ECONOMIC PRODUCTION AND PROCESSING OF AGRICULTURAL FIBRE PLANTS FOR HIGH QUALITY APPLICATIONS IN AUTOMOTIVE, BUILDING AND FURNITURE INDUSTRY

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ABSTRACT There is an increasing demand for high-quality fibres and shives (hurds) from hemp and flax as alternative raw materials in industries such as automotive and building industry. Fibres are mainly used for composite reinforcement instead of synthetic fibres. Shives are used for animal bedding, but processing trials in wood industry for the production of low weight particle boards from shives are also very promising. Experience in cultivation and harvesting as well as modern processing technologies are needed for fibre producers to supply technical hemp and flax fibres as well as shives at competitive prices under the changing conditions of international raw material markets. For detailed investigations of all processing stages of fibre production a complete processing line has been developed, installed and tested at the Leibniz Institute for Agricultural Engineering (ATB). With the novel ATB line high quality fibres and shives can be produced from retted and unretted hemp, flax and oilseed flax straw without technical changes of the machine line. In the last two years the ATB pilot plant has been operated by a cooperation of farmers, a fibre processor and a machine producer at industrial scale. The experiences from industrial operation has been used to develop a modern fibre processing line with a throughput of up to 5 t h\textsuperscript{-1} hemp straw in only one short line.

Keywords: hemp, flax, oilseed flax, bast fibre, shive, hurd, fibre processing, plant layout, economic efficiency

INTRODUCTION A pilot plant for bast fibre processing with a capacity up to 3 t h\textsuperscript{-1} hemp straw has been developed and evaluated with partners from industry at the ATB (Figure 1). In this plant innovative technologies have been applied for bale opening, decortication, fibre and hurd cleaning (Fürll et al. 2008). With the same technology retted and unretted fibre straw from hemp, flax and oilseed flax can be processed to high quality fibres for technical applications. Furthermore, test runs have shown that fibre plants such as kenaf, ramie, nettle or fruits and leaves of palm trees can also be processed with this technology. Experiments with hemp and flax have shown that the excellent decortication quality achieved by this technology essentially simplifies the cleaning process. Thus, a reduction of the cleaning line to a 2-staged process is feasible (hurd content approx. 2%...
ATB line, traditional lines > 7 %). Experiences with this pilot plant have been the basis for further technological developments at industrial scale.

Figure 1. Flow sheet of the ATB pilot plant (Munder et al. 2004)

1 straw bale 6 conveyor 11 condenser
2 bale cutting (Guillotine) 7 decortication machine 12 fibres
3 metal detector 8 condenser 13 hurds
4 stone separator 9 step cleaner
5 straw metering system 10 horizontal opener

EFFICIENT FIBRE PROCESSING In existing plants, long processing lines are related to high investment cost, low mass flows and a high susceptibility to operational problems. The new decortication machine (modified hammer mill) developed at the ATB using impact stress to brake the connection between fibres and hurds is the key to solving operational problems encountered in existing processing lines (Munder et al. 2004), see Figure 2, C.

Figure 2. Industrial processing lines for short fibres from hemp and flax
Straw price, labour costs and stable plant operation are the main impact factors for economic hemp fibre production. Taking also the logistics costs for reliable straw supply (Gusovius 2009) and optimum plant lay-out (Pecenka 2009) into consideration the best long term economic results can be realised with a processing line designed for a straw throughput of approx. 5 t h\(^{-1}\) at present. Praxis experiences from the last two years are the basis for planning new powerful and economic processing capacities for a modern fibre industry working in good cooperation with farmers. The developed technology is appropriate for processing of different agricultural varieties and qualities of fibre crops (hemp, flax, oilseed flax, kenaf), see table 1. Processing capacities up to 10 t h\(^{-1}\) are possible, an important prerequisite to open markets like particle board and composite industry for renewable raw materials from agriculture.

Table 1. Fibre yield and shive content

<table>
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<tr>
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<th>Fibre yield [%]</th>
<th>Shive content [m-%]</th>
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<tbody>
<tr>
<td></td>
<td>fibre length</td>
<td>fibre length</td>
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<tr>
<td></td>
<td>20 to 160 mm</td>
<td>&lt; 20 mm</td>
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<tr>
<td>Hemp, less retted</td>
<td>22 to 24</td>
<td>3.6</td>
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<tr>
<td>Flax, unretted</td>
<td>27 to 29</td>
<td>2.4</td>
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<tr>
<td>Oilseed flax, unretted</td>
<td>23 to 26</td>
<td>2.7</td>
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(Hemp, flax and oilseed flax grown in Germany in the years 2002 and 2003, ordinary fertilisation, standard sowing and harvesting dates)

**CONCLUSION** The comparison with other existing processing systems made for hemp fibre production in Europe showed several technical advantages of the novel ATB line. Most important advantages are the high quality of fibres and hurds, the high flexibility to different input materials (e.g. hemp and flax – also unretted) and the short and simple processing line consisting of only one decortication and two cleaning stages (Gusovius et al. 2008). Furthermore, a straw throughput of more than 4 t h\(^{-1}\) is the basis for economic fibre production for all new processing lines at current straw prices of more than 150 € t\(^{-1}\). Linked to the results of a comprehensive analysis of straw supply logistics and different fibre processing technologies, the design of a hemp processing line with a capacity of approximately 5 t h\(^{-1}\) straw throughput in only one line would be optimum for commercial processing plants under current European conditions.


