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EVALUATION OF A GARLIC DETACHER

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Abstract

Experiments were conducted to study the mechanical detaching of garlic. A 3 horsepower electric motor driven detacher was fabricated at the AEnRI workshop. The machine is scaled down copy from a larger American made garlic detacher. The garlic bulbes fall from the machine hopper on the top of a horizontal conveyor belt moving below the detaching drum, which rotates in opposit direction. The detaching action occured when the lower surface of the bulb moves in a direction and at a speed different from the upper side of the bulb by the action of the frictional forces. The effect of garlic bulb size as well as coefficient of friction of garlic material and belt material was studied. The effect of drum speed (V_d), belt speed (V_b) and drum to belt clearance on the performance of the detacher was also studied. Detaching increased at the lower Vd/Vb. Damage increased with the increase of V_d/V_b and at the smaller clearance between the belt and the drum.

Final results showed that maximum detaching performance gave 43% single cloves, 37% double attached cloves and about 5.5% multiple attached cloves were achieved at V_d/V_b ratio of 0.37.

INTRODUCTION

Egypt plants more than 125000 feddans of garlic representing the second important vegetable crop, after onion. Average production of garlic crop is 7 tons/ feddan which is considered the second highest world productivity after Spain (General Administration of Agricultural Extension 1987). Homer et al, (1988), stated that many varieties of garlic have been planted in Egypt such as Baladi, Chinese and American garlic. The Egyptian garlic variety (Baladi) is the prevailing variety because of its good storage characteristics, bigger bulb containing large number of cloves. He also added that the structure of garlic bulbs is different than that of onion bulb. Garlic bulb consists of a group of small bulbs known as cloves which are coated with a thin soft skin. Cloves are used as seed for planting new garlic fields. Hassan, A.A. (1989) stated that garlic bulb structure includes 4 to 8 rows of garlic cloves. Each one contains 8-14 cloves where the inner layers are smaller than those at the outer layers. The Baladi variety includes up to 60 cloves meanwhile the chinese variety includes a relatively less number of cloves ranging from 5 to 20 cloves distributed on two layers. Hassan, A.A. (1991) reported that selecting large garlic bulbs and garlic cloves for planting will help increase productivity. Uniform planting also produce uniform garlic bulbs. A.T.U.T. (1996) recommended that when planting garlic, the cloves are detached from the bulb where 100 to 250 kg of cloves are required for one feddan according to the variety. Large sound and healthy bulbs are selected. Detaching cloves from garlic bulbs is recommended to be done short time before planting. Selecting big cloves for planting is also recommended.

Mohsenin (1970), reported that the physical properties of materials such as shape, size, volume, surface area are important in many problems associated with the design or development of a specific machine, analysis of the behavior of the product in handling of the material, stress distribution in the material under load, electrostatic separation of grains, light reflectance and color evaluation. Regarding the important design parameters in conveying of solid materials using air or water, accurate estimates of the frontal area and the related diameters are essential for the determination of terminal velocity, drage coefficient, and Reynolds number. He also stated that in certain applications where both shape and size affect the conveying process, the relationship can be expressed by a single, two dimensional system as follows:

I = f (sh, s) where "I" is an index influenced by both shape "sh" and size "s". In other applications, the index "I" may be a function of not only shape and size but also of such other parameters as orientation "o", packing "p", firmness "f" .. etc, as follows: I = f (sh, s, o, p, f, ...). Handerson et al., (1981), mentioned that the performance of a machine for reducing the size of material is characterised by the capacity, the power required per unit of material reduced, the size and shape of the product before and after reduction, and the range in size and shape of the resultant product. They added that cleaning, sorting, and partial or perhaps final grading or classifying the products being considered are based on the following characteristics of the material: size, shape, specific gravity, and surface characteristics. The first three parameters are the most important. Surface characteristics as differentiated from shape affect the coefficient where an air blast is used for separation.

Spivakovsky and Dyachkov (1986), mentioned that the conveyor belts should meet the following requirements : low hygroscopicity, high strength, low own weight to ply specific elongation, high flexibility, high receptivity to ply separation, and long service life. Rubberized belts meet these requirements better than other types and are, therefore, generally preferred. The rubberized textile belts are made from several layers, known as plies, of a rough woven cotton fabric, known as belting. The cacaos, absorbing longitudinal tensile stresses and the impact of the load on the belt, the rubber cover and "shim coats" serving to cement the plies protect them against moisture and mechanical damages. Chung et al, (1989), illustrated that the friction coefficient depends not only on the material in contact but also on the condition of the material surface. They reported that the dynamic friction coefficient was less than the static value. Mohsenin, (1970), reported that the friction coefficient of organic material is independent of the normal pressure and agreed with what has been found for dry friction of engineering materials.

MATERIALS AND METHODS

Experiments were carried out at the AEnRI head quarter workshop to study mechanical detaching of garlic bulbes. The main objective of the operation is to use a mechanical method for detaching garlic for planting purposes.

The mechanical detaching machine :

A portable electric motor drum type garlic detacher was used for the study. The machine was scaled drown in size at the AEnRI workshop from an original American made larger machine. Wheels were fixed to the machine frame to facilitate easy transportation for operating the machine at different locations.

The machine, Fig. 1., consists of three functional units in addition to the machine frame, power transmition and the electric motor. The description of the machine operation and functional units may be presented as follows:

1. The machine hopper located at the rear end of the machine, with its vertical wall facing the detaching drums has adjustable rectangular chute allowing garlic bulbs to be fed by gravity on a 40 cm width belt.
2. The feeding belt is a cotton Indian yellow 3 mm thickness 3 plies-40 cm width moving on two rollers spacing 180cm. The drive roller is mounted at the front end of the machine frame which rotates to allow the upper side of the belt to be always tight. The rear roller (idler) on which the feeding belt is moving is also used for belt tightening. Sprockets and chains are used to transport power to the

belt where the linear speed of the belt can only be changed by changing the number of sporcket teeth.

3. The detaching system consists of the three equal size drums. The drum is a steel cylinder which is coated with two layers. The inner layer is compressable rubber which was covered by a one centemeter cotton robe outer layer. A sheet of plastic was finally fixed on the cotton robe, the gross diameter of the drum is 23 cm. The free end of the drum arm is attached to a spring loaded pin to facilitate flexible clearance at the garlic bulbs feeding side of the drum. Spring pressure may be adjusted to facilitate operating the machine at variable conditions.

The whole set of the three detaching drums are mounted to a special frame where the clearnace between the drums and the belt could be adjusted.

Experimental procedure:

The experiments were carried out to study the parameters controlling the operation of the machine as follow:

1. Physical properties of the garlic bulb and garlic material that can affect detaching operation.
2. The effect of both feeding belt and drum speeds on the rate of garlic bulb flow from the machine hopper by gravity.
3. Performance of the detaching system and the percentage damage occured at variable speeds of detaching drum (Vd) and variable speeds of feeding belt (Vb) and the effect of Vd/Vb ratio on the performance of machine operation.
4. Effect of drum to belt clearance and input particle size on detaching performance and damage.

To conduct the above mentioned experiments the machine was operated at the variables as follows:

Feeding belt speeds: 0.48, 0.58, 0.73 m/sec.

First drum speeds: 0, 0.27, 0.32, 0.40 m/sec.

Second drum speeds: 0, 0.27, 0.32, 0.40 m/sec.

Third drum speeds: 0, 0.27, 0.32, 0.40 m/sec.

Drum to belt clearance : 50, 30, 15 mm

Theoretical approach:

When a garlic bulb passes between the feeding belt and the drum, a coupling of two forces generated to two opposit directions at the contact surfaces. The forces generated due to firiction depend on the vertical force exerted by the drum. As indicated in fig.2. the force components are the drum weight (Wd) and the spring pressure (Fs).

Maximum force applied to the garlic bulb expected to accure when the line passing through the center of the bulb and the axle of the drum is vertical. The force may be calculated from the following relation (by taking moments around the hinge):

$F_{max} * L_1 = W_d * L_1 + F_s * L$

Where : F_{max} = The maximum force applied on the garlic bulb.

L_1 = Distance between the center of the bulb and the hinge of the arm carrying the drum.

W_d = Weight of the drum and attachments.

F_s = Force exerted by the spring if it became active.

L = Distance between the axle on which the spring is loaded.

Force applied to the bulb Fmax. will determine the value of frictional force between the bulb and the drum (F_{frd}) and the frictional force between the bulb and the belt (F_{frb}) as the following:

$F_{frb} = F_{max} * C_{frb}$.

$F_{frd} = F_{max} * C_{frd}$

Where: F_{frd} = Frictional force between drum and bulb.

F_{frb} = Frictional force between feeding belt and bulb.

C_{frd} = Coefficient of friction between drum and bulb.

C_{frb} = Coefficient of friction between feeding belt and bulb.

Accordingly, the value of F_{max} will determine the value of the coupling force by which the detaching action is accomplished. When a bulb is passing between the drum and the belt, the force applied on the bulb may be:

a- Force may be zero (F=O) if the diameter of the bulb is less than the drum/ belt clearance.

b- Force may be less than the drum weight (F< Wd) if the bulb diameter is little more than the clearance where the difference could be compressed before the bulb can carry the complete weight of the drum, also if the bulb was detached before the total weight of the drum.

c- Force may be more than drum weight (F>Wd) if the difference between the bulb size is larger than the clearance and the bulb is rigid enough to push the drum up against the spring.

RESULTS AND DISCUSSION

Physical properties of garlic bulbs (variety : Seds "41") which are expected to affect detaching operation were determined. Size of garlic bulb and the coefficient of friction of garlic material in contact with the feeding belt and detaching drum surfaces are the properties largly affecting the machine operation. The size of the bulb will determine the contact area when the bulb is passing through the clearance between the drum and the belt. It determines the extent of adjusting the clearance of each of the three drums in relation to the feeding belt.

The coefficient of friction of the garlic materials on both of feeding belt material and drum material was determined as indicated in Table 1. which also shows the moisture content of garlic at the time of the experiments was recorded. Coefficient of friction of garlic materials in contact with machine parts was higher in case of feeding belt (0.514 - 0.573) than that of the detaching drum (0.412-0.487).

Table 1. Coefficient of friction of garlic in contact with drum and belt.

Machine Mechanizm	Moisture contents %	Garlic materials			
		Complete bulb with trash	Complete bulb without	Detached bulbs	Cloves
F.belt	49.4	0.573	0.530	0.557	0.514
Drum		0.487	0.417	0.447	0.412

The amount of garlic fell by gravity from the machine hopper to the feeding belt was affected by both belt speed and drum speed. The first detaching drum is close enough to the hopper feeding chute that the garlic materials fall from the chute (accumulate) between the drum and the hopper preventing more garlic bulbs from falling before starting operation.

Figure 3. shows the relationship between the feeding rate passing through the hopper chute by gravity and the speed of the feeding belt at variable drum speeds. Since the drum rotates in a direction opposit to that of the feeding belt the lower the drum rotational speed the lower the feeding rate. Maximum feed rate from 3-4 kg/

min was recorded when drum is at rest (speed zero rpm). The figure also shows that the higher the belt speed the higher the rate of garlic fed to detaching system.

The performance of the machine was evaluated by determining the effect of machine variables on detaching operation. To evaluate the detaching operation, the output after each drum was examined and classified into single cloves, double and multiple attached cloves. The percentage of damaged cloves was also recorded.

Figure 4. shows the effect of the ratio of drum surface linear speed to the feeding belt speed on detaching performance. As shown in the figure, less than 10% single cloves and 20% double cloves of the total weight were detected after the first drum at 50 mm drum/belt clearance. The percentage of both single and double cloves seems to increase at the lower drum to belt speed ratio. Multiple attached cloves for the same test were up to 80 percent, after the same drum. The clearance of the same second drum to the feeding belt was adjusted to 30 mm. The garlic materials came out from the first drum directly fed to the second drum for more detaching action. When examining the output after the second drum, the percentage of single cloves ranged from 26% to 40% and that of the double cloves ranged from 18% to 33%. Similar to the action of the first drum, the lower the ratio of V_d/V_b the more detaching action can accomplish. Multiple attached cloves were less than 20% at the lowest V_d/V_b of 0.37 and increased to about 40% at the high V_d/V_b of 0.83. Finally the garlic materials were examined and classified at the outlet of the final drum (15 mm clearance). The percentage of single cloves increased to 44% and double cloves increased to 37% at the lower V_d/V_b of 0.37. The multiple attached cloves were about 6% at the same speed ratio and increased at higher speed ratios.

In all the experiments the differance between the weight of the garlic fed to the drum and the sum of single cloves, double and multiple attached cloves was less than 6% of the total fed weight, representing the trash removed from the garlic bulbs while detaching.

For all the detaching drums, the percentage of damaged cloves was always less than 8% at the speed ratio of 0.37 which increased to about 11%, 15% and 20% at the high speed ratios of 0.55, 0.69 and 0.83 respectively.

Figure 5. shows the effect of the clearance between the detaching drum and the feeding belt on detaching performance and seed damage. When feeding complete garlic bulbs to the first drum (50 mm clearance), 5% single cloves and 12.0% double attached cloves were acheived. At the second drum (30 mm clearance) the percentage of single and double cloves increased to 34.%, and 25.% respectively. At

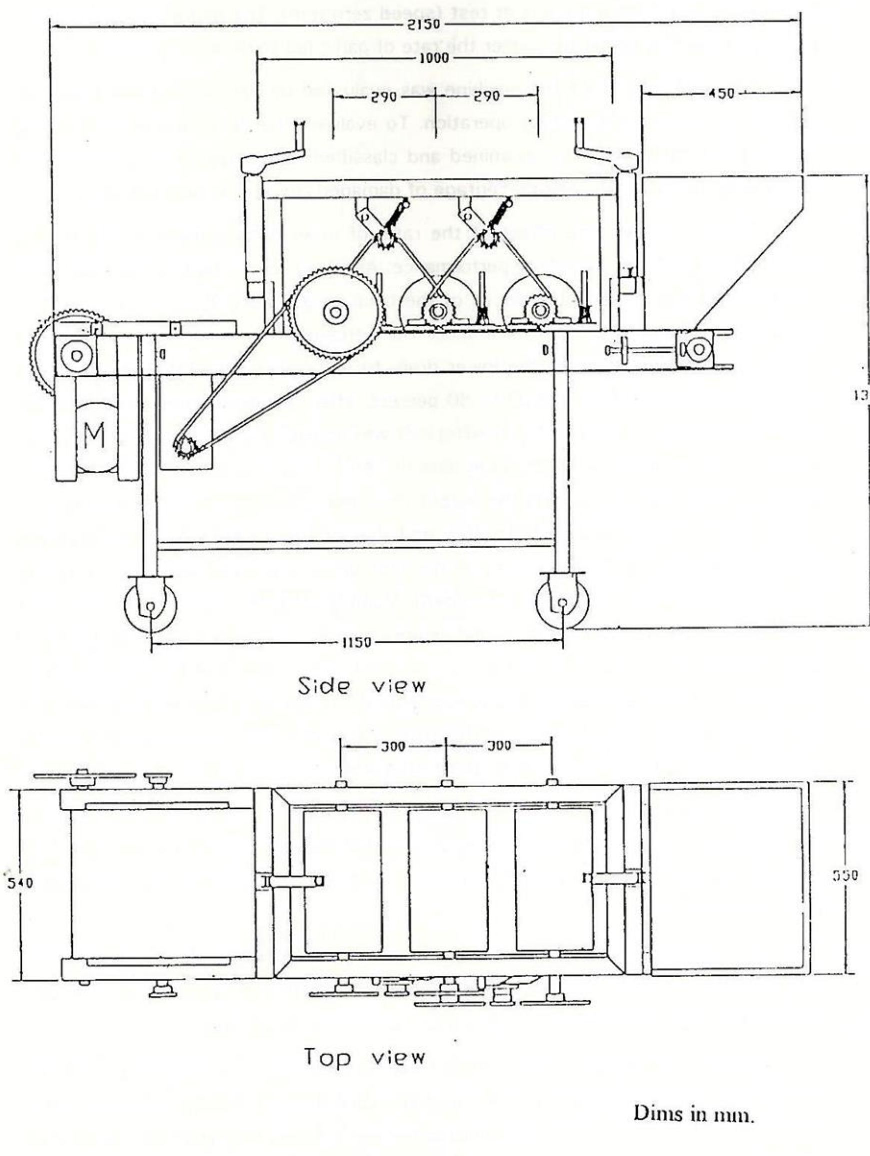

Fig.1. Components of the garlic detacher.

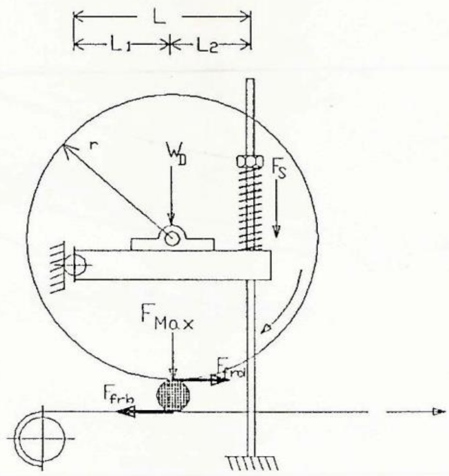

Fig.2. Maximum forces applied to the garlic bulb during detaching operation.

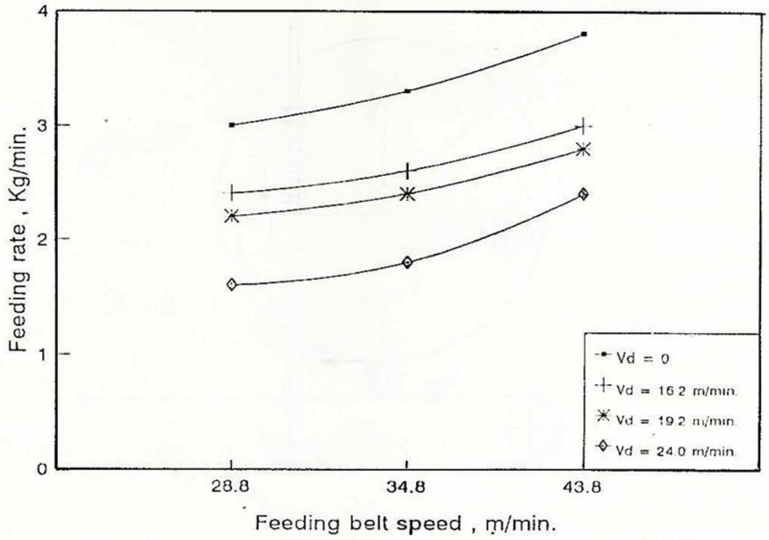

Fig.3. Feeding rate as affected by both feeding belt speed and drum speed.

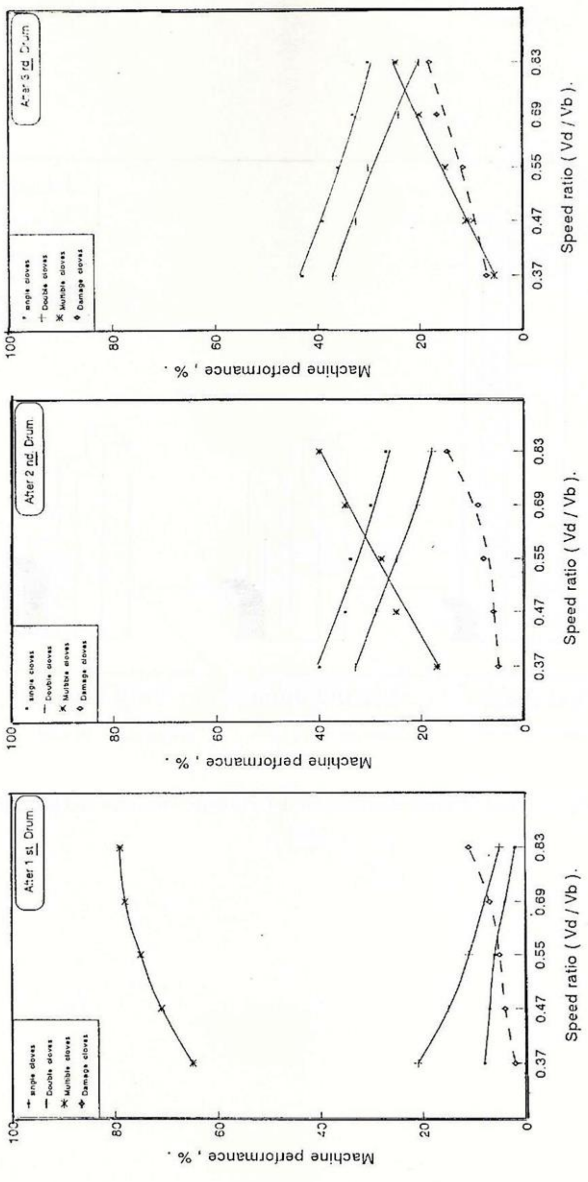

Fig. 4. Performance of garlic detacher and speed damage as affected by belt/drum relative speed.

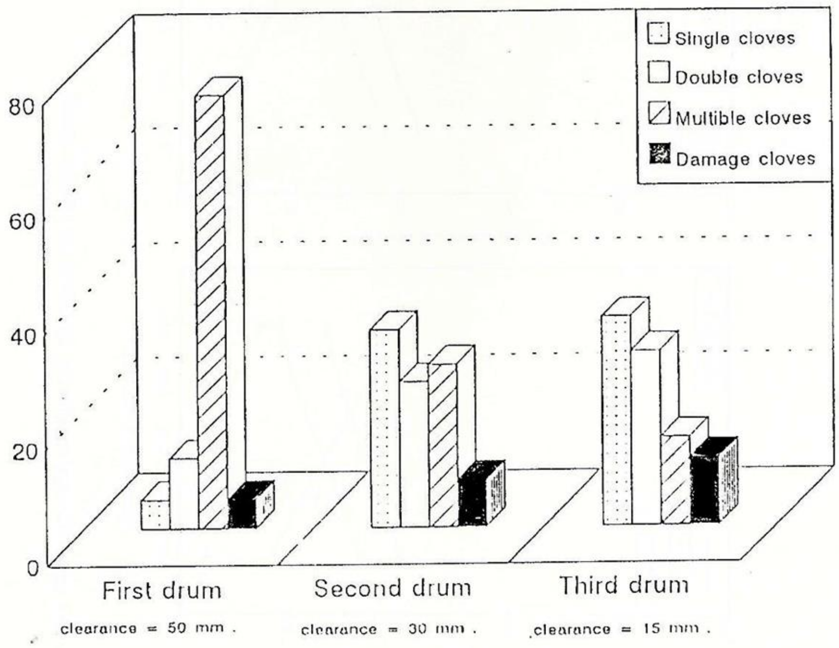

Fig. 5. Effect of drum clearance on detaching performance and damage.

the final stage where the drum/belt clearance was 15 mm, the percentage of single and double cloves reached 36% and 30% respectively.

Damage represented broken cloves, detached cloves, scraped cloves and crushed garlic material, increased from 5% at clearance 50 mm to 8% at clearance 30 mm and finaly reached 11.5 at the outlet of the machine.

CONCLUSION

The results showed that the higher the drum/belt speed ratio Vd/Vb the lower the detaching action and the higher the percentage of damaged cloves. At the higher Vd/Vb of 0.83 the percentage of single cloves and double attached cloves were 2% and 5% after the first drum, respectively. After the second drum, single and double cloves increased to 37% and 18% respectively. After the third drum, the results showed 30% single cloves, 20% double attached and 24% multiple attached cloves. At the low Vd/Vb of 0.37, the percentage of single cloves and double attached cloves was 8% and 21% after the first drum respectively. After the second drum single and double cloves increased to 40% and 33% respectively. After the final detaching drum, the results showed 43% single cloves, 37% double attached and 5.5% multiple attached cloves. At the same speed ratio of Vd/Vb = 0.37, percentage damage was 2%, 5% and 7% after the three detaching stages.

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تقييم أداء آلة لتفريط الثوم

سمير قرنى حرب

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يعتبر الثوم من محاصيل الخضر الهامة فى النواحى الغذائية والطبية فضلاً علي أنه محصول تصديرى، ومن هنا بدأ الإهتمام بتطوير تكنولوجيا إنتاج هذا المحصول بهدف الحصول على إنتاج عالى من المحصول والجودة ضماناً للتسويق الجيد، ومن ضمن عمليات الانتاج تفريط رؤوس الثوم وتفصيصها إلى فصوص للحصول على تقاوى سليمة. وقد تم تنفيذ آلة متوسطة الحجم كنموذج مصغر لآلة أخرى أمريكية الصنع ماركة كونستر. والآلة لها مصدر قدرة كهربائى ثلاثة حصان يستخدم لتشغيل سير ناقل بعرض ٤٠ سم مشدود بين إسطوانتين المسافة بين محوريهما ١٩٠ سم أسفل صندوق "قادوس" من الصاج له بوابة من أسفل يسقط خلالها الثوم بالتثاقل (بالجاذبية الأرضية) على السير المتحرك. وجهاز التفصيص عبارة عن ثلاث إسطوانات قطر الواحدة ٢٣سم وطولها ٤٠سم والمسافة بين محوري اسطوانتين متتاليتين ٢٩ سم والاسطوانه مغطاه بغطاء داخلى من المطاط وأخر خارجى عبارة عن طبقة من التيل المجدول، وتستمد الإسطوانات حركتها عن طريق مجموعة من التروس و تدور فى إتجاه عكس إتجاه حركة السير لإعطاء الإحتكاك المضاد على رأس الثوم لإحداث الفعل المؤثر على عملية التفريط، ويمكن التحكم فى الخلوص بين كل إسطوانة والسير الناقل بما يتلائم مع حجم رؤوس الثوم (الحجم السائد) بحيث يكون أكبرخلوص عند أول درفيل بجوار فتحة التلقيم وأقل خلوص عند أخر درفيل.

وقد أظهرت النتائج أنه كلما كانت السرعة النسبية بين حركة كل من الدرفيل والسير الناقل أقل ما يمكن كلما زاد معدل التفريط والحصول على نسبة عالية من الفصوص الفردية وأقل نسبة من كل من الفصوص الملتصقة والفصوص المكسورة أو المهروسة (التالفة ميكانيكيا):

فعند (سرعة الدرفيل / سرعة السير) = ٨٣, . كانت نسبة الفصوص الفردية ٣٠٪، والفصوص المزدوجه ٢٠٪، والفصوص الملتصقة (أكثر من فصين) ٢٤٪، ونسبة الضرر الميكانيكى ١٨٪. أما عند (سرعة الدرفيل / سرعة السير) = ٣٧, . فكانت نسبة الفصوص الفردية ٤٣٪، والفصوص المزدوجه ٣٧٪، والفصوص الملتصقة (أكثر من فصين) ٥,٥٪، ونسبة الضرر الميكانيكى ٧٪.

وقد أوضحت التجارب أن أنسب سرعة للتشغيل هى ٢٧, . م/ث للدرفيل ، و ٧٣, . م/ث للسير الناقل.