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Determination of moisture ratio in parts of the hop cone during the drying process in belt dryer

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Abstract. The paper deals with monitoring the moisture content of hop cones and their parts (strigs and bracts) in PCHB 750 hop belt dryer. When drying hop cones, the critical point is the sufficient drying of the strig. These are therefore dried to a moisture content of 6 to 8%. This exact moisture provides a sufficient guarantee ensuring that the strig is dried up. On the other hand, bracts are dried up to such a level which makes pressing the hops impossible. Therefore, after drying, the bracts are remoistened. This is called hops conditioning. After conditioning the moisture content of hops is optimal, ranging between 8 and 11%. There is no doubt that drying or any further moistening does not benefit the hop cone.

During the experiment, the moisture content was determined regarding the whole hop cones as well as the bracts and strigs separately, the samples of which had been taken from the hops prior to entering the dryer, from different parts of belts in the dryer and subsequently before and after the conditioning. The moisture content was determined by means of Mettler HE53 moisture analyzer. After the bracts and strigs had been dried, we calculated their weight ratio which was approx. 90% of bracts and 10% of strigs. Based on this ratio the weighted average was calculated which corresponds to the moisture content of the whole hop cone.

The measured values indicate that the average moisture content of hops below 10% was already at the beginning of the third belt of the dryer. The hops had been unnecessarily overdried along the whole third belt. Another output refers to the moisture ratio of hop cones, bracts and strigs in different parts of the dryer. The obtained values will serve as a basis for the follow-up design of a device for monitoring the dryer parameters and its visualisation.

Key words: hop, hop cone, bract, strig, drying, belt dryer, moisture.

INTRODUCTION

The composition of hops is continuously changing not only during the ripening period and harvest, but more importantly during their drying, storing and processing into various hop products. Moisture is an essential qualitative parameter of hops and other crops (Vitázek & Jurík, 2015; Aboltis & Palabinskis, 2016; Aboltis & Palabinskis, 2017). The optimal moisture content of dried hops is within the range between 8–11%. If the moisture content of dried hops is less than 7%, the hops tend to shatter, i.e. are likely to fall into bracts and strigs, which is undesirable regarding the lupulin losses during any further processing. When the water content is higher than 13%, the hops are at risk of becoming mouldy as well as of deterioration resulting from a change in the colour, or even in an extreme case at risk of self-ignition. Where it is found that there is an excessive water content, those hops are brought back to the grower to be re-dried. Growers are well aware of the risks regarding poor drying of hops, because the number of real cases when the hops had to be re-dried is extremely low (Doe & Menary, 1979; Krofta et al., 2017).

The aim of the article was monitoring the moisture content of hop cones and their parts in hop dryer.

MATERIALS AND METHODS

The monitoring in all the dryers in operation was not focused on the moisture content of hops but of the productive environment inside each dryer. Fig. 1 depicts a scheme of the particular PCHB 750 belt dryer together with data on the speed for each belt.

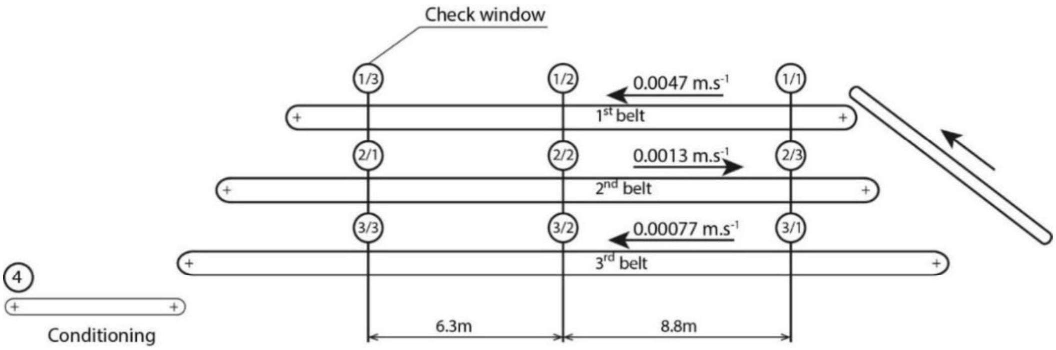

Figure 1. Scheme of the dryer belts indicating the speed of each belt and all sampling points.

Fixed Comet T3419 (Fig. 2) sensors of temperature and relative humidity are installed onto the belt dryers (Fig. 1), nearby the check window (Fig. 3). 8 sensors in the set are always connected to one Comet MS6D multi-channel data logger (Fig. 4). The data from the multi-channel data loggers are stored on the hard drive of the computer (Rybka et al., 2017).

Figure 2. A sensor with transmitter.

The data obtained from these fixed sensors, however, do not indicate an overview of the current hop moisture or even of the individual parts of hops – cone, bract and strig. Therefore, we decided to measure the moisture content of the cone and its parts in the individual sections (the check windows, Figs 1 and 3) of the belt dryer. The actual hop moisture is measured by individual growers by means of various kinds of very out-dated measuring instruments which are not very accurate.

In the laboratory, it is possible to determine the hop moisture content by means of drying a defined amount of ground hops in the laboratory dryer where forced-air ventilation is used, or by the moisture analyser.

Figure 3. A sensor with transmitter and display installed nearby the dryer check window.

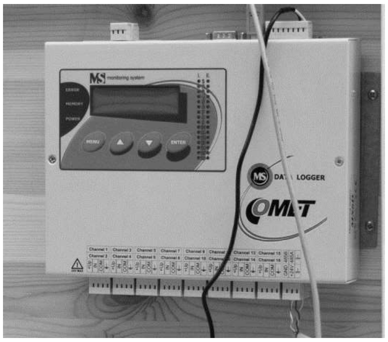

Figure 4. Comet MS6D multi-channel data logger.

When measuring in the laboratory dryer, 5 to 10 grams of ground hops are weighed into an aluminium or glass sample container. The bowl containing the weighed sample is inserted (without the lid) into the dryer that was warmed up to a temperature of 105 °C. This sample is dried for 1 hour. At the end of this period, the bowl with dried hops is closed with a lid and inserted into the desiccator to cool off. After cooling to room temperature, the bowl is weighed. In case we dry fresh green hops, similar procedure is followed, only the cones are cut into smaller pieces in advance and the drying period is longer. In the case of green hops, the drying period of 1.5 h is sufficient.

Another method is determination of the hop moisture content on the moisture analyser, where the sample moisture is continuously shown on the device integral display. The sample amount is approximately 3 grams in this case and the hops need to be evenly spread over the whole surface of the weighing bowl. The end of drying is indicated by the moment when the weight loss of the sample during the defined time interval is lower than its pre-defined value.

Figure 5. HE43 moisture analyser by Mettler-Toledo.

For the purposes of our measurement of the hop moisture content we used the HE43 moisture analyser produced by Mettler-Toledo (Fig. 5). According to the methodology of 'Assessment of Qualitative Parameters of Hops During Drying and Ageing' (Green & Osborne, 1993; Krofta et al., 2017), the limit values for the moisture content of hops are:

< 8% overdried hops,
9–11% optimal values,
11–12% acceptable increased moisture,
> 12% high moisture content, hops need to be re-dried.

The laboratory analyses monitored the moisture content of all samples of the hop cone and its parts – bracts and strigs (Fig. 6). The samples (three samples from each check window) taken for the purposes of laboratory measurement were taken at each check window.

Figure 6. Hop cone cross section.

RESULTS AND DISCUSSION

For the Saaz hop variety, the samples had been taken in the PCHB 750 hop belt dryer, the owner of which being Agrospol Velká Bystřice Co., Ltd., from all the check windows and both at the beginning and at the end of conditioning. The hop cone moisture and, separately, the moisture of bracts and strigs was determined on the HE43 moisture analyser provided by the Mettler-Toledo company. These results are presented in Table 1 and the graph in Fig. 7 and are similar Münsterer, (2006).

Table 1. Average measured values to establish the drying curve (Fig. 1)

Check window		1/1	1/2	1/3	2/1	2/2	2/3	3/1	3/2	3/3	4
Measurement time by belt speed, min		0	25	55	70	132	216	235	365	450	555
Cones	Weight, g	8.99	7.05	4.75	3.97	5.54	2.90	2.58	1.85	1.66	1.88
	Moisture, %	75.80	70.60	66.76	60.99	51.70	30.49	11.60	5.58	5.78	7.65
Bracts	Weight, g	7.22	5.57	4.00	3.10	4.26	2.33	2.04	1.60	1.46	1.78
	Moisture, %	75.81	69.34	62.00	58.80	48.50	25.10	9.30	4.69	3.79	7.80
Strigs	Weight, g	1.39	1.15	0.75	0.67	1.03	0.55	0.46	0.23	0.17	0.18
	Moisture, %	80.71	76.13	72.64	71.20	65.20	46.50	39.90	15.44	5.52	5.39

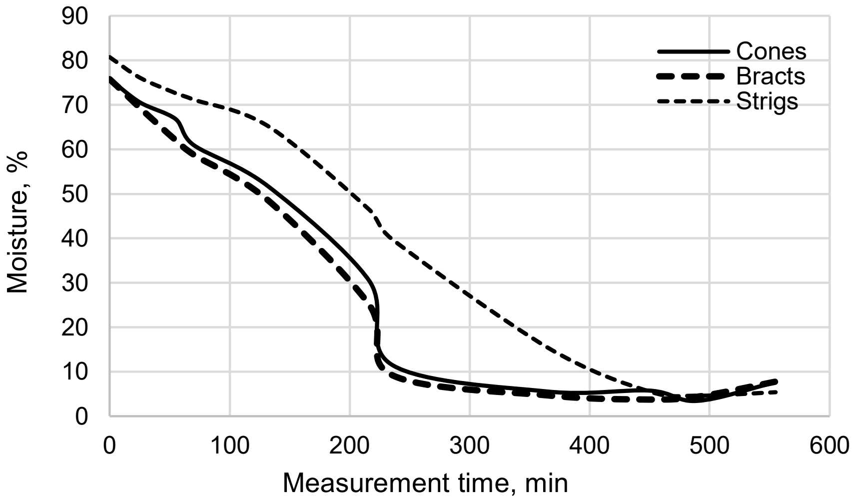

Figure 7. Dependence of the moisture content of cones, bracts and strigs on the measurement time (drying curve).

Fig. 7 shows the drying curve that enables to trace the relationship between the moisture content of bracts and strigs. The figure depicts the reason why hop cones are overdried during regular drying to be moistened again when conditioned at the end of the process. The graph clearly shows that the moisture content of strigs declines slowly compared to the one of bracts. The moment we measure the cone moisture content of e.g. 10%, the strigs may have 40 to 45%. If these hops were pressed, strigs would become a source of high moisture that makes the hops deteriorate. Finally, from the measurements we determined the ratio by mass of bracts to strigs being approximately 8:2 to 9:1.

CONCLUSION

Any deficiencies in the form of dissimilar moisture contents of the separate hop cone parts should be removed by monitoring the moisture content throughout the entire process of drying in the belt dryer and subsequent storage of the hops in conditioning chambers, where the moisture content of bracts and strigs evens out spontaneously. Afterwards, the hops can be pressed without risk. This innovative technology is, however, the subject for future research.

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