Processing of Wet Preserved Hemp to Fibre Boards in a Pilot Plant

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Abstract
A novel technology based on processing of wet preserved hemp has been examined at the Leibniz Institute for Agricultural Engineering Potsdam-Bornim (ATB) for many years now. At the usual harvest date in September, weather conditions are often detrimental to harvest of quality hemp straw in Europe. The harvest of hemp by means of a chopper followed by anaerobic storage is favourable for the farmer, because that typical weather risk can be avoided. Additional steps are the same as for ensiling. A pilot plant with a processing capacity of 300 kg per hour (dm) fibre material has been built up at the ATB and is tested at present. The whole plant material can be processed to final products such as insulation materials or fibre boards without any loss. By the use of natural binders for fibre board production the end products of the pilot plant are 100 % made of renewable raw materials, ecological, biodegradable and environmentally friendly.

INTRODUCTION

The cultivation of fibre plants such as hemp and flax has gained much importance for the European agriculture during the last 15 years. Research and practice in natural fibre technology have shown that alongside their use as textiles, natural fibres can also be used successfully as reinforcing fibres in composite materials, in building materials, as heat and sound insulation materials, and in many other applications. For example, if they are used to replace glass fibres in composite materials, they achieve virtually the same material properties. At present, approximately 19000 t of natural fibres (not counting cotton and wood fibres) are annually used only as reinforcement fibres in composites for the automotive industry in Germany alone [4].

For farmers, cultivating natural fibre plants represents an alternative crop and alternative source of income. Furthermore, there are ecological advantages, for example because cropping hemp does not require the use of any plant protection agents [1]. It is advantageous to include hemp in crop rotation because following crops produce up to 30 % higher yields [3]. The traditional production of hemp and flax fibres in Europe is based on field drying and retting of fibre straw. At the usual harvest time in September, weather conditions are often unfavourable for the processing of hemp to high quality fibres for industrial purposes. Therefore, traditional hemp and flax fibre production is connected to a certain economic and logistic risk for the farmers and fibre processors in many typical cultivation areas all over the world. Further disadvantages at present are above all the higher prices of natural fibre products for the final consumer by comparison with traditional construction and insulation materials. For farmers in the EU, in turn, the proceeds gained from natural fibre straw hardly cover costs, now that subsidies have been reduced.

This results in the following conflict at present:

- There are increasingly fewer farmers who are willing to cultivate natural fibres in Germany.
- The excessively high final consumer prices for building and insulating materials lead to only insufficient demand, even taking into account ecological aspects and market launch programmes.
- Although it processes increasing quantities every year, the automotive industry prefers to procure cheaper fibres from abroad.

Hence, cost reductions are imperative throughout the entire production chain of bast fibres in order to improve chances for cultivating natural fibre plants in future [7, 8].

PILOT PLANT FOR THE PROCESSING OF WET PRESERVED HEMP

A new process for processing hemp based on weather-independent harvest and post-harvest techniques has been developed at the ATB. The objective consists in developing an alternative process line for conditioning and processing wet-preserved hemp, characterised by:

- A reduction in process costs,
- Reduced investment in plant for fibre pulping and processing the preserved matter,
- Simplicity of the plant coupled with reliable operation, and
- Securing of product quality.

While in the traditional process hemp is mowed at harvesting time, dried on the field and possibly also retted, the preserved material line consists of chopping the hemp from the stand. The chopped material is then preserved in horizontal clamp silos or tube silos, for example like maize [6]. After harvesting and storage, the new process produces the desired final product from the preserved material directly, using the whole plant mass. In principle two process lines are conceivable (Fig. 1). In the first process chain the final product is made from the whole, wet preserved, chopped material (Fig. 1, fraction a). In the second chain a part of the fibres is separated after harvest and processed further separately (Fig. 1, fraction b). The advantages of these process lines consist in reducing the weather risk at harvesting time in September and in processing the whole plant mass to a final product without losses. Applications for this process are seen in the production of insulation panels, building construction panels, packing materials, linings, as well as in the use of fibres to reinforce thin concretes. With this novel agricultural technology, new raw materials from agriculture at reasonable prices can broaden the typical choice of raw materials for the fibre industry. Especially for the wood fibre industry this is of major importance as increasing raw material prices and shortages of supply with quality wood are about to appear.

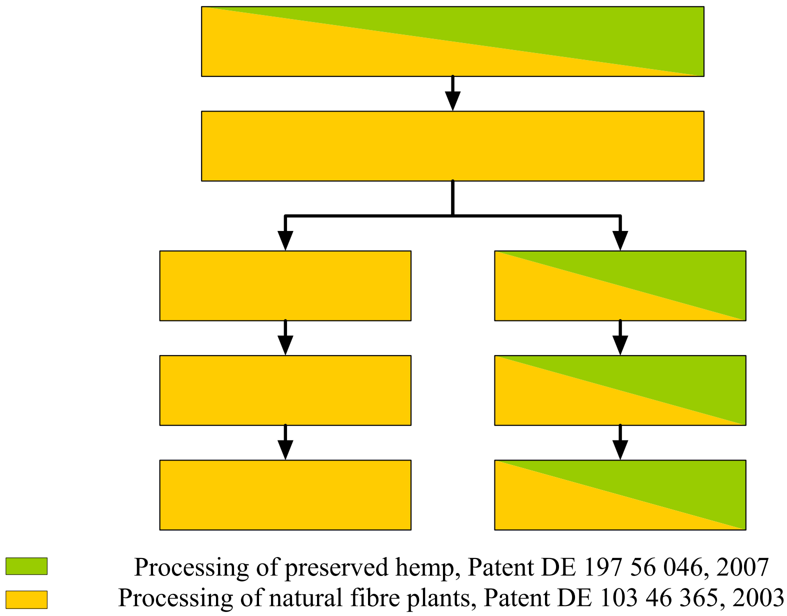

Fig. 1. Process for harvesting, preserving and processing of fibre plants

Processing of wet-preserved hemp in the pilot plant at the ATB is carried out using a so called dry/half-dry method adopted from the wood fibre industry [5] (Fig. 2).

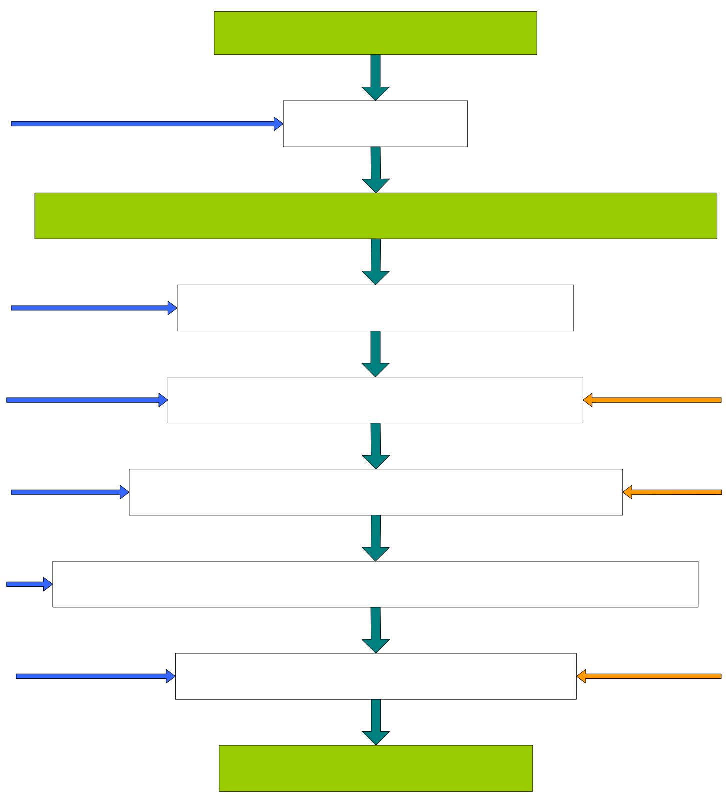

Fig. 2. Processing line for processing wet-preserved hemp

The ongoing research work comprises all process stages from raw material production to several end products. Current sub-projects focus mainly on the following areas: cultivation, harvesting and preservation, conditioning and processing technology, and economic assessment of the overall process. For processing of the raw material to high-quality products in the pilot plant the following process steps are mainly under examination:

a) Selection / extraction / provision of raw materials
b) Particle pulping / particle modification
c) Particle (fibre) drying
d) Particle - binder combination (gluing of the fibre material) / natural binders.
e) Structuring / fleece forming / primary pressing
f) Press forming / reforming and structure fixing
g) Finishing post-treatment of the fibre boards and 3-D compacts

RESULTS

The pilot plant has been put into operation in March 2007 and is tested at present (Fig. 3).

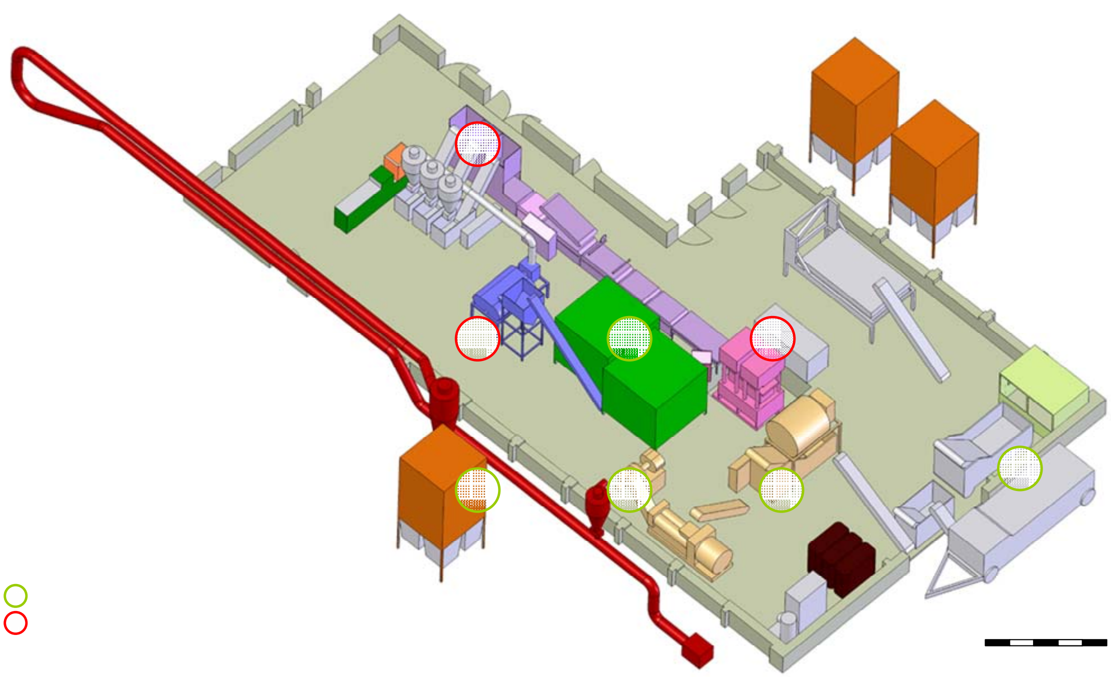

Fig. 3. 3D-Layout of the pilot plant for the processing of fibre plants

First samples like MDF and HDF fibre boards have been produced. According to the current results, the mechanical properties of the test samples are comparable with the properties of commercial products made of wood fibres. But silage-like odours of the raw material can be disadvantageous for several end products. First trials have shown that the novel processing technology is appropriate to reduce the content of odorous components. Butyric acids and other odorous acids are released to the exhaust air by means of the thermal treatment of the raw material in the defibration and drying stage of the process. Therefore, end products do not have any unfavourable silage-like odours.

The application of natural binders such as starch, lactid acid or inexpensive by-products from agriculture instead of common synthetic binders e.g. on the basis of phenolic-formaldehyde is another important part of the ongoing research. Advantages of such binders are the lower health risk and the environmental friendly production. Furthermore, such fibre boards are completely made from renewable raw materials from agriculture. The disposal by incineration for energy purposes is CO_2 neutral. Several test samples made with different natural binders already fulfil the requirements of European standards (EN 622 - 2) regarding the mechanical properties (Fig. 4). But there is still an important need and potential for optimisation [9, 10].

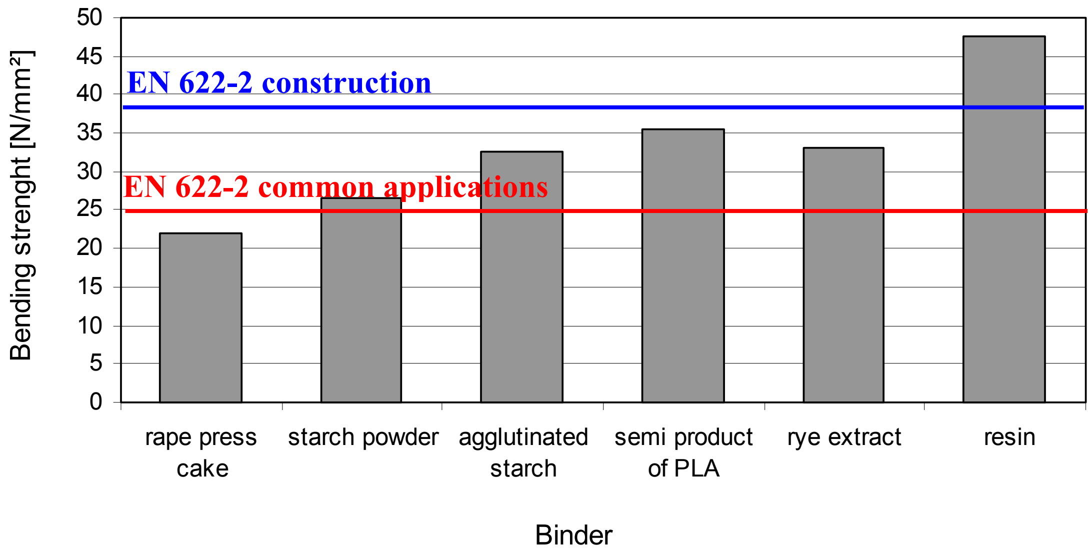

Fig. 4. Bending strength of fibre boards from wet-preserved hemp and wood (6:4) with the use of different natural binders (thickness 10 mm, density 1140 kg/m³, binder content 10 mass-%)

CONCLUSION

Experiences from construction and testing of a novel fibre processing plant have shown that wet preserved hemp can be processed to high quality fibre boards. The typical weather risk of the hemp harvest can be largely eliminated for the farmer. Also other fibre plants from agriculture and forestry or mixtures of different raw materials can be processed in the pilot plant at reasonable costs. The novel technology is appropriate to establish decentralized processing plants at farm level. Main advantages of such plants for hemp processing will be the alternative income for the farmer, the environmentally sound production of fibre boards and the enrichment in crop rotation.

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