DJAS., Vol. (3) (I): (1 - 10) (2024)

DJAS
Damietta Journal of Agricultural Sciences
مجلة دمياط للعلوم الزراعية

Damietta Journal of Agricultural Sciences

Volume 3 , Issue I , 2024

DJAS

Damietta Journal of Agricultural Sciences
http://publication.du.edu.eg/journal/ojs302design/index.php/agr/index
ISSN: 2812-5347(Print)- 2812-5355 (Online)

Manufacture and Performance Evaluation of a Local Machine for Grading Onion Crop

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ARTICLE INFO

Key words: Onion, grading, grader, design, development, grading efficiency.

ABSTRACT

Practical experiments were carried out to evaluate the performance of a locally manufactured grading machine for grading onion crop to increase product value, improve product quality and raise its export value. The main parts of the grading onion machine were as follows: feeding unit, grading unit, collection unit, chain and sprockets, and power source and transmission. The performance of the fabricated machine was studied according to the following parameters: Four different feeding rates of (0.9, 1.2, 1.5 and 1.8 Mg/h); three different inclination angles at horizontal level of (0, 5 and10°) for whole grading machine, and three different cylinder rotating speeds of (10, 20 and 30 rpm) corresponding to (0.25, 0.51 and 0.76 m/s), respectively. The performance of the fabricated machine was evaluated taking into account the following indicators: machine productivity, grading efficiency, mechanical damage percentage, energy consumed, operation cost and criterion cost. Experimental results showed that the suitable operating parameters for grading onions using the manufactured machine were: feeding rate of 1.8 Mg/h, cylinder rotating speed of 20 rpm and inclination angle of 10º, which recorded highest machine productivity, grading efficiency, acceptable mechanical damage percentage; minimum energy required and operational cost of 1.716 Mg/h, 95.3%, 11.6%, 0.33 kW.h/Mg and 10.03 L.E/Mg, respectively, also gave an acceptable criterion cost.

1- INTRODUCTION

Onion (*Allium cepa*, L.), is a plant species of the family Alliaceae with food and medical properties, contains many essential vitamins and mineral materials **(Karthik and Satishkumar, 2016)**. In Egypt, onion is the fourth major exported crop after cotton, rice, and citrus. The total cultivated area was about 89332 ha with total production of 3142264 Mg, **(Annual bulletin, 2022)**. Grading process plays a major role in the food processing industries. Grading of fruits and vegetables is one of the most important operations since it adds value to the product and gives better economic return to the producer. The purpose of grading onion is to conform to commercial standards and to facilitate marketing. Manual grading is mainly done manually by farmers, agents, whole sellers, retail sellers and customers through intensive labor input and long day work.

Manual grading of onion is often inconsistent since quality perception varies from one person to another: hence prone to human errors and variability. Manual grading of onion takes a long time, and hence labor cost will be high, and grading can be negatively affected due to a shortage of labor in peak seasons. Grading based on the individual human being vision judgment is very poor and inefficient in terms of uniform product production. Due to various reasons stated above, most farmers market their products without grading and obtain very low price. Above all, the new marketing trends, adopted by World Trade Organization (WTO), demand high quality graded products **(Narvankar and Jha, 2005)**. Huge amount of energy is invested in this operation and the produce is handled for number of times in this operation which results in increasing of wastage and may decrease marketing value **(Gayathri *et al.*, 2016)**. Therefore, modern technologies, like automatic grading systems are an utmost need. Sizing is one of the most important operations affecting onion export. It determines the weight of standard sale package, thereby increasing marketing attractiveness, and simplifies the mechanization of different handling systems, such as cutting and peeling. Sizing also, influences heat transfer processes, since size-graded produce allows heat transfer uniformity during drying, cooling, and freezing processes **(Mostafa, 2003)**. Mechanical grading done on the basis of size, shape, weight, color **(Ukey and Unde, 2010)**. These are expensive and beyond the reach of ordinary onion growing farmers having small land holding. Hence, the need of an efficient small capacity onion grader was felt mainly to grade the onion bulbs at farm level. Grading done based on size and shape is important for marketing uniform high quality produce. Grading gives direct benefit to all parties concerned in the buying and selling transactions. It is essential to the business of processors, wholesalers, and retailers. Consumers get a benefit whenever the packages carry the official grade marking **(Ghanem *et al.*, 2021)**. In this regard, the aim of this study was manufactured a local machine for onion grading. The main objectives of this study were as following:

- Manufacture a grading machine for onion crop with local materials.
- Determination of suitable operating parameters such as, feeding rate, rotating cylinder speed and inclination angle which affecting the performance of the grading machine.
- Evaluation the local grading machine from the economic standpoint.

2- MATERIAL AND METHODS

A grading machine operated with electric motor was manufactured and constructed in a private workshop in Taftish El-Sirw village, Faraskour district, Damietta governorate, Egypt through the year 2020/2021 for grading onion crop based on onions size. The field experiments were carried out in the summer season of 2021/2022 at the same previous location to evaluate the performance of the constructed grading machine for onion crop to increase product value, improve product quality and raise its export value.

2.1Materials

2.1.1. Onion used:

In this study, one of the most popular onion cultivars (Beheri) was brought from a private farm in Damietta Governorate, Egypt. The onions were inspected to remove the damaged or defective ones before grading with the locally manufactured machine.

2.1.2. Manufactured chopping machine:

The grading machine was manufactured and evaluated for onion crop grading. **Fig. (1)** showed a photograph of the manufactured grading machine, and the main parts of the manufactured grading machine are presented in a drawing engineering in **Fig. (2)**.

Fig. (1): A Photo of the manufactured grading machine.

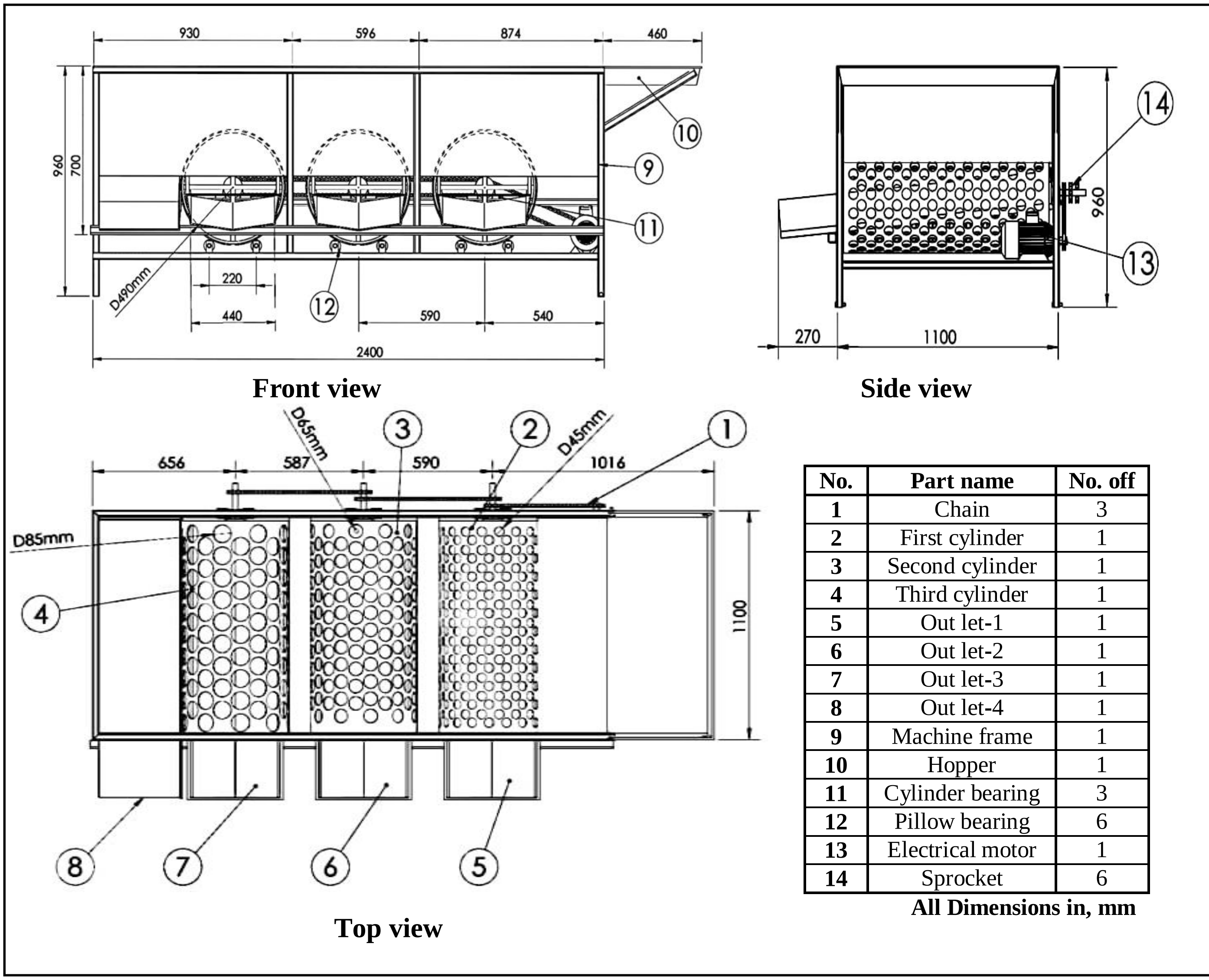
♦ **The feeding unit:** consisted of a horizontal mild steel sheet installed on the machine frame at the front side. The dimensions of feeding unit were (110 cm for length and 92 cm for width). In addition, it has three vertical sides with a height of 15 cm to avoid scattering onions and direct them to the grading cylinders.

♦ **The grading unit:** consists of three bored cylinders (acting as a sieve); each cylinder made of mild steel with total length of 110 cm and diameter of 49 cm. The grading cylinders were bored using laser to obtain the required holes with smooth finishing for minimizing scratching or damaging in onions.

The first cylinder was bored with 4.5 cm diameter holes for separating small onion size, the second cylinder was bored with 6.5 cm diameter holes for separating medium onion size and the third cylinder was bored with 8.5 cm diameter holes for separating large onion size. Each graded cylinder laid on two bearing with dimensions of 5, 3 and 3 cm for outer diameter, inner diameter and thickness, respectively at the circumference of the rear side; and laid on one bearing with dimensions of 5, 3 and 3 cm for outer diameter, inner diameter and thickness, respectively at the middle shaft of the front side. The middle shaft on each graded cylinder with dimensions of 20 and 3 cm for length and outer diameter, respectively supported with a sprocket with dimensions of 10, 2 and 0.2 cm for outer diameter, inner diameter, and thickness, respectively to transport the same rotating speed for each graded cylinder.

♦ **The collection unit:** Three collection units were fixed under the graded cylinders with inclination angle of 10° to collect the graded onions at the side of the machine. Each collection unit made from galvanize steel sheet with thickness of 2 mm in trapezoidal shape opening from above side. The overall dimensions of the collection unit were of 120, 40 and 20 cm for length, width and height, respectively. The collection units collect three different sizes of onions based on diameter namely: Small (< 4.5 cm), Medium (4.5 – 6.5 cm) and Large (6.5 – 8.5 cm). In addition, the onions with diameter more than (8.5 cm) were collected behind the graded cylinder with large bores of 8.5 cm.

♦ **Chain and sprocket:** A sprocket is a toothed steel wheel connected with a chain or track. Sprockets and chains are used for power transmission from one shaft to another



No.	Part name	No. off
1	Chain	3
2	First cylinder	1
3	Second cylinder	1
4	Third cylinder	1
5	Out let-1	1
6	Out let-2	1
7	Out let-3	1
8	Out let-4	1
9	Machine frame	1
10	Hopper	1
11	Cylinder bearing	3
12	Pillow bearing	6
13	Electrical motor	1
14	Sprocket	6

Fig. (2): Front view, side view and top view of the onion grading machine.

where slippage is not admissible. The graded machine has 6 sprockets fixed on 4-cylinder shafts with the same dimensions of 10, 2 and 0.2 cm for outer diameter, inner diameter and thickness, respectively to transport the rotating speed for each graded cylinder. The first sprocket fixed on the motor shaft, the second and third fixed on the first graded cylinder shaft, the fourth and fifth fixed on the second graded cylinder shaft and the sixth one fixed on the third graded cylinder shaft.

♦ **Power source:** An electrical three phases motor of 1 hp (0.735 kW) at maximum rated speed of 900 rpm was powered the grading machine. A gear box with reduction speed of (1:15) attached with the electrical motor to transmit its rotating motion through the sprocket and chain to the three graded cylinders.

♦ **Inverter:** It was used to change motor rotating speed. The specifications of the used inverter were as follows: GEISC made in China, Model KE300B-0R7G-S2 with 220-380V, power 0.75kW, and input: 11A AC 1PH 220V±15% 50/60Hz, maximum output current 4.6A AC 3PH 0~220V 0~300Hz, speed change range 1-50.

♦ **The machine frame:** It was manufactured from hollow steel bars (3.5×3.5 cm) and steel sheets with 2 mm in thickness. The overall frame dimensions were 240, 96 and 110cm in length, height and width, respectively. The machine frame is based on two adjustable stands to control the machine.

inclination angle to the horizontal. The main frame has places to fix the electric motor, grading cylinders, collecting units and power transmission system.

♦ **Power transmission**: The machine was powered by an electric motor 1 hp (0.735 kW). An inverter device (2) is connected to the electric motor (1) to control the speeds of the electric motor used in conducting transactions. The electric motor transmitted its rotating motion to the first moving revolving cylinder shaft by sprocket (3) having dimensions of (7, 2.5 and 0.5 cm) for outer diameter, inner diameter and thickness and chain (4) having dimension of 106 for length. The rotating motion was transmitted from moving the first revolving cylinder shaft to the second revolving cylinder shaft by sprocket (3) having dimension of (7, 2.5 and 0.5 cm) for outer diameter, inner diameter and thickness and chain (4) having dimension of 102 for length. The middle shaft was taken its motion from the first revolving cylinder shaft by sprocket having dimension of (7, 2.5 and 0.5 cm) for outer diameter, inner diameter and thickness and chain having dimension of 102 for length. The last shaft was taken its motion from the second revolving cylinder shaft by sprocket and chain with the same previous parameters.

2.2. METHODS:

2.2.1. Experimental conditions:

Onions were fed into the grading machine manually and then rolled down into the grading units. The principle of grading operation begins with the rotating motion of the graded cylinders through the motion source. Onions with small, medium, and large diameters passing through the respective holes during rotation and are collected in the respective tray inside the grading unit. Preliminary experiments were carried out to determine the most affective parameters on the fabricate onion grading machine. The main experiments were carried out to evaluate the performance of the local grading machine. The performance of the grading machine was experimentally measured using the following parameters:

-Four different feeding rates of 0.9, 1.2, 1.5 and 1.8 Mg/h.

-Three different cylinder speeds of 10, 20 and 30 rpm, corresponding to (0.25, 0.51 and 0.76 m/s), respectively.

-Three different inclination angles at horizontal level of 0, 5 and 10 degrees for grading unit.

2.2.2. Measurements and determinations:

The performance evaluation of the local onion grading machine based on size was performed taking into consideration the following indicators:

■ **Machine productivity:** The machine productivity was calculated according to the following equation **(Radwan, 2000)**:

$$P_M = (M \times 60) / Tg \quad \text{.............(1)}$$

Where: P_M: machine productivity, Mg/h.

M: mass of graded onions, Mg.

Tg: grading time, h.

■ **Machine grading efficiency:** The grading efficiency of one unit was calculated according to **(Amin, 1994)** as follows:

$$\eta_1 = N_1 / n \times 100 \quad \text{................(2)}$$

Where:

η_1: grading efficiency for one unit, %.

N_1: mass of the classified onions for each outlet.

n: total mass of onions for each outlet.

■ **The total efficiency of the machine** was calculated as the average of the efficiencies of each category using the following equation **(Narvankar *et al.*, 2005)**:

$$\eta t = (\eta_1 + \eta_2 + \eta_3)/3 \quad \text{..............(3)}$$

Where:

ηt: total grading efficiency of the machine, %.

η_1, η_2, η_3: efficiencies of the classified onions for first, second, and third outlets.

■ **Mechanical damage percentage:** The percentage of mechanical damage during grading operation was determined by visual observation. The graded onions were sorted carefully to determine the damaged onions due to cylinder motion. The weight of total damaged onions was gathering from each collection unit and noted. Thereafter, the damage percentage was estimated using according to **(El-Raie *et al.* 2012)** as follows:

$$D_P = \frac{W_{d1} + W_{d2} + W_{d3} + W_{d4}}{W_t} \quad \text{.....(4)}$$

Where:

D_p: damage percentage, %.

W_{dl}, W_{d2}, and W_{d3}: weight of damaged onions collected at 1, 2, 3 and 4 outlet units, respectively, kg.

W_t: total weight of onions, kg.

■ **Power required:** Power required (kW) was estimated using clamp meter to determine electrical current change during grading operation. The required power was determined according to **(Ashby, 1988)**:

$$P_o = \sqrt{3} \cos\theta \times l \times V \times (1/1000) \quad \text{....... (5)}$$

Where:

Po: required power, kW.

I: current intensity, A.

V: Voltage, 380 V.

cos θ: constant, 0.7.

■ **Energy consumed:** The following formula was used to obtain the energy consumed **(Awady *et al.*, 2003)**:

$$Er = Po/P_M \quad \text{.............. (6)}$$

Where:

Er: energy consumed, kW.h/Mg.

P_M: machine productivity, Mg/h.

■ **Operating cost:** The grading machine hourly cost was calculated based on the fixed and variable costs using the following formula, **(Awady *et al.*, 2003)**:

$$Co = Mc/P_M \quad \text{........... (7)}$$

Where:

Co: operational cost, L.E/Mg.

Mc: machine hourly cost, L.E/h.

The machine hourly cost was determined using the following equation, **(Awady, 2003)**.

$$Mc = P/h\ (1/a + i/2 + t + r) + (W.e) + m/192 \quad \text{...... (8)}$$

Where:

Mc: grading machine hourly cost, L.E/h.

P: price of machine, L.E.
h: yearly working hours, h/year.
a: life expectancy of machine, year.
i: interest rate/year, %.
t: taxes and overheads ratio, %.
r: repair and maintenance ratio, %.
W: motor power, kW.
e: electric hourly cost, L.E/kW.h.
m: monthly average wage, L.E/month.
192: monthly average working hours, h.

The machine hourly cost was determined using the following equation with effect of analysis of equipment as shown in **Table (1)**.

Table (1): Initial cost for local onion grading machine.

Onion grading machine	Machine price (L.E)	Yearly working, hours (h/year)	Life expectancy of machine (year)	Interest rate/year (%)	Taxes and overheads ratio (%)	Repair and maintenance rat (%)	Motor power (kW)	Electric hourly cost (L.E/kW.h)	Monthly average wage,(L.E/month)	Monthly average working hours (h)
	25000	2304	10	10	6	8	0.735	1.44	2500	2500

■ **Operating cost:** Criterion cost can be determined using the following equation **(Awady *et al.*, 2003)**:

$$Cc = Co + Cd \ldots\ldots\ldots\ldots\ldots\ldots (9)$$

Where:
Cc: criterion cost, L.E/Mg.
Cd: damage cost, L.E/Mg.

3- RESULTS AND DISCUSSION

In order to select the appropriate operational parameters for the grading process, it was necessary to determine the percentage of total mechanical damage of onions, machine grading efficiency, machine productivity and operational cost. These parameters varied with onion feeding rates, cylinder rotating speeds and machine inclination angle at horizontal level. In other words, the quality of graded onions is largely depending upon the performance of the grading unit.

3.1. Effect of some operating parameters on machine productivity:

Results in Fig. (3) showed the effect of feeding rate on machine productivity. Increasing onion feeding rate from 0.9 to 1.8 Mg/h led to increase machine productivity values from 0.750 to 1.596, from 0.822 to 1.716 and 0.789 to 1.650 Mg/h at different cylinder rotating speeds of 10, 20 and 30 rpm, respectively and constant inclination angle 10º. These results show that increasing feeding rate from 0.9 to 1.8 Mg/h led to increase machine productivity.

Concerning the effect of cylinder rotating speed on machine productivity, results in Fig. (3) showed also that increasing cylinder rotating speed from 10 to 20 rpm leads to increase machine productivity values from 1.374 to 0.518, from 1.482 to 1.584 and from 1.596 to 1.716 Mg/h, respectively at different inclination angles of 0º, 5º and 10º and constant feeding rate of 1.8 Mg/h. while any further increase of cylinder rotating speed from 20 to 30 rpm leads to decrease the machine productivity from 1.518 to 1.440, from 1.584 to 1.542 and from 1.716 to 1.650 Mg/h at the same previous conditions. These results showed that increasing cylinder rotating speed during the grading process from 10 to 30 rpm leads to decrease machine grading productivity. This decrease in machine grading capacity by increasing cylinders rotating may be attributed to the decrease of onion speed which resulted in reducing the time of grading and consequently increasing the grading capacity. In other words, increasing the speed of cylinders increases the throughput of onion from the cylinder's openings which in turn, increase the machine grading capacity. These results agree with **(El-Raie (2012)** and **Genidy 2003)** concluded that the machine grading capacity increased by 22.2 % when the cylinder speed of feeding cells was increased from 10 to 40 rpm (0.11- 0.42 m/s) at different levels of tilt angles during grading the muskmelon. **(Gunathilake *et al.* 2016)** reported similar results for onion bulbs of size diameter at 3º inclined angle adjustment of the grading cylinder and rotational speed of 15 rpm and capacity was observed 630 kg/h.

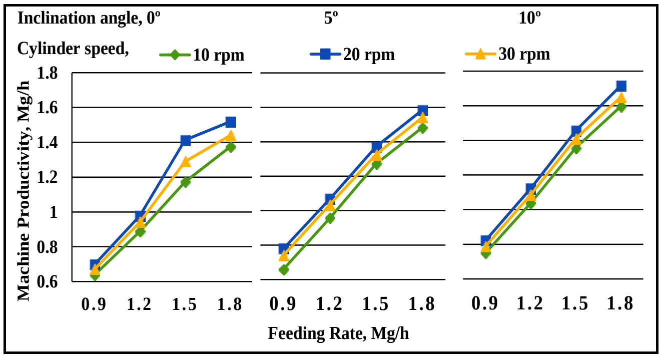


Fig.(3). Effect of feeding rate on machine productivity at different cylinder rotating speeds and different inclination angels.

As to the effect of inclination angle on machine productivity, results in Fig. (3) showed also that Increasing inclination angle from 0 to 10° led to increase machine productivity values from 0.699 to 0.822, from 0.978 to 1.122, from 1.413 to 1.455 and from 1.518 to 1.716 Mg/h at different feeding rates of 0.9, 1.2, 1.5 and 1.8 Mg/h, respectively and constant cylinder rotating speed of 20 rpm. These results show that increasing inclination angle from 0º to 10º led to increase machine capacity with a decrease in the time of grading. These results agree with **(EL-Raie *et al.* 1998)** who showed that the most suitable tilt angle of grading unit ranged from 3 to 6 deg.

3.2. Effect of some operating parameters on machine efficiency:

Results in Fig. (4) showed the effect of feeding rate on machine efficiency percentage. Increasing onion feeding rate from 0.9 to 1.5 Mg/h led to increase machine efficiency percentage values from 83.3 to 90.4, from 91.3 to 97.0 and 87.7 to 94.0 % at different cylinder rotating speeds of 10, 20 and 30 rpm, respectively and constant inclination angle 10º. While increasing onion feeding rate from 1.5 to 1.8 Mg/h leads to decrease the machine efficiency percentage from 90.4 to 88.7, from 97.0 to 95.3 and from 94.0 to 91.7 % at the same previous conditions. These results show that increasing feeding rate from 0.9 to 1.8 Mg/h led to increase machine efficiency percentage. The results revealed that total grading efficiency increased as onion feeding rate were increased from 0.9 to 1.5 Mg/h. However, at 1.8 Mg/h cylinders feeding rates the total grading efficiency tended to decrease slightly. These results agree with **(Abd El-Rahman 2011)** recorded the maximum machine grading capacity during the grading process at 65 rpm cylinders revolving speed and 150 kg/h cylinders feeding rate, was 121.3 kg/h. Meanwhile, the lowest grading capacity was 45.4 kg/h at 35 rpm cylinders revolving speed 75 kg/h cylinders feeding rate.

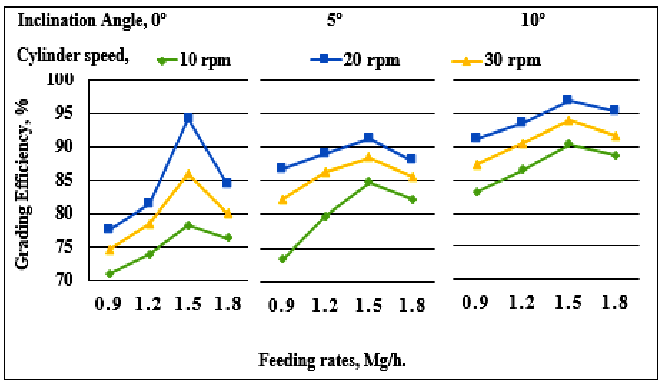


Fig.(4). Effect of feeding rate on grading efficiency at different cylinder rotating speeds and different inclination angels.

Concerning the effect of cylinder rotating speed on grading efficiency percentage, results in Fig. (4) shows also that increasing cylinder rotating speed from 10 to 20 rpm leads to increase machine efficiency percentage values from 76.3 to 84.3, from 82.3 to 88.0 and from 88.7 to 95.3 %, respectively at different inclination angles of 0º, 5º and 10º and constant feeding rate of 1.8 Mg/h. While any further increase of cylinder rotating speed from 20 to 30 rpm leads to decrease the machine efficiency percentage from 84.3 to 80.0, from 88.0 to 85.7 and from 95.3 to 91.7 % at the same previous conditions. The total grading efficiency tended to decrease slightly as cylinders revolving speed was increased from 20 to 30 rpm. The total grading efficiency increased as cylinders revolving speed increased from 10 to 20 rpm. This increase was followed by an obvious decrease in the machine. This decrease in the grading efficiency especially at the higher cylinders cylinder rotating speed may be due to the increase in the onion speed, which, in turn shortened the time of grading, and makes difficult penetration of onions through the cylinder's openings. The results of the grading efficiency agree with **(Matouk *et al.* 1999)** added that, at high sieve rocking speed the grading efficiency of fruit decreased.

As to the effect of inclination angle on grading efficiency. Results in Fig. (4) shows also that increasing inclination angle from 0 to 10º led to increase machine efficiency percentage values from 77.7 to 91.3, from 81.5 to 93.5, from 94.2 to 97.0 and from 84.3 to 95.3 % at different feeding rates of 0.9, 1.2, 1.5 and 1.8 Mg/h, respectively and constant cylinder rotating speed of 20 rpm. These results show that increasing inclination angle from 0º to 10º led to increase machine efficiency percentage with a decrease in the time of grading. Our results agreed with those of **(Yehia *et al.* 2017)** explained by increasing grading speed and fruit batch the grading efficiency decreased in general. The maximum grading-efficiency of 98.9 % were obtained with grading speed of 4 - 7 rpm and feed rate of 5 kg. Meanwhile, the minimum grading efficiency of 83.6 % were obtained with grading speed of 13 rpm, and feed rate of 20 kg.

3.3. Effect of some operating parameters on mechanical damage percentage:

Results in Fig. (5) shows the effect of feeding rate on machine damage. Increasing onion feeding rate from 0.9 to 1.8 Mg/h led to decrease mechanical damage values from 10.6 to 9.0, from 16.0 to 11.6 and 26.6 to 15.6 % at different cylinder rotating speeds of 10, 20 and 30 rpm, respectively and constant inclination angle 10º. The excessive increase in the onions mechanical damage percentage was observed when grading at 1.8 Mg/h feeding rate. This increase may be ascribed to the increase in rolling action of onion, which always associated with the increase the impact time of onion. In addition, onion may not sustain the impact. Therefore, the injuries occurred when onion hit each other during the grading process. These results show that increasing feeding rate from 0.9 to 1.8 Mg/h led to increase mechanical damage.

Concerning the effect of cylinder rotating speed on mechanical damage, results in Fig. (5) shows that increasing cylinder rotating speed from 10 to 30 rpm leads to increase mechanical damage values from 6.6 to 11.6, from 8.3 to 13.3 and from 9.0 to 15.6 %, respectively at different inclination angles of 0º, 5º and 10º and constant feeding rate of 1.8 Mg/h. These results show that, increasing the cylinder rotating speed from 10 to 30 rpm caused a gradual increase in the total mechanical damage percentage. These results agree with **(Yehia *et al.* 2017)** found that the fruit damage increased by increasing grading speed and decreased by increasing fruit batch for P.V.C. and rubber-coated cylinders.

As to the effect of inclination angle on mechanical damage. Results in Fig. (5) shows also that increasing inclination angle from 0 to 10º led to increase machine damage values from 10.0 to 16.0, from 8.0 to 12.5, from 6.8 to 12.8 and from 9 to 11.6 % at different feeding rates of 0.9, 1.2, 1.5 and 1.8 Mg/h, respectively and constant cylinder rotating speed of 20 rpm. These results show that using inclination angle from 0 to 10º led to increase the percentage of machine damage. These results agree with **(Matouk *et al.* 1999)** reported that the mechanical damage percentage of fruit increased as the speed of fruit feeding chain increased from 0.15 - 0.3 m/s.

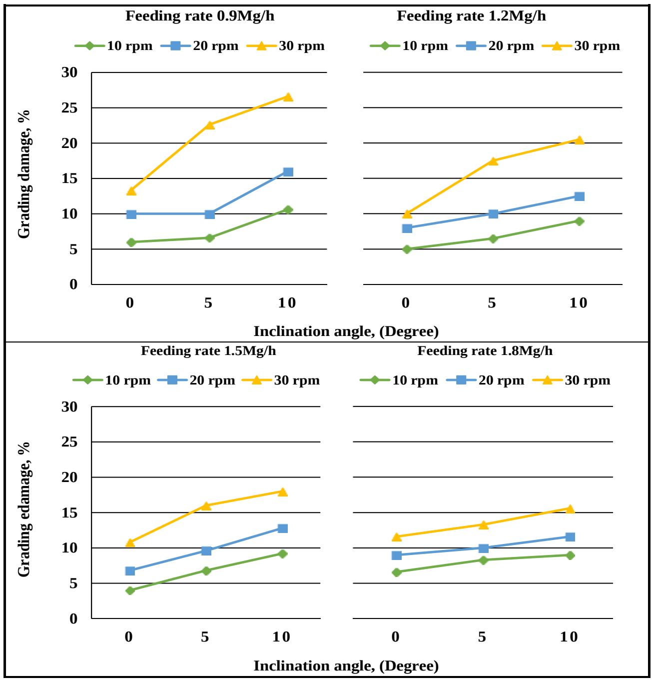


Fig.(5). Effect of inclination angle on machine damage at different feed rates and cylinder rotating speeds.

3.4. Effect of some operating parameters on energy consumed:

Results in Fig. (6) shows the effect of feeding rate on energy consumed. Increasing onion feeding rate from 0.9 to 1.8 Mg/h led to decrease energy consumed values from 0.60 to 0.28, from 0.68 to 0.33 and 0.89 to 0.43 kW.h/Mg at different cylinder rotating speeds of 10, 20 and 30 rpm, respectively and constant inclination angle of 10º. These results show that increasing feeding rate from 0.9 to 1.8 Mg/h led to decrease consumed energy. As a result of the existence of an inverse relationship between the energy consumed and machine productivity.

Concerning the effect of cylinder rotating speed on machine energy consumed, results in Fig. (6) shows also that increasing cylinder rotating speed from 10 to 30 rpm leads to increase energy consumed values from 0.33 to 0.49, from 0.30 to 0.46 and from 0.28 to 0.43 kW.h/Mg, respectively at different inclination angles of 0º, 5º and 10º and constant feeding rate of 1.8 Mg/h. These results show that increasing dram rotating speed from 10 to 30 rpm led to increase consumed energy.

As to the effect of inclination angle on machine energy consumed. Results in Fig. (6) shows also that increasing inclination angle from 0 to 10° led to decrease machine energy consumed values from 0.80 to 0.68, from 0.57 to 0.50, from 0.40 to 0.39 and from 0.37 to 0.33 kW.h/Mg at different feeding rates of 0.9, 1.2, 1.5 and 1.8 Mg/h, respectively and constant cylinder rotating speed of 20 rpm. These results show that increasing inclination angle from 0 to 10° led to decrease the consumed energy. These results agree with **(Huda *et al.* 2019)**.

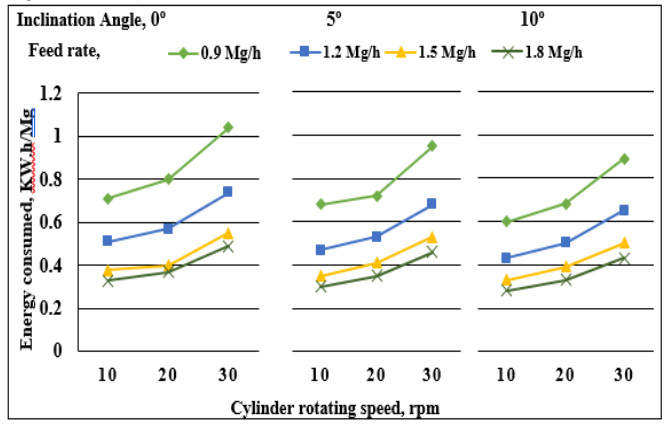


Fig.(6). Effects of cylinder rotating speed on machine energy consumed at different feed rates and inclination angles.

3.5. Effect of some operating parameters on operational cost:

Results in Fig. (7) shows the effect of feeding rate on operational cost. Increasing onion feeding rate from 0.9 to 1.8 Mg/h led to decrease machine operational cost values from 22.96 to 10.79, from 20.95 to 10.03 and 21.83 to 10.44 L.E/Mg at different cylinder rotating speeds of 10, 20 and 30 rpm, respectively and constant inclination angle of 10º. These results agree with **(Karthik *et al.* 2018)**.

Concerning the effect of cylinder rotating speed on machine operational cost, results in Fig. (7) shows also that increasing cylinder rotating speed from 10 to 20 rpm leads to decrease machine operational cost values from 12.53 to 11.34, from 11.62 to 10.87 and from 10.79 to 10.03 L.E/Mg, respectively at different inclination angles of 0°, 5° and 10° and constant feeding rate of 1.8 Mg/h. while any further increase of cylinder rotating speed from 20 to 30 rpm leads to increase the machine operational cost from 11.34 to 11.96, from 10.87 to 11.17 and from 10.03 to 10.44 L.E/Mg at the same previous conditions. These results show that increasing cylinder rotating speed from 10 to 20 rpm led to decrease machine operational cost and increasing cylinder rotating speed from 20 to 30 rpm led to increase machine operational cost. These results agree with **(Mostafa 2003)** showed that, the optimum operational conditions at 0.23 m/s for grading onion bulbs by size.

As to the effect of inclination angle on machine operational cost. Results in Fig. (7) shows also that increasing inclination angle from 0 to 10° led to decrease machine operational cost values from 24.64 to 20.95, from 17.60 to 15.35, from 12.19 to 11.84 and from 11.34 to 10.03 L.E/Mg at different feeding rates of 0.9, 1.2, 1.5 and 1.8 Mg/h, respectively and constant cylinder rotating speed of 20 rpm. These results show that increasing inclination angle 0 to 10° led to decrease operational cost. As a result of the existence of an inverse relationship between the operational cost and machine productivity. This increase in machine productivity from 0.9 to 1.8 Mg/h led to decrease operational cost from 0.9 to 1.8 Mg/h. These results agree with **(Ghanem *et al.* 2021)** who showed that the cost of grading onions affected by both the frequency of the vibratory motion and the angle of inclination of the grading unit.

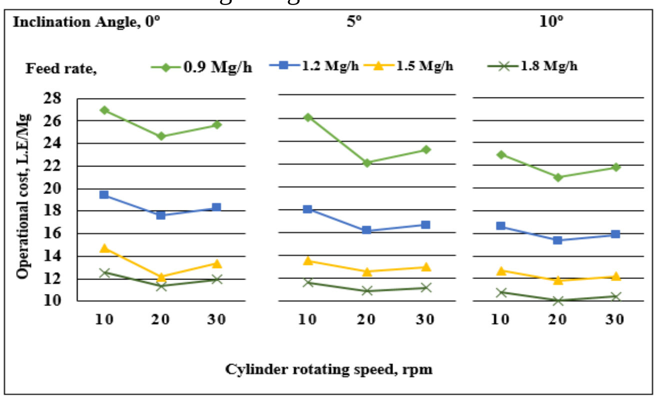


Fig.(7). Effects of cylinder rotating speed on machine operational cost at different feed rates and inclination angles.

3.6. Effect of some operating parameters on criterion cost:

Results in Fig. (8) shows the effect of feeding rate on criterion cost. Increasing onion feeding rate from 0.9 to 1.8 Mg/h led to decrease machine criterion cost values from 556.3 to 460.8, from 820.9 to 593.3 and 1355.1 to 793.7 L.E/Mg at different cylinder rotating speeds of 10, 20 and 30 rpm, respectively and constant inclination angle 10°. These results show that increasing feeding rate from 0.9 to 1.8 Mg/h led to decrease machine criterion cost. These results agree with **El-Sharabasy *et al.* (2021)**.

Concerning the effect of cylinder rotating speed on machine criterion cost, results in Fig. (8) shows also that increasing cylinder rotating speed from 10 to 30 rpm leads to increase machine criterion cost values from 345.9 to 595.3, from 428.3 to 677.9 and from 460.8 to 793.7 L.E/Mg, respectively at different inclination angles of 0, 5 and 10° and constant feeding rate of 1.8 Mg/h. These results show that increasing cylinder rotating speed 10 to 30 rpm led to increase machine criterion cost. This increase in machine criterion cost by increasing machine damage cost.

As to the effect of inclination angle on machine criterion cost. Results in Fig. (8) shows also that increasing inclination angle from 0 to 10° led to increase machine criterion cost values from 524.6 to 820.9, from 417.6 to 640.3, from 352.2 to 655.1 and from 461.3 to 593.3 L.E/Mg at different feeding rates of 0.9, 1.2, 1.5 and 1.8 Mg/h, respectively and constant cylinder rotating speed of 20 rpm. These results agree with **Suliman *et al.* (1998)**.

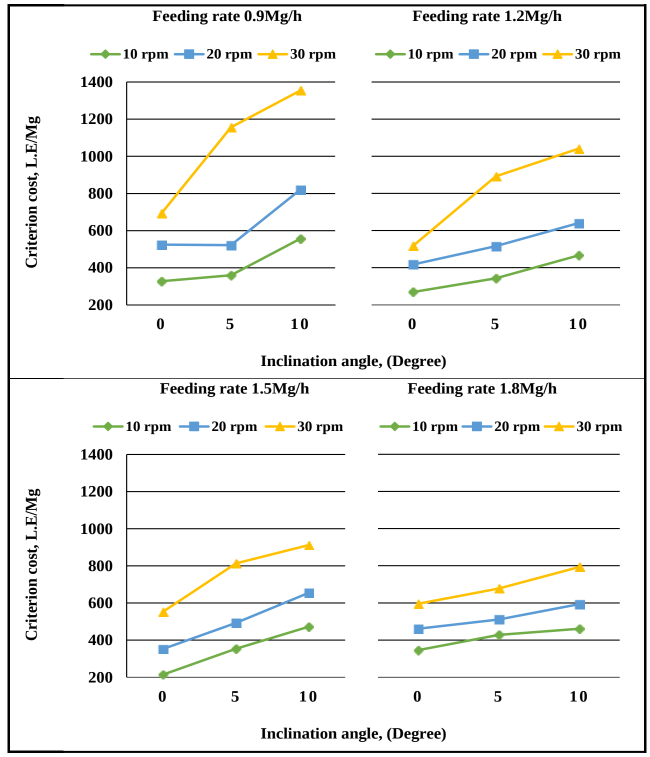


Fig. (8). Effect of feeding rate on machine criterion cost at different cylinder rotating speeds and different inclination angels.

4- CONCLUSION

This study recommends using a locally manufactured machine for grading onion crop based on size at feeding rate of 1.8 Mg/h, cylinder rotating speed of 20 rpm and constant inclination angle 10° for gets the highest productivity and efficiency with acceptable mechanical damage percentage, minimum energy consumed and operational cost of 1.716 Mg/h, 95.3%, 11.6%, 0.33 kW.h/Mg and 10.03 L.E/Mg, respectively, also gave an acceptable criterion cost

FUNDING:

This research did not receive any funding.

CONFLICT OF INTEREST:

The authors declare that they have no conflict of interest.

AUTHORS CONTRIBUTION

El-Sharabasy, M. M. A., and Esraa M. Abo Ahmed: developed the concept of the manuscript. Esraa wrote the manuscript. All authors checked and confirmed the final revised manuscript.

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تصنيع وتقييم أداء آلة محلية لتدريج محصول البصل

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الملخص العربى

يعتبر البصل أحد المحاصيل التصديرية الهامة في مصر، حيث بلغت المساحة المنزرعة حوالي ٨٩,٣٣٢ هكتار بإنتاجيه بلغت ٣,١٤٢,٢٦٤ ميجا جرام. ويتطلب تصديره مواصفات تسويقية عالية الجودة تتوقف بدرجة كبيرة على عملية تدريج البصل لأنها تعطي قيمة مضافة للمنتج وعائدا اقتصادياً للمزارع وعمل على تسهيل عملية التعبئة والتسويق، بالإضافة إلى الامتثال للمعايير التجارية العالمية التي تتطلب منتجات عالية الجودة. المشكلة الرئيسية لعملية التدريج اليدوي أنه عرضه للأخطاء البشرية بسبب اختلاف الرؤية والادراك من شخص لآخر، كما أنه يستغرق وقت أطول وبالتالي زيادة تكلفة عملية التدريج. كان الهدف من

هذه الدراسة هو تطوير آلة محلية الصنع مناسبة لتدريج محصول البصل وتقليل الخسائر وخفض تكاليف التدريج. تم تصنيع آلة التدريج من مواد أولية محلية لتقليل تكاليف الإنتاج وإتاحتها للمزارعين بأسعار مناسبة. تمت عملية التصنيع بإحدى الورش الخاصة بقرية تفتيش السرو – مركز فارسكور – محافظة دمياط من خامات محلية الصنع بغية تحقيق التنمية الاقتصادية بأقل تكلفة ممكنة. تم تنفيذ التجارب العملية بتفتيش السرو – مركز فارسكور لتقييم أداء هذه الآلة للوصول إلى أفضل القيم التشغيلية لتحقيق أعلى إنتاجية بأقل تكلفة ممكنة. **وكانت أهداف هذا البحث كالآتى:**

١- تصنيع وتطوير آلة محلية الصنع لتناسب تدريج محصول البصل.
٢- تحديد أنسب عوامل التشغيل التي تؤثر على أداء آلة تدريج محصول البصل.
٣- تقييم أداء آلة تدريج البصل المصنعة محلياً من الناحية الاقتصادية.

ولتقييم أداء الآلة تم أخذ عوامل التشغيل التالية:

١- أربع معدلات تغذية للبصل هي: ٠،٩، ١،٢، ١،٥ و١،٨ ميجا جرام / ساعة.
٢- ثلاث سرعات دوران لأسطوانات التدريج هي: (١٠، ٢٠ و ٣٠ لفة/د) تقابلها ثلاث سرعات خطية هي: (٠،٢٥ ، ٠،٥١ و ٠،٧٦ م/ث).
٣- ثلاث درجات ميل للآلة على الافقي هي: (صفر، ٥ و ١٠°).

تم تقييم أداء آلة تدريج البصل والمصنعة محلياً من خلال القياسات التالية: الإنتاجية، كفاءة التدريج، نسبة التلف الميكانيكي، القدرة والطاقة المستهلكة، تكاليف التشغيل والتكاليف الحدية (الكلية).

ومن خلال التجارب العملية تم الحصول على النتائج التالية:

١- الانتاجية: أظهرت النتائج أن أعلى إنتاجية كانت ١،٧١٦ ميجاجرام/ساعة وذلك عند معدل تغذية ١،٨ ميجاجرام/ساعة وسرعة دوران اسطوانات التدريج ٢٠ لفة/د وزاوية ميل ثابتة للآلة ١٠°. وأن أقل إنتاجية كانت ٠،٦٣٩ ميجا جرام/ساعة وذلك عند معدل تغذية ٠،٩ ميجا جرام/ساعة وسرعة دوران اسطوانات التدريج ٢٠ لفة/د وزاوية ميل ثابتة للآلة صفر°.

٢- كفاءة التدريج: أظهرت النتائج أن أعلي نسبة كفاءة تدريج كانت ٩٧،٠ % وذلك عند معدل تغذية ١،٥ ميجاجرام/ساعة وسرعة دوران الأسطوانة ٢٠ لفة/د وزاوية ميل ثابتة للآلة ١٠°. وأن أقل كفاءة درجة تدريج كانت ٧١،٠ % وذلك عند معدل تغذية ٠،٩ ميجاجرام/ساعة وسرعة دوران اسطوانات التدريج ١٠ لفة/د وزاوية ميل ثابتة للآلة صفر°.

٣- التلف الميكانيكي: أظهرت النتائج أن أعلي نسبة ضرر ميكانيكي كانت ٢٦،٦ % وذلك عند معدل تغذية ٠،٩ ميجاجرام/ساعة وسرعة دوران اسطوانات التدريج ٣٠ لفة/د وزاوية ميل ثابتة للآلة ١٠°. وأن أقل نسبة تلف ميكانيكي كانت ٤،٠ % وذلك عند معدل تغذية ١،٥ ميجاجرام/ساعة وسرعة دوران اسطوانات التدريج ١٠ لفة/د وزاوية ميل ثابتة للآلة صفر°.

٤- الطاقة المستهلكة: أظهرت النتائج أن اعلي طاقة مستهلكة كانت ١،٠٤٧ كيلووات.ساعة/ميجا جرام وذلك عند معدل تغذية ٠،٩ ميجاجرام/ساعة وسرعة دوران اسطوانات التدريج ٣٠ لفة/د وزاوية ميل ثابتة للآلة صفر°. وأن اقل طاقة كانت ٠،٢٨ كيلووات.ساعة/ميجاجرام عند معدل تغذية ١،٨ ميجاجرام/ساعة وسرعة دوران اسطوانات التدريج ١٠ لفة/د وزاوية ميل ثابتة للآلة ١٠°.

٥- تكاليف التشغيل: أظهرت النتائج أن أعلي تكلفة تشغيل كانت ٢٦،٩٥ جنيه/ميجاجرام وذلك عند معدل تغذية ٠،٩ ميجاجرام/ساعة وسرعة دوران الأسطوانة ١٠ لفة/د وزاوية ميل ثابتة للآلة صفر°. وأن أقل تكلفة تشغيل كانت ١٠،٠٣ جنيه/ميجا جرام وذلك عند معدل تغذية ١،٨ ميجاجرام/ساعة وسرعة دوران الأسطوانة ٢٠ لفة/د وزاوية ميل ثابتة للآلة ١٠°.

٦- التكاليف الحدية (الكلية): أظهرت النتائج أن أعلي تكلفة كلية للآلة كانت ١٣٥٥،١ جنيه/ميجا جرام وذلك عند معدل تغذية ٠،٩ ميجاجرام/ساعة وسرعة دوران اسطوانات التدريج ٣٠ لفة/د وزاوية ميل ثابتة للآلة ١٠°. وأن أقل تكلفة كلية كانت ٢١٤،٧ جنيه/ميجاجرام وذلك عند معدل تغذية ١،٥ ميجاجرام/ساعة وسرعة دوران اسطوانات التدريج ١٠ لفة/د وزاوية ميل ثابتة للآلة صفر°.

التوصيات :

توصي الدراسة باستخدام آلة تدريج البصل محلية الصنع عند معدل تغذية ١،٨ ميجاجرام/ساعة وسرعة دوران اسطوانة التدريج ٢٠ لفة/د وزاوية ميل ثابتة للآلة 10°، والتي تحقق أعلى إنتاجية وكفاءة تدريج وأقل نسبة تلف ميكانيكي بقيم ١،٧١٦ ميجاجرام/ساعة و ٩٥،٣ % و ١١،٦ %، على الترتيب. وعلاوة على ذلك، حققت هذه المعاملات أقل قيمة للطاقة المستهلكة مع أقل قيمة لتكاليف تشغيل الآلة بقيم ٠،٣٣ كيلووات.ساعة/ميجاجرام و١٠،٠٣ جنيه/ميجاجرام، على الترتيب، كما أعطت تكاليف كلية للتدريج مقبولة.


DJAS., Volume (3) , Issue (I) , 2024