HOP MATERIAL SEPARATION ON ROLLER CONVEYOR

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Abstract. This paper focuses on the issues of hop material separation concerning the technology of hop cultivation on low trellis. It is supposed that a mechanical separating machine line with a roller conveyor as its part will be used for purposes of separation. A parameter, which influences a proper function of the roller conveyor, is tested. Namely, it is the gap between the rollers. The object of the measurement was to discover the dependency of hop-material fall through on the gap size, and to show in detail the effect of the gap size on the quality of leaf separation. For this purpose a model of a roller conveyor had been designed and constructed. The model has 9 rollers altogether, the pitch of which can be infinitely adjusted. The fall through dependency was being found out for 4 different gap sizes between the rollers. The biggest gap possible with the current constructional solution was 63 mm, and the smallest was 48 mm. The measurements were carried out using a sample of hop material taken by a mobile harvester operating in low trellises. The measurement proved that majority of the hop material (89 up to 91 %) falls through the first two gaps. It was also found that the gap size between the rollers has no influence on the fall through of hop cones and small-size admixtures, practically all of which fell through. Other measurements proved that the smallest gap possible (48 mm) was the most effective in terms of leaf separation.

Key words: hops, separating machine, roller conveyor.

Introduction

Nowadays, hops are cultivated above all for purposes of beer production, being one of the basic raw materials for brewing. Their utilization for other purposes is not presented in the world statistics. What is known, however, is their importance in pharmaceutics and in cosmetics [1].

Extraordinary climatic and soil conditions contribute to an outstanding aromatic character of Czech hops. Saaz Semi-early red-bine hop is still the most recognized aromatic hop worldwide [2; 3].

One of the key problems of the Czech hop industry is a complicated hiring of labour for the most difficult operations, such as, e.g., hanging and sticking of hop strings, and hop-bine training. For these reasons, some growers tend to switch to hop growing on low trellis, where there is no need to carry out these operations anymore. In the new growing system hop bine spontaneously climbs (winds) around a special plastic net, which is a substantial part of a low trellis [4; 5].

Traditional hop varieties (bred for high trellises) when grown on low trellises, reach only app. 63 % of the yield reached from growing on classic constructions. According to breeders and economic experts, new "dwarf" varieties bred for low trellises should reach at least 80 % of the yield gained from varieties grown on classic trellis [6; 7].

In the Czech Republic, low-trellis hop growing is in the experimental stage and the present area covered by low-trellis hop fields is less than 50 ha [3]. For this type of growing technology other machinery is needed. The hops grown on low trellis are harvested by a mobile picker, pulled by a tractor. The hop material brought by the mobile picker further undergoes separation in the machine line, which is adapted as opposed to a classic machine picking line. The aim of separation is to separate hop cones from stems and leaves [8].

This paper is focused on the part of a separating machine, which is placed after the secondary picker, namely the roller conveyor with infinitely adjustable pitch of each roller. This roller conveyor serves as a roller sieve. Proper functioning of the roller conveyor depends on several parameters. They are the rotational frequency of the rollers, roller profile, and the gap between individual rollers. To be able to determine the precise significance of these parameters, a model of such a roller conveyor was designed and constructed [9].

Material and methods

Model of roller conveyor

The model (Fig. 1) is a scale copy of the roller conveyor which will constitute a part of the final version of the separating machine employed to separate hops grown on low trellis. This separating machine is the first of its kind in the Czech Republic, it is still under development and its production will be provided by the Machinery Plant of Chmelařství, cooperative Žatec. The model has 9 rollers altogether of 60 mm in diameter. The rollers are 600 mm long. The first roller is fixed to the frame, whereas it is possible to infinitely adjust the pitch of the remaining 8 rollers, thus changing the gap size between them. The space bellow the rollers was divided by means of KAPA boards, so that we were able to determine the amount of the hop material fallen through the rollers. The input of hops is provided by a belt conveyor which is 600 mm wide and 1000 mm long.

Fig. 1. **Model of roller conveyor**

The model throughput is 450 kg·h^{-1} of hop material and it is derived from the throughput of the real roller conveyor 2 m wide, which constitutes a part of the separating machine that is now being developed. This throughput corresponds to the peripheral speed of the conveyor belt 0.27 m·s^{-1} and rotational frequency of the conveyor rollers 40 min^{-1}. These values were set by means of frequency inverters. Also the vertical distance of the belt conveyor from the roller conveyor corresponds to the real one.

Methodology of the measurement

The measurement was implemented in the second third of September 2014, in the course of harvesting hops which were cultivated on low trellis. Hop material was brought fresh on every single measuring day by a hop grower from the town of Kněžice nearby Žatec.

The measurement was made using the variety Sládek, which turns out to be the best for profit-making hop growing on low trellis, judged on the basis of four-year long observations and findings from previous years [3].

The average size of the hop cones was determined out of the sample counting 100 pieces. The average value of the hop cone length was 28.8 mm and the average value of the hop cone diameter was 15.6 mm.

The measurements were divided into two parts. The first part of measuring primarily focused on determining the dependency of hop material fall through on the gap size between the rollers, followed by the second part of measuring which dealt with leaf separation. The point of this measurement was to discover more precisely the dependency of leaf separation on the gap size between the rollers.

The sample of hop material had been chosen in a way so that the percentage representation of individual components (hop cones, leaves, stems and small-sized admixtures) was preserved. The throughput of the roller conveyor model, which is 450kg·h^{-1}, corresponds with the sample weighing 450 g (Fig. 2).

The measurement proceeded this way – the sample of hop material was mixed and evenly spread out onto the conveyor belt. Then the roller drive was switched on, followed by belt conveyor drive. The hop material was being steadily separated and due to KAPA boards, which had been installed bellow each roller, it was falling through into 7 containers. Individual components of the hop material, which fell through between the rollers, were further weighed accurate to 1 g.

The dependency of hop material fall through on the gap size between rollers was measured gradually for four gap sizes between the rollers (48, 53, 58 and 63 mm). The measurement was repeated five times for each gap size. A sample of hop material was each time used only for one set of the measurements. To measure another gap a new sample was used.

Fig. 2. **Sample of material evenly spread on the conveyor belt**

The purpose of the second part of measuring was to find out what the effect of the gap size between the rollers is on the leaf separation. That means what proportion of leaves, eventually hop cones, was carried as a drop-off into the waste.

This measurement proceeded in a similar way to the one in the first part, with the difference that the hop material sample consisted only of hop cones and a mixture of leaves. It had been selected in a way so that, again, the percentage representation of these two components was preserved. By the mixture of leaves small-sized, medium-sized and large leaves are meant. Thus, the sample did not contain any stems or small-sized admixtures, as with the first part measuring. The sample weight remained equal as in the first part of the measurement, i.e. 450 g, out of which 168 g were hop cones, and 282 g were leaf mixtures.

After the separation was completed, the material which was carried into the waste as a drop-off was further separated into hop cones and leaves, and weighed.

Results and discussion

The measured results from the first part are depicted in the graph of Fig. 3, which clearly shows the percentage proportion of hop material which fell through between the rollers, as it proceeded in the direction from the belt conveyor to the first separating gap between the second and the third roller and on towards the other rollers.

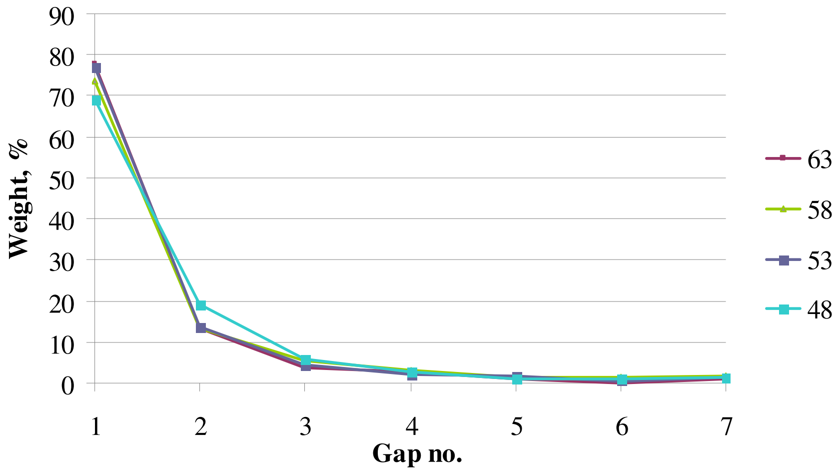

Fig. 3. **Weight percentage of fall through in the gaps between the rollers**

The graph in Figure 3 clearly demonstrates that for the selected 4 sizes between the rollers (48, 53, 58 and 63 mm) the graphic courses are almost identical. The graph also shows that approx. 88 to 91 % out of total weight of the fallen-through hop material fall through in between the first two gaps and the rest in between the other five gaps. The graph does not illustrate the part of hop material which did not fall through but was carried into the waste as a drop-off. Taking into account the total sample weight, it was approx. 14 to 29 %.

In the drop-off practically no cones were found with all four gap settings. That seems to indicate the fact that with this number of rollers even the smallest possible gap size is big enough for all the cones but also majority of admixtures to fall through. The admixtures which fell through between the rollers were formed by leaves, small-sized twigs, and also by other small-sized admixtures, such as, e.g., picked dry stems from previous years. Contrarily, the admixtures which did not fell through and were carried into the waste as a drop-off, were formed by bigger leaves, medium-length and long stems.

The dependency of leaf separation on the gap size was obtained in the second part of the measurement. The graph in Fig. 4 depicts the percentage proportion of leaves out of total weight of leaves which did not fall through and were carried as a drop-off into the waste. With the biggest gap of 63 mm, only less than 1 % of total weight of the leaves was carried into the waste, which means that almost all the leaves fell through together with the cones between the rollers. On the contrary, with the smallest possible gap, which can presently be set, less than 18 % were carried into the waste. That indicates the fact that the gap size constitutes a certain effect on leaf separation. The hop cones practically were not carried into the waste; only in case of the smallest gap of 48 mm it was about 0.1 %.

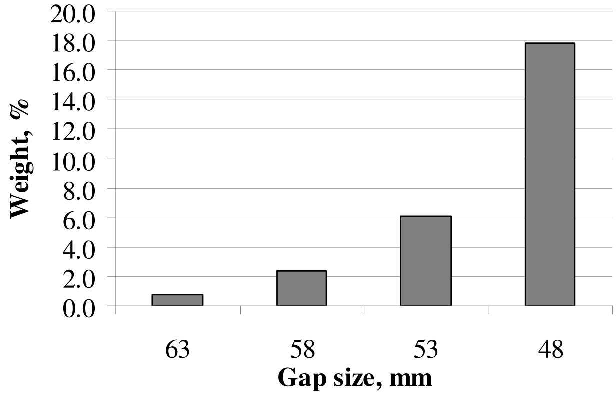

Fig. 4. **Weight percentage of leaf proportion in the waste with individual gaps**

Conclusions

The aim of the first part of the measurement was to determine the dependency of hop material fall through on the size of the gap between the rollers, for the purpose of which a sample of hop material was used in which the proportion of all its components was preserved. This measurement proved that approx. 90 % of all the fallen-through hop material fell through in between the first two gaps. Furthermore, this measurement showed that medium-length and long stems are always separated perfectly and the gap size constitutes no effect on the separation. The gap size has no effect either on the fall through of hop cones and small-sized admixtures, practically all of which fell through each time.

The second part of the measurement revealed that the gap size represents a substantial effect on the separation of leaves. The smaller the gap was set, the larger proportion of leaves got into the waste as a drop-off. With the set gap of 48 mm over 17 % of total leave weight fell through, while with the set gap 63 mm it was only 0.76 %. With regard to hop cones, as well as in the first part of the measurement, practically no cones were carried into the waste.

Based on the average size of the hop cones it can be concluded that another gap closing should not affect their fall through, on the contrary, it is supposed that the proportion of separated leaves should be even larger.

The current constructional solution unfortunately did not enable another closing of gaps between the rollers. Therefore, based on the results obtained from the measurements, designs of new rollers including their attachment are being prepared, which would enable another closing of gaps between the rollers. The measurements carried out in the harvesting season of 2015 will be, besides other criteria, focused also on various roller profiles, which might affect the separation of leaves positively.

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