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DEVELOPMENT A THRESHER FOR WHEAT CROP OF BEATER TYPE FOR MAXIMUM PRODUCTIVITY

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ABSTRACT

The aim of this study is development a thresher machine which commonly used under Egyptian condition in order to give high purity, low losses (fan losses + losses behind sieve), less unthreashed grain and less total grain damage. This developed expect to increase the production by increasing feed rate, through remove the feeding auger to increase feed rate due to increasing production.

The studied variable included: Drum speed 747, 870, and 993 r.p.m. feed rate, 1 ɔ0, 1200, and 1400 kg/h., air speed suction 16, 32, and 64 m/s, air blower speed 3, 6, and 9 m/s. (sieve oscillation 415, 593, and 771 rpm), sieve tilt angle 2, 5, and 8 degree, and moisture content 13.5 %. On purity, fan losses, losses behind sieve, unthreashed grain, total grain, damage and machine productivity.

The optimum conditions of machine to be operated at the maximum efficiency are: Drum speed 870 rpm feed rate, 1200 kg/h., air speed at suction 32 m/s, blower air speed 6 m/s. (sieve oscillation 593 rpm), sieve tilt angle 5 degree, and moisture content 13.5 %. With machine purity 99.30 %, fan losses were 0.11 %, losses behind sieve zero %, unthreashed grain 0.05 %, and total damage grain zero %. And machine productivity 800 kg/h.. It was found that the operation cost of the machine is 15.55 L.E./h., unit cost 19.445 L.E. / ton, seed losses equivalent 0.27 L.E./ton, and criterion cost (operating cost + losses) 19.72 L.E./ton.

INTRODUCTION

Mechanization of threshing operation is important due to saving in effort, operation time, and reducing losses, either in grains or in hay and straw. Seeds are the foundation of human and animal life on earth-the food we eat, the fiber we wear, and most of the products used in our daily life, are created from seed. The quality of seed is essential for growing crops, which ultimately results in a better quality of life. The wheat is one of the most important agricultural crops in Egypt. The growing area is about 2.3 million feddan producing about 6,254,583 ton/year, (The economic affairs sector 2001). The operation involves the thresher of grain in threshing room the separate pencile from straw, and the separate grain from chaff and other impurities by air flow, the objective being to obtain the largest possible purity and recovery of the grains. There are many kinds of threshers and different specifications. So it has to study the problem face this machine during operation and solved it to be manufactured and suit the Egyptian farm.

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Helmy, M. A., (1988) Found that, the local threshing machine is strongly recommended for its good performance. The threshing efficiency, unit energy, total grain damage, unthershed grain and cut straw were 99.1%, 1kW.h/t, 6.5
%, 0.86 % and 22.5%, respectively, at 20.52 m/s cylinder speed and 0.25kg/s feed rate for 18.8% and 13.5% grain and straw moisture contents as an optimum condition of the local threshing machine.

Khan et al. (1989) reported that, in the axial flow machines threshed material is spiraled between the threshing drum and the duration in the machine as compared with conventional threshers. Longer duration threshing at lower impact levels results in more through threshing and less grain damage. Use of the peg tooth type threshing drums in the axial flow paddy threshers minimizes the need for close drum conceives clearance and this reduces grain damage. They added also that the tests indicated a wheat threshing output of traditional thresher was ranged from 114 to 348 kg/h at drum speeds of 650 to 800 rpm, respectively. The cleaning efficiency ranged from 73 to 96%, the total losses ranged from zero to 7%. Broken grain was observed at the 650 and 700 rpm however at 800 rpm drum speed, it was 4%. The best performance was obtained at drum speed of 700 rpm which threshing output was 420 kg/h with 90% cleaning efficiency. It was concluded that further improvements are needed to improve the cleaning efficiency and to minimize losses.

Khan, (1990) modified the locally turkish type thrasher to be used with multi crop type. The modification involved the design of a set of adjusted louvers inside the threshing drum cover to operate as axial flow system.

Khan et al. (1991) showed that a maximum wheat threshing output of 800 kg/h for IRRI-Pak thresher was obtained at threshing drum speed of 950 rpm .And maximum paddy threshing output of 1400 kg/h was obtained at threshing drum speed of 700 rpm.

Arif (1994) concluded that increase of cylinder speed increase the machine capacity, milled grain loss ratio, and threshing efficiency.

Awady and El Sayed (1994) stated that when air stream is used for separation of product from its associated foreign materials, knowledge of terminal velocity of all particles is involved. For these reasons, terminal velocity has been used as an important aerodynamic characteristic of materials such applications as pneumatic conveying and separation from foreign materials.

Mohamed (1994) found that the machine power was directly proportional with drum speed, feed rate, moisture content and grain damage. The machine power was reversly proportional with unthershed grain. Total losses were significantly affected by application power. The optimum threshing cylinder speed is 650 rpm for rice. The optimum machine power for threshing operation of wheat is 9.15 hp and the optimum threshing operation of rice is 4 hp. The machine investment cost is 4.59 L.E./h and total cost for threshing operation is 16.84 L.E./h.

Ebaid (1995) concluded that the highest purity of 98.8 % and lowest fan losses of 0.13 % were obtained at sieve tilt angle of 5 degrees, feeding rate of 2.2 t/h, air speed 21 m/s and 110 x 30 cm2 sieve area. Losses behind sieve increased from 0.11 to 0.128 % with sieve tilt angle increasing from 2 to 8 degrees at feed rate of 2.2 t/h, air speed of 21 m/s and sieve area of 110 x 20 cm2.

Lischynski et al. (2001) mentioned that the economics of growing wheat are marginal and many people are interested in extracting more value from the crop by utilizing the straw for industrial purposes. Examples of these uses are straw board, pulping and ethanol plants. Results indicated that, as expected, there is a definite relationship between the S/G ratio and the area of the province. The average S/G (straw/grain) ratios for CWRS, CWAD, and CPS as a type of wheat were 1.37, 1.20, and 1.00, respectively. Also, The results showed that relationships exist that can be used to predict straw yield based on rainfall, straw type, straw height and cutting height.

Government of Pakistan, (2002). Generally, seed has contaminants of various kinds when it comes into the processing plant, especially if it has been harvested with an improperly adjusted combine or thresher or threshed directly on the ground. Cleaning can be done because seeds differ in length, width, thickness, density, shape, surface texture, color, affinity for liquids, and electrical conductivity, but the most commonly used characteristics are seed size and density. Cleaning increases the seed quality by improving physical purity and germination. That means that inert matter must be removed. Also, they added in order to make the seed suitable for cultivation, impurities like weeds, immature seeds, inert matters, infected seeds, other crop seeds have to be removed.

MATERIAL AND METHODS

1-Materials:

In this study, the thresher machine is used for wheat threshing and winnowing. All experimental tests were done in 2002 at Manshiya location, Billbaes distract, Sharkia Governorate to thresh wheat crop. Thresher machine has one input counter shaft through the tractor P.T.O can connect. Power transfer from counter shaft to threshing drum through three V-belts.

Problem of this machine was found such as:

1-Increasing feed rate the crop was accumulated under the auger.

2-Decreasing the machine productivity it reefers to decrease the feed rate.

3-Increasing operation time.

4-Increasing the operation of cost and criterion cost of using the machine .

Machine specification:

General: **Type:** Tractor P.T.O power throw in Beater type thresher, Manufacture: Pakistan Gove. overall length, width, and height are 3800, 1800, and 2200 mm, resp. and power inputs from tractor P.T.O shaft.

Feed opening: For wheat = 1250 x 300 mm.

Threshing drum: Drum diameter with knives 730 mm, length 1330 mm. No. total of 88 knives, 250 mm long, 25 mm wide. Knives are distributed on 8 lines each having 11 knives.

Auger feed: Diameter with star 140 mm, length 1330 mm, total of 28 stars, 100 mm long, 150 mm wide. Stars are distributed on 7 lines each having 4 stars.

Concave: 3 mm thick. metal sheet, width 1370 mm and length 1330 mm. It's including group of horizontal bars manufactured from metal, the distance between each two bars 565 mm and its diameter of 685 mm.

Screen: 5 mm thick. metal sheet, screen length, and width 1250 and 770 mm, respectively. And eccentric stork 19 mm. It is consists of an upper and lower screens and hangs on four adjustable link rods. The upper screen has one part with 6 mm diameter holes for separating chaff and straw from grain. The lower screen is mounted 10 cm below and parallel to the upper screen. It has two parts: the first part with 1 mm diameter holes is for removing fine dust particles, and the second part with 9 mm diameter holes sieve to pass the grain to spout.

Fan: 2 mm thick. metal sheet, the airflow was produced by means of two fans, a) Suction fan: centrifugal with radial blades, diameter of fan 750 mm, and width 450 mm. Number of blades fan 4 mounted radially, length and width 300 and 200 mm, respectively. It is to pick up large straw pieces over the upper screen. b) blower fan: it has 3 numbers of blades, length and width 300 and 100 mm, respectively. It is to remove chaff and light impurities from grain as they drops from the lower screen to spout.

Machine before modification:

The thresher machine consists of, main frame, cover, auger feed, threshing drum, concave, oscillating screen, and fan (suction and blower fan), as shown in fig. (1 – a).

Machine after modification:

The thresher machine consists of, main frame, cover, threshing drum, concave, oscillating screen, and fan (suction and blower fan), as shown in fig. (1 – b).

Instrumentation

Speedometer.

Speedometer was used to measure the rotation speed in three ranges. First range: 40 - 500 rpm., second range: 400 - 5000 rpm., and third range: 4000 - 50000 rpm direct reading

Anemometer instrument.

An anemometer instrument was used for measuring the air speed, temperature, and pressure. It is made in Japan by SATAKE CO., and ranged from 0 to 50 m/s. The measurement theory depends on the declination of the sensor inside the instrument. The movement of the air pushes the sensor then voltage indicates the variation of the air speed. Its source of power is battery.

Digital dial caliper.

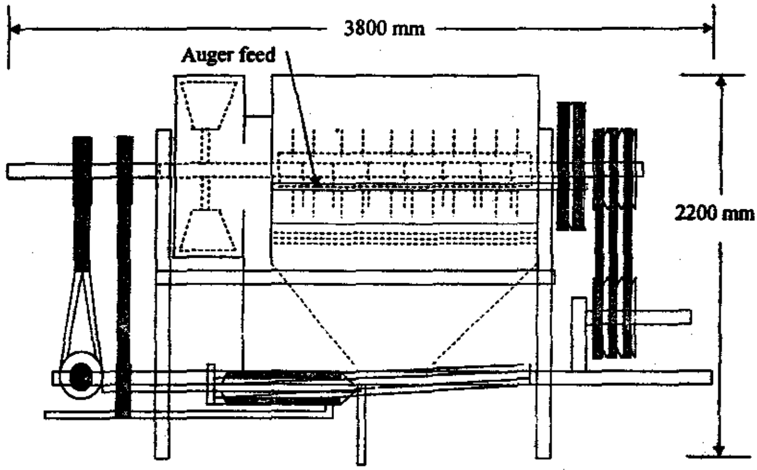
Dimensions of rice were determined considering the three axes xx, yy, and zz. A digital caliper reading up to 15 cm was used. Its accuracy is 0.05 mm.

Electronic balance.

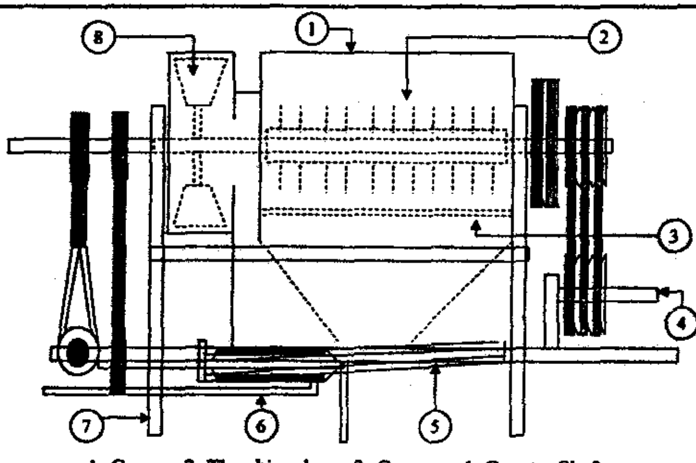
An electronic balance (made by Japan) was used for weighing samples before and after cleaning. Its scale ranged from 0 to 5 kg max., with accuracy of 0.2 g.

Moisture -content meter.

A moisture content-meter (made by Finland) was used for measuring the grain moisture-content on wet basis. Its source of power is battery. The measurement by electrical sensitive. The (Wile 35 Moisture Meter) measures the moisture-content percentage of whole grains, and the hay probe accessory measures the moisture content of grains and straw.



(1-a) : Sketch of thresher machine before modification.



1- Cover; 2- Threshing drum; 3- Concave; 4- Counter Shaft ;
5- Screen ; 6- Blower fan; 7- Main frame and 8- Suction fan.

(1-b): Sketch of thresher machine after modification.

Fig. (1): The thresher machine.

Factors effect on threshing effectiveness for aeromechincal and thresher machine after modification.

The following parameters were considered during the thresher machine testing.

1- Drum speed: three different speeds were tested 747, 870 and 993 rpm.
2- Air speed: three different speeds for both of suction and blower fans were tested 16, 32, 64 and 3, 6, 9 m/s, respectively.
3- Sieve oscillation speed: three different speeds were tested 415, 593 and 771 rpm.
4- Sieve tilt angle : three different angles were tested 2,5 and 8 degree.
5- Feed rate : three different feeding rates were tested 1000, 1200, 1400 kg/h.

2) Methods:

Purity: Is net grains ratio after removing the impurities (mass basis).

Purity % = (mass of clean sample / mass of sample before cleaning) * 100--(1)

Fan losses: Are mass of grain lost from fan outlet with straw

Fan losses % = (grain collected from fan outlet / total grain output) * 100.--(2)

Losses behind sieve: Are mass of grain lost behind sieve.

Losses behind sieve % = (grain collected behind sieve / total grain output) *100---(3)

Unthreshed grain:

Unthreshed grain, % = [(Weight of unthreashed grain/ (Production + Losses)] X 100.---(4)

Total grain damage:

The damaged seeds were stored manually and weighed. The percentages of seed-damage were calculated, related to grain output.

Estimating the costs of using the machine:

Cost of operation is calculated according to equation given by Awady (1978), which has the following form:

$$C = P/H(1/y + i/2 + t + m) + (A. k. f. u) + S/144, \quad (5)$$

Where: C = Total hourly cost, P = Price of machine, H = Estimated yearly-operating hours, y= Estimated life-expectancy of machines in years, i = Interest rate, t= Taxes and overhead rates, m =Maintenance and repairs ratio, A =Ratio of rated power and

lubrication related to fuel cost (1.2).K= Power in kW or hp, f= Specific fuel-consumption in L/kW.h or /hp.h, u = Price of fuel per L, S = Monthly salaries, and 144 =Estimated working hours per month.
*Notice that all units have to be consistent to result in C = L.E./h.

Operating cost (L.E./ton) = machine cost(L.E./h) / machine productivity (ton/h) ----------------------(6)

Seed losses cost (L.E./ton) = total grain losses % x reduction value of kilogram price (L.E./ton)---------------(7)

Criterion cost (L.E./ton) = operating cost (L.E./ton) + grain losses cost (L.E./ton) --------------------------------(8)

Crop properties:

Wheat grains (Sakha 69 variety) .

Dimensions of wheat grains used in the experiments as following:
Length (L) = 6.76, width (W) = 3.64, and thickness (T) = 3.05
Average plant height, 96.50 cm mass of 1000 kernels, 41.66 g
Grain / straw ratio 1:1.55
Also, volume, geometric diameter, arithmetic diameter, percent of sphericity, bulk density, true density, and moisture content for wheat grain reported by Ebaid 2001 are shown in table 1.

Table 1 : Physical properties of wheat grains.

Type of crops	V, mm3	Dg, Mm	Da, Mm	S, %	Bd, kg/m3	Td, kg/m3	M.C,. %
Wheat	39.276	4.22	4.48	62.40	758.25	1291.65	13.5

Where:

V: Volume, mm^3 Dg: Geometric diam., mm Da: Arithmetic diam., mm
S: Percentage of sphericity, % Bd: Bulk density, kg/m^3 Td: True density, kg/m^3, and
M.C.: Moisture content, %

The calculated equations: According to El-Raie, A. E., 1981,
V= π /6 (L*W*T), mm3, Dg = (L*W*T)1/3 mm,
Da = (L+W+T)/3, and S = 100*(L*W*T)1/3 /L

RESULTS AND DISCUSSION

All experiments were done without auger .

1- Effect of drum speed on unthreshed grain and total grain damage.

Fig, 2 shows that by increasing drum speed the unthreashed grain decreased and total grain damage increased. Increasing drum speed from 747, to 870, and 993 rpm the unthreashed grain decreased from 2.75, 0.65, and 0.23 % respectively and total grain damage increased from 0.00, 1.21, and 2.06 % at feed rate 1400 kg/h, moisture content of 13.5 % and sieve tilt angle of 20.

2- Effect of feed rate on:

unthreshed grain and total grain damage.

Fig, 3-a shows that unthreashed grain and total grain damage increased as the feed rate increases in general from 1000, to 1200, and 1400 kg/h.

The unthreashed grain increased from 0.05, to 0.15, and 0.60 % respectively and total grain damage increased from 0.00, to 0.65, and 1.25 % respectively as the feed rate increased from 1000, to 1200, and 1400 kg/hr. at drum speed of 870 rpm, moisture content of 13.5 % and sieve tilt angle of 50.

Purity and losses (losses behind sieve+ Fan losses).

Fig. 3-b shows that purity, decreased and fan losses increased by increasing feed rate, but from the experiments there were no major effects from feed rate on losses behind sieve at sieve tilt angles of 2 and 50 ,but by increasing sieve tilt angle to 80 and increasing feed rate from 1000, to 1200, and 1400 kg/h, there were losses behind sieve.

. By increasing feed rate from 1000, to 1200, and 1400 kg/hr. the purity decreased from 99.30, to 97.90, and 95.11 %, respectively and fan losses increased from 0.11, to 0.20, and 0.31 % respectively at drum speed of 870 rpm, moisture content of 13.5 %, sieve tilt angle of 50, air speed suction of 32 m/s. and air speed blower of 6 m/s. (sieve oscillation of 593 rpm).

3- Effect of air speed on on Purity and losses (losses behind sieve + Fan losses).

Fig. 4 shows that purity and fan losses increased by increasing air speed, but there were no effect for losses behind sieve by increasing air speed. But at high sieve tilt angle (80) increased losses behind sieve.

Purity increased from 96.89, to 99.30, and 99.39 %, and fan losses increased from 0.00, to 0.11, and 0.14 % as the air speed increased from 16, to 32, and 64 m/s. suction respectively and 3, to 6, and 9 m/s. blower respectively (sieve oscillation from 415 to 771 rpm) at feed rate of 1000 kg/h. and sieve tilt angle of 50.

Increased fan losses is considered due to increase of air quantity sucking more grain with air.

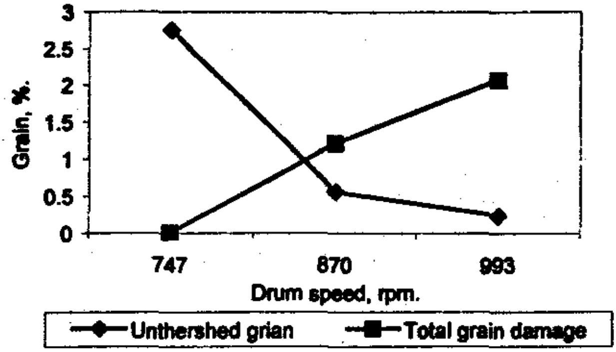


Fig. 2: Effect of drum speed on unthershed grain and total grain damage.

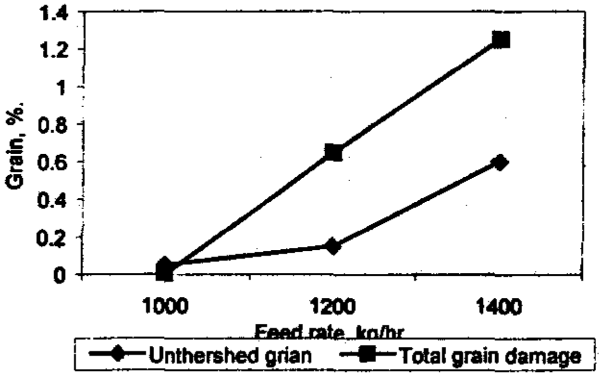


Fig.3-a : Effect of feed rate on unthershed grain and total grain damage.

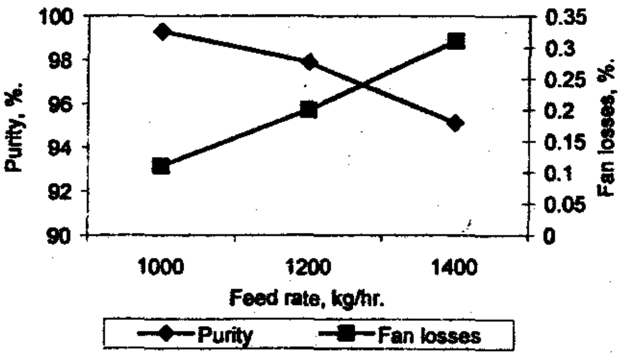


Fig. 3-b: Effect of feed rate on purity and fan losses.

4- Effect of sieve tilt angle on:

4-1 Purity.

Fig. 5 shows that purity increased by increasing sieve tilt angle. The purity was found to increase as sieve tilt angle increased at different air speed, feed rate, and drum speed. By increasing sieve tilt angle from 2 to 5, and 8 the purity increased from 89.87 to 94.99, and 95.01 % respectively at drum speed of 747 rpm, feed rate of 1200 kg/h. and air speed of 16 m/s. suction, 3 m/s. blower. (sieve oscillation 415 rpm.). It reefers to at low sieve tilt angle (20) the threshed material accumulated on the sieve gave chance to pass big straw size and impurities through the grain spout which drops with grain.

4-2 Losses.

Losses behind sieve.

Losses behind sieve increased by increasing sieve tilt angle. There was no effect for sieve tilt angle on losses behind sieve at low sieve tilt angles (2 and 50). But at high sieve tilt angle (80) there is losses behind sieve. It reefers to increased jerking movement of threshed materials at high sieve tilt angle cause losses behind sieve. Meanwhile, at low sieve tilt angle there is no chance for threshed materials to move fast over the screen and accumulate on the sieve and no chance for grains to drop behind sieve with straw and impurities.

Fan losses.

The lowest fan losses were obtained at sieve tilt angle of 50. Data in fig. 5 show the effect of sieve tilt angle on fan losses. At drum speed of 870 rpm, feed rate of 1000 kg/h and air speed suction of 32 m/s, blower 6 m/sec (sieve oscillation of 593 rpm), at sieve tilt angle of 2,5, and 80 ,the fan losses were found 0.33, 0.11, and 0.19 %, respectively. At low sieve tilt angle (20) the threashed material accumulated on the sieve and enabled the fan to suck more grain with impurities and straw from threashed material. Also the small distance between fan and sieve enables the fan to suck grains. Meanwhile greater sieve tilt angle (80) gives jerking movement to grain enabling the fan to suck more grains with impurities and increase the fan losses. The best sieve tilt angle was found 50 which gives least fan losses.

5- Estimating the cost of using the machine

Before modification, it was found that the operation cost of machine is 15.55 L.E./h, unit cost 31.11 L.E. / ton, seed losses equivalent

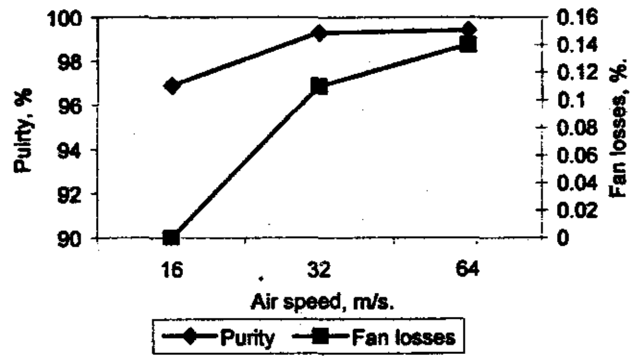


Fig. 4: Effect of air speed on purity and fan losses.

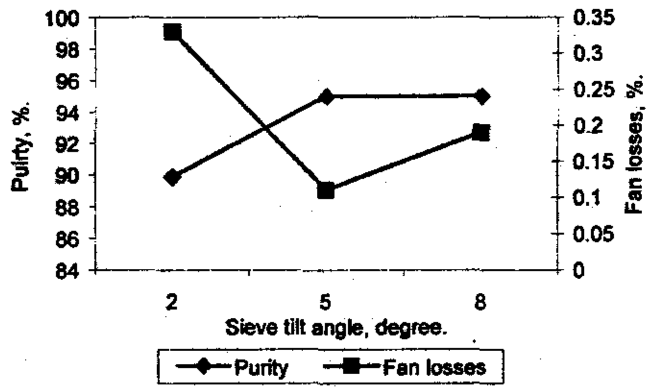


Fig. 5: Effect of sieve tilt angle on purity and fan losses.

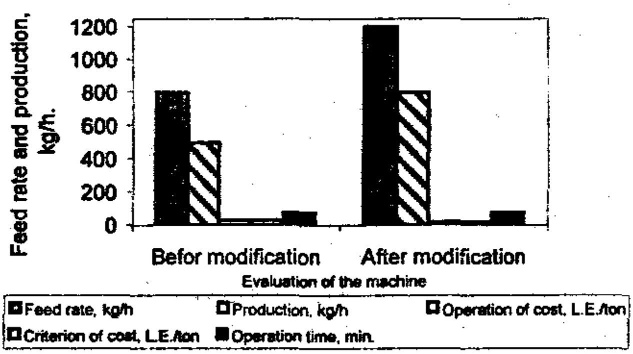


Fig. 6 : Evluation the machine before and after modification.

0.27 L.E./ton, and criterion cost (operating cost + losses) 31.387 L.E./ton.

After modification, it was found that the operation cost of the machine is 15.55 L.E./h, unit cost 19.44 L.E. / ton, seed losses equivalent 0.27 L.E./ton, and criterion cost (operating cost + losses) 19.72 L.E./ton.

6- Evaluation the machine before and after modification.

Table 2: Different between machine with auger and machine without auger

Item	Feed rate, Kg/h,	Production, Kg/h.	Unit of cost, L.E./ton	Criterion cost, L.E./ton.	Operation time, sec.
Before modification	800	500	31.11	31.387	75
After modification	1200	800	19.44	19.72	75

Data shown in table 2 and fig.6 show the different between machine with auger and machine without auger. Machine in case with auger can not increase feed rate than 800 kg/h. It reefers to accumulate the crop under the auger due to loosing time and effort, decreasing production 500 kg/h, unit of cost 31.112 L.E/ton, criterion cost 31.387 L.E./ton and operation time75 min.

But in case machine without auger feed rate than 1200 kg/h, production 800 kg/h, unit of cost 19.445 L.E/ton, criterion cost 19.72 L.E./ton and operation time75 min.

COUNCLOUSION

For high purity, low losses (fan losses + losses behind sieve), less unthreashed grain and less total grain damage the following conditions are recommended for the type of machine. Drum speed: 870 rpm, feed rate:1200 kg/h, air speed suction and blower:32 and 6 m/s. (sieve oscillation 593 rpm), sieve tilt angle 5 degree, and moisture content 13.5 %.

With the above recommended-conditions, the following optimum conditions were obtained:

Purity 99.30 %, fan losses:0.11 %, losses behind sieve zero %, unthreashed grain 0.05 %, total grain damage zero and machine productivity 800 kg/h (0.8 ton/h).

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تطوير الة لدراس محصول القمح ذات السريان النصف قطرى لزيادة الأنتاجية

د/محمد طة عبيد[١] د/عبد الرحمن عبدالروف عبدالرحمن[١] د/جابر الغمرى رضوان[١] د/حسن البناعثمان[٢]

يعتبر محصول القمح من اهم المحاصيل الرئيسية فى جمهورية مصر العربية، حيث تبلغ المساحة المنزرعة منه حوالى ٢,٣ مليون فدان بالنتاجية تبلغ ٦،٢٥٤،٥٨٣ طن/سنة. كما تعتبر عملية الدراس وفصل الحبوب من العمليات الزراعية الهامة حيث انها توفر الوقت والجهد والعمالة وتقلل الفواقد وتزيد درجة النظافة. لذا تعتبر عملية دراس القمح بواسطة الات الدراس من اهم العمليات التى تستحوذ على اهتمام المزارع المصرى الصغير. ومن هذا المنطلق زاد الاهتمام بكل من عمليتى الدراس والتذرية واللتان تعتبران من اهم العمليات للمحافظة على جودة المنتج ونقاء السلالات عن طريق توفير اصناف عالية النقاوة لدى المنتجين وخالية من اى شوائب ومتوافرة فى الوقت المناسب.

ونظرا لتعدد الات الدراس المستوردة واختلاف طرق تشغيلها ومواصفاتها فكان لابد من الوقوف علي مشاكل ماكينات شرق اسيا وطرق العلاج حتى يمكن تصنيعها وتطبيقها فى مجال الحقل المصرى بخامات محلية فى الورش الصغيرة.

وقد كانت المشكلة هى انخفاض انتاجية الماكينة وهذا راجع الى انخفاض معدل التغذية حيث توجد بريمة امام فتحة درفيل الدراس تعيق عملية التغذية بمعدلات عالية حيث يتم تراكم للمادة المدروسة تحت بريمة التغذية ممايؤدى الى تعطيل الماكينة وبالتالى زيادة الوقت اللازم وانخفاض الانتاجية وبالتالى وزيادة التكاليف وفى البحث محاولة الاستغناء عن البريمة لتوفير الوقت والجهد والتكلفة وزيادة الإنتاجية.

وتناول البحث بعد التعديل دراسة تأثير كلا من سرعة درفيل الدراس (٧٤٧،٨٧٠،٩٩٣ لفة/دقيقة) ، معدل التغذية (١٠٠٠،١٢٠٠،١٤٠٠ كجم/ساعة)، سرعة الهواء لكلا من مروحة السحب والطرد (١٦،٣٢،٦٤ و ٣،٦،٩ م/ث على التوالى) تردد الغربال (٤١٥،٥٩٣،٧٧١ لفة/دقيقة) وزاوية الميل (٢،٥،٨ درجة). على كل من النظافة، وفواقد المروحة، والفواقد خلف الغربال، والرؤوس الغير مدروسة، والحبوب المكسورة ، وإنتاجية الماكينة.

وقد وجد ان الماكينة اعطت كفاءة نظافة ٩٩,٣٠%، وفواقد خلف الغربال صفر %، وفواقد المروحة ٠,١١ %، ورءوس غير مدروسة ٠،٠٥ % وحبوب مكسورة صفر %، وانتاجية ٨٠٠ كجم/ساعة (٠,٨ طن/ساعة). عند سرعة درفيل الدراس ٨٧٠ لفة/دقيقة ، معدل التغذية ١٢٠٠ كجم/ساعة، سرعة الهواء لكلا من مروحة السحب والطرد ٣٢ م/ث و ٦ م/ث. تردد الغربال (٥٩٣ لفة/دقيقة) وزاوية الميل للغربال ٥ درجة. وكذلك وجد أن تكاليف تشغيل الالة ١٥,٥٥ جنية/ساعة وتكلفة التشغيل ١٩,٤٤ جنية/طن وتكلفة فواقد الحبوب ٠,٢٧٥ جنية/طن والتكلفة الحدية ١٩,٧٢ جنية/طن.

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(٢) باحث اول – معهد بحوث الهندسة الزراعية – مركز البحوث الزراعية - الدقى –جيزة.