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DESIGN OF SIMPLE CORN SHELLERS FOR FARMER HOUSE

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Abstract

The objective of present investigation is to design simple farmer house corn shellers. Two simple maize shellers, hand and motor type were fabricated and tested to obtain the torque and power requirements for husked corn ear shelling process at different moisture contents. The study revealed the following results:

1- Hand sheller:

When grain moisture content decreased from 14 to 10 %, grain visible breakage and/or cracks as well as unshelled grain were negligible at all study variables, while grain cleaning efficiency decreased from 99.81 to 99.52 % and torque needed for shelling decreased from 0.12 to 0.04 N.m, and the performance rate increased from 21 to 24 kg/h.

- The house hand sheller may be recommended for use with an economical advantage (operating cost of one ton + cost of the grain losses) of 90.96 LE/ ton compared to manual shelling, which would cost 142 LE/ton.

2- Motorized sheller:

When grain moisture content decreased from 14 to 10 %, grain visible breakage was negligible at all study variables, meanwhile cracks decreased from 3.4 to 2.1 %, unshelled grain decreased from 2.0 to 1.16 %, while grain cleaning efficiency decreased from 99.2 to 99.0 % and power needed for shelling decreased from 30 to 12 Watt (0.040 to 0.016 hp), and the performance rate increased from 87 to 90 kg/h. The cracks, performance rate, and power requirements increased by increasing the threshing drum speed, meanwhile the unshelled grain, and cleaning efficiency decreased.

- The house motorized sheller may be recommended for use with an economical advantage (operating cost of one ton + cost of the lost grains) of 40.33 LE/ ton.

INTRODUCTION

Corn is considered as one of the most important grain crops in Egypt. The annual cultivated area of corn in Egypt is around 2 million feddans (0.84 ha) yearly. The total production of grains from this area is about 5.5 million tons (Ministry of Agriculture, 2000). The hand shelling process is still done daily in the farmer house to feed animals, birds and also in preparing food. There are many large and moderate types of the corn

shelling machines available in Egypt, but there is no simple mechanical or hand sheller for the farmer's house. Abdel Mageed and Hemeda (1991) concluded that the moisture content has the greatest influence on the mechanical properties of grains. The sphericity of kernels have positive correlation coefficient with the rupture force when laid on edge position and negative coefficient when laid flatly. Mahmoud and Buchele (1975) studied the kernel damage of corn at different moisture contents for three different orientations. The ears of corn were fed into conventional shellers with their axes oriented parallel to the axis of the drums. Whereas, the shelling process of the combine cylinder has been studied by viewing high-speed film. The ears of corn were fed into the concave, with the axis of the ear oriented perpendicular to, at an angle to, and parallel to the axis of the cylinder. They found that the roll-in orientation suffered the least damage at all moisture contents tested. The minimum damage for all orientations was between 20 and 22% moisture content. Abou El-Kheir (1976) mentioned that the visible grain damage progressively increased with increasing the cylinder speed, while decreasing the unshelled losses. Gunasekaran and Paulsen (1985) investigated the breakage resistance of two corn genotypes. Corn samples dried at different air temperatures were used to investigate the effect of drying rates on the breakage susceptibility, which increased. The average applied force and compressive energy absorbed at the yield and rupture points for individual kernels, which were found, decreased. Harris, and Wilkes (1991) concluded that the power requirements of a corn sheller will vary from 10 to 35 hp (7.5 to 26.25 kW), the cylinder speed ranged from 600 to 1000 rpm, and the capacity was influenced by the percentage of husk on the ear, the moisture content of the kernels, the feeding rate, and the size of the cylinder. The large stationary units will shell 40 to 50 tons/h, while the smaller portable units will shell from 3.25 to 8.13 tons/h. some corn shellers are equipped with blowers to handle both the shelled corn and the cobs separately. Sacking attachments are available for some of the portable units. Metwalli *et al.* (1995) stated that the small manual or electrical shelling machines that were used for Al-Gharbia, Dakahlia and Kafr El-Sheikh Governorates were of very limited capacity and high losses.

The objectives of the present investigation are:

(1) Determination of some physical properties of corncobs.

(2) Design of two simple shellers (hand and motorized shellers).

(3) Fabricate and test simple hand and motorized corn shellers.

MATERIALS AND METHODS

The experiments of the motorized corn and hand shellers were carried out in the Agricultural Engineering Research Institute (Lab. of the Mechnization of Field and Horticulture Crop Res. Dept.).

1. Features of shellers:

a- Hand sheller specifications:

The fabricated hand sheller was designed to suite the common Egyptian corn varieties. It has octagonal cylindrical shape, of 24 mm side length and 80 mm height (Fig1). It consists of 4 similar steel plates, each one of 89 mm length, 80 mm height and one mm thickness (Fig. 2). The plate was formed by cutting and bending the edges (Fig. 3). The sides were assembled by welding. The final form will be given the name (AEnRI-Sh1).

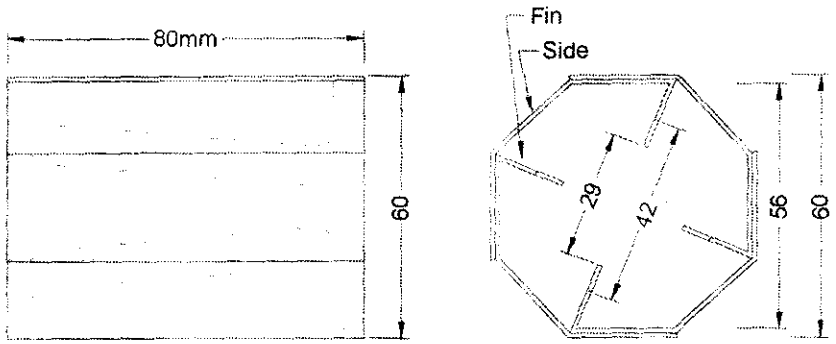

Fig. 1. Hand sheller (AEnRI-Sh1).

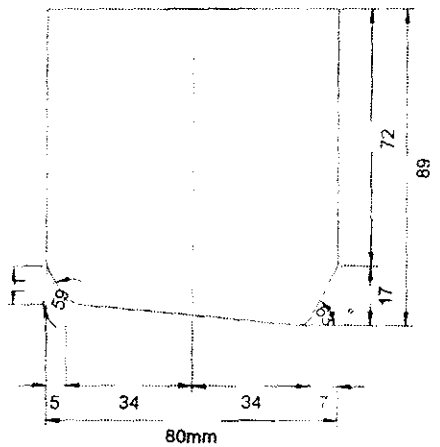

Fig. 2. Steel plate shape.

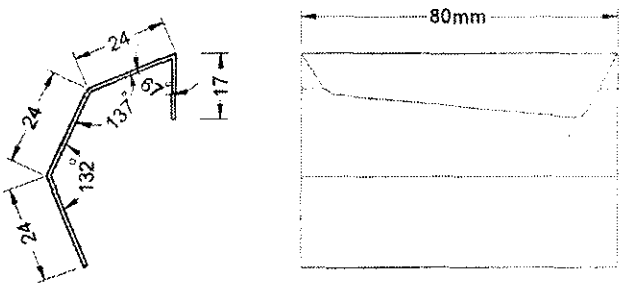

Fig. 3. The formed plate.

Shelling process was done, by pushing the corn ear inside the hand sheller, and twisting it to the right and left directions, consequently then the seeds drop by gravity.

b- Motorized sheller description:

The sheller is sketched in Fig. (4). It will be given the name (AEnRI-Sh2), since it is a new design for the corn sheller. It has a small threshing cylinder that rotates in a small housing. The assembly is bolted to the sheller frame for simple removal when need to repair. The drum cover has a feed intake opening at the top. The threshing cylinder is hollow with 4 fins fixed inside the cylinder, 105 mm cylinder length, 60 mm inside diameter, 70 mm outside diameter, and 39 mm top clearance of fins, 29 mm bottom clearance of fins. When the corn ear is inserted inside the cylinder the fins remove the seeds from the cob, and the threshed seeds and cob drop through the hollow part of the cylinder.

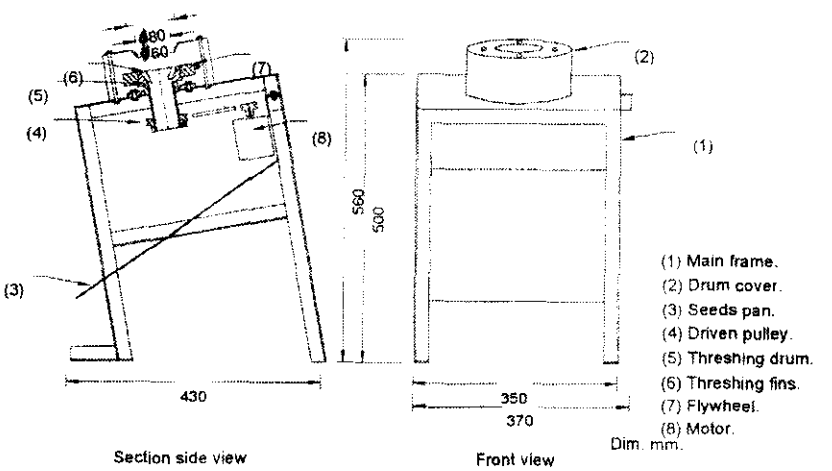

Fig. 4. Motorized sheller (AEnRI-Sh2).

2- Crop varieties:

The Egyptian corn varieties used in this study were S. H. 10; S. H. 122; S. H.124; S. H. 310; S. H. 320; S. H. 321; S. H. 322; Bashaier 13 and Nefertity 3.

3- Invisible grain damage:

The following equation was used to calculate the percentage of invisible grain-damage.

$$g_{inv.d} = (g_{inv} / t_{gp}) . 100$$

Where:

$g_{inv.d}$ = Percentage of the grain invisible damage, %.

g_{inv} = Grain invisible damage, kg.

t_{gp} = Total clean grain production, kg.

4- Cleaning efficiency:

The cleaning efficiency was calculated according the following equation:

$$\eta_c = t_{gp} / (t_{gp} + Im) . 100$$

Where:

η_c = Cleaning efficiency, %.

Im = Impurities, kg.

RESULTS AND DISCUSSION

1- Some physical characteristics of corn varieties:

Table (1) shows some physical characteristics of corn ear for the most important common cultivars. These characteristics were considered in the design of the hand, and the motorized shellers.

Table (1): Some physical characteristics of the common corn cultivars:

Variety	Corn ear length, cm	Corn ear dia., (average) cm	No. of kernel rows.	Weight of 1000 kernel, g
S.H. 10*	25	5	14	420
S.H. 122	22	5	14	350
S.H. 124	21	5	14	350
S.H. 310	24-27	5	14-16	380-400
S.H. 320	25	5.1	14	430
S.H. 321	22	5.1	14-16	350
S.H. 322	20	5.1	16	370
Bashier 13	20-24	5	14-16	460
Nefertity 3	20-22	4.75	14	375

* S.H. = Single hybrid.

2- Effect of moisture content on the grain damage:

The effect of the grains moisture content on the invisible grain damages is shown in Fig. (5). It is clear that the invisible grain damage decreased from 0.41 to 0.1% for the hand sheller and from 3.4 to 2.1% for the motorized sheller by decreasing the grain moisture content from 14 to 10 %, respectively. This may be due to the increase of kernel hardness by decreasing the kernel moisture content.

3- Effect of moisture content on cleaning efficiency:

The effect of the grains moisture content on the shellers cleaning efficiency is shown in Fig. (6), which shows that the cleaning efficiency increased from 99.52 to 99.81 % for the hand sheller and from 99.00 to 99.20 % for the motorized sheller by increasing the moisture content from 10 to 14 %, respectively. This may be due to the increase in the cohesion force of the corncob.

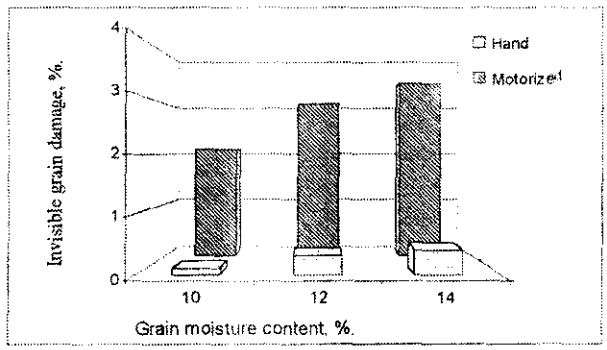

Fig. 5. The relationship between moisture content and invisible grain damage of shelled corn crop for motorized and hand shellers.

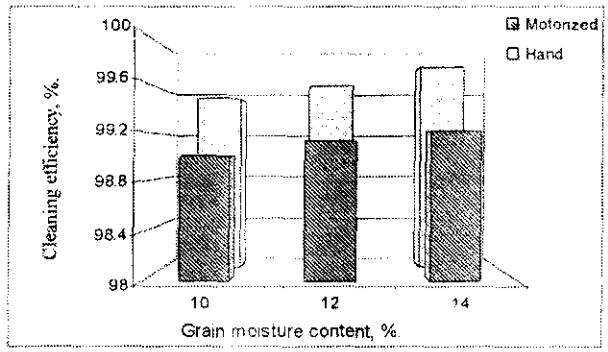

Fig. 6. The relationship between moisture content and grain cleaning efficiency of corn crop for motorized and hand shellers.

4- Effect of grains moisture content on unshelled grain losses:

There was not any unshelled corn grain losses by using the hand sheller at different grain moisture contents. The effect of the moisture content on the unshelled grain is shown in Fig. (7). It is shown that, by increasing the moisture content from 10 to 14 %, the unshelled grain increased from 1.16 to 2.00 %, respectively.

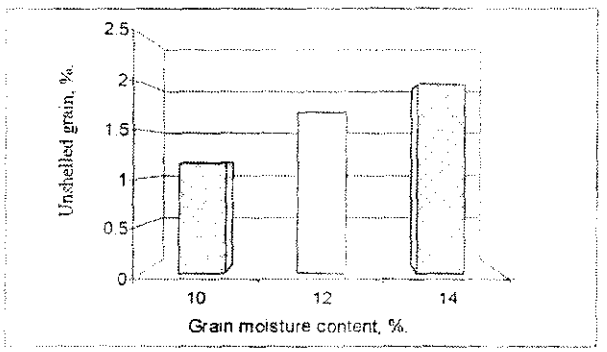

Fig. 7. The relationship between moisture content, % and the unshelled grain losses.

5- Torque requirement:

The relationship between torque requirement and grain moisture content for the hand sheller is shown in Fig. (8). By decreasing the moisture content from 14 to 10%, the torque decreased from 0.12 to 0.04 N.m, respectively. This may be due to the increase in the adhesion force between grains and corncob.

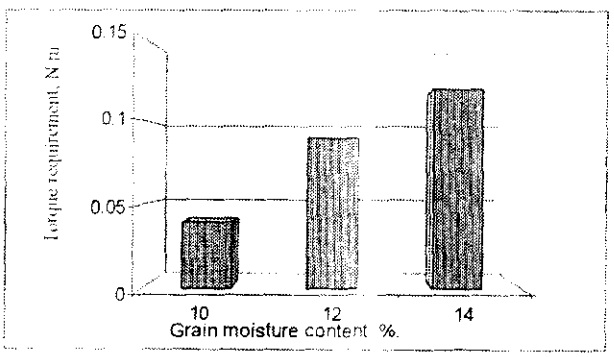

Fig. 8. The relationship between moisture content, % and torque , in N.m for threshing corn grain.

6- Power consumed:

The relationship between power consumed and grain moisture content for the motorized sheller is shown in Fig. (9), indicating that decreasing the grain moisture content from 14 to 10%, the power decreased from 30 to 12 Watt (0.040 to 0.016 hp), respectively. This may be due to the decrease in adhesion force between grains and corncob.

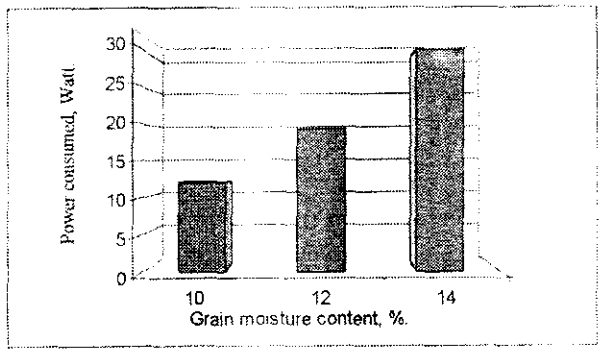

Fig. 9. The relationship between moisture content and power consumed, in Watts for the motorized sheller.

7- Performance rate:

The effect of grain moisture content on the performance rate is shown in Fig. (10). Where the decrease in the grain moisture content from 14 to 10 %, increased the performance rate from 21 to 24 kg/h and from 87 to 90 kg/h for the hand and motorized shellers, respectively.

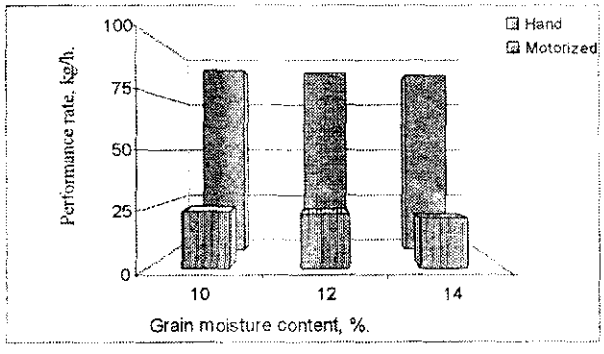

Fig. 10. The relationship between moisture content and performance rate, kg/h of corn for motorized and hand shellers.

8- Threshing drum speed:

At 14% grain moisture content and increasing the drum speed from 2.6 to 3.5 m/s (1100 to 1400 rpm), the performance rate, and power requirement increased from 80 kg/h to 87 kg/h, and from 15 to 30 Watt, respectively, meanwhile the unshelled grain, and cleaning efficiency decreased from 2.8 %, to 2.0 % and from 99.5 % to 99.2%, respectively and the effect of drum speed on the grain invisible damage was irrelevant variations (Figs. 11 and 12).

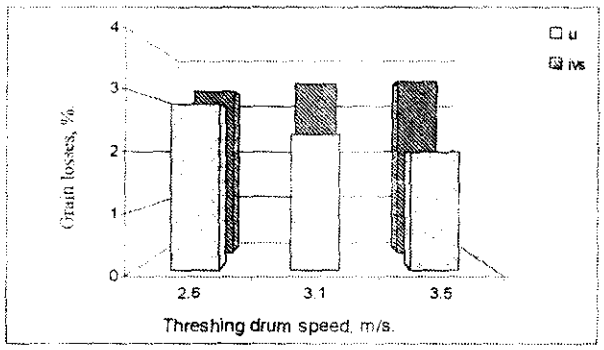

Fig. 11. The relationship between threshing drum speed m/s and the invisible grain damage (inv) %, unshelled grain (u) %, and cleaning efficiency (ce) % at 14 % of grain moisture content.

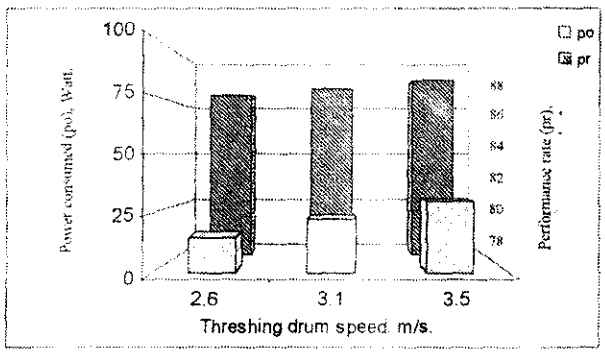

Fig. 12. The relationship between, threshing drum speed m/s and performance rate pr, and power requirement po at 14% of grain moisture contents.

9- Unit cost:

The total cost was estimated by summing the fixed and variable costs, which were: sheller initial price, depreciation, interest, taxes, housing, lubricating oil, repairs and labour wages.

The cost of shelling one ton of corn grain was estimated to be 33.33 LE and 89.5 LE for the motorized and hand shellers, respectively, while the cost of shelling one ton manually was 142 LE.

CONCLUSION

The physical characteristics of corn ears were, from 20 cm to 27 cm corn ear length, from 4.75 cm to 5.10 cm corn ear diameter, 14 and 16 seeds rows on the cob, and from 350 g to 460 g weight of kernel. which was considered in the design of the hand, and motorized shellers.

When the grain moisture content decreased from 14 to 10 %, grain visible breakage were negligible at all studied parameters, the invisible grain damage decreased from 0.41 to 0.1% for the hand sheller and from 3.4 to 2.1% for the motorized sheller, the unshelled grain decreased from 2.00 to 1.16 % for the motorized sheller and there was not any unshelled grain by using the hand sheller, the cleaning efficiency decreased from 99.81 to 99.52 % for the hand sheller and from 99.20 to 99.00 % for the motorized sheller, the torque requirement decreased from 0.12 N.m to 0.04 N.m for the hand sheller, the power consumed decreased from 22.5 to 12 Watt (0.040 to 0.016 hp) for the motorized sheller, the performance rate increased from 21 to 24 kg/h for the hand sheller and from 87 to 90 kg/h for the motorized sheller.

At 14% grain moisture content, increasing the drum speed from 2.6 to 3.5 m/s (1100 to 1400 rpm), the grain invisible damage, performance rate, and power consumed increased from 3.2 % to 3.4 %, 80 kg/h to 87 kg/h, and 15 Watt (0.02 hp) to 0.03 Watt (0.04 hp), respectively, meanwhile the unshelled grain, and cleaning efficiency decreased from 2.8 %, to 2.0 % and 99.5 % to 99.2%, respectively.

The cost of shelling one ton of corn grain was 33.33 LE/ton and 89.5 LE/ton for the motorized and hand shellers, respectively.

The house corn-sheller is recommended for use with an economical advantage (operating cost of one ton + cost of the lost grains) of 40.33 LE/ton and 90.96 LE/ton for the motorized and hand shellers, respectively.

REFERENCES

1- Abdel Mageed, H. N. and M. A. Hemeda. 1991. Effect of some physical and chemical properties on rupture force of corn kernels. Misr J. Agric. Eng., 8 (2): 110 - 119.

2- Abou El-Kheir, M. M. 1976. A study on possibilities of corn husking and shelling by threshing machines. M. Sc., Thesis, Agric. Eng. Dept., Al-Azhar Univ., 36 – 42.

3- Gunasekaran, S. and M. R. Paulsen. 1985. Breakage resistance of corn as a function of drying rates. Trans. of ASAE, 28 (6): 2071 – 2076.

4- Harris, P. S. and L. H. Wilkes. 1991. Farm Machinery And Equipment, Textbook. Tata McGraw-Hill Pub. Co. pp: 391 sixth edition, eighth reprint.

5- Mahmoud A. R. and W. F. Buchele. 1975. Corn ear orientation effects on mechanical damage and forces on concave. Trans. of ASAE, 18 (3): 444 – 447.

6- Metwalli, M. M.; M. A. Helmy; S. M. Gomaa and M. E. Badawy. 1995. Performance evaluation of some maize shelling machinery. Misr J. Agric. Eng., 12 (2): 420 - 438.

7- Ministry of Agriculture and Land Reclamation. 2000. Agricultural Economics and Statistics, Central Administration of Agricultural Economics, Egypt.

8- National Maize Research Prog., 2000. Field Crops Res. Inst. Annual Report, Agric. Res. Center, Ministry of Agriculture, Egypt.

تصميم فراطة أذره مبسطة لبيت المزارع

الأمين محمد عارف

معهد بحوث الهندسة الزراعية - مركز البحوث الزراعية - وزارة الزراعة.

يعد محصول الذرة من المحاصيل الاقتصادية الهامة فى مصر حيث يزرع على مساحة حوالى ٢ مليون فدان سنوياً وبإنتاجية متوسطة ٥,٥ مليون طن (وزارة الزراعة وإستصلاح الأراضى ٢٠٠٠). وتعد الذرة الشامية من المحاصيل التى يحتاجها بيت المزارع الكبير والصغير طوال العام. فيقوم بتفريط الحبوب يدوياً أو بإستخدام آلات معقدة التركيب منها ما هو محلى الصنع ومنها ما هو مستورد وكلا النوعين بمحرك أو يدار يدوياً أو بجرار. توجد بعض الأدوات اليدوية البسيطة منتشرة فى العالم وغير معلومة فى مصر حتى الأن. الأمر الذى دعى إلى إجراء هذه الدراسة لتصميم وإختبار أداة يدوية للتعرف على العزم اللازم للتفريط ومنها يمكن إيجاد آلة بموتور متوسطة الإنتاجية تناسب منزل المزارع الصغير. وكانت أهم النتائج المتحصل عليها:

١- تقديم نموذجين لتفريط الحبوب الأول هو الأداة اليدوية وتم تسميته (AEnRI-Sh1) والثانى هو آلة التفريط وتم تسميته (AEnRI-Sh2).

٢- بانخفاض المحتوى الرطوبى من ١٤ إلى ١٠ ٪ انخفضت النسبة المئوية للكسر الغير ظاهرى من ٠,٤١ إلى ٠,١ ٪ ومن ٣,٤ إلى ٢,١ ٪ وكانت نسبة الحبوب غير المفرطة صفر وإنخفضت من ٢,٠٠ إلى ١,١٦ ٪ وانخفضت النسبة المئوية لنظافة الحبوب من ٩٩,٨١ إلى ٩٩,٥٢ ٪ ومن ٩٩,٢٠ إلى ٩٩,٠٠ ٪ بينما ارتفعت الإنتاجية من ٢١ إلى ٢٤ كج/س ومن ٨٧ إلى ٩٠ كج/س لكلاً من الأداة (AEnRI-Sh1) والآلة (AEnRI-Sh2) على التوالى وأنخفض العزم المطلوب للتفريط من ١٢٠٠ نيوتن . متر إلى ٤٠٠٠ نيوتن . متر، على التوالى للأداة اليدوية (AEnRI-Sh1) وأنخفضت القدرة المطلوبة للتفريط من ٣٠ وات إلى ١٢ وات على التوالى للآلة (AEnRI-Sh2).

٣- بزيادة سرعة درفيل الدراس من ٢,٦ م/ث إلى ٣,٥ م/ث (١١٠٠ لفة/دقيقة إلى ١٤٠٠ لفة/دقيقة) إرتفعت نسبة الحبوب المكسورة بنسبة غير محسوسة وكذلك بالنسبة لإنتاجية الآلة من الحبوب وللقدرة من ٣,٢ ٪ و ٨٠ كج/س و ١٥ وات إلى ٣,٤٪ و ٨٧ كج/س و ٣٠ وات، على التوالى بينما إنخفضت نسبة الحبوب الغير مفرطة والنسبة المئوية للنظافة من ٢,٨ ٪ و ٩٩,٥ ٪ إلى ٢,٠ ٪ و ٩٩,٢ ٪ على الترتيب.

٤- قدرت تكلفة تفريط طن من حبوب الذرة ٨٩,٥ جنيه مصرى و ٣٣,٣٣ جنيه مصرى لكلاً من الأداة اليدوية (AEnRI-Sh1) والآلة (AEnRI-Sh2) على الترتيب، بينما كانت تكلفة تفريط طن من حبوب الذرة يدوياً ١٤٢ جنيه.