Developing a Unit for Chaff Bagging During Threshing

El-Fakhrany, W. B.; S. Shalaby¹ and W. M. El-Balkimy²
¹ Agricultural Engineering Research Institute, Agri. Res. Center.
² Agricultural Engineering Research Institute, Agri. Res. Center.

ABSTRACT

The aim of the present study is to develop a bagging device depends primarily on a cyclone and fits for bagging the wheat chaff during threshing operation. The developed device was constructed in El-Gemeza Agricultural Research Station El-Gharbia Governorate. For obtaining high performance of the developed device; some parameters were tested at different levels such as: air outlet diameter of 50, 90 and 120 cm, mesh holes diameter of 3, 6 and 10 mm latterly thresher air velocity of 14.4, 17.9, 20.1 and 23.6 m/s. The air velocity at air outlet and chaff outlet were measured, also the chaff losses, grain losses, impurity ratio and cleaning efficiency were determined. The highest air velocity at air outlet of 5.4 m/s was obtained at air outlet diameter of 90 cm, mesh holes diameter of 10 mm and thresher air velocity of 23.6 m/s. The lowest values of air velocity at chaff outlet, chaff losses and grain losses of 0.2 m/s, 0.36% and 0 respectively were obtained at air outlet diameter of 120 cm, mesh holes diameter of 10 mm and thresher air velocity of 14.4 m/s. The lowest value of impurity ratio of 0.03% and the corresponding cleaning efficiency of 97.7% were obtained at air outlet diameter of 120 cm, mesh holes diameter of 10 mm and thresher air velocity of 23.6 m/s.

INTRODUCTION

Egyptian farmers consider wheat chaff as a by-product beside grains; while it is indispensable in feeding of livestock throughout the year. The field information indicates that, the monetary value of wheat chaff after threshing directly of about 2000 L.E/fed. and up to 3000 L.E/ fed. through the winter. The traditional way of wheat chaff bagging operation is extremely tedious and requires more time, in addition to it is harmful especially to the respiratory health of workers. Also, the workers cannot entirely clean the chaff place, which will affect the next crop in that place, in addition to increase the chaff losses.

With regard to utilization the wheat chaff in livestock feeding Hanna and Suliman (1982) mentioned that Egypt has a unique agricultural feature. It has a very strong livestock program but with meager green fodders during the summer season. This situation makes the cattle feeding almost entirely dependent on the wheat straw after it has been cut and properly bruised by stationary threshers. Using a combine that usually throws back the wheat into the fields does not provide the exact requirements of the Egyptian farmers. Kaliel and Kotowich (2002) stated that the cost of wintering beef cows in western Canada is the single most important cost of beef production and accounts for 60–65% of the total cost of production in a cow-calf operation. Ellinbank (2005) mentioned that chaff is hay cut into small pieces for feeding to livestock. It is a good fodder, and at its best is cleanly and evenly cut, free of dust, of good colours and with a fresh aroma. Chaff is usually cut into 6–10 mm long pieces. Cereal chaff can be up to 20 mm for cheeps and horses, or even slightly longer for cows. Nutritional value is not changed by the cutting from hay to chaff but utilization by the animal may be better. An unevenly cut chaff lacks appeal to the eye and so may be downgraded in value. An excess of fines or dust particles is detrimental to animal health. Hamdia et al. (2011) declared that a feed is an important one of production inputs; its value is represented about 58.3% of the total value of agricultural production inputs in 2008. There are about 12 million animal units, the needs of those animal units of green feed were estimated about 39.8 million tons, about 9.6 million tons of straw, and about 15.9 million tons of concentrated feed. These needs were estimated at about 18.4 million tons of starch equivalent, and about 2.1 million tons of protein digested. The available quantity for consumption of feed was estimated about 64.8 million tons of green feed, about 9.2 million tons of straw, and about 5.1 million tons of concentrated feed. The available quantity for consumption were estimated at about 11.6 million tons of starch equivalent, and about 1.8 million tons of protein digested during the average period (2003-2008). By Estimating the feed balance in Egypt during the average period (2003-2008), showing a surplus in the green feed is estimated at about 24.9 million tons, also showing a deficit in the straw and the concentrated feed about 0.3494, 10.9 million tons respectively. This noted a deficit estimated at about 6.8 million tons of starch equivalent and about 225.2 thousand tons of digested protein.

With regard to specifications of wheat chaff Mckean and Jacobs, (1997) stated that the physical content revealed that parts of wheat plant like internodes (68.5%), leaf-sheath (20.3%), leaf-blade (5.5%), nodes and fines (4.2%) and grains and debris (1.5%) shows varied mass percentage of wheat straw fractions. El-Danasory and Imabi (1998) showed that yield of straw about 3752 kg/fed., the labor required for manual picking and packing per wheat straw of one feddan after harvesting with combine was 6 labors with 9 working hour per day then the time required per one feddan was 54 hours. Also, they added that the average losses of straw were 13.7% and high cost of picking and packing of straw after harvesting (165 L.E/fed.). Khoder and Abdel-Hameed (1999) indicated that farmers and residents are exposed to high levels of organic dusts during harvesting and post harvesting processes. This may lead to adverse health effects. Pulmonary diseases, allergenic and asthma are common between farmers during wheat harvesting season. Consequently, this hazardous agent should be controlled to protect farmers and rural residents against such source of air pollution.

Utilization of the cyclone in bagging the wheat chaff Ogawa and Hikichi (1981) proposed that the solid particles entering the cyclone immediately bifurcate into two layers of dust due to the eddy current based on the
secondary flow on the upper cover surface in the coaxial space between cyclone body and exit pipe. One of them
goes around the coaxial space on the upper cover surface and rotates around the exit pipe with the gas
flow. The other rotates and descends along the surface of the cyclone body. Then, on the surface of the cone,
the dust layer, which is pressed onto the cone surface by the centrifugal force, descends aided by gravitational
force and descending airflow in the boundary layer. Lastly, these dust layers are deposited in the dust
bunker. However, Zhou and Soo (1990) mentioned that
some of the deposited dust rolls up from this dust layer
by the secondary flow in the boundary and flows
through the exit pipe. Centrifugal effects, which are
responsible for collecting fine particles, depend directly
on the tangential velocity of the solid particles.
Therefore, the tangential velocity of the gas flow, which
relates to the pressure drop, must be increased in order
to increase cyclone efficiency. These processes are the
mechanism of separation of solid particles in
cyclones. Ogawa (1997) reported that cyclones are widely
used for removal dust of gaseous flows in industrial
processes. Cyclone dust collectors have been used in
many industrial facilities to collect solid particles from
gas-solid flows and to reduce air pollution originating in
chimney smoke from chemical plant drier equipment.

Awady et al. (2003) showed that cleaning
efficiency and total losses were positively affected by air
speed. Also, El-Balkimy (2006) mentioned that, the
total seed losses and cleaning efficiency were increased
by increasing the blown air velocity. He added that,
increasing the blown air velocity from 1.5 to 3 m/s led
to increase the seed losses and cleaning efficiency from
1.2% and 90.71% to 6.17% and 98.53% respectively.

The main objectives of this study was develop and
construct a bagging device depends primarily on a
cyclone and fit for bagging wheat chaff during threshing
operation.

MATERIALS AND METHODS

The developed device was manufactured in the
workshop of El-Gemeza Agricultural Research Station
El-Gharbia Governorate. The experiments carried out at
July 2016 to study the possibility of connecting a large
cyclone to the Turkish threshing machine for bagging
the wheat chaff during threshing operation.

The developed device

The developed device consists of a cyclone, four
pillars, and base as mentioned in Figs. (1,2). The
cyclone has special dimensions depending on the height
of the threshing machine, the quantity of wheat chaff,
entering air velocity and size of bagging unit. The
cyclone consists of chaff and air inlet 50 cm vertical ×
40 cm horizontal; barrel 150×100 cm of D×H; cone
150×75×50 cm of D₁×D₂×H and upper air outlet with
variable diameter. The upper air outlet was closed by a
lozenge wire mesh with a variable diameter to minimize
the chaff losses. The cyclone based on four removable
pillars (pipe 3.75×190 cm of D×H) and the pillars joined
with a removable base (150×150 cm) by mean of four
fixed pipes 5×20 cm of D×H at a distance of 68 cm
from the cyclone (the removable base and pillars to
facilitate the transporting of the device). During the
work, the removable base is fixed in the soil in front of
the threshing machine, and the four removable pillars
are joined with the cyclone, then two men can raise the
cyclone by the pillars and connect it by the base. Thus,
the device was assembled, after that the device is
connected to chaff outlet on the threshing machine by a
tube of cloth 75 cm in length. Thus, the wheat chaff exit
from the threshing machine with high velocity then
enter to the cyclone by means of the tubes of cloth.
The cyclone role is separates the chaff from air, as
the mix enters the cyclone tangentially and creates a vortex
in the cyclone and chaff particulates move toward the
cyclone wall and then settle into the bagging unit which
located above the base.

The used threshing machine

Turkish threshing machine was used in the
following study, the mentioned thresher has a spike tooth
drum with drum diameter of 70 cm, drum length of
120 cm and number of spike tooth 44 (30 cm long and
0.8 cm thickness). The power was transmitted from
tractor [Nasr, four-stroke diesel engine 44.10 kW (60
hp)] to thresher machine by a pulley and belt.

Studying variables

During the experiments, the following parameters
were examined: 1- Blown air velocity of the threshing
machine 14.4, 17.9, 20.1 and 23.6 m/s. 2- The diameter of
upper air outlet in the cyclone 50, 90 and 120 cm. 3-
The large diameter of the lozenge wire mesh 3.0, 6.0
and 10 mm. All treatments were carried out in three
replications for more accurate average data.

Measuring instruments

The following measuring instruments were used
during the present study:—
- A digital anemometer DT-618 was used to measure
  the air velocity.
- A touch type tachometer DT-2856 was used to
  measure drum and fan velocities.
- A digital electric balance of 50 kg of capacity and
  1 gm of accuracy was used to weight different
  samples.
- A graduate cup was used for determining the bulk and
  true densities.
- Three sieves with different mesh dimensions (3.0, 6.0
  and 10 mm) to categorize the chaff.

Experimental measurements

The influence of the mentioned variables on the
performance efficiency of the developed device was
evaluated by carrying the following measurements.

1- Air velocity at chaff and air outlets in the cyclone

The air velocity at the chaff outlet in the cyclone
should be close to zero, so an anemometer instrument
was used to measure the air velocity (m/s) at the chaff
and air outlets in the cyclone as a result of the change in
diameter of air outlet in the cyclone.
The chaff losses are the chaff which blowing with the air either from the chaff outlet or the air outlet in the cyclone, and this item of losses can be determined according to the following formula:-

\[ C_{lh} = \frac{C_{lw} - C_{lR}}{C_{lw}} \times 100 \]  

(1)

\[ C_{lw} = S_w - (G_w + Gl_w + N_d) \]  

(2)

2-Chaff losses

The chaff losses are the chaff which blowing with the air either from the chaff outlet or the air outlet in the cyclone, and this item of losses can be determined according to the following formula:-

\[ C_{lh} = \frac{C_{lw} - C_{lR}}{C_{lw}} \times 100 \]  

(1)

\[ C_{lw} = S_w - (G_w + Gl_w + N_d) \]  

(2)

**Table 1. The measured specifications of wheat chaff (Gemeza12)**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Average value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particle lengths</td>
<td></td>
</tr>
<tr>
<td>&lt; 3 mm (%)</td>
<td>14.08</td>
</tr>
<tr>
<td>3 to 6 mm (%)</td>
<td>8.61</td>
</tr>
<tr>
<td>6 to 10 mm (%)</td>
<td>34.04</td>
</tr>
<tr>
<td>&gt; 10 mm (%)</td>
<td>43.27</td>
</tr>
<tr>
<td>Friction angle</td>
<td>27.91°</td>
</tr>
<tr>
<td>Static coefficient of friction</td>
<td>0.53</td>
</tr>
<tr>
<td>Repose angle</td>
<td>46.52°</td>
</tr>
<tr>
<td>Bulk density, kg/m³</td>
<td>68.2</td>
</tr>
<tr>
<td>True density, kg/m³</td>
<td>329</td>
</tr>
</tbody>
</table>

**3-Grain losses and threshing efficiency**

Grain losses are the grains which collected from the chaff as a result for inappropriate fan velocity. These grains were collected, weighed and finally showed as a percentage by the following formula:-

\[ Gl = \frac{Gl_w}{G_w} \times 100 \]  

(3)

Where:-\( Gl \) is the percent of grain losses and \( Gl_w \) is the weight of grain which collected from the chaff gm and \( G_w \) is total weight of grain gm.

**4-Impurity ratio and cleaning efficiency**

Impurity is foreign materials mixed with the grainsand was not suctioned by the suction fan as a result to deficient velocity of fan or more pressure in air outlet. These foreign materials were collected by hand.
from three randomized samples and weighed, then the impurity ratio was calculated by the following formula:

\[ I = \frac{F_w}{S_w} \times 100 \]  
\[ C_e = 100 - I \]  

Where: \( I \) is impurity ratio (%), \( F_w \) is weight of the collected foreign materials (gm), \( S_w \) is weight of the sample (gm) and \( C_e \) is the cleaning efficiency (%).

RESULTS AND DISCUSSION

Air velocity at air and chaff outlets in the cyclone

Air velocity at upper air outlet

All volume of air which enters the cyclone should come out from the upper air outlet, provided that the diameter of that outlet was adjusted. The data plotted in Fig.(3) showed that, increasing the diameter of upper air outlet from 50 to 90 cm increased the velocity of the air which comes out from it by 42.5%, 158.3% and 53.6% at mesh holes diameters of 3, 6 and 10 mm; and thresher air velocity of 17.9 m/s. Then continued to increase by 23.8% with increasing the diameter to 120 cm at mesh holes diameter of 3 mm only, but decreased at 6 mm and 10 mm of mesh holes diameters by 3.2 and 23.3% at the same air velocity of the thresher of 17.9 m/s. That is because the opened area at the small diameter represents a small portion of the top surface of the cyclone; consequently the air is bump into the closed area then moves down and comes out from the chaff outlet. Also, at the diameter of 90 cm, the air velocity nearby the circumference of the hole was higher than that in the center. In addition to; decreasing the air velocity at 120 cm of air outlet diameter with 6 and 10 mm of mesh holes diameters is a result of increasing the opened area. The air velocity at air outlet was increased also by increasing each of mesh holes diameter and thresher air velocity. Increasing mesh holes diameter from 3 to 10 mm increased the air velocity by 600, 104.8 and 26.9% at 50, 90 and 120 cm of air outlet diameters respectively and 17.9% of thresher air velocity. Also, increasing thresher air velocity from 14.4 m/s to 23.6 m/s increased the air velocity at air outlet by 62.5, 50 and 32.1% at air outlet diameters of 50, 90 and 120 cm respectively and 10 mm of mesh holes diameter.

Decreasing air velocity with smallest diameter of mesh holes of 3 mm is a result of partial prevention of air passage from mesh holes. As well, increasing air velocity at air outlet with increasing the thresher air velocity is a result to increase the air pressure in the cyclone which corresponded with increasing the thresher air velocity.

Air velocity at chaff outlet

Air velocity at chaff outlet should be equal to zero or at least close to zero to prevent the chaff losing with air current. The obtained data explained that; any increasing in diameter of air outlet or mesh holes was corresponded with decreasing in air velocity at chaff outlet; on the other hand, the air velocity at chaff outlet was increased by increasing the thresher air velocity as mentioned at Fig.(4). The air velocity at chaff outlet was decreased by 96.82 and 92.4% with increasing the diameter of air outlet from 50 to 120 cm at mesh holes diameter of 10 mm and thresher air velocities of 14.4 and 17.9 m/s respectively; as well, it decreased by 87.50 and 71.43% by increasing the diameter of mesh holes from 3 to 10 mm at 120 cm of air outlet diameter and thresher air velocities of 14.4 and 17.9 m/s respectively. This is due to, the air passage from the top (air outlet) become more easily by increasing each of air outlet diameter and mesh holes diameter; consequently, the air was not repressed inside the cyclone. On the other hand, the air velocity at chaff outlet was increased from 1.6, 0.7 and 0.2 m/s to 4.1, 3.8 and 2.4 m/s by increasing the thresher air velocity from 14.4 to 23.6 m/s at air outlet diameter of 120 cm and mesh holes diameters of 3, 6 and 10 mm respectively. This is due to; the increment of the thresher air velocity led to repress the air inside the cyclone and force it to go out from the down (chaff outlet).

![Fig. 3. Effect of the diameter of air outlet, the diameter of mesh holes and thresher air velocity on air velocity at air outlet](image-url)
Fig. 4. Effect of the diameter of air outlet, the diameter of mesh holes and thresher air velocity on air velocity at chaff outlet

**Chaff losses**

A negative relation was remarked between the percent of chaff losses and each of air outlet diameter and mesh holes diameter; while, the relation was positive between the percent of the chaff losses and the thresher air velocity as clarified in Fig.(5). Increasing the diameter of air outlet from 50 to 120 cm decreased the chaff losses by 99.46 and 98.90% at 14.4 and 17.9 m/s of thresher air velocities respectively and 10 mm of mesh holes diameter. Also increasing the diameter of mesh holes from 3 to 10 mm decreased the chaff losses by 96.61 and 93.65% at 14.4 and 17.9 m/s of thresher air velocities respectively and 120 cm of air outlet diameter. The reason of that, the smallest diameters of air outlet and mesh holes cause high velocity of air at chaff outlet, which causes more chaff losses as a result of blowing the chaff which collected inside the bag. On the other hand, the percent of chaff losses was increased from 10.61, 3.81 and 0.36% to 23.73, 18.03 and 8.93% by increasing the thresher air velocity from 14.4 to 23.6 m/s at diameter of air outlet of 120 cm and diameters of mesh holes of 3, 6 and 10 mm respectively. This is due to increase the velocity of air passed from chaff outlet by increasing the thresher air velocity. The lowest value of chaff losses of 0.36 % was obtained at 120 cm, 10 mm and 14.4 m/s of air outlet diameter, mesh holes diameter and thresher air velocity respectively. While, the highest value of chaff losses of 88.71% was obtained at 50 cm, 3 mm and 23.6 m/s of air outlet diameter, mesh holes diameter and thresher air velocity respectively.

**Grain losses**

The grain losses represent the grains which suctioned with the chaff as a result to inappropriate fan velocity. The obtained data referred to, neither diameter of air outlet nor diameter of mesh holes affected the grain losses, but it was increased by increasing the thresher air velocity as mentioned in Fig.(6). The percent of grain losses increased from 0.0 to 0.86% by increasing the thresher air velocity from 14.4 to 23.6 m/s at 120 cm and 10 mm of air outlet diameter and mesh holes diameter respectively. The reason of that, increase the suction force of fan to be more than the critical velocity of wheat grains, causing suction of grains with the chaff.

**Impurity ratio and cleaning efficiency**

Impurity ratio was decreased with increasing each of; air outlet diameter, mesh holes diameter and thresher air velocity as mentioned in Fig. (7), whereas the cleaning efficiency was increased as mentioned in Fig. (8). Increasing the diameter of air outlet from 50 to 120 cm decreased the impurity ratio by 59.83 and 76.96%, while the cleaning efficiency was increased by 1.47 and 1.39% at mesh holes diameter of 10 mm and thresher air velocities of 14.4 and 17.9 m/s respectively. Also, the impurity ratio decreased by 55.55 and 73.20% and the cleaning efficiency increased by 1.23 and 1.14% with increasing the diameter of mesh holes from 3 to 10 mm at air outlet diameter of 120 cm and thresher air velocities of 14.4 and 17.9 m/s respectively. This is due to, the small diameter of air outlet and mesh holes cause high air pressure inside the cyclone, which decreases the fan efficiency. In addition to, increasing the thresher air velocity from 14.4 to 23.6% decreased the impurity ratio from 0.96 to 0.03% and increased the cleaning efficiency from 99.04 to 99.97% at air outlet diameter of 120 cm and mesh holes diameter of 10 mm. This is because of increasing the thresher air velocity means increase the suction force of fan, consequently; decreasing impurity ratio and increasing cleaning efficiency.

The lowest value of impurity ratio of 0.03 % with the corresponding highest value of cleaning efficiency of 99.97% were obtained at 120 cm, 10 mm and 23.6 m/s of air outlet diameter, mesh holes diameter and thresher air velocity respectively. While, the highest value of impurity ratio of 4.49% with the corresponding lowest value of cleaning efficiency of 95.51% were obtained at 50 cm, 3 mm and 14.4 m/s of air outlet diameter, mesh holes diameter and thresher air velocity respectively.

**Economic analysis**

Through the season of storage of wheat chaff of 2016, the field study indicates that, the total cost of storing one feddan of wheat chaff by workers is 500 L.E.; where, this work can be distributed evenly over 8 workers with 2 carts; consequently, the wage of the worker is 50 L.E./fed.
Fig. 5. Effect of the diameter of air outlet, the diameter of mesh holes and thresher air velocity on chaff losses

Fig. 6. Effect of the diameter of air outlet, the diameter of mesh holes and thresher air velocity on grain losses

Fig. 7. Effect of the diameter of air outlet, the diameter of mesh holes and thresher air velocity on impurity ratio
The bagging operation is conducted by 4 workers, so the total cost of bagging operation by workers is 200 L.E/fed. The total cost of manufacturing the developed device is about 2500 L.E, and can perform throughout a later five seasons. Assuming that the length of threshing season is one month and daily operating time is 8 hours, so the developed device can perform about 1200 hours (five hours), so the fixed cost is about 2.5 L.E/h. Whereas, the normal range of the time required for threshing one feddan of wheat is 4 hours; consequently, the total fixed cost of bagging wheat chaff of one feddan by the developed device is 10 L.E/ fed

CONCLUSION

For optimizing the wheat threshing machines, minimizing each of grain and chaff losses of wheat, maintaining the cleaning efficiency and protecting the health of workers; a chaff wheat bagging device was developed and evaluated, and the following is a summary of the obtained results:

1- Increasing the air outlet diameter from 50 to 120 cm decreased the air velocity at chaff outlet, chaff losses, and impurity ratio and increased the cleaning efficiency. The air velocity at air outlet increased by increasing the diameter of air outlet from 50 to 90 cm, and then decreased by increasing it to 120 cm. The grain losses not affected by varying of air outlet diameter.

2- Increasing the mesh holes diameter from 3 to 10 mm decreased the air velocity at chaff outlet, chaff losses and impurity ratio, while it increased the air velocity at air outlet and cleaning efficiency. The grain losses not affected by varying of mesh holes diameter.

3- Increasing the threshing air velocity from 14.4 to 23.6 m/s increased air velocity at air outlet, air velocity at chaff outlet, chaff losses, grain losses and cleaning efficiency, while it decreased the impurity ratio.

4- The optimum conditions for using the developed device are 120 cm of air outlet diameter, 10 mm of mesh holes diameter and 17.9 m/s of threshing air velocity. Where, the air velocity at air outlet was 3.3 m/s, air velocity at chaff outlet was 0.6 m/s, chaff losses was 0.82%, grain losses was 0.22%, impurity ratio was 0.41% and cleaning efficiency was 99.59%.

5- The total costs of the developed device were about 10 L.E/fed. compared with 200 L.E/fed. for the traditional method.

REFERENCES


الهدف من الدراسة هو تطوير جهاز تعبئة التين أثناء عملية الدراسة، واختبار أداء جهاز تعبئة التين المطور في تعبئة تين القمح (جميز ٦٢) حيث أجريت التجارب بمحطات البحوث الزراعية بالجيزة في يوليو ٢٠١٦ ويتكون الجهاز المطور من مكونات مثبت على أربع قوائم مسطحة الفك والتركيب، وتثبت القوائم الأربعة على قاعة الجهاز المربعة الشكل والمغطاة بالصمام المحمل، وهي تستطيع تثبيت الجهاز في القرص وحول وحدة التعبئة وتسايل فكى أثناء التشغيل. ودائمًا يكون من جزء علوي برملي الشكل بقدر ١٥ متر إرتفاع ١ م وتحكي هذ الجزء على فتحة الإتصال بداخل الدراسة أثناء التشغيل وفتحة أخرى علوية لخروج الهواء المتفاصل، والتي قد تم دراسة مستويات مختلفة لطول فتحة قطعها ٥٠ و٥٢ سم، وقد تُستعمل جهاز متعدد شكل متفاصل لقطرها وثب و٣ و٦ و١٣ سم والمهدف من استخدامها هذه الشبكة السلوكية هو تقليل فائد التين مع الهواء. والسيكلون يكون من جزء آخر سطفي مخزوني الشكل قطره العلوى هو قطر الجزء البيني وقطره السفلي ٥٣ سم وارتفاع المحروكي ٥٠ سم، والعمود السطفي منه هي فتحة خروج التين.

وتم أيضاً دراسة تأثير مستويات مختلفة من سرعة الهواء المتدفعة من مروحة الشفط في الدراسة في ٢٠١٦ و٤.٩١، ١٣.١، ١٦.١ و٢٣.٣ م/ث، وذلك على كل من سرعة الهواء عند فتحة خروج الهواء وسرعة الهواء عند فتحة خروج التين ونسبة الفاقم من التين ونسبة الفاقم من الحبوب خلال المرفوعة ونسبة الشباوب وكفاءة التنظيف. وقد تم بين النتائج أن: زيادة قطر فتحة خروج الهواء من ٥٠ إلى ٧٠ سم أدى إلى تنافص كامل من: سرعة الهواء عند فتحة خروج التين ونسبة الفاقم من التين وكذلك نسبة التشابوب مع الحبوب. بينما سرعة الهواء عند فتحة خروج الهواء زيادة بزيادة قطر من ٥٠ إلى ٧٠ سم، ثم تناقصت زرايدة مره أخرى إلى ٢١٠ سم. أيضاً نسبة الفاقم من الحبوب من خلال مروره الشفط لم تتأثر بزيادة قطر فتحة خروج الهواء زيادة فتحة الشبكة السلوكية من ٣ إلى ٣٠ سم أدت إلى تنافص كامل من: سرعة الهواء عند فتحة خروج التين ونسبة الفاقم من التين وكذلك نسبة التشابوب، بينما أثرت سرعة الهواء عند فتحة خروج التين وكذلك كفاءة التنظيف أيضاً نسبة الفاقم من الحبوب من خلال مروره الشفط لم تتأثر بزيادة قطر فتحة الشبكة السلوكية زيادة سرعة الهواء المتدفعة من مروحة الشفط من ٤ لـ١٤ م/ث أدى إلى زيادة كل من: سرعة الهواء عند فتحة خروج الهواء، سرعة الهواء عند فتحة خروج التين، نسبة الفاقم من التين ونسبة الفاقم من الحبوب، وكذلك وكفاءة التنظيف. بينما تناقصت نسبة التشابوب مع الحبوب. وبإجمالي النتائج أن قطر المتدفعة من فتحة خروج الهواء هو ١٢٠ سم وقطر فتحة الشبكة السلوكية هو ٢٠ سم وأن سرعة الهواء المتدفعة من مروره الشفط في الدراسة هو ١٨.٦ م/ث. حيث كانت سرعة الهواء عند فتحة خروج التين هي ٠.٨ م/ث وسعة الهواء عند فتحة خروج التين ٠.٩٣ م/ث ونسبة الفاقم من خلال المروره ٣٠.١% ونسبة التشاوب ٠.٤% وكفاءة التنظيف ٩٩.٥%.