Natural Binders for Fibreboard Made of Hemp

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Abstract
A novel technology and pilot plant for production and preparation of hemp fibre has been developed, along with its application in fibreboard production. The raw material is obtained through anaerobic storage of wet harvested and chopped whole hemp plants. Similar to wood fibre processing, the raw material goes through an extruder mill, refiner and dryer. Further steps are binder application, fleece forming and hot pressing into the final shape. A new production line offers an income alternative for agricultural producers and ecological diversification of crops. Fibreboard as well as three-dimensional pressed parts could be applied in the furniture, automotive and construction industries. The end products are competitive to conventional ones qualitatively, economically and ecologically. They are high quality due to the great strength of the plant fibre compared to conventional wood fibre. Also the other included plant parts such as leaves, flowers etc. contain their own natural juices, materials and bonding properties, which contribute to higher strength and water resistance. The mixing of the fibrous material with binder is optimized, so that binder quantity is reduced and its distribution improved. Natural binders such as starch, sugar, cellulose, plant oils and proteins were compared to a conventional synthetic binder, phenol-formaldehyde resin. Selection of natural binders should either be cheap or agricultural waste disposed of from some other production process, although useful here. Natural binders are inexpensive, ecological, natural, renewable, biodegradable and environmentally friendly, but slightly harder to apply, form weaker bonds and usually are not water resistant. Economic evaluation has shown that the price of the products made in an existing pilot plant already falls in the range of the mass products priced on the market. Mechanical characteristics of the produced fibreboard have been investigated and they reach those of the commercial products, with a potential to be increased through the further optimization of the process.

INTRODUCTION

In the Leibniz Institute for agricultural engineering, Potsdam-Bornim (Germany) a novel technology [4,6] and pilot plant for production and preparation of the hemp fibre has been developed, along with its application in fibreboard production. The raw material is obtained through anaerobic storage [3] of the wet harvested and chopped whole hemp plants. The raw material is processed through an extruder mill, refiner and dryer. Further steps are binder application, fleece forming and hot pressing into the final shape. A new production line offers an income alternative for agricultural producers and ecological diversification of crops. Fibreboard as well as three-dimensional pressed parts could be applied in the furniture, automotive and construction industries. The end products are competitive to conventional ones in quality, economics and ecology. They are high quality due to the great strength of the plant fibre compared to conventional wood fibre. Also the other included plant parts such as leaves, flowers etc. contain their own natural juices and materials with the bonding properties, which contribute to higher strength and water resistance. The mixing of the fibrous material with binder is optimized, so that binder quantity is reduced and its distribution improved [5,7,9]. Natural binders such as starch, sugar, cellulose, plant oils and proteins were compared to a conventional synthetic binder, phenol-formaldehyde resin. Selection of natural binders should either be cheap or agricultural waste disposed of from some other production process, although useful here. Natural binders are inexpensive, ecological, natural, renewable, biodegradable and environmentally friendly, but slightly harder to apply, form weaker bonds and usually are not water resistant. Economic evaluation has shown that the price of the products made in the existing pilot plant falls in the range of the mass products priced on the market. Mechanical characteristics of the produced fibreboard have been investigated and they reach those of the commercial products [1,2], with a potential to be increased through the further optimization of the process. The raw material (wet preserved hemp) is shown in Fig. 1. Samples of the end products are shown on Fig. 2.

Fig. 1: Wet preserved hemp as a raw material for fibreboard production

Fig. 2: Samples of the fibreboard

METHODS

In current investigations of fibreboard production, the combinations of the fibre from wet preserved hemp and pine wood are used in 60:40 dry mass ratios. As a comparison some of the boards were made exclusively from the pine wood fibre. The binders used in the experiments are natural binders such as starch, cellulose, raps pressed cake (waste from the raps oil production), solution of PLA, glucose, etc. as a semi product of the lactic acid and rye plant rests from the glucose production as well as conventional synthetic binder, phenol formaldehyde resin. Some of the boards are pressed without any binder.

In Fig. 3 the machine for the binder application is shown. The fibrous material is mixed in the two bars mixing chamber, and sprayed with the binder through the four nozzles from above. In Fig. 4 the used materials are shown.

Fig. 3: Beleimmischer, Pilotanlage des Leibniz-Instituts für Agrartechnik Potsdam-Bornim e. V. (ATB)

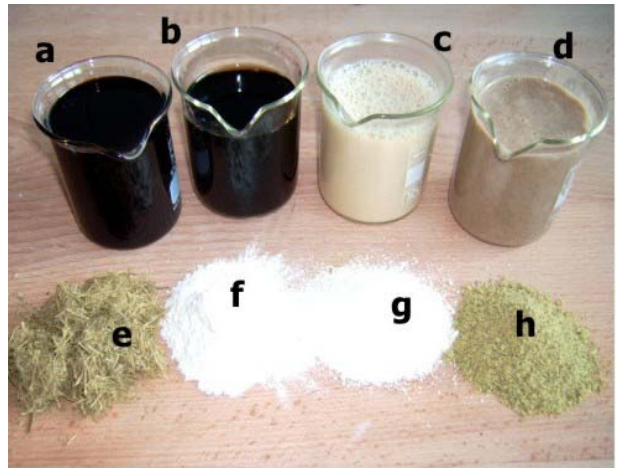

Fig. 4: Used materials: a-Phenol resin, b-PLA semi product, c, d-plants rests of glucose production, e-fibre, f-starch, g-cellulose, h-raps pressed cake

The bending strength of produced fibreboard is investigated. The sample board for measuring the bending strength is shown in Fig. 5.

Fig. 5: Fibreboard (bending test sample) made of preserved hemp (thickness 10 mm, density 500-1200 kg/m³, pressing temperature 200 °C, pressing time 6 min.)

RESULTS

In Fig. 6, the bending strengths of the fibreboard made of hemp silage in a mixture with 30% wood fibre are presented. As a comparative value, the minimum required strength with regards to the EN 622-2 standard for HDF boards of common purpose use in dry areas is given, along with the requirement for highly reliable boards for construction purposes in moist areas. Figure 7 shows the quality comparison between fibreboard made of preserved hemp and that made of wood fibre.

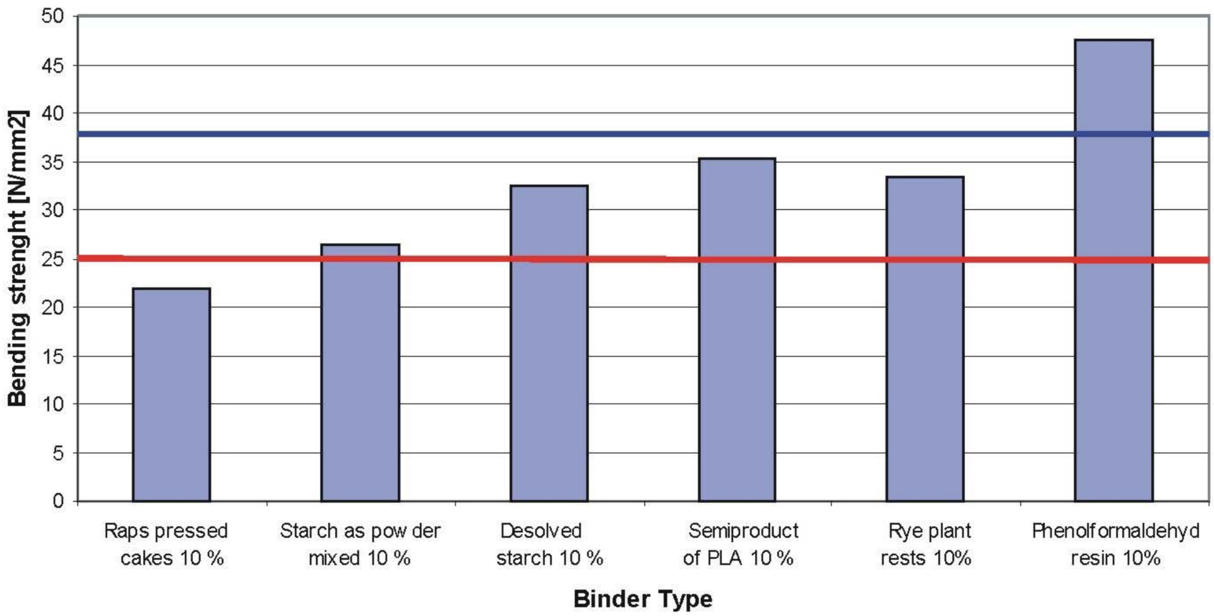

Fig. 6: The bending strength of natural fibreboard with different binders (material: hemp silage mixed with wooden fibre 6:4, density 1140 kg/m³, thickness 10mm). ▬ minimum required strength towards EN 622-2 for HDF boards for common purposes in dry area, and ▬ for highly reliable boards for construction purposes in moist area.

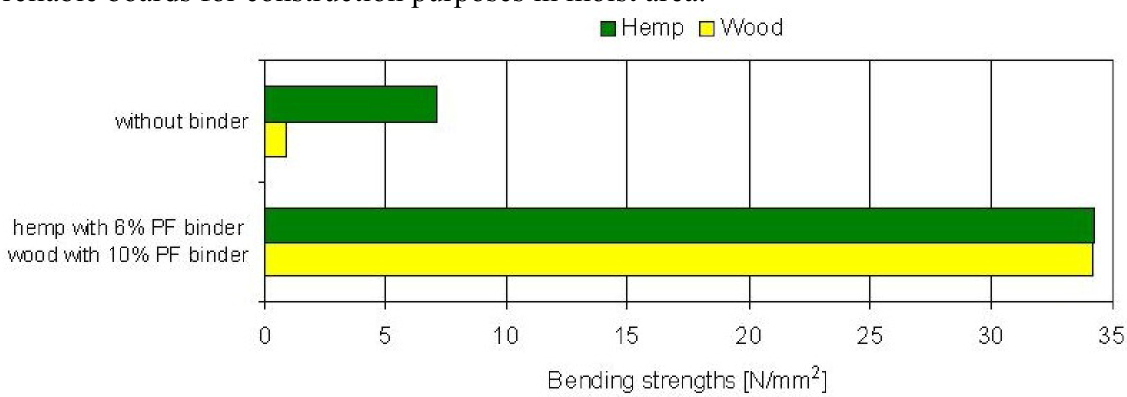

Fig. 7: The bending strength of fibreboard made of hemp and wood fibre (thickness 10 mm, density 790 kg/m³, pressing time 6 min., binder PF resin)

DISCUSSION

Mechanical strength of fibreboard made of preserved hemp and natural binders reaches those of the conventional wood fibreboard.

The fibreboard made of preserved hemp could be produced with a 40 % savings of the binder compared to the fibreboard made of wood.

In the case of fibreboard made without any binder, preserved hemp is superior to wood as a raw material.

Wet preserved hemp, when used as a raw material for fibreboard production contains its own characteristically natural juices and substances originating from leaves, flowers, seeds and other non-fibrous parts of the plants. Under hot pressing conditions, those substances develop bonding characteristics and probably polymerize.

REFERENCES

1. DIN EN 310, Holzwerkstoffe; Bestimmung des Biege-Elastizitätsmoduls und der Biegefestigkeit, Ausgabe:1993-08, Beuth-Verlag, Berlin, (1993).
2. DIN EN 622, Faserplatten - Anforderungen; Ausgabe:2003-09, Beuth-Verlag, Berlin, (2003)
3. Ernte, Konservierung und Erstverarbeitung von Hanf aus einer Feuchtgutlinie, Forschungsbericht des ATB Potsdam-Bornim, Institut für Agrartechnik Bornim e. V. (ATB), (2000/3).
4. FÜRLL CH. et al, Verfahren zur Aufbereitung von Naturfaserpflanzen, Patent DE 103 463 658, (2005).
5. KLAUDITZ W., MEINECKE E., Über die physikalischen und technischen Vorgänge bei der Beleimung und Verleimung von Holzspänen bei der Herstellung von Holzspanplatten, Westdeutscher Verlag, Köln, (1962).
6. KÜHNE G., Konzeption einer Verfahrenslinie für die Verarbeitung von konserviertem Hanf, Dresden, (not published) (2004).
7. 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).
8. MÜLLER, M., Möglichkeiten der Herstellung stärkegebundener lignocelluloser Formkörper als Variante dämmender, biologisch abbaubarer Werkstoffe, Dissertation an der Technischen Universität Dresden, Dresden, (1997).
9. RADOSAVLJEVIC, LJ., Natural fibreboard: method of binder spreading to achieve a high quality products, XVI CIGR world congress, 2006, Bonn, Germany, Book of Abstracts, p.609., (2006).