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Study on Hexagon-enveloping Leaf-stripping Mechanism for Corn Stalk

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Abstract: In order to deeply study the leaf-stripping principle for corn stalk, the hexagon-enveloping leaf-stripping experimental device was designed. To achieve higher leaf-stripping percent and provide important references for the separation equipment for corn stalk, it is necessary to find out the laws of leaf-stripping of such mechanism and to select the main influencing factors of separation performance from a number of factors. Through the study on hexagon-enveloping leaf-stripping mechanism for corn stalks, the leaf-stripping principle of such mechanism was more clear, and the optimization of structural and kinematic parameters achieved by the experiment whose influencing factors were the four selected ones (feeding speed, rotary speed of leaf-stripping roll, clearance and included angle between two leaf-stripping plates) could be directly applied to the development of efficient rind-pith or leaf-stripping separation for corn stalks.

Key words: hexagon-enveloping, leaf-stripping, corn stalk

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Introduction

In China, annual production of corn stalk is about 250 million tons, which is one third of the total annual production of all kinds of stalks (Han *et al*., 2002). As a valuable renewable resource, corn stalk has been utilized in the field of crop farming, raising livestock, industrial production, etc (Yang *et al*., 1996; Liu, 2003; Cui *et al*., 2008). But utilization of corn stalk is still at the primary stage, because of the limitation of economic and technological development (Gao *et al*., 2008).

Corn stalk is mainly composed of leaves, rinds and piths, which are of different chemical compositions and nutrient levels. Pith and leaf can be utilized as livestock fodder, because they are rich in crude protein, crude fat, sugar, etc. And the main component of rind is cellulose and lignin, which can be utilized in the field of paper-making and man-made board (Yang *et al*., 1995). In general, there are interferences among them, during the process of being utilized as a whole directly, so it is difficult to develop new applications (Wang *et al*., 2012; Li, 2014). Meanwhile, collecting corn stalk requires huge investment in human resources and transportation cost, for the reason that

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corn stalk is of scattered distribution, fluffy, small bulk density, high proportion of leaf (mass ratios of leaf, rind and pith are about 50%, 35%, and 15%, respectively) and large storage space. Therefore, in order to improve the utilization rate of corn stalks, as well as to promote the sustainable development of agriculture and to increase farmers' income, the way of making the best use of corn stalks became the critical issue of comprehensive utilization of corn stalks and hot spots or difficult problems of the society.

All in all, it is necessary to separate leaves, rinds and piths from corn stalks (Chen *et al*., 2012; Liu, 2011). According to the physiological characteristics of corn stalks, the first question for this should be to solve the separation of stems and leaves of corn stalks.

At present, a number of studies about the separation of stem and leaves of corn stalks have been carried out in China (Sun and Guo, 2001; Gao, 2001; Zhang, 2002; Gao *et al*., 2003; Zhu *et al*., 2012), such as flatten-rubbed method, and shock-separation method. But there are lots of problems with these methods, for instance, easily broken shock components, great damage to the rind, complicated structure, low productivity or low leaf-stripping percent. Therefore, in order to avoid those problems and to deeply study the leaf-stripping principle for corn stalk, the hexagon-enveloping leaf-stripping experimental device was designed. To achieve higher leaf-stripping percent and to provide important references for the separation equipment for corn stalks, it is necessary to find out the laws of leaf-stripping of such mechanism and to select the main influencing factors of separation performance from a number of factors.

Design Idea of Hexagon-enveloping Leaf-stripping

Corn is a C4 plant, and the photosynthetic efficiency of it is higher than that of C3 plant. The base of leaves grows on the node of stem, and is wrapped around the internodes of stem. Moreover, leaves are on both sides of the stem alternate, so stem nodes and leaves are of the same number. With the decrease of the diameter of corn stalks, the mass ratio of leaves increases, but the stem is on the other foot.

The results of previous studies by Gao *et al*. (2003) showed that the differences of binding strength of stem and leaf among different varieties of corn stalks were insignificant, usually 10.1 to 10.3 $N \cdot mm^{-1}$; binding strength of stems and leaves increased from down to up sequentially on the whole; the longitudinal tensile strength of leaves that wrapped around the internodes of stems was two to four times of the one in the lateral direction. The reasons for these results were that leaves began to become yellow and dry when corn plant grew to a certain stage.

The above analyses showed that there were large differences in structure and characteristics among different components of corn stalk and the same parts of corn stalks in different positions. To realize the effective separation of stems and leaves, the differences between stems and leaves of corn stalks and their own characteristics must be taken into account comprehensively. Meanwhile, in order to provide conditions for the separation of rind and pith of corn stalks, as well as to ensure the integrity of stem during the separation process, the design idea of hexagon-enveloping leaf-stripping was proposed and the overall scheme was designed on the basis of hypothesis of stripping leaves with the help of variable-diameter sleeve.

Device's Overall Structure and Working Principle

To design appropriate leaf-stripping mechanism for corn stalks to realize the effective separation of stem and leaves, it is necessary to make a statistical analysis of the dimensions of corn stalks firstly, such as height and diameter. The measurement object was corn stalks that harvested from the Xiangfang Experimental Base of NEAU (Northeast Agricultural University) in spring. To get the accurate evaluation of separation, it is necessary to select stalks that having reached the