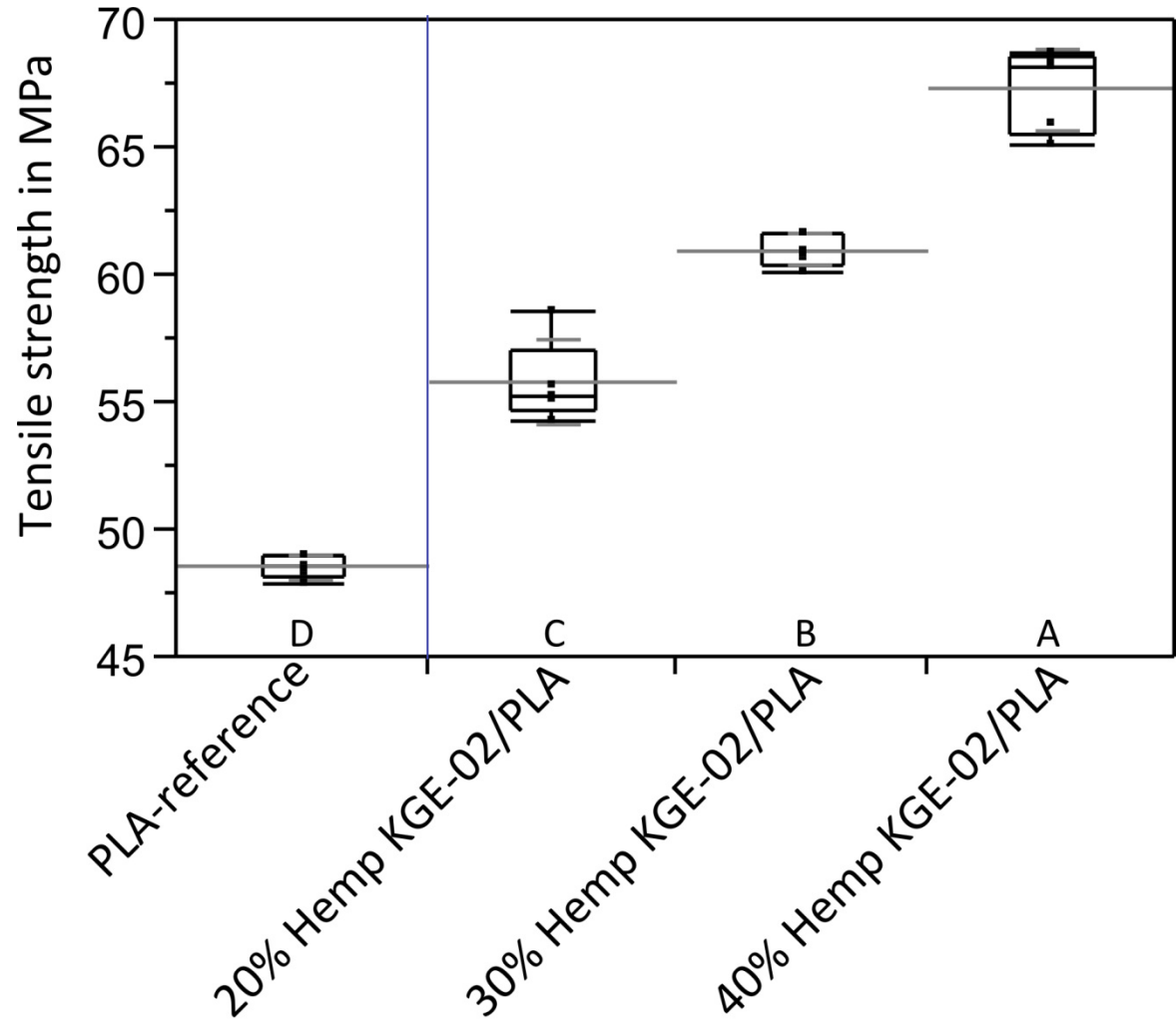
Tensile strength of PLA/hemp



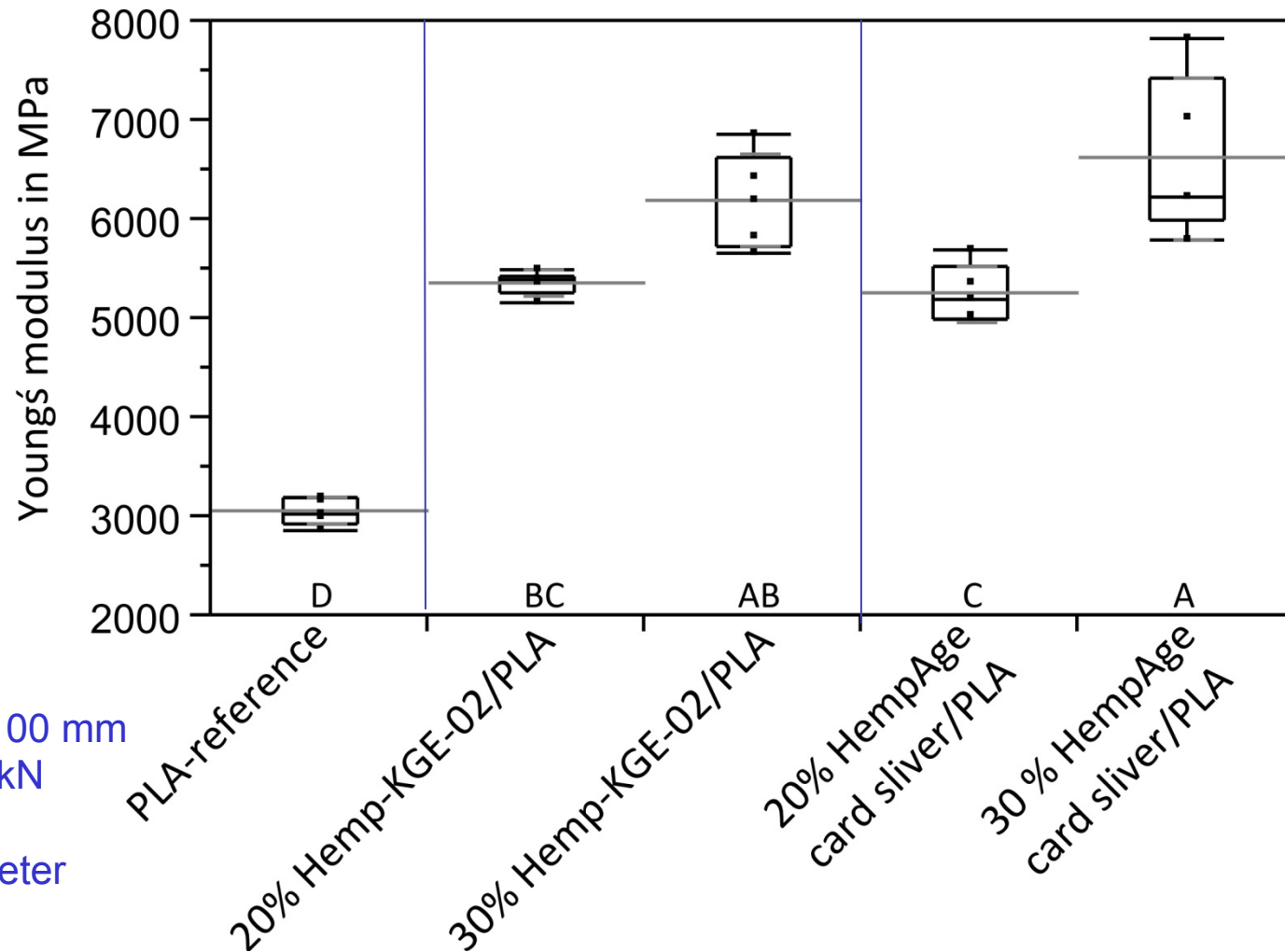
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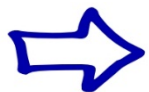
Box-and-whisker diagrams (black): Tensile strength of the PLA/hemp composites (KGE-02) (mean value & conf. interval in grey).



Youngs's modulus of PLA/hemp

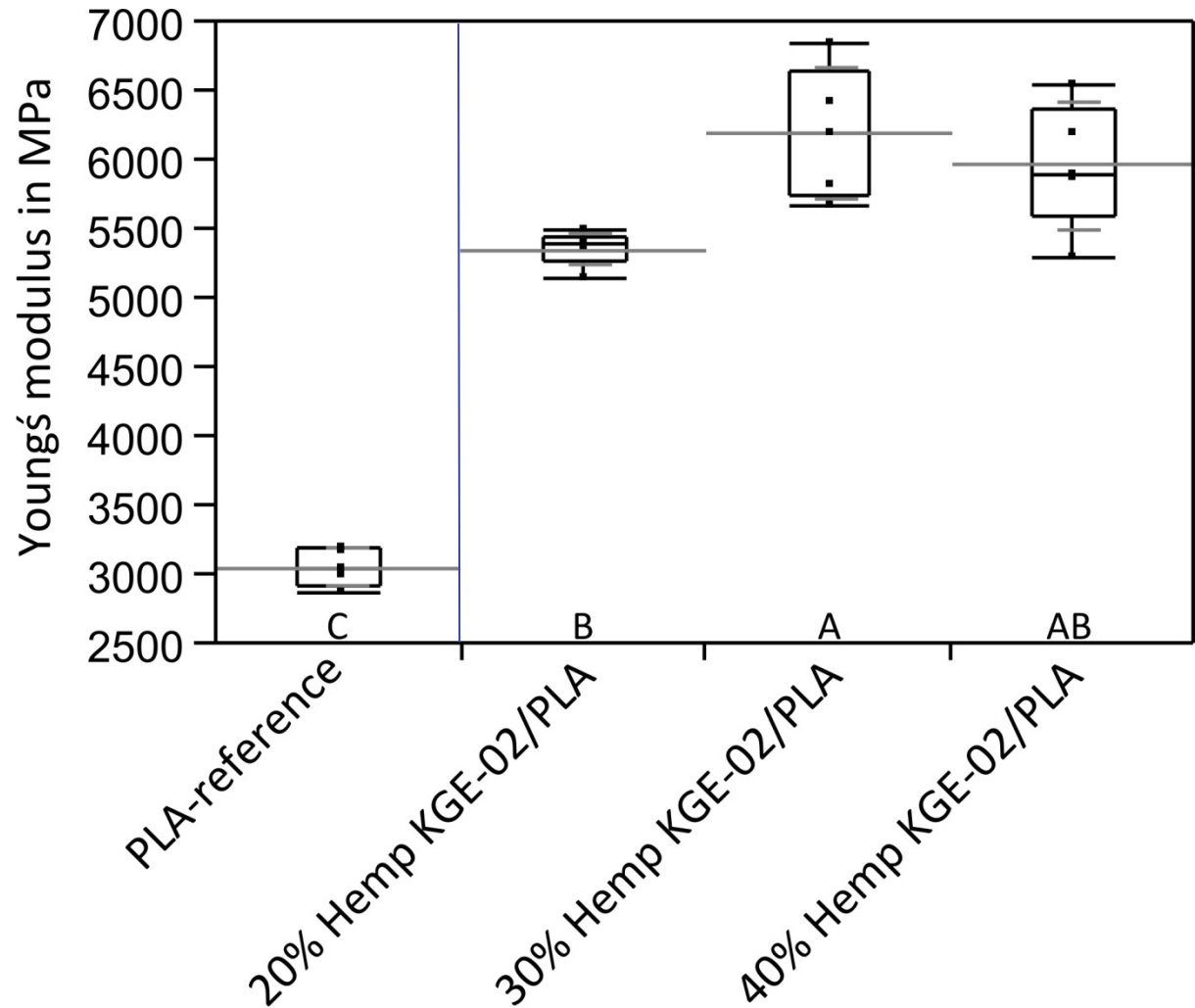


- DIN EN ISO 527
- Sample 1A / l = 100 mm
- Zwick Z020 / 20 kN
- 2 mm/min
- Video extensiometer
- 5 samples

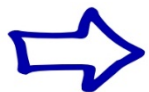


Box-and-whisker diagrams (black): Youngs' modulus of the injection moulded PLA/hemp composites (mean value & conf. interval in grey).

Youngs's modulus of PLA/hemp

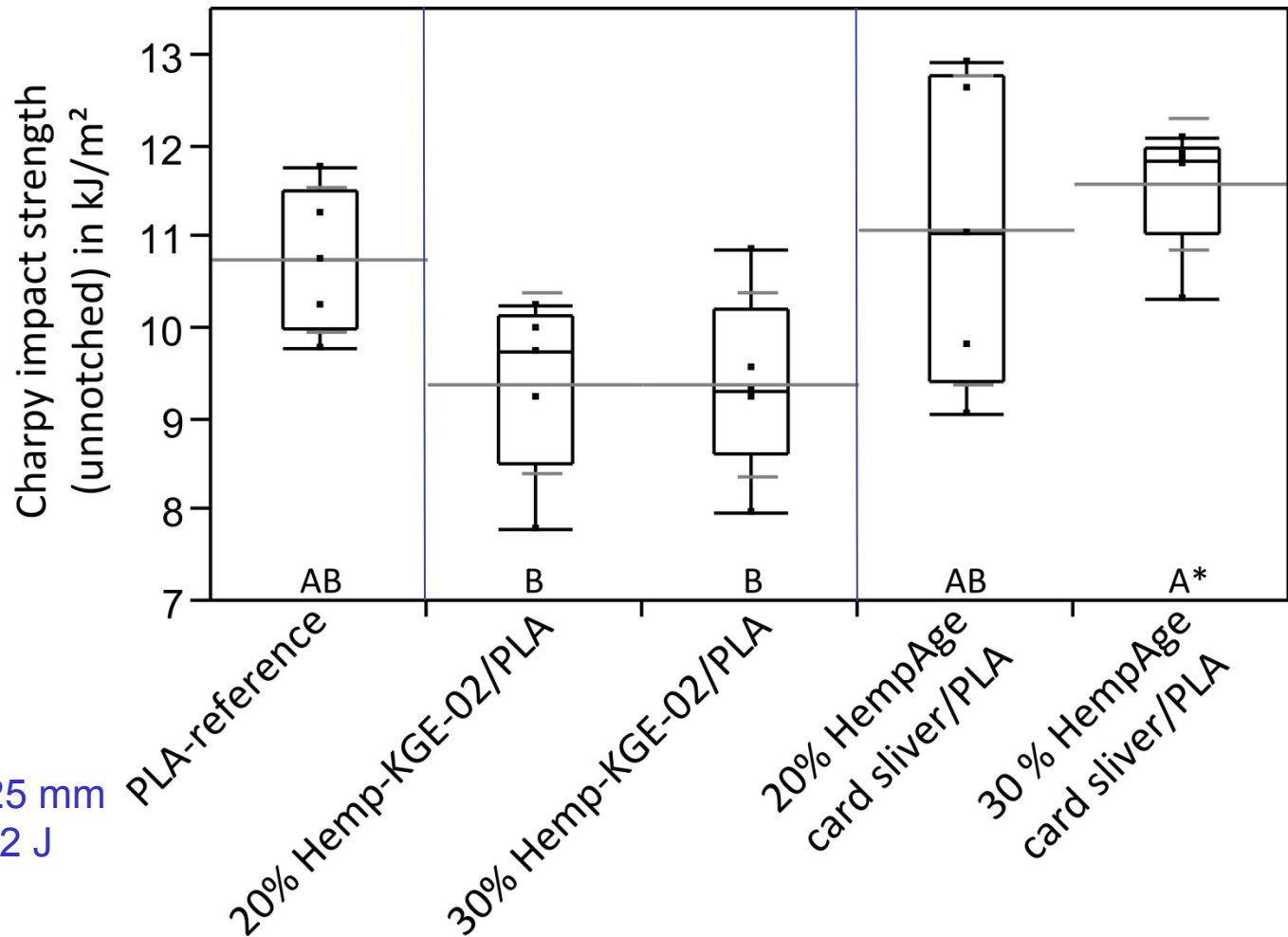


- DIN EN ISO 527
- Sample 1A / l = 100 mm
- Zwick Z020 / 20 kN
- 2 mm/min
- Video extensimeter
- 5 samples

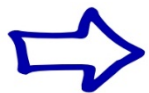


Box-and-whisker diagrams (black): Youngs' modulus of the PLA/hemp composites (KGE-02) (mean value & conf. interval in grey).

Charpy impact of PLA/hemp



- DIN EN ISO 179
- Zwick type 5102
- Pendulum: l = 225 mm
- Pendulum size: 2 J
- 5 samples



Box-and-whisker diagrams (black): Charpy impact (unnotched) of the PLA/hemp composites (mean value & conf. interval in grey).

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Hemp fibre pellets for injection moulding

Development of a industrial natural fibre-pellet-production to enable the use of natural fibre as reinforcement for (bio-based) plastics in injection moulding and extrusion



Funded by



Process Chain: Natural Fibre-Reinforced Plastics

NFRC compound in mass production



Production of
hemp & flax fibre
bundles



(Richter et al. 2010)

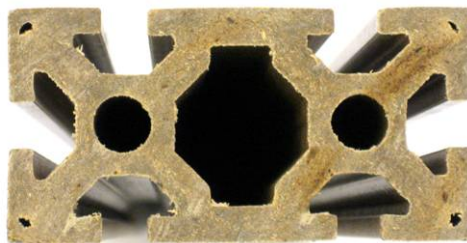
Injection moulding /
extrusion:
various products
(consumer products, casing of
electr. equipment, furniture,
automotive industry)



Feeding of natural fibre via fibre
pellets (adapted under
economic and technical
aspects)

(Haag & Müssig, 2012)

Hemp Fibre Pellets for Extrusion



Haag, K. / Scholz, S. / Schirp, A. / Carus, M. & Müssig, J. 2013:
Pellets für die Extrusion.

In: Kunststoffe (ISSN 0023-5563), Vol. 103., 4, (2013), p. 67 - 69



Hemp fibre pellets for injection moulding

Light-retted hemp

➔ Light-coloured
soft pellets



➔ Compounds with PP:
Fibre mass content 35 %



(Haag & Müssig, 2012)

Conclusion

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Many thanks for your attention!



Prof. Dr.-Ing.

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The pellet results were obtained within the project: „Entwicklung einer industriellen Naturfaser-Pellet-Produktion zur Nutzung von Naturfasern als Verstärkung von (Bio-) Kunststoffen in Spritzguss und Extrusion“ – AZ 27717-34, funded by the Deutsche Bundesstiftung Umwelt DBU, Osnabrück, Germany.

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