Gusovius, Hans-Jörg; Pecenka, Ralf; Hoffmann, Thomas; Radosavljevic, Ljubomir and Fürll, Christian

Biobased binders for the production of fibre boards made of wet preserved hemp

A novel technology for the supply and processing of fibrous biomass has been developed and a pilot plant was installed for fibre board production. The raw material is gained through anaerobic storage of wet harvested and chopped whole hemp plants. One of the main research issues are investigations to replace harmful synthetic binder. Rest- or by-products from other processing procedures should be utilized as an ecologic as well as economic viable alternative. The results show that fibre boards glued with such binders can be manufactured and fit within the requirements according German standards for mechanical stability.

Keywords
Hemp, fibres, fibreboard, silage, natural binders

Abstract
Landtechnik 64 (2009), no. 4, pp. 281 - 283, 6 figures, 11 references

A novel technology for the supply and processing of fibrous biomass like hemp or flax crops has been developed and a pilot plant was installed for fibre board production at the Leibniz Institute of Agricultural Engineering Potsdam-Bornim [5, 7, 8]. The raw material is gained through anaerobic storage of wet harvested and chopped whole hemp plants [10] (**figure 1**). The preserved raw material is processed into a dry fibrous particle mixture in the pilot plant using a twin screw extruder (extruder mill), a disc mill (refiner) and a stream dryer. A fleece is formed after binder application which is processed into boards in a hot press. These simple or three dimensional fibre boards can be utilized in the building or furniture industries; an application in the automotive industry is conceivable (**figure 2**).

An optimization of the most ambitious processing step „binder application" in loose fibrous particle mixtures could already be achieved within previous research activities [1, 2, 8]. The utilization of bio based binders as a substitute for synthetic binders like phenol formaldehyde resin (PF) was verified as well [4].

Materials and methods

A fibre particle mixture of 60 % preserved and processed hemp and 40 % softwood was utilized for the experiments. Comparative examinations were carried out with pure hemp resp. softwood fibres. Following binder substances were tested (**figure 3**):

- plant based starch products,
- canola seed cake, as by-product of oil production,
- solution of poly lactic acid (PLA) and glucose, as intermediate of PLA production,
- bio based residues of the same process (based on rye groats) and
- phenol formaldehyde resin (PF) as relation variant.

Further test samples were prepared without binder. The application and even distribution of the binder substances could be achieved by the utilization of a novel and optimized mixing machine which was developed at the Leibniz Institute of Agricultural Engineering Potsdam-Bornim as well (**figure 4**). The mixing machine is characterized by an optimal binder distribution in the fibrous particle mixture due to a purpose oriented adjustment of the essential process parameters (rotation speed and

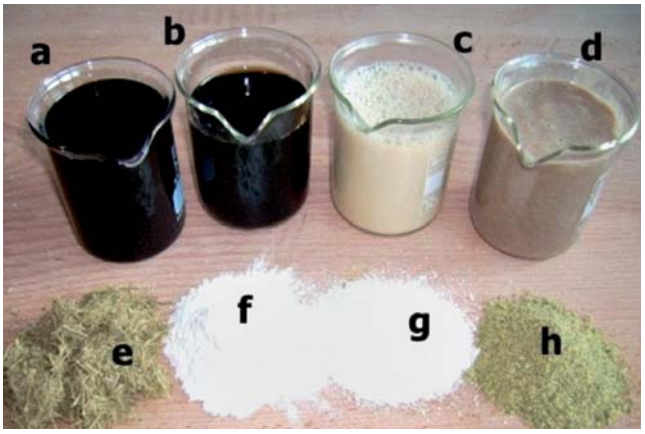
Fig. 1

Wet preserved hemp as a raw material for fibre board production

Fig. 2

Product samples of fibre boards

Fig. 3



Used materials: a) Phenol resin, b) PLA semi product, c) and d) plant rests of glucose production, e) fibres, f) starch, g) cellulose, h) rape pressed cakes

Fig. 4

Mixing machine for binder application at pilot plant of Leibniz-Institute of Agricultural Engineering Potsdam-Bornim e. V. (ATB)

arrangement of mixing units, selection of spraying nozzles and their process parameters) [11].

Especially the bending strength is next to others an important characteristic to specify the quality of fibre boards. This specific value was determined by using a material testing machine Zwick Z010 by considering the regulations of DIN EN 310 [3]. The test samples feature the dimensions 300 x 50 x 10 mm.

Results

The standard values for high density fibre boards (HDF) utilized in common applications according to DIN EN 622-2 [6] as well as for high quality boards in humid environments act as comparison basis for the validation of the experimental boards (**figure 5**). The utilization of bio based binders except canola seed cake enables the production of fibre boards which fulfil the requirements of the German standard of minimal 25 N/mm^2. Higher values could be observed for samples glued with starch based binders whereas the combination with sugars (PLA solution) was resulting in best parameters. Standard values for high quality applications could not be achieved.

These results were compared with the determined bending strength data of test samples made out of pure fibres (100 % wet preserved and processed hemp fibres resp. 100 % softwood fibre) glued with phenol formaldehyde resin or without any binder (**figure 6**). It becomes apparent that board samples based on hemp fibres without any binder as well as by reduced synthetic binder utilization show better mechanical characteristics than such made out of softwood fibres.

Conclusions

It could be shown that fibre boards produced at the pilot plant of the ATB, based on wet preserved hemp fibres and glued with bio based binders, can achieve the mechanical characteristics of conventional products. A reduction of applied amount of synthetic binder by 40 % is possible when the fibre raw material is gained from wet preserved hemp instead of softwood.

Test samples without any additional binder and based on hemp fibres have better mechanical properties in contrast to such made from softwood fibres. Plant particles like leaves, flowers and seeds, still existent even after the anaerobic storage, obviously enable additional gluing characteristics or possibly polymerize within the course of board manufacturing.

Literature

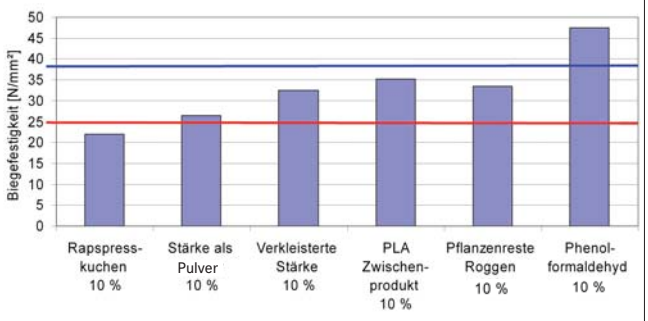
[1] Klauditz, W. und Meinecke, E.: Über die physikalischen und technischen Vorgänge bei der Beleimung und Verleimung von Holzspänen bei der Herstellung von Holzspanplatten, Westdeutscher Verlag, Köln, 1962

[2] May, H.-A.: Entwicklungsarbeiten zur Verbesserung des Wirkungsgrades der Beleimung von Spänen in industriellen Beleimungsmaschinen bei der Holzspanplattenherstellung. Dissertation an der Technischen Universität Braunschweig, Braunschweig, 1973

[3] DIN EN 310, Holzwerkstoffe; Bestimmung des Biege-Elastizitätsmoduls und der Biegefestigkeit. Ausgabe:1993-08, Beuth-Verlag, Berlin, 1993

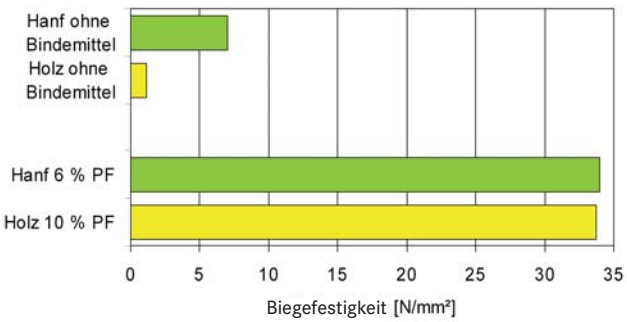
[4] Müller, M.: Möglichkeiten der Herstellung stärkegebundener lignocelluloser Formkörper als Variante dämmender, biologisch abbaubarer Werkstoffe. Dissertation an der Technischen Universität Dresden, Dresden, 1997

Fig. 5



Bending strength of natural fibre boards with different binders (material: wet preserved hemp mixed with wooden fibres 6:4, density 1140 kg/m³, thickness 10 mm)
— Minimal required strength towards EN 622-2 for HDF boards for common purposes in dry area
— Minimal required strength for highly reliable boards for construction purposes in moist area

Fig. 6



Bending strength of fibre boards made of hemp and wood fibres (thickness 10 mm, density 790 kg/m³, pressing time 6 min., binder PF resin or no PF resin)

[5] Ernte, Konservierung und Erstverarbeitung von Hanf aus einer Feuchtgutlinie. Forschungsbericht des ATB Potsdam-Bornim, Institut für Agrartechnik Bornim e. V. (ATB), (2000/3)

[6] DIN EN 622-2, Faserplatten - Anforderungen; Ausgabe:2003-09, Beuth-Verlag GmbH, Berlin, 2003

[7] Fürll, Ch. et al: Verfahren zur Aufbereitung von Naturfaserpflanzen. Patent DE 103 463 658, (2005)

[8] Pecenka, R., Fürll, Ch., Idler, Ch. und Radosavljevic, L.: A Novel Technology for the Processing of Wet Preserved Natural Fibre Plants from Agriculture. Im Tagungsband zum XVIth CIGR World Congress, Bonn 03.-07.09. (2006)

[9] Radosavljevic, L.: Natural fibre boards: method of binder spreading to achieve a high quality products; XVI CIGR world congress, 2006. Bonn, Germany, Book of Abstracts, p.609, (2006)

[10] Pecenka, R., Idler, Ch., Grundmann, P., Fürll, Ch. und Gusovius, H.-J.: Tube ensiling of hemp – Initial practical experience. Agrartechnische Forschung (Agricultural Engineering Research) 13 (1): 15-26, (2007)

[11] Radosavljevic, L., Hoffmann, T., Pecenka, R. und Fürll, Ch.: Mathematical model of the binder application for the production of fibre boards. 2nd International Conference on Innovative Natural Fibre Composites for Industrial Applications, 15.04.2009-18.04.2009. Rom, (2009)

Authors

Dr. Hans-Jörg Gusovius is scientific co-workers at the department of post harvesting technology at the Leibniz Institute of Agricultural Engineering Potsdam-Bornim, Max-Eyth-Allee 100, 14469 Potsdam-Bornim, E-Mail: hjgusovius@atb-potsdam.de

Dr.-Ing. Ralf Pecenka is scientific co-workers at the department of post harvesting technology at the Leibniz Institute of Agricultural Engineering Potsdam-Bornim, E-Mail: rpecenka@atb-potsdam.de

Dr. rer. agr. Thomas Hoffmann is head of the department of post harvesting technology at the Leibniz Institute of Agricultural Engineering Potsdam-Bornim, E-Mail: thoffmann@atb-potsdam.de

Ljubomir Radosavljevic was postgraduate and **Prof. Dr.-Ing habil. Christian Fürll** was longtime head (retired) of the department of post harvesting technology at the Leibniz Institute of Agricultural Engineering Potsdam-Bornim, E-Mail: cfuerll@atb-potsdam.de