SEPARATION OF IMPURITIES FROM DRY HOPS

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Abstract. The clods detected as impurities in dry hops come from hop growers to the processing line.Their source is muddy soil in the hop gardens during rainy harvest. Soil is formed into rounded clods in the separation machine. Clods come with hop cones to the drying machine and then to the processing line. The designed separation device, located at the end of the drying machine, should not damage the hop cones, nor change the humidity and hop cones and free leaflets of the cones must stay together after separation. The process must be continuous for ensuring pressing. The principle of the device is based on the air flow which changes the trajectory of low weight hop cones during free fall. The designed device includes a conveyor belt and radial fan. The conveyor belt and fan speeds were set by the frequency changer. At first, free fall trajectories without a radial fan were measured for comparison with the math calculated values. The calculation was made for two different speeds of the conveyor belt. The lower speed 0.44 $m \cdot s^{-1}$ was choosen because of the drying machine troughtput. The higher speed 1.73 $m \cdot s^{-1}$ was the maximum speed of the conveyor belt. The result of the measurements is that the trajectory of horizontal throw of hop cones and clods was the same inconsiderately with their weight. It confirms the mathematically calculated values. As the second, there was a measurement with a radial fan. We watched a change of the trajectories due to the air flow. The measurement was sequentialy recorded by camera. The speeds of the conveyor belt were the same as in the first case. The speed of the air flow was changed from 3 to 5 $m \cdot s^{-1}$. The results show that for hop cones separation it is better to have lower speed of the conveyor belt 0.44 $m \cdot s^{-1}$ and the speed of the air flow from 4 to 5 $m \cdot s^{-1}$. The lower speed of the conveyor belt and air flow is better for prevention of undesirable separation of hop cones and free hop cone leaflets.

Keywords: hop, clods, air flow.

Introduction

By the analysis, the clods were detected in dry hops comings from hop growers to the processing line. The origin of the clods is muddy soil during rainy harvest. Muddy soil gets to the hop-picking line by tractor and trailer tires. In the second case, the soil which falls off from the tires, is shoveled straight into the hop-picking line by the staff. In the third case, the soil is flown away from the tires straight into the transported hop. For the separation part of the hop-picking line it is not possible to separate the soil from the hops, this soil forms into clods (Fig. 1) These clods are not separated from the hops during separation because of a similar bevaviour as hop cones [1]. Then the clods come into the hop-drying machine and then into the bales with hops.

Fig. 1. **Clods formed by separation**

The clods are separated at the processing line by three separation devices (Fig. 2). Broken clods do abrasive damages in the duct components. For these reasons a device for separation of the clods and heavy impurities from dry hops was laboratory designed and tested.

Fig. 2. **Separation device at processing line**

Materials and methods

The designed device has to satisfy these requirements:

- not to damage hop cones
- not to change hop cone humidity
- not to separate hop cone leaflets from hop cones
- be continuous for successive pressing.

After evaluation of these requirements we designed a device which is using air flow. The principle of this device is based on the changing of freefall trajectories of hop cones by the air flow. We used a minimum air flow velocity which can change the hop cone freefall trajectory. To change the freefall trajectory of hop cones is relatively simple because of their low weight against clods. The scheme of the device is in Figure 3.

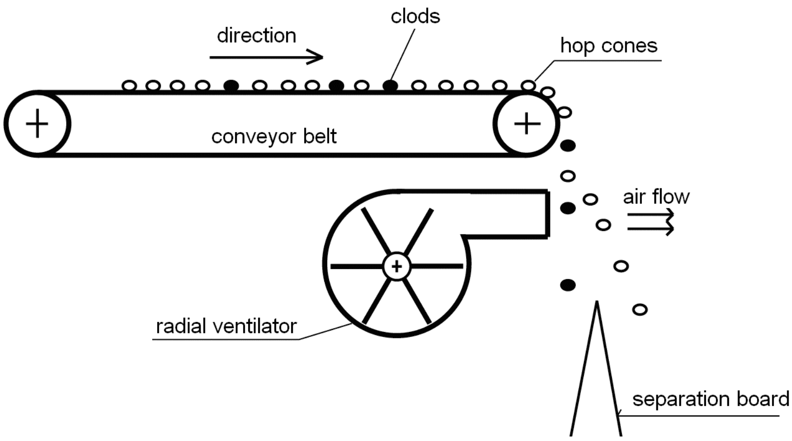

Fig. 3. **Scheme of designed separation device**

We supposed it would be placed between the hop-drying machine and the press [4]. There was assembled a laboratory measurement device for finding out the optimal velocity of the air flow and the conveyor belt (Fig. 4).

The designed device consists of a conveyor belt and radial fan. The velocity of the conveyor belt and the frequency of rotation of the fan were adjusted by frequency changers (Fig. 4). The first measurement was realized without a fan. In this case we found out the trajectories of hop cones and clods without air flow for a comparison with the mathematical values. The second part was realized with a fan. In this case we found out the changes of the trajectories. The measurements were recorded with CANON camera in both cases.

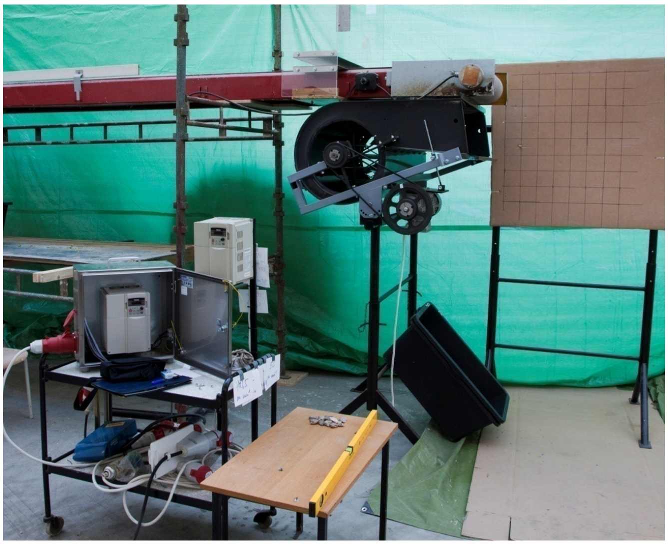

Fig. 4. **Experimental measurement device**

Horizontal throw and trajectories of fall

Horizontal throw is a movement when starting velocity is given to the body in a horizontal direction only. Finally, the movement of this body is assembled of free fall and uniform rectilinear movement. The final trajectory is a parabola with a top at the starting place of throw [2]. The horizontal distance from the starting place of the throw is called the throw distance. It can be calculated by formula:

$$d = v_0 \cdot \sqrt{\frac{2h}{g}} \tag{1}$$

where d = distance of throw, m;
v_0 = starting velocity of throw, m·s^{-1};
h = hight of throw, m;
g = standard gravity, m·s^{-2}.

This formula shows that a distance of throw does not depend on the weight of the thrown body. Calculation was done for two velocities of the conveyor belt [3; 5]. The minimum velocity was choosen because of the drying machine troughtput and the maximum velocity was the maximum speed of the conveyor belt. Grafical representation of the calculated values of the trajectories is shown in Figure 5.

Fig. 5. **Calculated trajectories of horizontal throw for velocities**

The calculated trajectories show that the trajectory of horizontal throw of hop cones and clods is the same to the contrary of their different weights. Minimal deviation can be caused by drag.

Results and discussion

In Figure 6 the calculated trajectory (left) and experimentally found trajectory (right) are shown. By fusion of both trajectories we get a comparison and we confirm that the trajectories are the same (Fig 7).

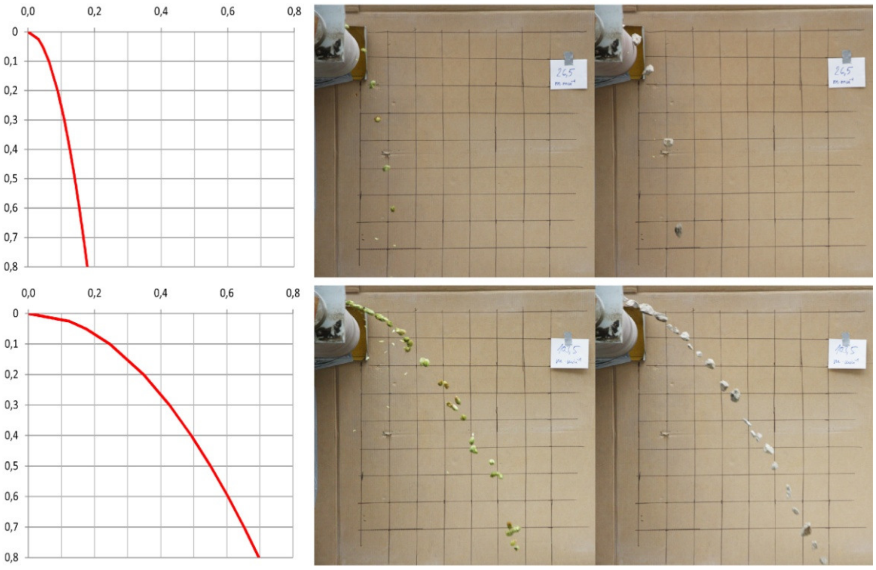

Fig. 6. **Comparison of calculated trajectories of hop cones and clods:** up, from left – calculation, cones, clods ($v_0 = 0.44$ m·s^{-1}), down, from left – calculation, cones, clods ($v_0 = 1.73$ m·s^{-1})

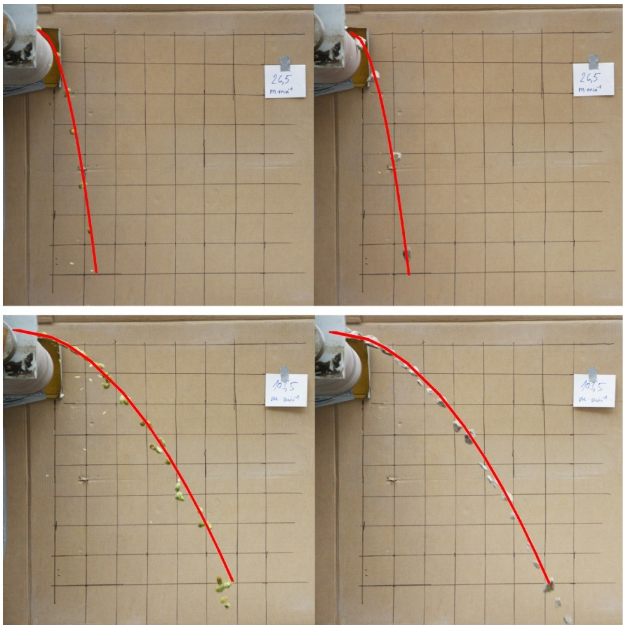

Fig. 7. **Fusion of calculated and measured trajectories:** up, from left – calculation (red), cones, clods ($v_0 = 0.44$ m·s^{-1}), down, from left – calculation (red), cones, clods ($v_0 = 1.73$ m·s^{-1})

Separation with air flow support

In this case we used two speeds of the conveyor belt too, $v_0 = 0.44$ and 1.73 m·s^{-1}. The air flow velocity of the radial fan was changed from 3 to 4 to 5 m·s^{-1}. Evaluations of the experimental measurements are shown in Figures 8 and 9.

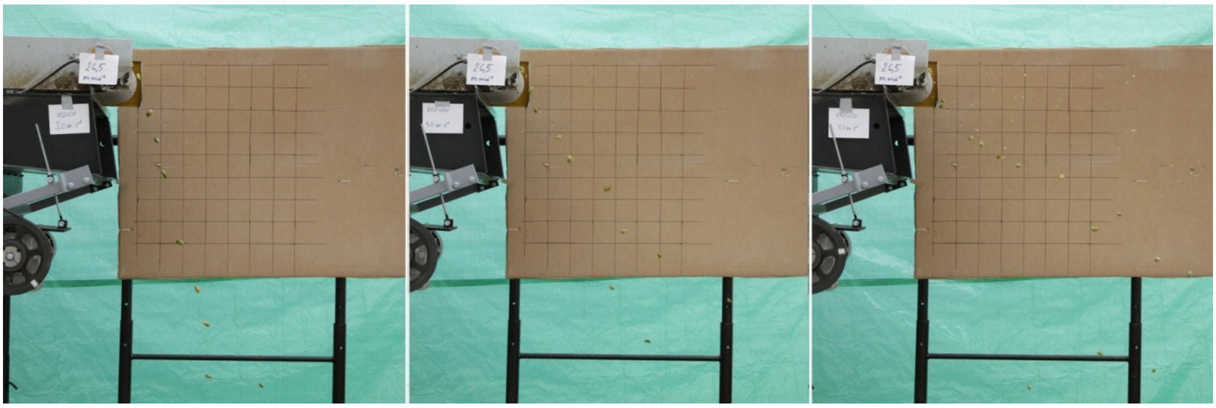

Fig. 8. **Changes of the trajectory of hop cones depending on air flow velocity:** conveyor belt speed $v_0 = 0.44$ m·s^{-1}, air flow velocity 3, 4 and 5 m·s^{-1} (from left)

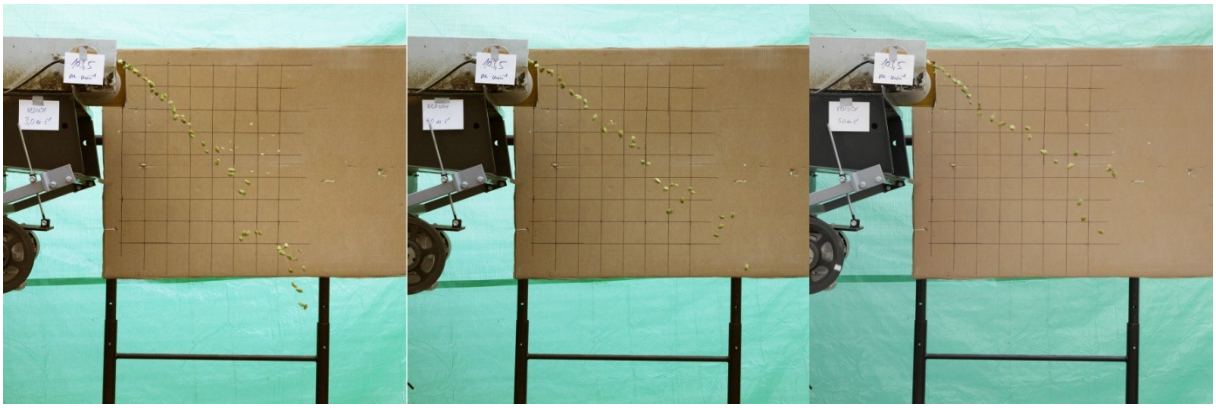

Fig. 9. **Changes of the trajectory of hop cones depending on air flow velocity:** conveyor belt speed $v_0 = 1.73$ m·s^{-1}, air flow velocity 3, 4 and 5 m·s^{-1} (from left)

Conclusions

The results show that the results of the experimental measurement and the results of the mathematical calculation are the same. The set up of the designed device is correct and there were no mistakes during the measurement. Next, the results show that a lower speed of the conveyor belt is better for hop cone separation. Deviation of the trajectory of hop cones is done by the difference between the air flow velocity and horizontal component of velocity of horizontal throw.

Acknowledgements

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References

1. Artim J., Angelovič M., Angelovičová M., Bernášek K., Honzík I., Jech J., Krčálová E., Kvíz Z., Mareček J., Polák P., Poničan J., Ružbarský J., Rybka A., Sloboda A., Sosnowski S., Sypula M., Žitňák M. Machines for plant production 3 – Machines and equipment for plant post-harvesting and plant storing (Stroje pre rastlinnú výrobu 3 – Stroje a zariadenia na pozberovú úpravu rastlinných materiálov a na ich skladovanie). Profi Press s.r.o. Prague, 2011, 368 p. ISBN 978-80-86726-41-0.
2. Brzkovský K. Experimental methods of measuring (Experimentální metody měření). ČVUT Prague,1993, 139 p. ISBN 80-01-00986-6.
3. Neubauer K. etc. Machines for plant production (Stroje pro rostlinnou výrobu). SZN Prague, 1989, 720 s. ISBN 80-209-0075-6. (In Czech).
4. Nový R. etc. Technique of medium (Technika prostředí). ČVUT Prague, 2006, 267 p. ISBN 80-01-03492-5. Srivastava A. K., Goering C. E., Rohrbach R. P. Engineering Principles of Agricultural Machines. ASAE Michigan, USA, 1993, 601 p. ISBN 0-929355-33-4.