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Conception of the technology of wood production from short rotation coppice – Part 2

Short rotation coppices (SRC) of fast-growing tree species are becoming more and more important in Germany. Already in the issue 1.2011 of Landtechnik a part of the current research and development projects in the field of SRC at the professorship of agricultural machines of the Technische Universität Dresden were presented. In this second part the importance of harvesting, drying and storage of wood chips will be shown in detail, as they have significant influence on the chip quality. Possible solutions, studies and required developments will be highlighted to existing problems.

Keywords
Short rotation coppice, energy wood production, wood chips

Abstract
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The multiplicity of testing methods for harvest of SRC shows that a number of problems in crop and following processes, ending in thermal use, are not resolved in an acceptable way. The harvest of poplar and willow, optionally robinia, rotates in intervalls (2–5 years) so that the most harvested material is only rod-shaped. That is the reason, why a material use is currently not predictable, with some exceptions. Therefore, the solution of a harvesting technology should consider also terms of agricultural production [1], when material is used for energy production. The most common method of mechanized loading of combustion or gasification systems bases on small pieces of wood. These requirements are also fulfilled by wood chips. Especially for small combustion plants (thermal power <100 kW) the highest quality standard is claimed.

Influential parameters on wood chip quality

After random measurements, the material from poplar, which growed up on SRC, consists of 28% to 32% of rind. Also a 4-year-old poplar and 7.5 m highly single tree consists of 29% of rind. However in a 2-year-old and 5.3 m highly willow only 22.5% of rind was found. This mixture of wood and rind is enriched with nutrients (especially carbohydrates) and is exposed to a biological decomposition of the rind directly after shredding (1.5 cm to 3 cm of root length). It begins with a warming by breathing and as a result it starts a degradation also at low temperatures by microbial conversion and mold formation. This explains the results found out by Scholz [2], when a weight loss of about 30% was measured while storing wood chips without systematic drying. In order to prevent any biological activity, a fast drying should be realized to reach moisture below 30%. So, the storage with very little loss of mass is guaranteed. Therefore a technical forced ventilation of rough wood chips is preferred because less air pressure will be necessary. In consequence, the energy demand can be minimized while drying and also producing (hacking) rough wood chips, because the number of cutting operations is reduced further. It is found that the selection and coordination of the process chain at each individual step is necessary. The production of rough wood chips with an average length of 5 cm reflects a good compromise between harvesting, drying and conveying systems. As noted by Firus and Belter [3] and other literature, an increasing length of wood chips means also a higher quantity of overlong pieces. Ongoing and planned R&D projects at the professorship of agricultural machines of the Technische Universität Dresden are aimed at identifying technical solutions for an efficient production of defined wood chips. As a result, a harvesting machine concept should be designed for an implemented machine for tractors. Self propelled forage harvesters normally use a horizontal collection of cutted poplar or willow rods, which is under several conditions difficult. However these problems can be avoided as far as possible, if a vertical collection of material will be used.

Drying and storage

Drying and storing of the harvested material with minimal losses is one of the primary objectives in order to keep a high quality standard. Among known solutions for drying processes the following assessment of drying results is done with respect to energetic aspects (**figure 1**). The size of the drying process in **figure 1** represents qualitatively the relationship between costs and benefits.

The storage without manipulation results in mass loss, which means in consequence energy loss. Ventilation by cold air was favored while testing several agricultural processes for drying. Large masses of harvested material were dried at low energy use with good drying results.

In advantage the process becomes independent from external heat sources, because no heat energy has to be added. This was confirmed by experiments under practical conditions. Therefore a sample container with quadratic section and a volume of 0.65 cbm was loaded at 1.75 m filling level. Ambient air was transported by radial ventilators through the harvested material (**figure 2**).

With an air speed of 0.07 m/s and an exchange rate of 144 cbm/h was reached through the wood chips. The loss of pressure was measured. The value of 35 Pa per one metre of rough wood chips was unexpected low.

Figure 3 shows the history for temperature and humidity (8 measurements per day) registered by data loggers. The water content of the wood chips is calculated with the values of mass reduction, measured by force sensors. The calculated drying rate depends on the relative humidity of the ambient air ("supply air") and shows a significant decrease when it reaches the saturation point of about 30% moisture, although there is no hardly change in humidity. This high drying rate is achieved in spite of daily average temperatures below 10 °C. So, a practical usability is seen in the ventilation of a dumped wood chip heap with a central ventilation channel on a flat paved ground. For an unhindered removal of the dry wood chips, the channel is built up like a telescope and should be removed at first. A model experiment in the linear scale of 1:4 (volume 1:64) shows that the total volume is ventilated equally. Therefore, the drying of large amounts which arise in the harvesting period is possible. A loss of mass by biological activity can be effectively prevented in this way. The energy balance is shown in **table 1**.

Currently, the estimation of costs of necessary drying is possible to ensure the quality of wood chips. The storage under roof, which saves the quality and allows more extensively manipulation, shows no disadvantages in comparison to the dome-drying procedure, because there are higher costs at operating and logistics. Furthermore, there is an increased loss of mass and a higher material consumption.

Preparation

If waste timber and poor stem wood are worked up with existing wood chip technologies, quality will be decrease compared to industrial wood chips. These lower quality, with a high proportion of very fine particles and also loaded with fungal spores, will be tolerated with a favorable view to the fuel price. However, this wood chip quality cannot be used for combustion plants with lower power (<100 kW) due to various reasons. With a following preparation after the drying process, especially sieving the fine fractions and removal of overlengths, wood chips will be produced in good quality. As one part of the current research projects, new solutions for the focused fractionation of wood chips will be developed. According to Gierer[4], the most available machines do not satisfy the specific requirements, currently.

Fig. 1

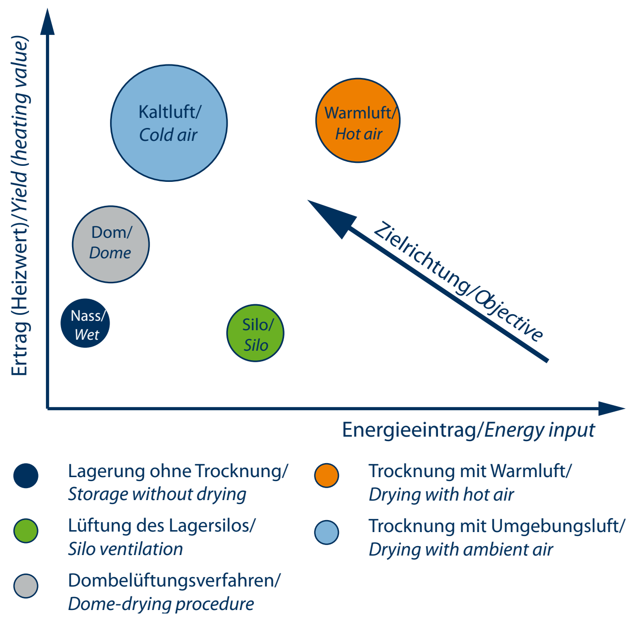

Fig. 1: Qualitative representation of energy input to heating value during the drying process of wood chips

Fig. 2

Fig. 2: Sample container for drying of wood chips (left), registration of weight loss by a load cell (right)

Fig. 3

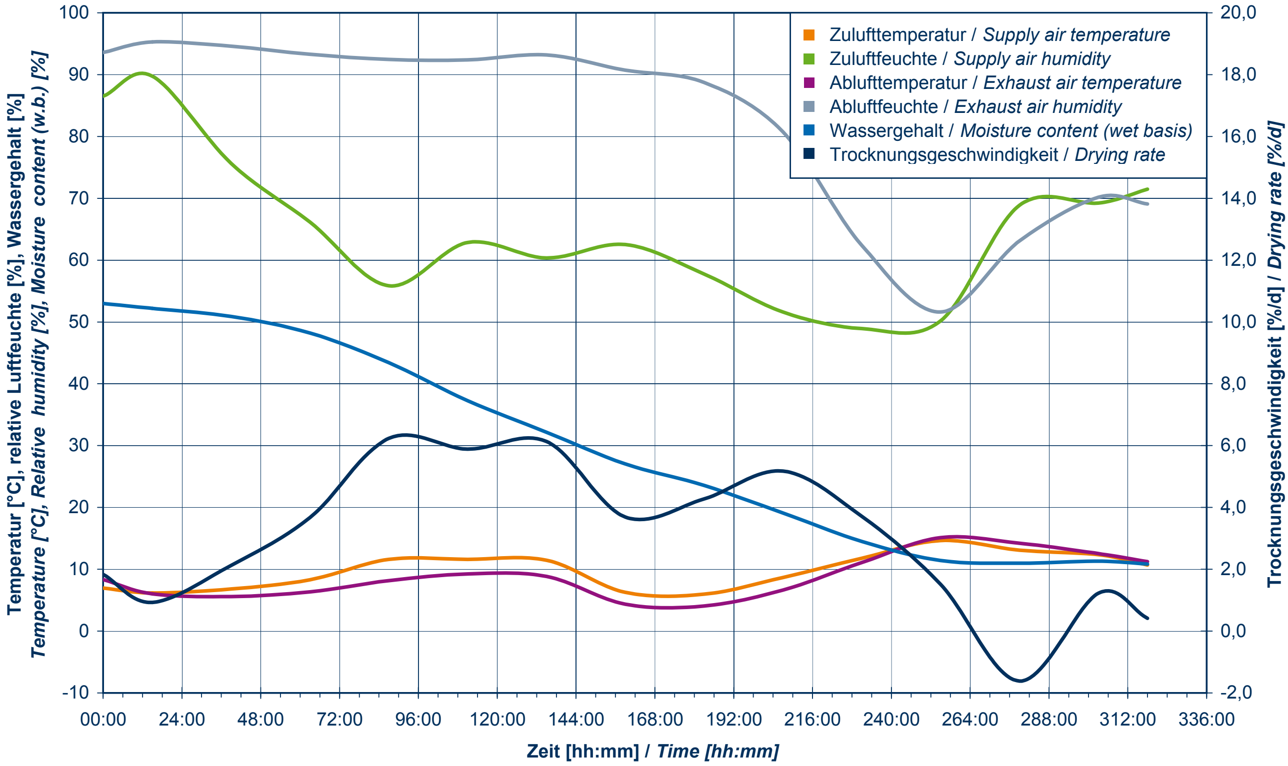

Fig. 3: Drying process of wood chips (poplar, chunky pieces)

Further R & D work

Following parts belong to currently projects will be worked off:

- Continuing the harvester project, which bases on the knowledge of the one-year experience
- Starting studies on cold-air drying on a scale of 1:1
- Continuing the preparation of wood chips, especially fractionation
- Determining of constructive and operational data for a reliable cost-benefit-analysis based on tests

For the following topics more R & D work is needed:

- Integration of a logistic concept for harvesting, storage, processing and marketing
- Localising the cheapest place of storage (producers, distributors or exploiters)
- Discovering the best method of storage (cold or warm air, silo, pile, or storage boxes)

Conclusions

Within the required process chain around the SRC more technical solutions within the individual process steps are still needed. The identified requirements for high-quality wood chips and compliance under conditions of harvesting, drying and storage are currently fulfilled in required sizes only by some processes which are offered at the market process.

In the future it is expected that other institutes will create further variants so that users get the possibility to choice between different solutions.

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Table 1

Table 1: Energy balance for air dried wood chips

Parameter/ ***Parameter***	**Wert/** ***Value***	**Energiebilanz/** ***Energy result***
Netzleistung Radiallüfter/ *Radial fan grid power*	0,1 kW	
Lagerstabilität erreicht bei/ *Storage stability aim*	Unter 30 % Wassergehalt/ *Less than 30 % water content*	
Energieverbrauch für Belüftung/ *Energy consumption for ventilation*		**14,4 kWh**
Masse der Hackschnitzelproben/ *Mass of the wood chip samples*	82 kg atro	
Frischmasse/ *Mass of raw material*	190,7 kg	Heizwert/*Heating value* 333,7 kWh
Getrocknete Masse/ *Mass of dried material*	117,1 kg	Heizwert/*Heating value* 374,7 kWh Heizwertgewinn/*Heating value profit* 41,0 kWh
Verlustminderung gegenüber der unbelüfteten Probe/ *Loss reduction compared to the non-dried sample*	25 %	Heizwertgewinn/*Heating value profit* 93,7 kWh
Heizwertgewinn insgesamt/ *Profit of total heating value*		**134,7 kWh**
Aufwand zu Gewinn/ ***Effort compared to profit***		**1 : 9,3**