# The development of eco-efficient wood-based pellet production

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## 1 Introduction

Up to 20 million tons of waste wood biomass per year are left unused in Finland mainly in the forests during forestry operations. Due to global demands to considerably increase the proportion of renewable energy, there is currently tremendous enthusiasm in Finland to substantially increase wood-based pellet production. Pellets are short cylindrical pieces (the diameter being usually 6–10 mm and the length 10–30 mm), which are produced mechanically by compressing the uniform material that has first passed through a hammer mill or mills to provide a homogeneous dough-like mass. The description of typical pelletizing process is shown in Figure 1.

As part of European objective to increase the eco- and cost-efficient utilization of bioenergy from the European forest belt, the aim of our research group is to promote the development of Nordic wood-based pellet production both in the quantitative as well as in the qualitative sense. The main fields of pellet research, and our chemical toolbox, developed for these studies, including a new specific staining and optical microscope method for understanding the binding mechanisms of pellet processing, and thus for the control and development of pellet production, are described in this paper.

## 2 Objectives of the research

In Finland the goal suggested by the EU sets the total proportion of renewable energy as high as 38% by 2020. The goal is demanding and requires also a strong increase of utilizing forestry waste biomasses which are classified as carbon dioxide emission neutral, in terms of the emission trading in the EU.

Concerning the utilization of strongly increasing amount of wood biomass energy, one reasonable solution in Nordic forest belt is decentralized and optimized wood pellet production. Forest economists have calculated that with present costs the maximum distance of profitable transport for forest chips, saw dust or shavings in Finland is ca.100 km, for round wood it is 1000 km, but for wood pellets transported by sea the figure, however, is as much as 5000 km.

These calculations, in conjunction with the general demands to increase the utilization of renewable energy as opposed to fossil fuels, explain why there is a strong strain to increase the production of wood-based pellets in particular. At present, nearly 200 pellet factories are in operation in Europe. However, most of them are small-scale applications. In Finland there are ca. 30 large-scale pellet factories in 2009 and the number of pellet factories has been increasing during the last decade. However, the problem occurs in the growth potential in pro-

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duction, because the present pellet plants are designed to utilize only dry raw material, mainly cutter shavings and wood chips, which are today almost totally utilized. One solution to grow the potential of large-scale pellet production is to increase the raw material basis by utilizing the large amount of waste wood biomass mentioned above in both cost- and eco-efficient way. Logically this demand requires also substantial increase in decentralized wood-based pellet production where small-scale pelletizing plants are situated near to the source of raw materials. The aim of producing high-quality pellets is very closely linked to both of these goals.

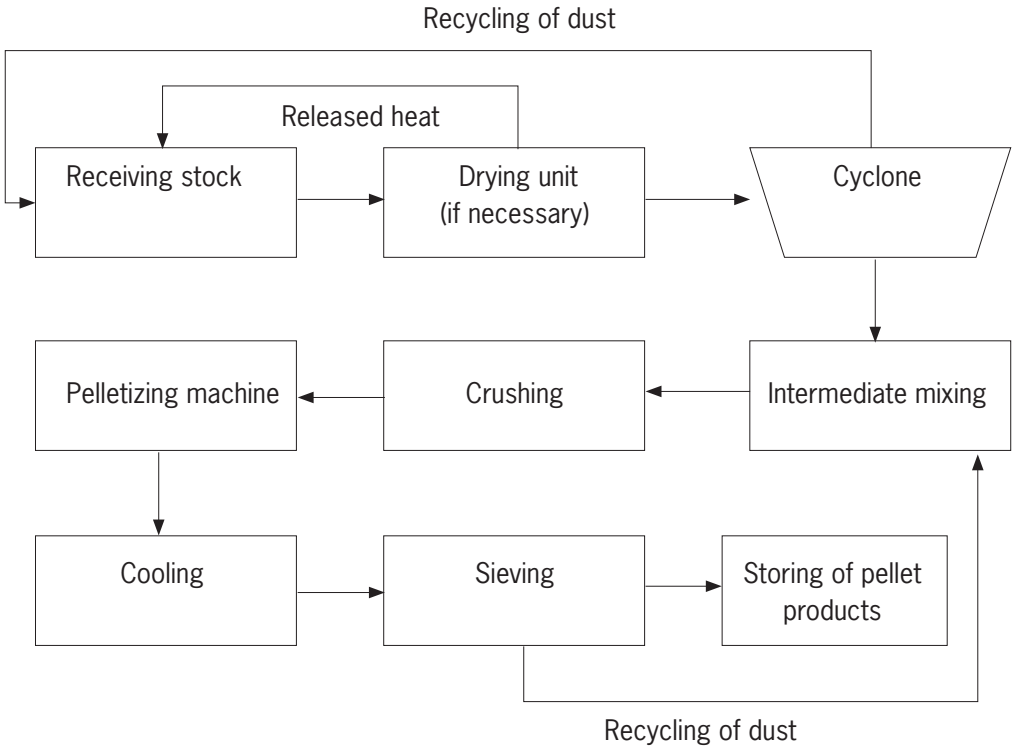


**Figure 1** Process description of a typical pellet plant

## 3 Results

### *3.1 The main fields of pellet research can be summarized as follows:*

1. Developing new materials for pellet production
2. Effective harnessing of industrial secondary flows
3. Binding material applications
4. Biodegradation of pellets and materials used
5. Binding mechanisms of wood-based pellets
6. Drying processes of pellet raw materials, including new technologies
7. Properties of ash in terms of its eco-efficient utilization

To the best of our knowledge the publications concerning wood pellets from the research methodological point of view are quite scarce in nature. Hence, our aim is to highlight environmental, energy-political and social considerations in order to support additional pellet production, develop research methods suitable for pellet production, and to internationally publish results of pellet research.

A large number of chemical methods useful in pellet research are in our use and can be used for pellet research. They are shown in table 1.

**Table 1** Pellet research methods or our "toolbox" for pellet production and development research

| Measurement | Equipment | Purpose of determination |
|---|---|---|
| Moisture content | Heat oven and scales | Amount of water content |
| Density | Volume and weight determinations | Compactness of materials |
| Caloric heat | Bomb calorimeter | Energy content |
| BOD tests | BOD OxiTop® equipments | Biodegradation/loss of materials |
| Dust content, strength properties | Vibrator, sieve analysis | Mechanical stability of the pellet |
| Structure analysis | Staining reagents and microscope | Information about pellet structure and cross-linking mechanism |
| TG analysis | Thermogravimeter | Volatilization of water and VOC's, ash content |
| Elementary analysis | ICP/OES | Heavy metals and/or nutrients |
| Particle size distribution | Laser diffraction particle size analyzer, image analysis | Information about particle size distribution in wood materials |

### *3.2 Some preliminary results and comments*

*BOD determinations:*

Biodegradation of pellets, their raw materials and possible binding materials could have a very important factor in the full-scale industrial manufacture of pellets, as high biodegradability may cause considerable economical losses during storage and transportation. All our biodegradation values measured are very low ($BOD_{28}$ < 0.4%) but even though potato peel residue itself – a potential binding agent – has high biodegradability, it seems to decrease the biodegradation of pellets, when it is used as a binding material. The effect can be explained by the prevention of oxygen gas adsorption in pellet pores.

*Sieve analysis:*

Wood dust is dangerous to human health, and storage silos it can cause spontaneous ignition. Therefore, small particle sizes are unwanted. Our results, which are in accordance with other experiments in the case of both pilot and full-scale pellet plants, show that the optimal proportion for the binding compounds studied in pellets is ca. 1–2%.

*Microscopic structure analysis:*

As the latest research step for examining the structure and binding mechanism in pellets we have developed and tested the optical microscope staining method for characterisation of starch containing binding compounds in wood pellets. Theoretically in the future, microscope structure analysis data could be used in optimization large-scale pellet production.

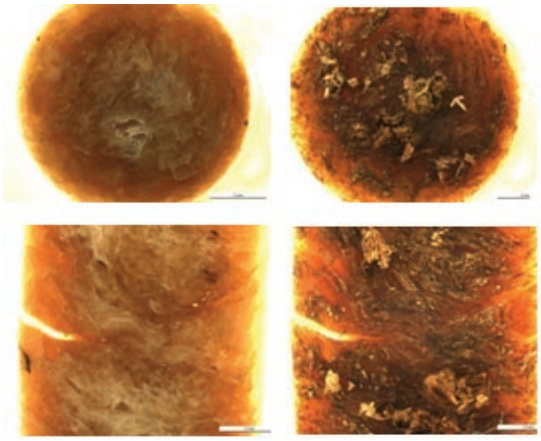

**Figure 4** Starch containing pellets unstained (left) and stained with potassium iodide (right).

## 4 Relevance of the research

A strong increase in the utilization rate of forestry waste biomass is required. A developed wood-based – or a combined pellet production and technology-based – industry that utilizes more wet and inferior quality forms of forestry biomass and industrial secondary flows in addition to the present pellet dry raw will be only one of several potential solutions to the problems presented above. Hence, wide-ranging and multidisciplinary studies and plans are needed to develop projects involving eco- and cost-efficient pellet production. The first results concerning the use of the optimized specific staining and microscopic method developed in our research group, using starch containing potato waste material as binding agent, are very interesting and suggest that this research method will be highly applicable in the future in terms of understanding the binding mechanisms of pellet processing, and thus for the control and development of pellet production. In our visions, different kind of pellet raw materials and reasonably integrated eco-efficient binding materials should be studied and utilized taking into account local resources.

**References**

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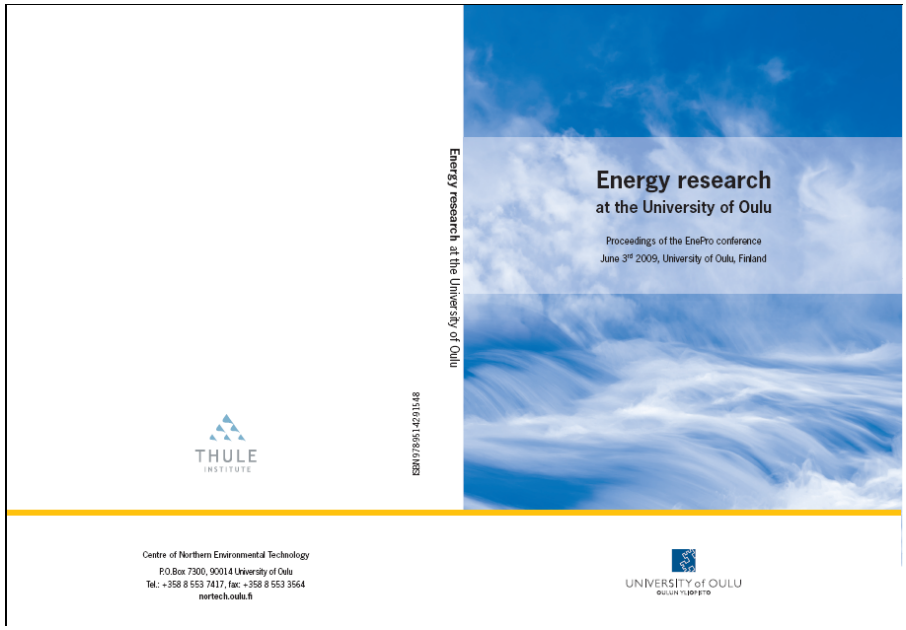


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