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Dependency of hop material fall through on the size of gaps between rollers of the roller conveyor in separating machine

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Abstract. This paper deals with a roller conveyor which forms a part of the separating machine for hops harvested from low trellises. One of the parameters that influences the correct operation of this conveyor is tested, namely the gap between the rollers. The aim of the test was to discover whether the fact that hop matter falls through the rollers depends on the size of the gap between the rollers. For testing purposes a model of the roller conveyor was designed, made, and subsequently tested in a series of experiments with the purpose of integrating it into a separating machine. The measurements were carried out using a sample of hop matter harvested from low trellises. The dependency of falling matter upon the gaps was determined in view of eight gaps between the rollers. The measurements revealed that the gap size has an influence on the falling of hop cones and small-sized admixtures only if the gap size is larger than the size of the hop cones. At the same time, this parameter has no substantial influence on the separation of medium-length and long stems which were separated perfectly.

Key words: hops, separating machine, roller conveyor.

INTRODUCTION

At present, hops are used above all as one of the basic ingredients in beer brewing. Other purposes are not mentioned in world statistics. Yet, we know the plant is important in pharmacy as well as cosmetics (Vrzalová & Fric, 1994).

Extraordinary climatic and soil conditions contribute to the outstanding aromatic character of Czech hops. The Saaz semi-early red-bine hop is still the most widely recognized aromatic hop in the world (EAGRI, 2013).

One of the key problems of the Czech hop industry is that is complicated to hire labour for the most difficult operations such as hanging and sticking hop strings and training hop-bines. For these reasons, some growers tend to switch to growing hop on low trellises, where there is no need for performing these operations anymore. In the new growing system, hop bines spontaneously climb (wind) around a special plastic net, which forms a substantial part of the low trellis (Štranc at al., 2010; Štranc at al., 2012).

When grown on low trellises, traditional hop varieties (bred for high trellises) produce only approximately 63% of the yield compared to that gained from classic constructions. According to breeders and economic experts, new ‘dwarf’ varieties bred for low trellises should produce at least 80% of the yield gained from varieties grown on classic trellises (Lewis, 1990; Darby, 1999).

In the Czech Republic, low-trellis hop growing is in the experimental stage and the area covered by low-trellis hop fields is less than 50 ha today (EAGRI, 2013).

Other kinds of machinery are needed for this type of growing technology. The hops grown on low trellises are harvested by a mobile picker pulled by a tractor. The hop material collected by the mobile picker further undergoes separation on a machine line, which is adapted from a classic machine picking line. The aim of the separation is to separate hop cones from stems and leaves (Jech at al., 2011).

This paper focuses on the part of the separating machine which is placed behind the secondary picker, namely the roller conveyor, each roller of which can be meticulously adjusted. Its importance lies in separating hop cones from stems and leaves. This roller conveyor serves as a roller sieve. The main function of the roller conveyor is to separate the hop material into small-sized fractions such as hop cones, leaves and fragments with a size smaller than the gap between individual rollers, and into large-sized fraction such as stems, clumps and big leaves which cannot fall through the rollers.

The right functioning of the roller conveyor depends on several parameters: 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 the roller conveyor was made, an actual size copy of the real roller conveyor (Krupička & Rybka, 2014).

MATERIALS AND METHODS

The first measurement, which was carried out in the laboratory of the Department of Agricultural Machines, dealt with the dependency of hop matter falling through the gap between the conveyor's rollers.

Model of roller conveyor

The model (Fig. 1.) is an actual size copy of the roller conveyor which forms a part of the final separating machine for hops cultivated on low trellises. The separating machine is the first of its kind in the Czech Republic, it is still under development, and it will be constructed by Chmelarstvi, cooperative Zatec, Zavod mechanizace. The model has 9 rollers with a 60 mm diameter. The rollers are 600 mm long. The first roller is fixed to the frame, whereas it is possible to adjust the pitch of the remaining 8 rollers, thus changing the size of the gap between them. The space below the rollers was divided with KAPA boards so that we are able to determine the amount of hop material that fell through the rollers. The hops input is a belt conveyor which is 600 mm wide and 1,000 mm long.

The model's throughput is 450 kg h^{-1} of hop material and it is derived from the throughput of the real 2 m wide roller conveyor. The throughput corresponds to the peripheral speed of the conveyor belt: 0.27 m s^{-1}, and the rotational frequency of the conveyor rollers: 40 min^{-1}. These values were set with the help of frequency inverters. The vertical distance of the belt conveyor from the roller conveyor corresponds to the actual device.

Figure 1. Model of roller conveyor.

Methodology of measurement

The measurements were done in September 2014 during the harvest of hops cultivated on low trellises. The hop material used for experimental measurements in the DAM laboratories was supplied by a hop grower from the town of Kněžice. The hops were collected and stored in high-capacity containers which were placed between the belt conveyor of the trailer—the trailer carried the hops forward from the mobile harvester, and the input belt conveyor of the separating machine.

The measurements were made using the Sladek variety, which is the best for profitable hop cultivation on low trellises, judged on the basis of a four-year long observation and findings from previous years (EAGRI, 2013).

The sample of hop material was chosen so that the percentage of individual components (hop cones, leaves and stems) was preserved. The throughput of the roller conveyor model, which is 450 kg h^{-1}, corresponds to the sample's (Fig. 2) weight: 450 g. The average hop cone size was determined on the basis of 100 sample pieces. The average hop cone length was 28.8 mm and the average cone diameter was 15.6 mm.

Figure 2. Sample of hop material evenly spread on the conveyor belt.

The measurement procedure was the following: the hop material sample was mixed and evenly spread on the conveyor belt. The sample layer was app. 40 mm high. Then the roller drive was switched on, followed by the belt conveyor drive. The hop material was steadily separated, and, owing to KAPA boards, which had been installed below each roller, the material fell through the roller gaps into seven containers. Individual components of the hop material that fell through the rollers were further weighed with a 1 g measurement accuracy.

The dependency of the hop material throughput on the size of the gap between the rollers was measured gradually in view of four different gaps between 60 mm rollers (gap sizes: 48, 53, 58 and 63 mm). Further on, the roller diameter was increased to 80 mm with Mirelon tubes (thermal insulating material made from foam polyethylene; Fig. 3). By increasing the diameter we obtained four more gap sizes (28, 33, 38 and 43 mm), which could not be fixed in the position with the current construction solution. The relationship between gap size and the amount of material falling through the gaps was also determined for these four gaps. The measurement was repeated five times for each gap size. A sample of hop material was used only for one set of measurements each time. A new sample was used for measuring each subsequent gap.

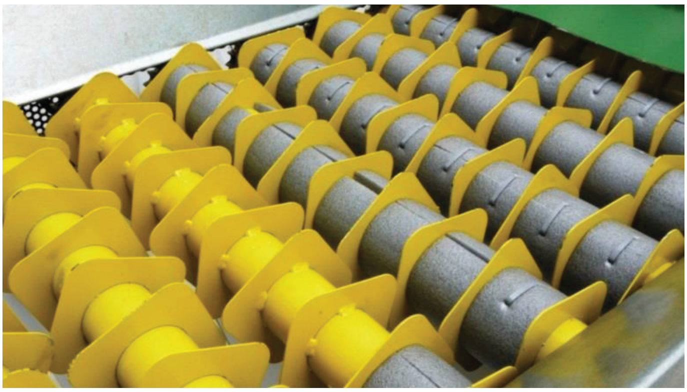

Figure 3. Increased roller diameter achieved with Mirelon tubes.

RESULTS AND DISCUSSION

The measured values were processed and the results are depicted in the graphs of Figs 4 and 5. Both graphs clearly show the percentage ratio of hop material separated in the gaps between the rollers, as the hop material proceeded from the belt conveyor to the first separating gap between the second and third roller and on towards other rollers. The graphs depict the percentage of the total weight of the sample which fell through in-between the gaps, the rest that is short of 100% represents the material that was separated as waste.

The graph in Fig. 4 clearly demonstrates that the graphic courses are almost identical for the selected four gaps between the rollers (48, 53, 58 and 63) with the roller diameter of 60 mm, which might suggest that gap size has no influence on the separation across the entire roller conveyor. However, it needs to be considered that mixture composition and cone size vary within every hop field and separating technology needs to be adapted accordingly. The graph shows that approximately 65–80% out of the total weight of the hop material falls through the first two gaps and the rest through the other five gaps. Practically no cones were found in the material that had fallen through with all four gap settings. As for the admixtures, the tendency was decreasing: when the gap was 48 mm, 32% of the total weight of sample admixtures ended up in the drop-off, while when the gap was 63 mm, 23% of the admixtures finished among the drop-off material. The rest of the admixture fell through the roller conveyor with the cones.

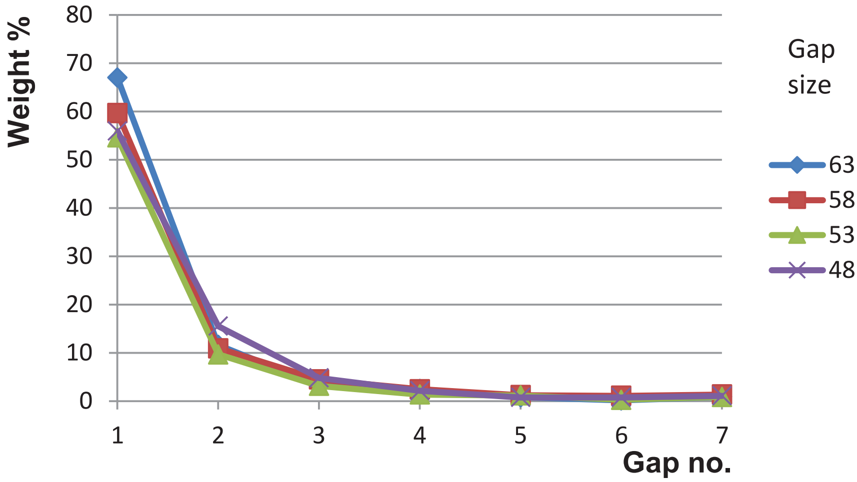

Figure 4. Weight percentage of material falling through each gap between the rollers, the roller diameter being 60 mm.

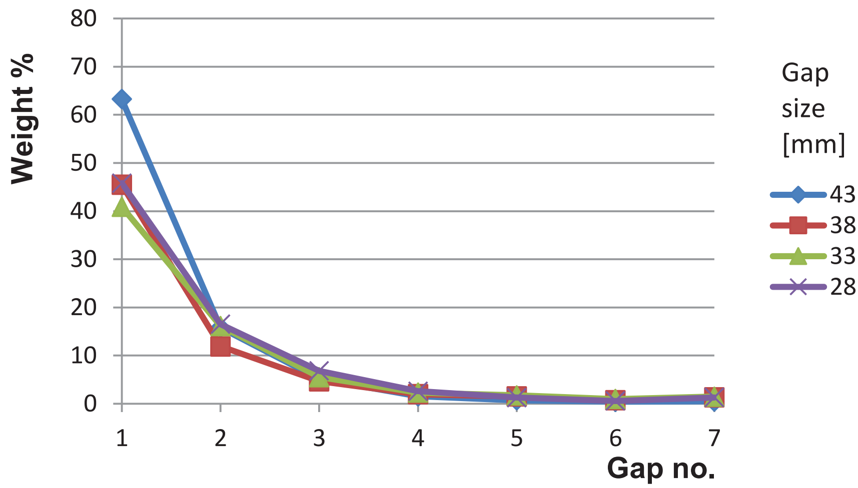

Figure 5. Weight percentage of material falling through each gap between the rollers, the roller diameter being 80 mm.

The graph in Fig. 5 illustrates the results of measurements similar to the previous case, only the roller diameter was increased to 80 mm with Mirelon tubes. Thus, the gaps between the rollers became smaller (28, 33, 38 and 43 mm). Graphic courses of the material falling through are similar to those represented in the graph from Fig. 4. The curves get notably closer from the second up to the seventh gap. When the gap size was set to the biggest value (43 mm), much more material fell through the first gap (contrary to the others), and percentagewise the figures are similar to the values of all the gaps in Fig. 4. Likewise, no cones detected in the drop-off here either. As for admixtures in the outlet, notable deviations (20–45%) were detected and no dependency can be observed. The remaining material again fell through with the cones.

To get a more detailed view of the composition of the mixture that fell through the individual gaps, the ratios of cones and admixtures, roller diameters and the smallest measured gaps between the rollers have been presented in the graphs of Figs 6 and 7. Distribution of ratios is similar to the other gaps. The admixture part in the material that fell through should be the smallest possible, the graphs, however, illustrate that both components (cones and admixtures) made up nearly half of the material that fell though the gaps, which is not the desired result. The largest part of the admixtures that fell through the gaps was made up of leaves, as proved by additional measurements which demonstrated that when the gap was 48 mm (rollers 60 mm in diameter) approximately 18% of the total weight fell through as drop-off and the remaining 82% of the total weight of leaves in a sample fell through the gaps. When the gap was 28 mm (rollers 80 mm in diameter) approximately 63% ended up in the waste and 37% fell through the gaps. This result proves the advantageousness of bigger diameters and smaller gaps. This conclusion cannot be taken too seriously since the measurements only had one variety and they were repeated a limited number of times.

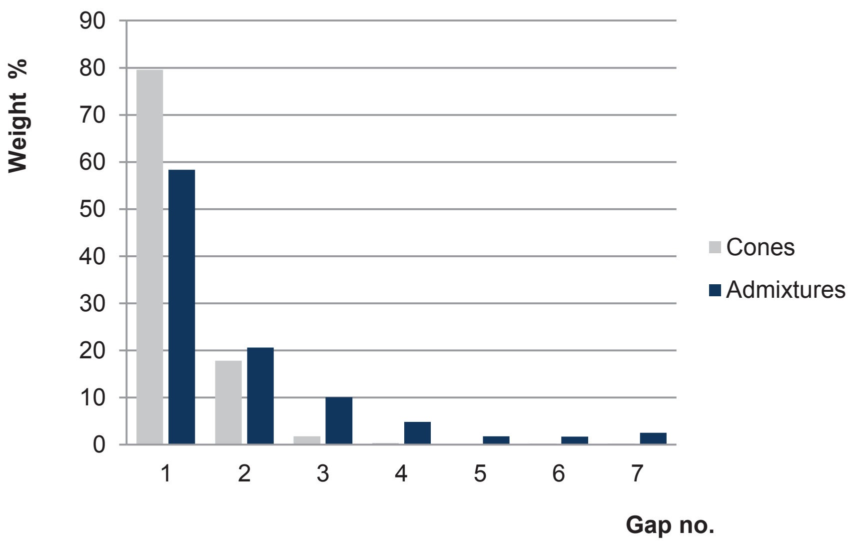

Figure 6. Cone and admixture weight percentage falling through individual gaps, the gap size being 48 mm and roller diameter 60 mm.

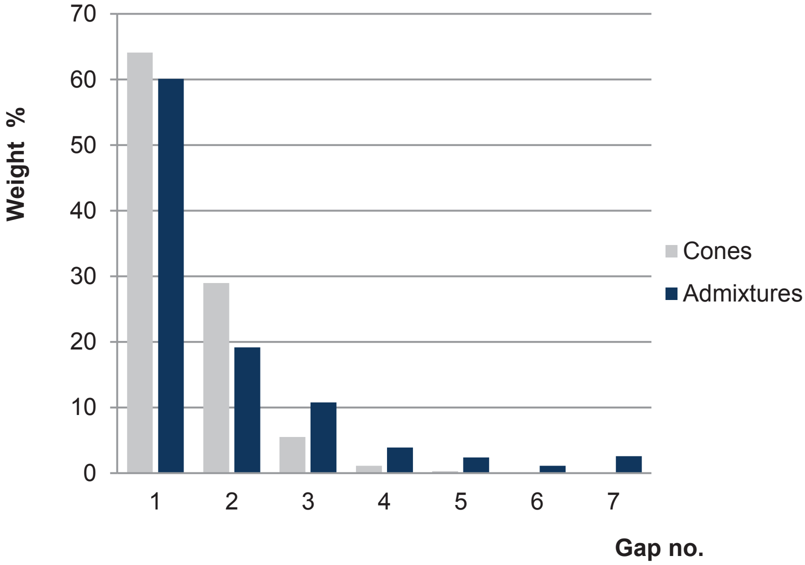

Figure 7. Cone and admixture weight percentage falling through individual gaps, the gap size being 28 mm and roller diameter 80 mm.

CONCLUSION

These measurements were performed with a real sample of hop material, which also consisted of small-sized twigs, pieces of torn leaves and other small-sized admixtures, such as picked dry stalks from previous years besides hop cones, stems and leaves. It was determined that neither the roller diameter nor the gap size has any influence on the separation of medium-length and long stems, which were separated perfectly in all cases. The gap size has no influence on the hop cones and small-sized admixtures falling through if the gap size is larger than the size of the hop cones.

However, gap size influenced the amount of hop material falling through the gaps between the first two rollers. When the gap was 33 mm, only 41% of the total matter weight fell through. When the size of the gap was increased, the percentage hop material that fell through also increased. When the gap was 53 mm, 56% of hop material fell through and when the gap was 63 mm (the largest in this this test), 67% of the hop material fell through. Based on previous measurements the smaller gaps appear to be more convenient in view of the separation of bigger leaves.

Further measurements will follow in the season of 2015—these will be performed with samples of hop material the individual components of which will be precisely defined in terms of size. This way, more accurate results will be attained. The measurements will be focused, among other things, also on various roller profiles, which could have a positive influence on the separation of leaves.

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