Mechanism and Experiment on the Materiel Movement of Whole-Stalk Sugarcane Harvesters

Fuxiang Xie*
School of Mechanical-Electronic and Vehicle Engineering, Wei Fang University, Weifang, 261061, China
*Corresponding author(E-mail: xfx608@126.com)

Jian Song
School of Mechanical-Electronic and Vehicle Engineering, Wei Fang University, Weifang, 261061, China

Xunlin Zhang
College of Mechanical and Electronic Engineering, Shandong University of Science and Technology, Qingdao, 266590, China

Abstract

The process by which materiel movement occurs in the device was examined through dynamic analysis. A force equation was established to investigate the changes in force between sugarcane fed into the harvester and the components of the device, and dynamic analysis was conducted on the fed sugarcane and rollers to obtain a materiel movement equation. Single factor tests were carried out on the harvester’s fan angle, the rotation rates of the feed and conveyor roller and peeling roller, and the central distances of the peeling roller, impurity separation roller, fan roller, and feed and conveyor roller. On the basis of the single factor tests, an orthogonal test was performed on fan wind angle, feed and conveyor roller speed, stripping roller speed, and the central roller distances determined in the single factor test. The test indexes were the impurity removal rate, impurity rate, and whole stalk ratio. All the tests showed that comprehensive balance testing indexes were derived: a wind angle of 105°, a feed and conveyor roller rotational speed of 100 r/min, a leaf peeling roller rotational speed of 1300 r/min, a central peeling roller distance of 280 mm, a central separation roller distance of 270 mm, a central fan roller distance of 300 mm, and central feed and conveyor roller distances of 340 and 310 mm. Test results on the quantity of sugarcane feeding showed that impurity removal was highest when three sugarcane stalks were fed into the harvester in a single batch.

Key words: Whole Stalk, Sugarcane Harvester, Materiel, Impurity Removal, Experiment.

1. Introduction

Sugarcane is currently the main sugar crop produced in China[1,2], yet the level at which sugarcane harvesting is mechanized in the country is low—a factor that has hindered the development of sugarcane harvesting technology in the region[3,4]. In domestic and overseas contexts, research is largely devoted to key technologies for the cutting, feeding, leaf peeling/stripping, and cane-end cutting components of sugarcane harvesters[5,6]. For example, a virtual prototype was built and experiments were conducted on the aforementioned harvester components in Zhejiang University[7,8], Nanjing Agricultural Mechanization Research Institute of the Ministry of Agriculture[9], Guangxi University[10-12], and South China Agricultural University[13-19].

The literature indicated that most sugarcane harvesters are simulated using virtual prototyping technology, but limited research has been devoted to the mechanism that underlies the internal materiel of such harvesters. To address this gap, the present study investigated the law that governs feeding, conveying, peeling, and cleaning movements in a whole-stalk sugarcane harvester. A materiel passageway was designed to perform theoretical and experimental analyses of the mechanism of materiel movement.

2. Structure and Working Principle

The materiel channel of a whole-stalk sugarcane harvester is composed mainly of a feed roller, the front portion of a conveyor roller, a leaf stripping roller, a fan roller, an impurity separation roller, and a rear conveyor roller (Figure 1). Sugarcane is fed into the front of the roller conveyor by a pair of sugarcane feed rollers, after which the sugarcane is conveyed into the stripping roller where leaves are stripped off. Then, the sugarcane and sugarcane leaves are conveyed into the impurity separation device, which consists primarily of a
fan drum and an impurity separation roller. These components are responsible for the interaction necessary to remove impurities. Finally, the sugarcane is fed through the rear conveyor device for outputting and collection.

Figure 1. Impurity discharging principle of the sugarcane harvester
1-Feed drum 2-Front of conveyor roller 3-Sugarcane leaf 4-Peeling roller 5-Fan roller 6-Impurity 7-Impurity separation roller 8-Sugarcane 9-Rear conveyor roller.

3. Structural Analysis

With the rotation of each pair of rollers, force, friction force, and self-gravity are produced by the sugarcane fed into the harvester and the feed, conveyor, stripping, fan, and impurity separation rollers. In accordance with the dynamic analysis of each key component, therefore, the kinematic parameters and geometric rules of sugarcane movement in the materiel channel were obtained. In the dynamic analysis of each component, the sugarcane was assumed to be a rigid body.

The path traversed by sugarcane particles in the conveyor roller is shown in Figure 2. At time $t$, contact between the conveyor roller and sugarcane begins at point $P_0$ then proceeds to point $P_1$. The rotation of central rollers moves in an upward direction toward mid-point $P_2$. The angle between velocity $P_0$ of the conveyor roller and the force in the X direction is $\beta_0$, and the angle between velocity $P_1$ of the conveyor roller and the force in the X direction is $\beta$. From points $P_0$ to $P_1$, the angle of rotating rollers is $\beta'$. The following assumptions were adopted: the gap between upper and lower rollers is $c$, the diameter of the sugarcane is $d$, the radius of the conveyor roller is $R$, the angular speed is $\omega$, and the maximum distance between the center and upper segments of the conveyor roller is $S$. Sugarcane transmission in the conveyor roller is divided into two stages. The first pertains to conveyance from positions $P_0$ to $P_2$, during which the angle of $\beta$ gradually decreases. The second stage refers to conveyance from points $P_2$ to $P_0'$, during which angle $\beta''$ gradually decreases. The two stages are equal, assuming that the first stage begins at $t_2$. The analysis of the movement track of the lower conveyor roller was the same as that of the upper conveyor roller. The starting contact point is $Q_0$, and the separation point from the sugarcane is $Q_0'$. The gravity produced in the sugarcane section in the conveyor roller is $G_1$, and the gravity produced in the sugarcane section in the upper conveyor roller is $G_0$.

Figure 2. Dynamic analysis of conveyor roller

On the basis of Figure 2, a mechanical analysis of sugarcane conveyance was performed. The $F$ in the $X$ direction is

\[
F = \int_0^{t_1} [(F_{x1} + F_{x2}) - (f_0 + f_1)]dT + \int_0^{t_2} [(F_{x3} + F_{x4}) - (f_0 + f_1)]dT - G_0
\]

where $F_{x1}$ is the force in the $X$ direction of the upper conveyor roller, $F_{x0}$ is the force in the $X$ direction of the lower conveyor roller, $f_0$ denotes the friction between the upper conveyor roller and the sugarcane, $f_1$ represents
the friction between the lower conveyor roller and the sugarcane, \( G_{x1} \) is the gravity produced in the X direction in the conveyor rollers, and \( N \) denotes the unit of force.

As the sugarcane moves, the upper conveyor roller and the sugarcane are balanced by force in the Y direction.

\[
F_{y0} = G_0 \sin \alpha, \quad F_{y1} = F_{y0} + G_{y1}
\]  

In equation (2), \( F_{y0} \) is the force of the upper conveyor roller in the Y direction, \( F_{y1} \) denotes the force of the lower conveyor roller in the Y direction, \( G_0 \) is the gravity produced by the conveyor roller, \( G_{y1} \) is the sugarcane gravity in the conveyor roller in the Y direction, and \( \alpha \) stands for the angle between the gravity produced by the movement of the sugarcane and the conveyor roller in the X direction.

\[
G_0 = mg, \quad G_{y1} = mg \sin \alpha
\]

In equation (3), \( m_0 \) denotes the quality of the conveyor roller, \( m_1 \) indicates the quality of the sugarcane section, and \( G_0 \) is the gravitational acceleration. Substituting equation (3) into equation (2) yields

\[
F_{y0} = m_0 g \sin \alpha, \quad F_{y1} = (m_0 + m_1) g \sin \alpha
\]

Because

\[
F_{y0} = F_{y0} \cot \beta, \quad F_{y1} = F_{y0} \cot \beta, \quad f_0 = uF_{y0}, \quad f_1 = uF_{y1}, \quad G_0 = mg \cos \alpha
\]

where \( \beta \) is the angle of the speed direction between the upper and lower conveyor rollers and the force in the X direction, and \( u \) is a dynamic friction factor. Substituting equations (4) and (5) into equation (1) yields

\[
F = \int_0^t [(2m_0 + m_1) g \sin \alpha \cot (\arcsin \frac{R-d-c}{R} - \alpha) \frac{R-d-c}{R} - \arcsin (\frac{R-d-c}{R} - \alpha)] - u \sin \alpha (2m_0 + m_1) dT + \\
\int_0^t [(2m_0 + m_1) g \sin \alpha \cot (\arcsin \frac{R-d-c}{R} - \alpha) \frac{R-d-c}{R} - \arcsin (\frac{R-d-c}{R} - \alpha)] - u \sin \alpha (2m_0 + m_1) dT - m_0 g \cos \alpha
\]

According to the design requirements of the materiel channel, the quality of the conveyor roller is \( m_0 = 44 \) kg in equation (6), and the quality of the sugarcane section in the conveyor roller is \( m_1 = 0.12 \) kg, \( g = 9.8 \) N/m2. The angle between the gravity of the upper conveyor roller and the X direction of the sugarcane is \( \alpha = 55^\circ \). The radius of the conveyor roller is \( R = 0.15 \) m, the gap between the upper and lower rollers is \( c = 0.02 \) m, and the diameter of the sugarcane is \( d = 0.03 \) m. The maximum floating distance of the center of the conveyor roller is \( S = 0.01 \) m, the angular velocity of the conveyor roller is \( \omega = 10.47 \) rad/s, and the dynamic friction coefficient is \( u = 0.4 \). As shown through high-speed photography, \( t_2 = 0.03 \) s. These parameters were replaced in equation (6), and the numerical integral was obtained using MATLAB.

\[
F_0 = \int_0^{t_2} [(2m_0 + m_1) g \sin \alpha \cot (\arcsin \frac{R-d-c}{R} - \alpha) \frac{R-d-c}{R} - \arcsin (\frac{R-d-c}{R} - \alpha)] - u \sin \alpha (2m_0 + m_1) dT
\]

\[
F_1 = \int_0^{t_2} [(2m_0 + m_1) g \sin \alpha \cot (\arcsin \frac{R-d-c}{R} - \alpha) \frac{R-d-c}{R} - \arcsin (\frac{R-d-c}{R} - \alpha)] - u \sin \alpha (2m_0 + m_1) dT
\]

The numerical integration indicated that the force acting on the conveyor roller gradually increases at first stage \( t \) (0–0.03 s) and that the maximum force is reached at 0.03 s. In second stage \( t' \) (0.03–0.06 s), force gradually decreases.

The numerical integration results were fitted using three polynomials as follows:

\[
F_0 = [(2.01 - 1.02)^2 + (-0.12 + 0.06)^2 + (0.04 - 0.00)^2] \times (1.0 + 0.05)
\]

\[
F_1 = [-2.85y^3 + 0.31y^2 - 0.01y + 0.0001] \times (1.0e + 0.05)
\]

Substituting equations (9) and (10) into equations (7) and (8) yields

\[
F = [(2.01 - 1.02)^2 + (-0.12 + 0.06)^2 + (0.04 - 0.00)^2] \times (1.0 + 0.05) + [-2.85y^3 + 0.31y^2 - 0.01y + 0.0001] \times (1.0e + 0.05) - 0.675
\]
According to the analysis of the mechanism underlying materiel movement, the main factors that affected the velocity of sugarcane movement were the material, diameter, central distance, and rotation rate of each pair of rollers.

4. Tests

4.1. Test equipment, Materials, and Indexes

An experiment was carried out in the machining training center of the Engineering College of South China Agricultural University. The test equipment was a test bed for a materiel channel, composed mainly of materiel channels, 48 kW tractors, and hydraulic systems. The experimental materials (i.e., sugarcane) were obtained from the experimental base of Zhanjiang Agricultural Reclamation and Agricultural Machinery Service Company. The variety of sugarcane used was “new platform sugar 16.” The impurity removal rate, impurity rate, and whole stalk ratio were treated as experimental indexes[3,4].

4.2. Test Methods

A. Single factor test

On the basis of the structural analysis of the sugarcane harvester materiel channel and the preparatory experiment, the factors considered in the single factor tests were the fan blowing angle (A), the rotation rate of the feed and conveyor roller (B), the rotation rate of the leaf peeling roller (C), and the central distances of the leaf peeling, impurity separation, fan, and feed and conveyor rollers (D1, D2, D3, and D4, respectively) (Table 1). The test indexes were impurity removal rate, impurity rate, and whole stalk ratio. Single sugarcane feeding was adopted, and 15 sugarcane stalks were fed at each trial. Each feeding was repeated three times, with an average value.

<table>
<thead>
<tr>
<th>Levels</th>
<th>A/°</th>
<th>B/r.min-1</th>
<th>C/r.min-1</th>
<th>D1/mm</th>
<th>D2/mm</th>
<th>D3/mm</th>
<th>D4/mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>95</td>
<td>100</td>
<td>900</td>
<td>280</td>
<td>270</td>
<td>300</td>
<td>340/310</td>
</tr>
<tr>
<td>2</td>
<td>105</td>
<td>150</td>
<td>1000</td>
<td>290</td>
<td>280</td>
<td>310</td>
<td>350/320</td>
</tr>
<tr>
<td>3</td>
<td>115</td>
<td>200</td>
<td>1100</td>
<td>300</td>
<td>290</td>
<td>320</td>
<td>360/330</td>
</tr>
<tr>
<td>4</td>
<td>125</td>
<td>250</td>
<td>1200</td>
<td>310</td>
<td>300</td>
<td>330</td>
<td>370/340</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>300</td>
<td>1300</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

B. Orthogonal test

With the single factor experiments as bases, the factors and levels to be implemented in an orthogonal test were determined. Studies on the speed of impurity discharging fans, the effects of the maximum wind speed of such fans on impurity removal effects, and the preparatory experiment showed the position of a fan outlet exerts a significant effect on test indexes. The fan outlet angle (angle between the fan outlet and the bottom line of the materiel channel) (A), the rotation rate of the feed and conveyor roller (B), the rotation rate of the leaf peeling roller (C), and the central distance of the roller (D) were selected as the orthogonal test factors. The test factors and levels of experimentation are shown in Table 2. The orthogonal test (four factors, three levels) was used as basis in designing the experiment, in which the L27 (313) orthogonal test table was used. The test method was the same as that applied in the single factor test.

<table>
<thead>
<tr>
<th>Levels</th>
<th>A/°</th>
<th>B/r.min-1</th>
<th>C/r.min-1</th>
<th>D/mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>95</td>
<td>100</td>
<td>900</td>
<td>340/310/280/300/280/310</td>
</tr>
<tr>
<td>2</td>
<td>105</td>
<td>200</td>
<td>1100</td>
<td>350/320/290/310/290/320</td>
</tr>
<tr>
<td>3</td>
<td>115</td>
<td>300</td>
<td>1300</td>
<td>360/330/300/320/300/330</td>
</tr>
</tbody>
</table>
C. Multiple sugarcane feeding test

Multiple sugarcane feeding experiments were carried out under the optimum parameters obtained through the orthogonal and single factor experiments. Multiple experiments were carried out at three, five, and seven root levels. The impurity removal rate, impurity rate, and whole stalk ratio were used as the test indexes; the average value was obtained and repeated 20 times at each level.

4.3. Test Results and Analysis

A. Single factor test on rotation rate of feed and conveyor roller

As shown in Figure 3(a), the optimum results were achieved at the first level of the impurity removal rate and the impurity rate occurring during the rotation of the feed and conveyor roller. An independent sample T test was performed using sample data on the B1 and B2, the impurity removal and impurity rates, and the Statistical Package for the Social Sciences (SPSS). The results showed that the significance of B1 and B2 for the impurity removal rate was sig=0.325>0.05 and that the significance of B1 and B2 for the impurity rate was sig=0.198>0.05. These findings indicated that the aforementioned rates had no significant difference, resulting in a 95% confidence interval in the two levels. B1 did not significantly increase the impurity removal rate and significantly reduced the impurity rate. Figure 3(a) shows that the rotation rate of the peeling and conveyor roller exerted little effect on the impurity removal rate and whole stalk ratio. The impurity removal rate was above 97.32%, the whole stalk ratio was greater than 80%, the rotation rate of the feed and conveyor roller was 100r/min, and the impurity rate (the lowest value) was 1.6%. As indicated by the results of a comprehensive balance test, when the rotation rate of the feed and conveyor roller was 100 r/min, the impurity removal effect reached its optimum level. The impurity removal rate was 97.32%, the impurity rate was 1.6%, and the whole stalk ratio was 86.67%.

![Figure 3(a) Feed speed of conveyor drum](image)

![Figure 3(b) Speed of peeling drum](image)

**Figure 3.** Results of single factor experiment on rotation rate of feed and conveyor roller

B. Single factor test on rotation rate of peeling roller

The results of the single factor experiment involving the rotation rate of the peeling roller are illustrated in Figure 3(b). The variance analysis of the experiment showed no significant difference between the experiment levels with impurity removal rate as the test index (F=0.865, sig=0.517>0.05). No significant differences were found between the levels with impurity rate as the test index (F=4.075, sig=0.033<0.05). As shown in Figure 3(b), the rotation rate of the peeling roller and the impurity removal rate gradually increased. The single factor analysis of variance indicated that the increasing trend was not significant. With increasing rotation rate of the peeling roller, the whole stalk ratio and impurity rate gradually decreased. When the rotation rate of the peeling roller was 1300 r/min, the impurity rate was at its minimum value (i.e., 1.6%). According to the results of a comprehensive balance test, when the rotation rate of the peeling roller was 1300 r/min, the impurity removal effect was at its optimum level. The impurity removal rate was 98.27%, the impurity rate was 1.6%, and the whole stalk ratio was 86.67%.

![Figure 4(a) Central distance of peeling roller](image)

**Figure 4.** Results of single factor experiment on central distance of peeling roller

C. Single factor test on central distance of peeling roller

The results of the single factor test on the central distance of the peeling roller are shown in Figure 4(a). The single factor variance analysis showed no significant difference between each experiment level with impurity removal rate as the experimental index (F=1.071, sig=0.414>0.05). With impurity rate as the experimental index (F=3.758, sig=0.06), however, a significant difference between each level was found (slightly greater than 0.05). As shown in Figure 4(a), with increasing central distance of the peeling roller, the impurity rate gradually increased. At central distances of 280 and 300 mm, the whole stalk ratio improved. The results of a comprehensive balance test revealed that the best effect was obtained at a central distance of 280 mm, an impurity removal rate of 98.27%, an impurity rate of 1.6%, and a whole stalk ratio of 86.67%.
D. Single factor test on central distance of impurity separation roller

The results of the single factor test on the central distance of the impurity separation roller are presented in Figure 4(b). The findings showed that D2 generated the best result for the impurity removal rate at the first experiment level and that the optimum result was achieved at the second level with impurity rate as the test index. With SPSS, an independent sample T test was carried out with D2a and D2b and impurity removal rate and impurity rate as the test indexes. The significance of D2a and D2b for the impurity removal rate was sig=0.797>0.05, and their significance for the impurity rate was sig=0.230>0.05, indicating that these rates exhibited no significant difference. Thus, a 95% confidence interval was achieved in the two experiment levels. D2a did not significantly increase the impurity removal rate and significantly reduced the impurity rate. Figure 4(b) shows that the impurity removal effect was highest at a central distance of 270 mm, an impurity removal rate of 98.74%, and a whole stalk ratio (the highest value) of 93.33%. As the central distance of the impurity separation roller increased, the impurity removal rate decreased. At a central distance of 280 mm, the impurity rate was at its lowest (1.6%), and each impurity rate was less than 2.86%. The findings of a comprehensive balance test showed that the central distance was 270 mm, the impurity removal rate was 98.74%, the impurity rate was 2.86%, and the whole stalk ratio was 93.33%.

E. Single factor test on central distance of fan roller

The results of the single factor test on the central distance of the fan roller are shown in Figure 5(a), which indicates that D3 achieved optimum impurity removal and impurity rates at the first experiment level. An independent sample T test was carried out with D3a and D3b and impurity removal rate and impurity rate as the test indexes. The significance of D3a and D3b for the impurity removal rate was sig=0.643>0.05, and their significance for the impurity rate was sig=0.334>0.05. Therefore, these rates exhibited no significant difference at a 95% confidence interval in the two experiment levels. D3a did not significantly increase the rate of impurity removal and significantly reduced the impurity rate. Figure 5(a) illustrates that at a central distance of 300 mm, the impurity removal effect improved (98.63%), the whole stalk ratio was at its highest (93.33%), and the impurity rate was at its lowest (1.28%). The findings of a comprehensive balance test showed that the best impurity removal effect was achieved at a central distance of 300 mm, an impurity removal rate of 98.63%, an impurity rate of 1.28%, and a whole stalk ratio of 93.33%.

F. Single factor test on central distance of feed and conveyor roller

The results of the single factor test on the central distance of the feed and conveyor roller are shown in Figure 5(b). D4 achieved the optimum impurity removal and impurity rates at the first experiment level. An independent sample T test was conducted with D4a and D4b and impurity removal rate and impurity rate as the test indexes. The significance of D4a and D4b for the impurity removal rate was sig=0.510>0.05, and their significance for the impurity rate was sig=0.744>0.05. These results showed that the rates had no significant difference at a 95% confidence interval in the two experiment levels. D4a did not significantly increase the impurity removal rate and significantly reduced the impurity rate. Figure 5(b) indicates that an increase in the central distance of the feed and conveyor roller exerted no significant change on the impurity removal rate and the whole stalk ratio. With increasing central distance, the impurity rate gradually increased. At central distances of 340 and 310 mm, the impurity removal efficiency reached its optimum level, the impurity removal rate was 98.63%, the impurity rate was 1.28%, and the whole stalk ratio was 93.33%.
were higher in the experiment on cut sugarcane than in the experiment on uncut sugarcane; the impurity rate removal effect worsened. Accord and the whole stalk ratio was 100%. With increasing number of sugarcane fed into the harvester, the impurity removal effect was at its best level. The impurity removal rate was 100%, the impurity rate was 1.65%, experimental results showed that when three sugarcane stalks were fed at one time into the harvester, the adhesion and stacking in the materiel channel, such number affects the impurity removal effect. The experiment are attributed primarily to the increase in the numb

86.67%. With increasing number of fed sugarcane, the quality of impurity removal worsened. The results of the obtained. The impurity

rate as the test index, significant differences were found between each level (F=13.822, sig=0.0<0.05). Th

The analysis of Figure 6 indicated that the best combination of test index effects on impurity removal rate was A2B3C2D3. The primary and secondary relationships between the experimental factors affected the rate of impurity removal in the order A>B>C>D. The best combination of test index effects on impurity rate was A1B1C3D1. The primary and secondary relationships affected the whole stalk ratio in the order D>B>C>A. Overall, the aforementioned test indexes were balanced; the best combination of effects on impurity removal rate, impurity rate, and whole stalk ratio was A2B1C3D1. The angle of the fan outlet was 105°, the rotation rate of the feed and conveyor roller was 100 r/min, the rotation rate of the leaf peeling roller was 1300 r/min, and the central distances of the rollers were 340, 310, 280, 300, 280, and 310 mm.

H. Experiments on multiple sugarcane feeding

The test results on the quantity of cut and uncut sugarcane feeding are shown in Figure 7. The variance analysis of the multiple feeding experiment on the uncut sugarcane indicated no significant difference between each experiment level (F=1.351, sig=0.328>0.05). With impurity rate as the test index, significant differences were found between each level (F=9.000, sig=0.016<0.05). Th

The test results on the quantity of cut and uncut sugarcane feeding are shown in Figure 7. The variance analysis of the multiple feeding experiment on the uncut sugarcane indicated no significant difference between each experiment level (F=1.351, sig=0.328>0.05). With impurity rate as the test index, significant differences were found between each level (F=9.000, sig=0.016<0.05). Th

Figure 5. Results of single factor experiment on central distances of fan and feed and conveyor rollers

Figure 6. Results of orthogonal test

Figure 6. Results of orthogonal test

Figure 6. Results of orthogonal test
was also lower in the uncut sugarcane experiment. The higher the number of sugarcane roots, the worse the impurity removal effect. The feeding of multiple cut sugarcane improved impurity removal.

5. Conclusions

The structure of a materiel channel in a whole-stalk sugarcane harvester was analyzed, and equations for the movement of sugarcane through the feed and conveyor, peeling, fan, and impurity separation rollers were established. In the materiel channel, sugarcane was subjected mainly to the axial force of each component and the tangential force and friction force perpendicular to the direction of the sugarcane movement. Through the force analysis of the components of sugarcane and the materiel channel, the equation of motion velocity of the sugarcane was obtained. The main factors that affected the velocity of sugarcane movement were the material, diameter, central distance, and rotation rate of each pair of rollers.

Single factor tests were carried out on fan angle, the rotation rate of the feed and conveyor roller, the rotation rate of the peeling roller, and the central distances of the peeling, impurity separation, fan, and feed and conveyor rollers. The single factor tests were used as basis for performing the orthogonal experiment, in which the best combination of test indexes was derived. The test results showed that comprehensive balance test indexes were obtained: the fan angle was 105°; the rotation rate of the feed and conveyor roller was 100 r/min; the rotation rate of the peeling roller was 1300 r/min; the central distances of the peeling, impurity separation, fan, and feed and conveyor rollers were 280, 270, 340, and 310 mm, respectively. The impurity removal effect was at its optimum level, the impurity removal rate was 98.27%, the impurity rate was 1.6%, and the whole stalk ratio was 86.67%.

The tests on multiple sugarcane feeding showed that the best impurity removal effect was obtained when three sugarcane stalks were fed into the harvester at a single time. The higher the number of sugarcane roots, the worse the impurity removal effect. The feeding of multiple cut sugarcane improved the impurity removal effect.

Acknowledgements

This work was supported by A Project of Shandong Province Higher Educational Science and Technology Program (J17KA150) and Shandong Agricultural Machinery Equipment Research and Development Innovation Project (2018YF005-05).

References


525


