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PROBLEMS AND SOLUTIONS OF STORING WOOD CHIPS IN PILES

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Abstract: Wood, including short rotation coppice, is a promising biofuel. Most of this wood is transported, stored and used as chips. The storage of chips of recently harvested wood in unventilated piles causes difficulties. Due to the high water content microorganisms, above all mould fungi, develop and result in high temperature and losses of dry matter. The first is bad for the operator's health and the latter cause a relevant loss of energy and money.

Key words: *bio-mass, wood chips, storage, quality.*

INTRODUCTION

Wood, including short rotation coppice, is a promising biofuel. Most of this wood is transported, stored and used as chips. The storage of chips of recently harvested wood in unventilated piles causes difficulties. Due to the high water content microorganisms, above all mould fungi, develop and result in high temperatures and losses of dry matter (SCHOLZ AND IDLER ET AL., 2005). The first is bad for the operator´s health and the latter cause a relevant loss of energy and money (FEICHT, 2001).

MATERIAL AND METHODS

For the storage experiments, manually felled 2 to 8 years old short rotation poplars and willows with a diameter of 120 mm in a height of 1.2 m as well as pine (material produced from forest thinnings) were used. The moisture content was at 50% to 60%.

The materials were stored in the following containers or piles:

- Silos of 1.5 m3 (h = 2.0 m, d = 1.0 m), consisting of cylindrical rigid PU foam bodies with rain protection (Fig. 1).
- Boxes of 10 m3 (h = 2.5 m, l = w = 2.0 m), consisting of rectangular arranged thermally insulated side walls with rain protection.
- Piles of 18 m³ to 2000 m3 (h = 3...6 m, w = 4...15 m), consisting of freely placed triangular stacks with and without rain protection. (Fig. 2).

Temperature measurements were taken at 4 to 5 levels with embedded PT 100 temperature sensors and mini data loggers or with 1.20 m long electronic stack thermometers. Measurements were taken at intervals of about 20 minutes to 7 days. Losses in dry matter were determined with the help of balance bags, as used in agriculture to determine silage loss (SCHOLZ AND IDLER ET AL., 2005). According to the type of storage (silo, box, piles), 6 to 66 balance bags in total were arranged at 3 to 6 levels.

The wood chips and chunks were produced using four different chippers and had an average length (median value) of 16 mm to 156 mm (HS 16 to HS 156), corresponding to an average screen perforation width of about 10 mm to 80 mm.

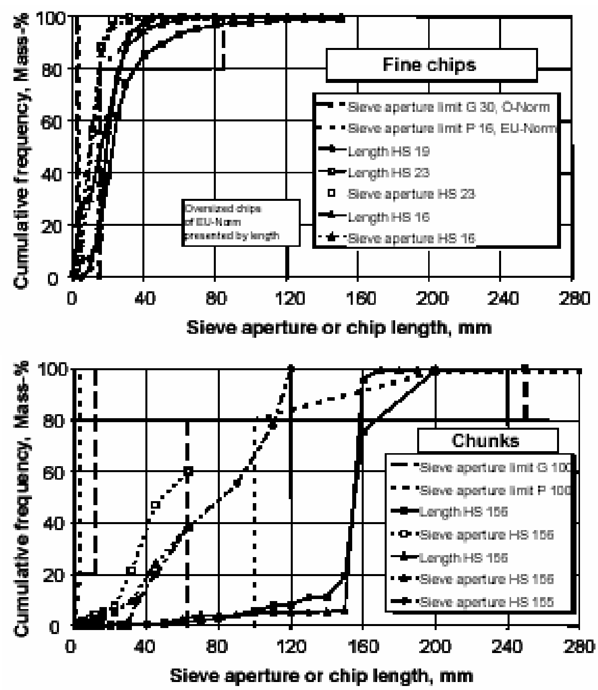

Figure 1. Length distribution of selected materials corresponding screening and manual measurements with class limits of the Austrian standard (ÖNORM M7133, 1988) and the European standard (PRCEN/TS 14961, 2004)

The number of mould fungi was determined using the indirect method. Here, 20 g of germ reduced chopped wood (ca. 1 cm³) was added to 180 ml of Ringer solution, diluted in a decade thinning row and put with a spatula either onto nutrient plates of malt extract agar with 0.01% chloramphenicol admixture or onto DG 18 agar. The DG 18 plates are analysed after 7 days incubation at 20 °C (mesophilic fungi) and the malt extract plates after 1 to 2 days incubation at 37 °C (thermophilic fungi). The number of colonies formed are counted and morphologically differing colonies identified. Measurement of the spore concentration of the mould fungi in the air was carried out in accordance with the technical standard for biological working substances TRBA 430 (TRBA NR. 430, 2001).

Temperature in the pile

The average temperature in the wood chip piles shows a characteristic course. Directly after storage it increases rapidly and reaches its maximum value of ¡Ü 60 °C after 10 to 30 (50) days. This value is to a large extent determined by the bulk volume, surface area, surrounding temperature and particularly by the size of the wood chips. 100 to 150 days after heaping up the pile (end of January) the temperature reaches a clearly lower value and after hat successively decreases to the air temperature (Fig. 2). The reason for the increase in temperature is the heat produced from the respiration of the sap wood cells which are still alive (< 40 °C), and due to the activities of micro organisms, particularly of the fungi (< 60 °C) and bacteria (< 70 °C).

Drying of the wood chips does not only depend on the temperature of the pile but also on the initial moisture content and the size of the chips. Drying is to a large extent complete after 100 to 150 days for fine as well as for coarse chips and even for whole trees (ø < 80 mm), thereby with the end of the high temperature phase in the piles. As a result of the high flow resistance, and the high temperature and the condensation produced by this under the surface of the pile, fine chips hardly dry to less than 30% moisture content during one year. Even middle chips (31 mm ... 50 mm) seldom fall below this value. Only chips with a length of more than 60 mm reach a moisture content of less than 30%.

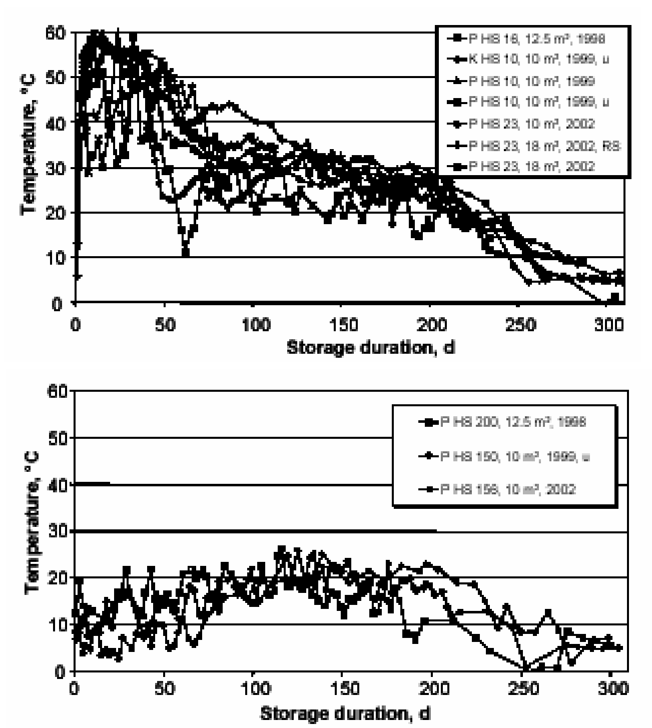

Figure 2. Course of temperature during storage of fine chips and chunks in piles HS x…chips or chunks of the median length of x mm, P...poplar, W...willow, K…pine, RS…rain protection, u...air permeable floor

Mould fungi and spores

The mould development shows close interactions with the temperature in the wood chip piles. Here, the number of fungi, measured in colony forming units per gram of fresh mass (cvu/g FM), increases analogue to the temperature in the first 10 to 30 (100) days to the maximum value of about 103 to 108 cvu/g FM. It remains more or less constant after that in contrast to the temperature and mostly only decreases slightly (Fig. 3). This discrepancy could possibly be due to the fungi spores characteristic of not dying in unfavourable conditions, but of remaining in a state of rest for longer periods of time and hardly changing in number.

The number of mesophilic mould fungi in the range of 10 °C to 50 °C is not or only slightly dependent on the average pile temperature. This means that in the storage of wood chips, the possibilities of influencing the development of mesophilic mould fungi is limited. However, the increased occurrence of thermophilics, thereby mainly the potentially human pathogenic types, can be prevented by avoiding temperatures over the average of 20 °C or maximum 35 °C.

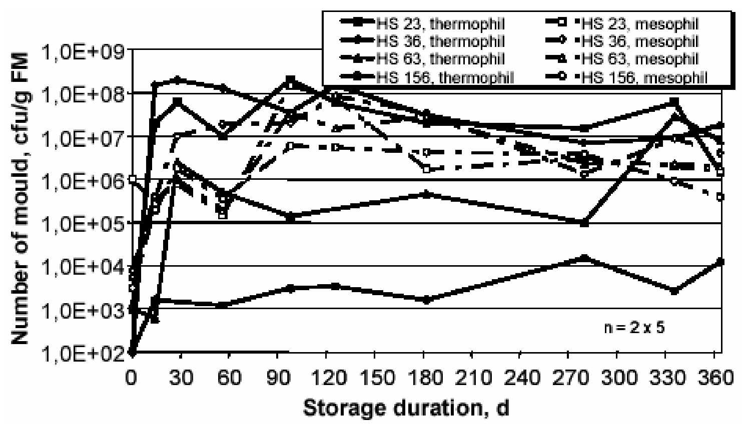

Figure 3. Mould development in 10 m³ piles of poplar chips of various length

The spread of spores, the air born germ cells of the mould fungi that are capable of reproducing, is dependent on numerous factors, especially on the air speed and the mould infestation. There is a good correlation between the number of fungi on the wood chips and in the number of spores in the air. The spore concentration in the air, determined at different distances and at different times in undisturbed wood chip piles lies within the range of 10^1 to 10^4 cvu/m^3. The measured values in the surrounding air are thereby exceeded by about one or two powers of ten.

If the structure of the pile is disturbed, as is necessary in mechanically depositing and redepositing the wood chips for instance, the spore concentration in the air can reach values of 10^5 to 10^8 cvu/m^3 for short time periods, depending on the distance. The technical control value for biological waste treatment plants of $5 \cdot 10^4$ cvu/m^3 for mesophilic mould fungi, for example, is therefore exceeded (TRBA NR. 211, 2001).

Loss of dry matter and energy

In the storage of wood chips losses occur which can mainly be attributed to mould fungi. The results of the experiments carried out show that the average dry matter loss in unventilated piles of freshly harvested wood chips is at 10% to 30% per annum. Locally, in particular in the peripheral zones, maximum values of over 40% p.a. can even occur (Fig. 4). However, a statistically relevant correlation between the infestation of mould fungi and the loss in dry matter is not deducible (SCHOLZ AND IDLER ET AL., 2005).

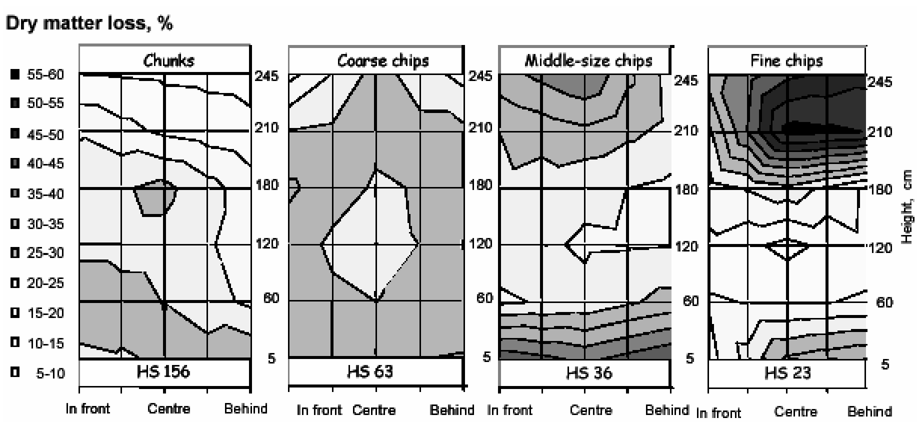

Figure 4. Typical profile of dry matter loss in 10 m³ piles of poplar chips after one years storage

In practice, it is not so much the loss in dry matter but far more the loss in technically usable energy which is decisive. Insofar as condensing boiler technology is not used, this results from the dry mass and moisture losses as well as the change in the lower heating value which, however, only changes slightly in long term storage. For fine chips HS 16, the energy loss is almost identical to the loss in dry matter and is at 20% to 30% p.a. For coarse chips > HS 120, it lies within the range of – 5% to + 5% p.a., due to the small loss in dry matter and due to the small moisture content (Fig. 5).

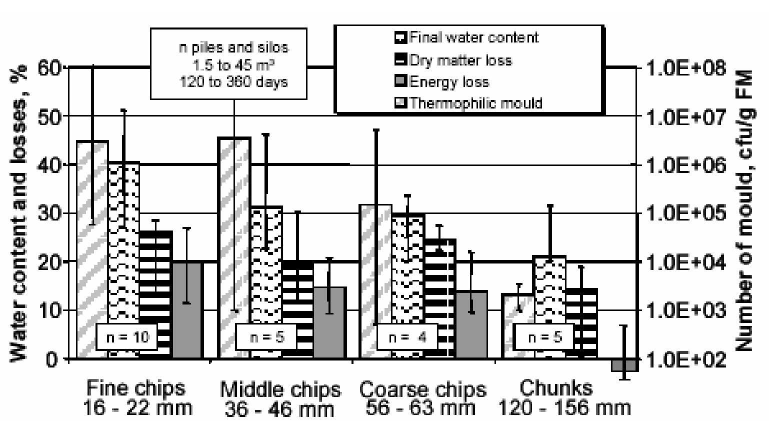

Figure 5. Mould fungi and final water content as well as dry matter and energy loss during storage of chips and chunks from poplar in unventilated piles

CONCLUSIONS

The loss of dry matter and the development of mould fungi cannot be completely avoided during storage of wood chips in unventilated piles, but the energy loss and the formation of fungi species hazardous to health can be reduced to an acceptable minimum. Therefore, the wood chips or chunks should have an average length of at least 100 mm (corresponding to a screen perforation width of 40 mm to 50 mm), thus in the upper range of the largest wood chip classes according to the existing Austrian standard or the draft of the European standard.

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PROBLEMI I REŠENJA ZA SKLADIŠTENJE DRVENIH ČIPSOVA U RASUTOM STANJU

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Sadržaj: Šumska stabla i usevi sa kratkom rotacijom predstavljaju značajan izvor biomase. Većina ovih materijala se transportuje, skladišti i koristi u formi čipsa. Kod kultura koje se odmah nakon ubiranja i usitnjavanja skladište, može doći do problema. Obzirom na visok sadržaj vlage i mikroorganizme, posebno gljive, dolazi do povišenja temperature u skladištima što uzrokuje gubitak u suvoj materiji. Sve ovo je negativno kako po zdravlje radnika tako i po ekonomsku i energetsku efikasnost.

Ključne reči: *čips od drveta, skladište, gljive, gubici, energija, ekonomija.*