Conference Paper

Simulation of the Pneumatic System of a Seed Drill with a Vertical Flow Direction

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Abstract

The purpose of the work is to reveal the influence of conical directing agents on the speed and trajectory of particles movement in the vertical pneumatic conduit of the sowing machine and to establish their rational parameters. With the help of numerical modeling the particle flight trajectories in the air flow were obtained. The carried out researches have shown expediency of application of the conical directing agent, allowing to take away a longitudinal stream of particles from walls of a pneumatic conduit and to centre their trajectories of movement along an axis of a pneumatic conduit. Particles are focused to the center of the distributor when the distributor covers the area of pneumatic conduit cross-section close to 25%.

Keywords: Pneumatic seed drill, pneumatic pipeline, distributor, directing element, confuser.

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1. Introduction

In the 20th century, mechanical seeders with wheel drive were traditionally preferred. Such sowing machines provided high precision of sowing, high uniformity of sowing both on the length of the row and between the coulters. Their speed of movement is up to 12 km/h [1-4]. However, over the last 50 years, due to the use of powerful, high-speed tractors, the trend of sowing units development has changed. In turn, the increase in the productivity of tractors pushes to the need to increase the speed of movement of the seeder (up to 15 km / h), as well as to increase the working width of the seeder - more than 6 m [1, 6]. Taking into account the need to transport the seeder to the field, preference is given to folding seeder designs. This, in turn, makes mechanical seeders less attractive, since the implementation of the folding design of the seeder is not feasible from the technological point of view. The use of a pneumatic system for the delivery and distribution of seeds reduces the uniformity of the seed supply on the coulters [5, 7]. This requires the improvement of the switchgear design.

There are several types of distributor heads for feeding the sowing particles to the coulters [9-11]. However, they are all sensitive to the position of the particles in the cross-section of the distributor head inlet. Ideally, the particles should be distributed evenly over the cross-section, or the distribution should be in accordance with the Gauss law and the seed distribution axis should coincide with the inlet axis. However, this condition is not really met, and as a result, the unevenness of the seed supply on the coulters often reaches 30% or more [5]. Different values of particle density and size [12, 13], sowing rates, significantly affect the turbulence of the flow in the pneumatic conduit [14], and consequently the distribution of particles in the cross-section.

2. Materials and Methods

2.1. Study object

The aim of the work is to reveal the influence of conical directing agents on the speed and trajectory of the sowing particles movement in the vertical pneumatic conduit of the sowing machine and to establish the rational parameters of the directing agent.

The research technique provided theoretical researches on definition of dependences and results of modeling of movement of particles of a sown material on a vertical site in front of a distributing head of pneumatic system of a sowing machine at installation of conical directing agents after a rotary knee of a pneumatic conduit.

2.2. Research tools

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The research technique provided theoretical researches on definition of dependences and results of modeling of movement of particles of a sown material on a vertical site in front of a distributing head of pneumatic system of a sowing machine at installation of conical directing agents after a rotary knee of a pneumatic conduit.

2.3. Research result

Using the design parameters of existing pneumatic seeders, simulation of the movement of particles (seeds, fertilizer pellets) in the vertical section of the pneumatic conduit after the swivel knee (Figure 1). Modeling was performed at an average air flow rate of 15 m/s at the inlet to the horizontal section. Analysis of the results shows an increase in the concentration of particles in the lower layers of the pneumatic conduit, which corresponds to the conclusions [5]. When the air flow moves along the inlet knee, particles move to its outer wall, reflect from the knee surface and then move along the wall of the vertical pneumatic conduit, noted in the works [5, 7, 8]. Part of the particles reflected from the side inclined walls of the knee begin spiral ascent in the pneumatic conduit [5, 8]. Particles are always pressed against the wall above the outer surface of the knee when leaving it. Regardless of the design of the vertical section, the asymmetrical arrangement of particles in the pneumatic conduit and the displacement of layers (jets) during the flight of particles relative to the longitudinal axis of the pneumatic conduit are clearly visible. Corrugated pneumatic conduit increases the turbulence of the flow, increasing the stochastic movement of particles, previously noted in the work [5, 7, 8].

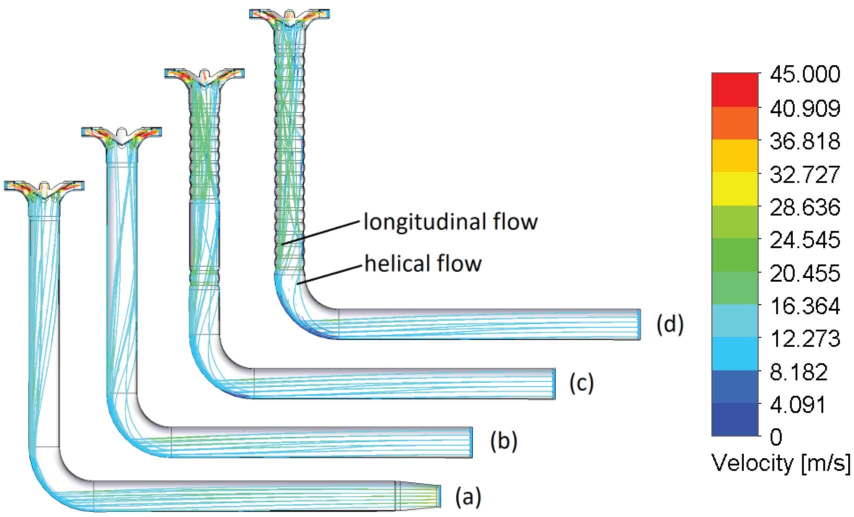

Figure 1: Particle motion trajectories obtained as a result of modeling of air flow at its average speed at the input of 15 m/s: (a) - in the presence of an ejector at the inlet; (b) - in the presence of a completely smooth pneumatic conduit; (c) - in the presence of corrugated sections of the pneumatic conduit (standard version); (d) - in the presence of a fully corrugated vertical pneumatic conduit.

To shift the particle trajectory from the pneumatic conduit wall above the outer surface of the feed elbow, it is proposed to use a conical guide at the bottom of the vertical pneumatic conduit. Its inner cavity is represented by a diffuser, a diffuser inverse to it and a cylindrical surface connecting them. Let's define theoretically the influence of the basic parameters of the configurator.

Analysis of the results of modeling the flow of air flows and particle trajectories (Fig. 2) has shown: (a) - there is a slight change in the movement of particles; mainly diagonal and spiral particle trajectories, with no clearly defined axial motion; (b) - particles with

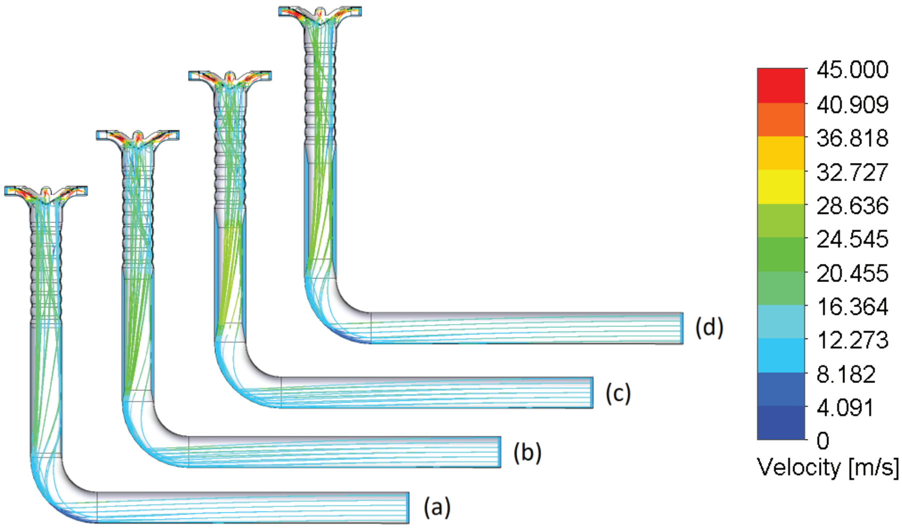

Figure 2: Results of 3D modeling of the particle trajectory in the vertical pneumatic conduit in the presence of a conical guide, the degree of overlap of the pneumatic conduit transverse area: (a) - 10%; (b) - 25%; (c) - 40%; (d) - 55%.

axial and zigzag trajectory are visible, and the first and the second are directed to the center of the distributor at an insignificant angle from the vertical; (c) - there is an increase in the chaotic movement of particles between the walls; (d) - at the exit from the distributor there are swirls of air flow, increasing the pressure loss. The particles are focused closest to the centre of the distributor in Figure 2 (b) at 25% of the air line cross-section area covered by the directional control valve.

When the cross-section of the air line is small, the action of the directional control valve does not differ from the lower corrugated belt of a typical air line. As the overlap grows, the longitudinal velocity of the air flow increases, ensuring the axial movement of particles. However, with the growth of the difference in the diameter of the particle guide nozzle from the side wall of the pneumatic conduit, the particles have time to accelerate in the radial direction, which leads to impacts on the corrugated surface of the pneumatic conduit.

3. Conclusion

When the cross-section of the air line is small, the action of the directional control valve does not differ from the lower corrugated belt of a typical air line. The increase in the overlap area leads to an increase in both axial and radial velocities, which makes it more difficult for particles to move based on their initial contact with the parapleter's nozzle. Closest to the center of the distributor the particles are focused at 25% overlap of the pneumatic conduit cross-section area by the directional control valve.

4. Discussion

The carried out researches have shown expediency of application of the conical directing agent, allowing to divert a longitudinal stream of particles from walls of a pneumowire and to centre trajectories of movement of particles along an axis of a pneumowire. Moreover, the use of a guide instead of corrugated sections in some cases can not only increase the efficiency of the seeder, but also increase its manufacturability.

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