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Comparison of conventional and rotary combine cleaning systems

Rotary cleaning systems are a promising alternative to conventional cleaning in the combine. A method was developed on the basis of which the construction and operational parameters of rotary cleaning could be ascertained. Comparing the parameters of the separation processes indicated an improvement was very likely in the case of the rotary system compared with the conventional.

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Keywords

Combine harvesters, cleaning system, separation process

Investigated here through a comparison of separation performance figures between rotary cleaning (RR) and conventional cleaning (KR) is whether the greater acceleration of the former system offers an increase in performance over the latter.

Design and working method for rotary cleaning

RR in this case comprises a vertical axle rotor (*fig. 1*). The details are as follows:

- Rotor movement (rpm n_R) with an additional oscillating movement (oscillating amplitude a, causative frequency f_e) acting on the rotor axle.
- Used are conical sieve rotors with a set angle α_R.
- Also used in conjunction with the rotor is an externally-sourced air current, the total force and direction of which is signified by v_L.

The material to be cleaned is added from above, lands on the rotor floor, and is thrown outwards against the rotor walls which act as sieves. In the following sieving procedure the material is thrown upwards against the rotor walls by mechanical and pneumatic forces and separates. At the same time the corn and non-corn components are also separated from each other. The remaining corn losses and the non-corn components leave the rotor over its upper edge.

Separation process parameters

In [1] are presented separation parameters calculated via movement models. *Table 1* presents the range of values of these parameters for a KR. The value range results from the variation of the kinematic performance value K_V (relationship of the components from Earth and sieve accelerations) in a range from K_V = 0.6 ... 1.2 where airflow is optimum for separation. For most of the parameters an increase had a positive effect on the separation process. The remaining performance values are marked through the development of an optimum.

Motion model for rotary cleaning

For calculation of RR separation process parameters a motion model was also required. A calculated motion trajectory for the material layer and the position of the rotor wall with the same radius is shown in figure 2. With similar supply curves for the material layer and the rotor, flow or quiet phases appear. When this does not occur, the material

Table 1: Separation process parameters of conventional cleaning system

Separation process parameters		Calculated range of values
Proportion of the throw phase within an oscillation period	maximum value required	58…62%
max. / Ø distance of harvest material layer from sieve		6,5 …8,0/ 1,8 …2,4 mm
max. / Ø loosening relationship		1,70…1,83/ 1,21 …1,32
Relative impact velocity		0,41 …0,54 m s^{-1}
Number of impulses with a sieve length of 0.5 m		4,2 … 5,3
Proportion of flow distance to total delivery distance		8 …16 %
Period of throw phase		116 … 162 ms
max. / Ø acceleration difference between corn and non-corn components		5,6 … 8,1 / 2,3 … 4,2 m s^{-2}
Delivery velocity	optimum value required	0,45 …0,50 m s
max. / Ø flow velocity		0,63… 0,74 / 012 … 0,18 m s^{-1}
max. / Ø normal acceleration		13,8 …21,1 /2,3 …4,7 m s^{-2}

Table 2: Operation and design parameter of rotary cleaning system

Construction parameters	Operational parameters	
	Mechanical parameters	Pneumatic parameters
r_U = 0,393 m h_R = 1m a_R = 30°	n_R= 55 min^{-1} f_e = 5,75 Hz a = 30mm	v_L= 1,3 m s^{-1} with vertical rotor wall throughflow

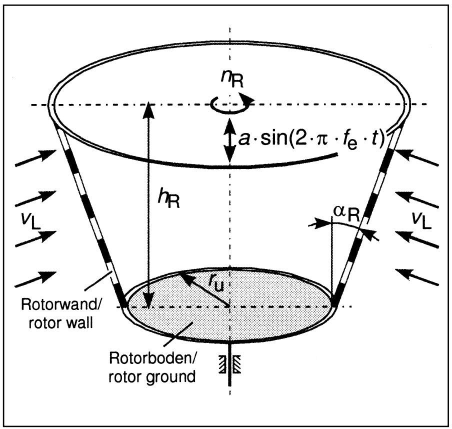

Fig. 1: Stucture of rotary cleaning system

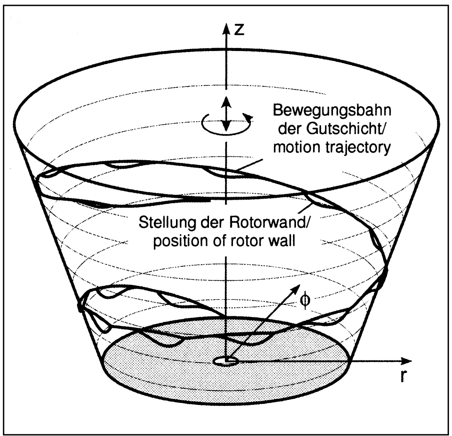

Fig. 2: Computed motion trajectory of rotary cleaning system

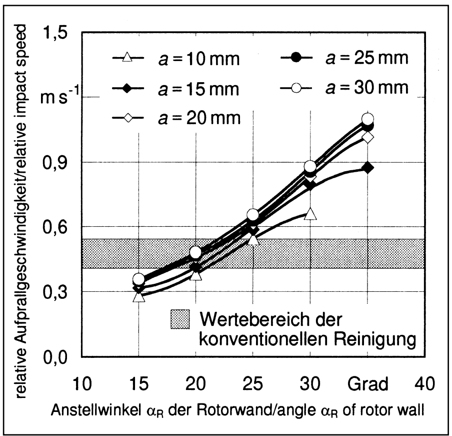

Fig. 3: Relative impact speed of rotary cleaning system

is in the throw phase. The validity of the motion model was checked through experimental investigations on the movement behaviour of a material layer.

Working and construction parameters of rotary cleaning

Through comparison of KR and RR separation parameters the construction and working parameters of the RR were determined. Here, it was taken into account that the supply velocity of both designs should be the same and that as many RR parameters as possible should have at least a similar value as that of the KR. As an example, *figure 3* shows the relative impact velocity which has a value over that of the KR where a higher oscillation amplitude and greater rotor wall setting angle is applied. This proved to have a positive affect on the separation process. *Table 2* shows the construction and working parameters determined by this procedure with predetermined values for the height of rotor h_R and its lower radius r_U. Where rotor specifications are altered, the causative frequency f_e and the rotor rpm n_R have to be suitably adjusted.

Performance comparison between conventional and rotary cleaning

The performance comparison between KR and RR was carried out based on the parameters of the separation process. Also calculated were the percentage parameter deviations of RR against KR for those parameters which were required for an increase in the values of the separation process (*fig. 4*).The percentage parameter deviation has as basis the existing parameter value of the KR in the case of an optimum kinematic parameter $K_V = 0.8$. Even though the maximum and average normal acceleration could not be increased without limit because of the increasing consolidation of the material, both these parameters were taken account of in this process because, in the case in question, the values for the maximum and average loosening relationship lay at the standard of the KR and through that led to an increase in the normal acceleration to an improved separation process.

With the RR, all parameters have values that are within, or greater than, the value range of the KR. The supply velocity and the maximum and average flow velocity are via the presence of remaining parameters recognised as optimum. The supply velocities are similar because of the methods used to determine the working and construction parameters. The flow velocities, on the other hand, produce substantially higher values because of the three-dimensional motion trajectories. However, where one reduces the three-dimensional flow velocity to that of the KR two-dimensional components, the values are similar to those of the KR.

According to these results an improvement of the RR separation process over that of the KR was to be expected. Because of the rotary motion of the rotor and the associated centrifugal forces, the material flow resistance within the RR should also be limited.

Summary

Rotary cleaning with a uniform revolving, vertically oscillating, conical rotor was compared on the basis of performance potential with a conventional cleaning system. A comparison of the separation process parameters proved that rotary cleaning offered an improvement in the separation process, associated with a reduced flow resistance, over the conventional system.

Literature

[1] *Hübner, R.*: Auslegung von Reinigungen im Mähdrescher. Landtechnik 53 (1998), H. 4, S. 232-233

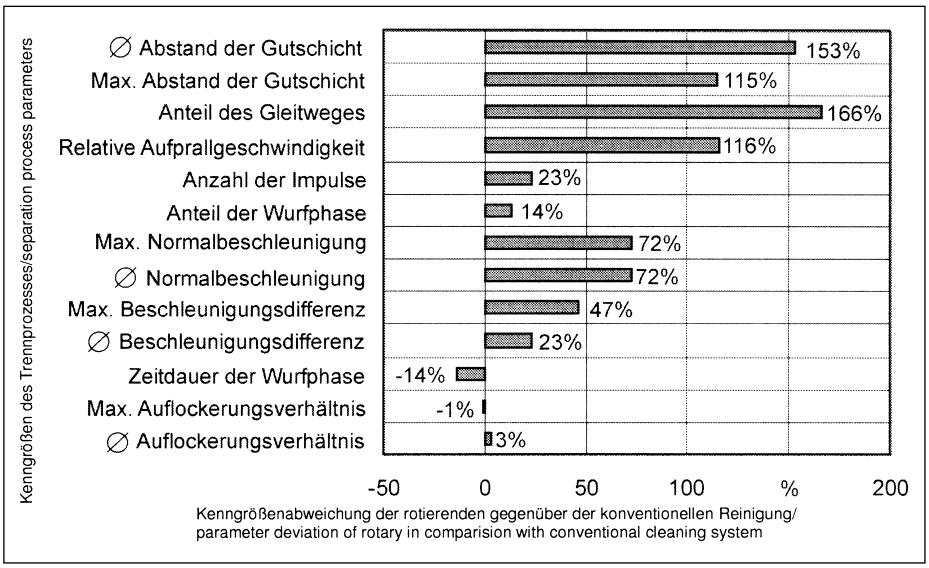

Fig. 4: Parameter deviation of rotary in comparison with conventional cleaning system