



Design and performance experiment of an outer grooved-wheel fertilizer apparatus with the helical tooth

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Abstract.

Traditional outer groove-wheel fertilizer apparatus (OGWFA) with the straight tooth exists the problem of breakage and pulsation in the fertilizing process. A new type of OGWFA with the helical tooth has been designed to solve this problem, and the amount of fertilizer can be adjusted. The helix angle of the helical tooth has been optimized by theory analysis and DEM simulation. It reveals that the helix angle should be ranged from 34.4° to 68.8°. The performances of the OGWFA with the helical tooth and the straight tooth have been compared by the bench experiment. It indicates that the variable coefficient and the breaking rate of the OGWFA with the helical tooth are lower than these of the OGWFA with the straight tooth.

Keywords.

Fertilizer apparatus, helical tooth, DEM.

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1. Introduction

Fertilizer apparatus is used widely as its advantages of low-cost, labor saving, and uniform fertilization. In the recent years, many researchers have carried out some works in this area. The outer groove-wheel fertilizer apparatus (OGWFA) is one of the most popular fertilizer apparatus in China as its simple structures, easy manufacture, and adjustment of the fertilizer amount. According to the practical observations for the traditional OGWFA with the straight tooth, the primary problem is the breakage and pulsation in the fertilizing process.

2. Design

Based on the good sphericity fertilizer used in the middle of China, a new type of OGWFA with the helical tooth has been designed to reduce the pulsation and to improve the performance of the fertilization. The amount of the fertilizer can be adjusted by a pair of helical groove-wheel located both sides of the axis. The adjustment can be achieved by controlled the depth of the blocked wheel within the outer groove-wheel. The structure of the OGWFA with the helical tooth is shown in Fig 1(a).

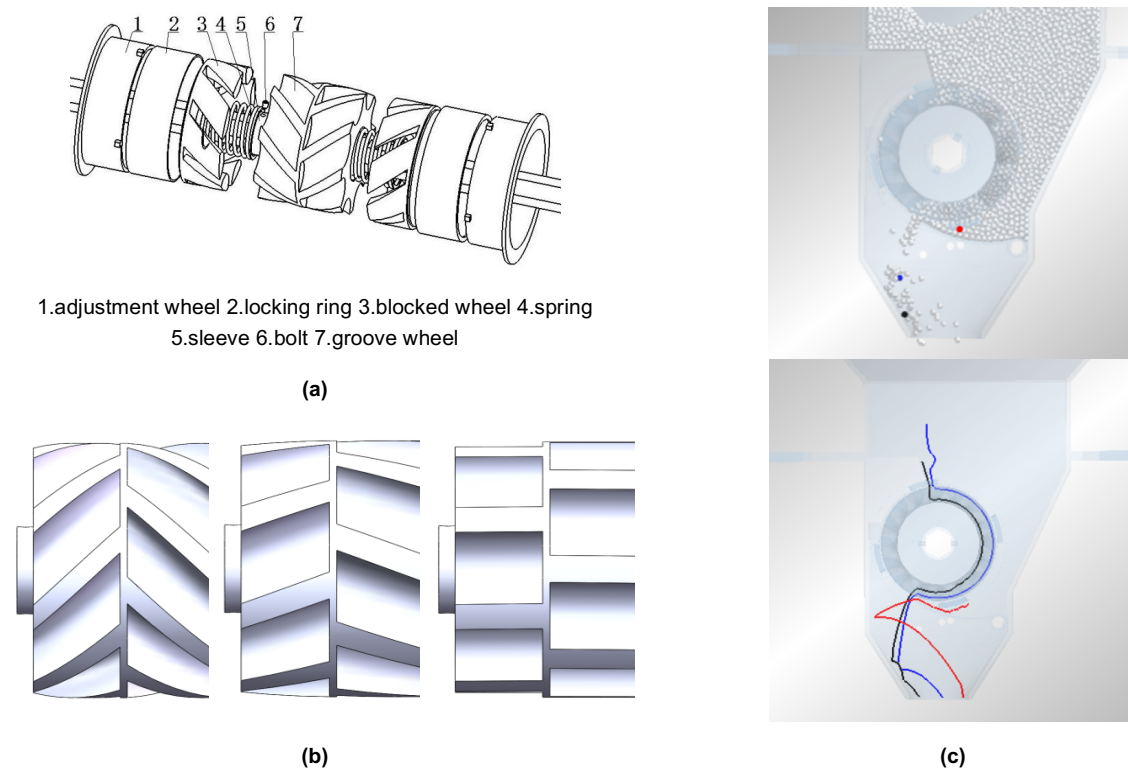


Fig 1. Structure of the OGWFA and its helical tooth with different helix angles, and its DEM simulation

3. Theory analysis and simulation

The helix angle is considered to be an important parameter to determine the performance of the OGWFA with the helical tooth. The motion of the fertilizer can be divided into the rotational speed v_t with the rotation of the groove-wheel and the translational speed v_z along the axial direction. The relation of the helix angle with v_t and v_z is given in Fig 2 by the kinematics analysis. It reveals that the helix angle should be ranged from 34.4° to 68.8° .

The motion of the fertilizer particle in OGWFA with the helical tooth has been simulated by Discrete Element Method (DEM) that is shown in Fig 1(c). The simulation models of the groove-wheel with three different helix angles are given in Fig 1(b). The effect of the helix angle on the variable coefficient of fertilization has been studied, and it indicates that the variable coefficient is minimum when the helix angle is 47.5° .

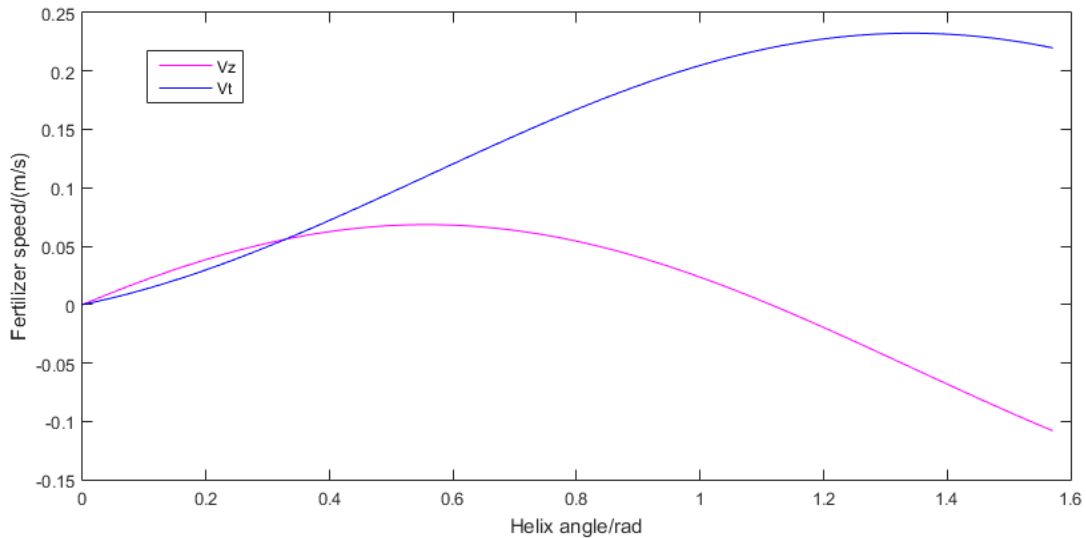


Fig 2. The relation of the helix angle with the rotational speed and the translational speed of fertilizer

4. Experiment

The bench experiment is given for the performance of the OGWFA with the helical tooth which with the helix angle is 47.5° as shown in Fig 4. The experiments have been repeated 10 times, and the comparison of the variable coefficient of OGWFA with the helical tooth and the straight tooth is given in Fig 5. The result indicates that the variable coefficient and the breaking rate of the OGWFA with the helical tooth are lower than these of the OGWFA with the straight tooth.

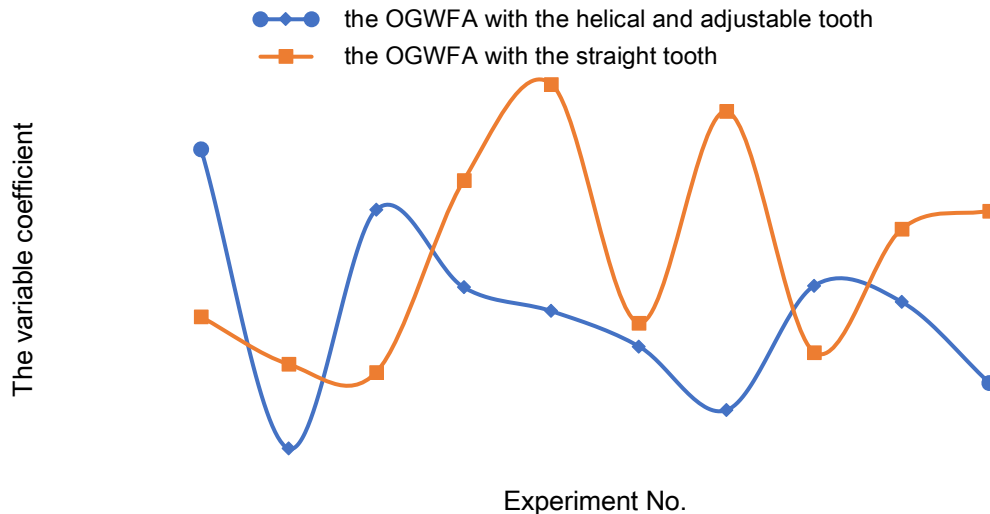


Fig 3. Comparison of the variable coefficient of OGW with helical and adjustable tooth and straight tooth

5. Conclusion

The new type OGWFA with the helical tooth can decrease the pulsation and reduce the breaking rate compared with the traditional OGWFA with the straight tooth.