EFFECT OF SOME OPERETIONAL FACTORS ON THE OPERATING COSTS IN SEED COATING PROCESS

Helmy M.A. *; A. Derbala; S. Badr*** and M. Amer****

ABSTRACT

The present study aimed to evaluate the effect of some engineering factors involved in processes of corn and wheat seed coating. The engineering factors were speed and slope of the coating pan, and speed of the spinner disk. The research study was carried out at the station of seed processing in Gemmiza agricultural research station [middle of the Nile Delta-Egypt]. The both of seeds were corn and wheat. The results revealed that, increasing the angle of coating pan and speed pan rotation leads to less needed time for coating 1 ton of corn and wheat seeds and vice versa. Then, the operating costs were reduced from 15.94 L.E/Mg to 10.53 L.E/Mg for corn and from 17.36 L.E/Mg to 12.68 L.E/Mg for wheat under θ_1 and θ_4, respectively and they reduced 16.92 L.E/Mg to 12.21 L.E/Mg for wheat and from 15.61 L.E/Mg to 11.31 L.E/Mg for corn under V_1 andV_4, respectively.

INTRODUCTION

Seed processing is that segment of the seed industry responsible for upgrading seed, improving planting condition of seed, and applying chemical protectants to the seeds. This Makes possible more uniform planting rates by proper sizing , improve seed marketing by improving seed quality ,prevent spread of weed seeds, protect crops against diseases by applying chemical protectants, reduce seed losses and facilitate uniform marketing by providing storage from harvesting time until the seed planting time.

The seed coating process is consider over cost on the price of the seeds so the costs of this process are a signal of the operation efficiency. Repair and maintenance costs tend to increase with the machine size and complexity, and thus with the purchase price [Pp] of the machine. The following

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equation can be used to estimate accumulated repair and maintenance costs **[ASAE1994]**

$$\frac{C_{rm}}{Pp} = RF1\left[\frac{t}{1000}\right]^{RF2}$$

Where:

C_{rm} : accumulated repair and maintenance costs [L.E],

t: accumulated use [hr], and

RF1: ASAE repair factor = 0.23

RF2: ASAE repair factor = 1.80

ASAE [1996] defined the real interest rate as follows:

$$Ir = Ip\text{-}Ig \,/\, 1+Ig$$

Where:

I_r = prevailing annual interest rate [decimal], and

I_g = general inflation rate [decimal].

Electricity costs for any given operation, per ton can be calculated using the following equation **[ASAE, 1994, Fang *et al*., 1998, Pasikatan *et al*., 2001]**:

$$C_s = P_L(Q_i / C_a)$$

Where:

C_s = electrical costs per one ton in L.E/Mg

P_L = the commercial price of kWh = 0.30 L.E

Q_i = electrical consumed by motor in kW/h and

C_a = effective machine production during the operation in ton/h

ASAE [1994 and 1996] indicated that fixed costs include depreciation of the machine, interest on the investment, taxes, insurance and housing of the machine. The total annual fixed costs can be calculated according to ASAE [1997] as the following equation:

$$C_{os} = \frac{C_{oa}}{P_p} = (1 - S_v)\left[\frac{I_r(1+I_r)^{\tau_L}}{(1+I_r)^{\tau_L - I_r}}\right] + \frac{K_{tis}}{100}$$

Where:

C_{os} = specific annual fixed costs [LE/Yr],

C_{oa} = total annual fixed costs [LE/Yr],

P_p = purchase price of machine [LE],
τ_L = economic life of machine [Yrs],
S_v = salvage value as fraction of purchase price,
I_r = real annual interest rate [decimal], and
K_{tis} = annual cost of taxes, insurance and shelter as percent of purchase price.

K_{tis} could be assumed 2% of the P_p unless better data are available; S_v is often assumed 10% of purchase price referring to **[Hunt, 1983]**.

Nga and Sarro [2006] stated that the machinery costs include two main components. The first are fixed costs that include insurance, depreciation, interest cost, shedding cost, workshop cost, registration cost and implements. These costs are independent of the amount of the machine used.

The second are the variable costs that include fuel or electric power, oil and grease, wearing parts, repair and maintenance and labor costs. These costs are dependent on the amount of the machine used. They added that, there are two major methods of determining machinery-operating expenses: producer surveys and direct estimation using equations based on survey information.

MATERIALS AND METHODS

In an endeavor to characterize the engineering factors contributed in efficient operation processes of seed coating, a research study was carried out at Gemmiza agricultural research station. Corn [*Zea Maize*] and wheat [*Triticum aestivum L.*] seeds were used as a material of study. Gustafson's Metered Slurry Treater, G17- Gross Bagger-SS-6 film coater was used, the sketchmatic diagrams for the machine is shown in Fig. [1]. Corn and wheat seeds were treated by a fungicide, Sumi-eight WP 2% at a rate of 0.5 g of soluted active ingredient for one kilogram of seeds [Ministry of Agriculture recommendation, 2006]. The weight of the metered seed was controlled by placement of the counterweight, while the amount of the chemical metered was determined by the size of chemical cup. The engineering factors considered in this study were: speed of the coating pan [V], slope of the coating pan [θ] and speed of the spinner disk [a]. The treatments were arranged in split- plot design with three replicates, i.e;

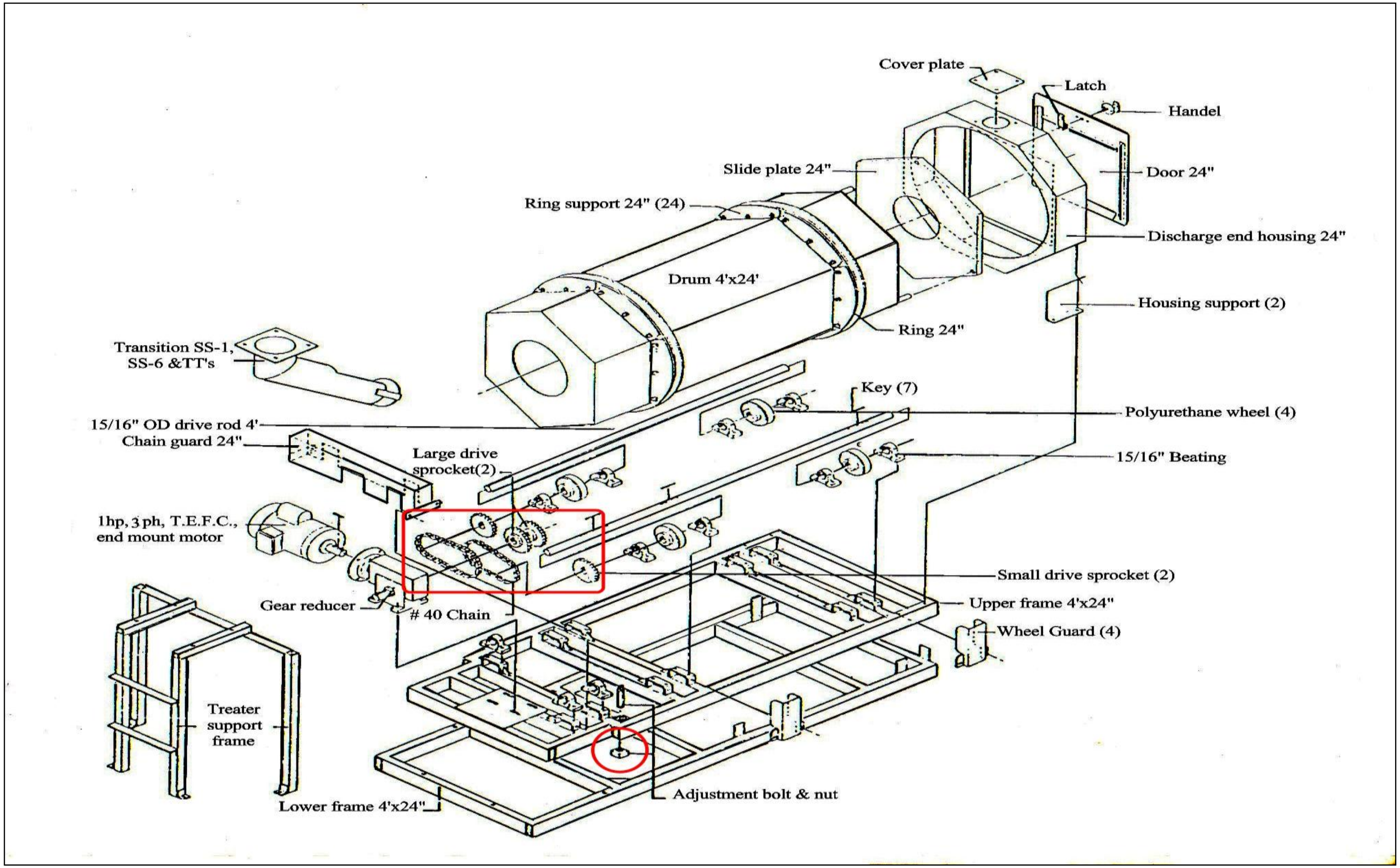

Fig. 1: Construction of the coating pan

- Four rates of coating pan speed, 0.3728, 0.4660, 0.5592 and 0.6524 m/s were excluded where V_2 was considered as the control. These values of pan speed were controlled by changing the cogwheel teeth number. Three drive cogwheels of 18, 28 and 33 teeth were manufactured and replaced with the original sprocket, which has 23 teeth.
- Four degrees of coating pan slope were measured as angle between the pan and the horizontal fixed frame of the set. The angles were 9.043×10^{-3} rad. [0º 31´ 5.19″], 18.086×10^{-3} rad. [1º 2´ 10″] [control], 27.66×10^{-3} rad.[1º 35´ 5.9″] and 36.71×10^{-3}rad. [2º 6` 12″].
- Four speed rates of spinner disk were obtained through manufacturing three drive pulleys of 7.5, 9.5 and 11.5 cm in addition to the original one that of 5.5 cm. These pulleys were fixed to the spinner disk on the same shaft, which produced speeds of 1430, 1049, 828 and 684 r.p.m for 5.5, 7.5, 9.5 and 11.5 cm diameters respectively. The speed was measured using a Hand Contact Tachometer.

Table 1:Technical specifications of hand contact tachometer

Instrument	Model	Manufacture	Speed ranges
Tachometer	DEUMO	Germany	Three speed ranges are available such as: 1st speed ranged from 40 to 500 r.p.m 2nd speed ranged from 400 to 5000 r.p.m 3rd speed ranged from 4000 to 50,000 r.p.m scale value: r.p.m ×100

Our study dealed definitely with final step, in which, the seeds are treated with fungicidal chemicals and then be packed.

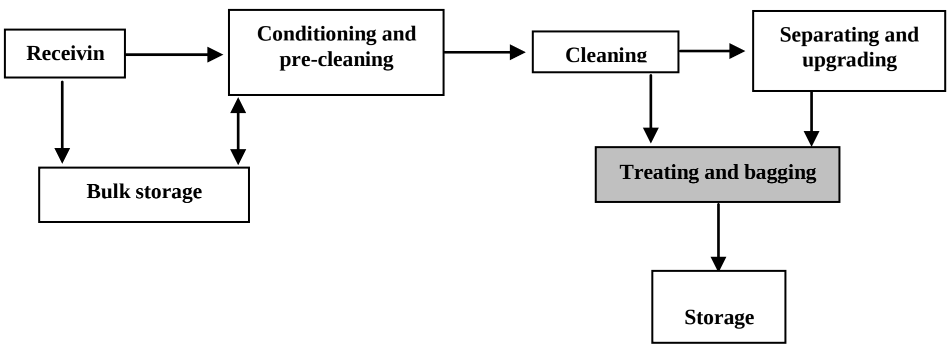

Fig. 2 : Basic flow and essential steps in seed

Power source

Electricity is available from public electricity board. However, a standby diesel generating set of 45 kW has been installed for meeting exigencies in the event of power shedding or failure.

Coating unit: Fig. (1)

Coating unit is an assembled unit represents the final step in seed processing operations. It consists of a steel rotating drum equipped with spinner disc and a unit for metering seed device for adjusting the doze of seed feeding plus a unit for pumping the treating material into rotating drum. The power source of the coating unit is two electric motors, one of 10.5 hp for rotating pan and another of 0.5 hp for pumping the coating material.

Labors, technicians and productivity

Usual daily productivity of the plant [without modification] is 20 ton of processed corn seeds and 18 ton of wheat processed seeds. This amount of seed is to be processed during a period of 12 hours in one shift of 6 men power engaged in a shift. Actual time period for treating corn and wheat is 90 days/season. It was approximately divided in equal two halves between the two crops, corn and wheat.

The total costs

1- **Fixed costs** that include purchase price [P_p], annual interest, taxes, insurance and shelter. Purchase price of the unit [as alone] is unknown. Therefore, it will be mentioned as P_p without definite currency value. Annual interest rate was assumed as 10% of purchase price, which was referred as P_p. Taxes, insurance and shelter were assumed as 2% of P_p.

2- Variable costs that directly related to the amount of operation. It includes power, labour, and repair & maintenance cost.

Repair and maintenance

Seed processing is a seasonal work and the entire machines will not operate all the time. The repair and maintenance were taken as 1% of the cost of the unit within actual operating time. Based on above information and assumptions, processing load and period available for processing, total cost of coating of corn and wheat seeds were estimated.

Power requirements and cost

Super clamp meter- 300 k Japan case made was used for measuring the current strength and potential difference. The consumed power [kW] was calculated by measuring the line current strength [I] and potential difference values [V]. The formula offered by [**Ibrahim, 1982]** was applied as follows:

$$\text{Total consumed power} = \frac{\sqrt{3}\, I.V.\eta.Cos\theta}{746}$$

Where:

I = line current strength in amperes,

V = potential difference [Voltage] being equal to 380 V,

Cos θ = power factor [being equal to 0.84],

√3 = coefficient current three phase [being equal 1.73] and

η = mechanical efficiency assumed to be [90%].

The energy consumption in [kW. h/Mg] was calculated using the following equation:

Energy consumption = consumed power to coat a unit weight of seeds (kW) / machinery line productivity in Mg / h = kW. h /Mg

Table 1: Assumptions for estimating Fixed Costs

No	Item	Value
1	Purchase Price (Pp)	Un-known
2	Shelting, taxes and insurance	2% of Pp
3	Interest rate	10 % of pp

The efficiency of the motors was considered to be 90% **[Ibrahem 1982]** this means 12.94 actual horsepower. Considering 1 hp = 746 Watt, so, total needed electric power = 14.66×746 ≈ 10.94 kW /hr. The consumed power [kW] was calculated by measuring the line current strength [I] and potential difference values [V]. Electric power cost was informed from the holding company of electricity distribution [middle Delta company for electricity distribution] by [0.3 L.E +10% as sales taxes], i.e., 0.33 L.E/1 kW. Electrical power cost for any given operation, per ton was calculated. The consumed power [kW] was estimated by dividing the actual accounted energy consumption [kW.h] by the corresponding average productivity [ton/h] and the difference in consumed power [kW] was calculated under all of studied factor.

Operating costs

Operating costs are dependent on the amount of the machine used. Hence, operating or variable costs increase in proportion to the amount of the machine used. Operating or variable costs include fuel or electrical power, oil and grease, labor, repair and maintenance.

Labor cost

In Egypt, the cost of labor varies widely with location. In the present study, data collected from private sector owners, show that the labor cost could be considered as 40L.E/ labor day, so the labor charge for man is simply this hourly rate multiplied by the operation time required for coating a unit weigh of seeds under different treatments [in hours] by the hourly cost of labor. The labor wage rate was estimated by 40 L.E/12 hrs according to the station records and the data collected nearby the area of work, this means that one labor hour costs 2.00 and 2.22 L.E i.e., 12 and 13.33 L.E per ton of corn and wheat respectively.

Repair and maintenance

To calculate the total repair and maintenance costs over the life of machine then dividing it by economic life of the machine in hours, the costs of repair and maintenance for one hour could be obtained, multiplying this cost by operation time in hours, actual repair and maintenance costs could be estimated per ton.

$$\frac{C_{rm}}{Pp} = RF1\left[\frac{t}{1000}\right]^{RF2}$$

Calculation procedures

To estimate the fixed costs [L.E] based on the assumptions that: economical life of the unit = 30 year [as informed by the station manager], corn and wheat treating processes expand for 90 days/season i.e., 90 × 12 hours/day [one shift of 12 hours/day] = 90 × 12 = 1080 hours/season, that meant:

[20 ton of corn/day] × 90 days = 1800 ton/1080 hours = 1.67 ton/hour, i.e., 1 ton/36 minute or [18 ton of wheat / day] × 90 days = 1620 ton / 1080 hours = 1.5 ton / hour, i.e., 1 ton / 40 minute.

Total annual fixed costs [Interest rate, shedding, taxes and insurance] = 12 % of purchase price [Pp]. Actual time period related to corn and wheat treating = 3 / 12 = 25 % of fixed costs, i.e., 12 % / 4 of purchase price [Pp] = 3 % Pp. In the same manner, sets of calculating steps were made to estimate the portion of repair and maintenance cost.

RESULTS AND DISCUSSION

In the present experimental study, the costs of coating process was calculated under every treatment for two crops as represented in Table 2 and 3 The data in, Fig.3 , 4 and 5 illustrate that:

Increasing both of the angle of coating pan and speed pan rotation leads to less needed time for coating 1 ton of corn and wheat seeds and vice versa.

The effect of changing speed of spinning disc has no meaningful variation on the time needed for coating 1 ton of corn and wheat seeds.

This may be attributed that, the most effective modification on productivity (a unit of production per a unit of time) was the angle of coating pan and/or pan rotating speed. Also, from the data in Tables 2 and 3, it could be driven that the economical savings due to applied factors, where decreasing the angle of coating pan slope from usual angle i.e., (18.086×10^{-3} rad.) to (9.043×10^{-3} rad.) leads to less productivity of the machine and by the way increased the costs by 13.45 % for corn and by 12.22 % for wheat. Increasing the angle of coating pan slope from usual angle i.e., (18.086×10^{-3} rad.) Up to (27.66×10^{-3} rad.), the productivity of the machine increased and by the way decreased the costs by 16.80 % for corn and by 6.27 % for wheat while increasing the angle of coating pan slope up to (36.71×10^{-3} rad.) saved 25.05 % of costs of corn coating and 18.03 % of wheat coating and the machine productivity increased and by the same values.

Table: (2) Productivity of machine and total costs for corn seed coating under different operational factors

Studied factor	Operation Time (min./ton)		Operating Costs					Total O.costs (L.E/Mg)	*Fixed costs (L.E/ Mg)	Total (L.E/Mg)
	Ref	After modification	Power req. (kW/Mg)	Power Cost L.E/Mg	Labor req. man/Mg	Labor Cost (L.E / Mg)	*Rep.& maintenance (L.E/ Mg)			
θ_1	36	41.0	6.59	2.18	0.34	13.60	0.158	15.94	1.5%(Pp)	15.94+1.5% of Pp
θ_2	36	36.0	5.79	1.91	0.30	12.00	0.139	14.05	1.5%(Pp)	14.05+1.5% of Pp
θ_3	36	29.5	4.75	1.57	0.25	10.00	0.116	11.69	1.5%(Pp)	11.69+1.5% of Pp
θ_4	36	27.0	4.34	1.43	0.225	9.00	0.104	10.53	1.5%(Pp)	10.53+1.5% of Pp
v_1	36	40.0	6.43	2.12	0.33	13.33	0.155	15.61	1.5%(Pp)	15.61+1.5% of Pp
v_2	36	34.5	5.55	1.83	0.29	11.60	0.134	13.56	1.5%(Pp)	13.56+1.5% of Pp
v_3	36	31.5	5.07	1.67	0.26	10.50	0.122	12.29	1.5%(Pp)	12.29+1.5% of Pp
v_4	36	29.0	4.66	1.54	0.26	9.66	0.112	11.31	1.5%(Pp)	11.31+1.5% of Pp
a_1	36	33.5	5.39	1.79	0.28	11.12	0.129	13.04	1.5%(Pp)	13.04+1.5% of Pp
a_2	36	33.5	5.39	1.79	0.28	11.12	0.129	13.04	1.5%(Pp)	13.04+1.5% of Pp
a_3	36	34.0	5.47	1.80	0.28	11.33	0.131	13.26	1.5%(Pp)	13.26+1.5% of Pp
a_4	36	34.0	5.47	1.80	0.28	11.33	0.131	13.26	1.5%(Pp)	13.26+1.5% of Pp

*Calculated as a percent of purchase price (Pp)

Table: (3) Productivity of machine and total costs for wheat seed coating under different operational factors

Studied factor	Operation Time (min./ton)		Operating Costs					Total O.costs (LE/ton)	*Fixed costs (LE/ton)	Total (LE/ton)
	Ref	After modification	Power req. (Kw/ton)	Power Cost (LE/ton)	Labor req. man/ton	Labor Cost (LE /ton)	**Rep.& maintenance (LE/ton)			
θ_1	40	45	7.24	2.39	0.37	14.80	0.172	17.36	1.5%(Pp)	17.36+1.5% of Pp
θ_2	40	40	6.43	2.12	0.33	13.20	0.153	15.47	1.5%(Pp)	15.47+1.5% of Pp
θ_3	40	37	5.95	1.96	0.31	12.40	0.144	14.50	1.5%(Pp)	14.50+1.5% of Pp
θ_4	40	33	5.31	1.75	0.27	10.80	0.126	12.68	1.5%(Pp)	12.68+1.5% of Pp
v_1	40	44	7.08	2.34	0.36	14.40	0.167	16.92	1.5%(Pp)	16.92+1.5% of Pp
v_2	40	38	6.11	2.02	0.31	12.40	0.144	14.56	1.5%(Pp)	14.56+1.5% of Pp
v_3	40	35	5.36	1.86	0.29	11.60	0.135	13.60	1.5%(Pp)	13.60+1.5% of Pp
v_4	40	32	5.15	1.69	0.26	10.40	0.121	12.21	1.5%(Pp)	12.21+1.5% of Pp
a_1	40	42	6.76	2.23	0.35	13.86	0.161	16.25	1.5%(Pp)	16.25+1.5% of Pp
a_2	40	43	6.92	2.28	0.35	14.19	0.165	16.64	1.5%(Pp)	16.64+1.5% of Pp
a_3	40	41	6.59	2.18	0.34	13.53	0.157	15.87	1.5%(Pp)	15.87+1.5% of Pp
a_4	40	40	6.43	2.12	0.33	13.20	0.153	15.47	1.5%(Pp)	15.47+1.5% of Pp

*Calculated as a percent of purchase price (Pp)

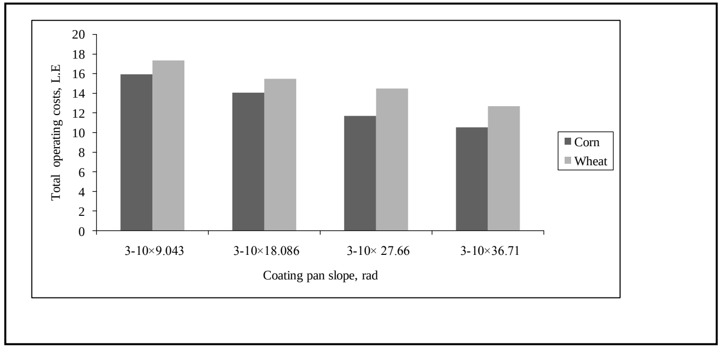

Fig 3: The effect of coating pan slope on Productivity and costs

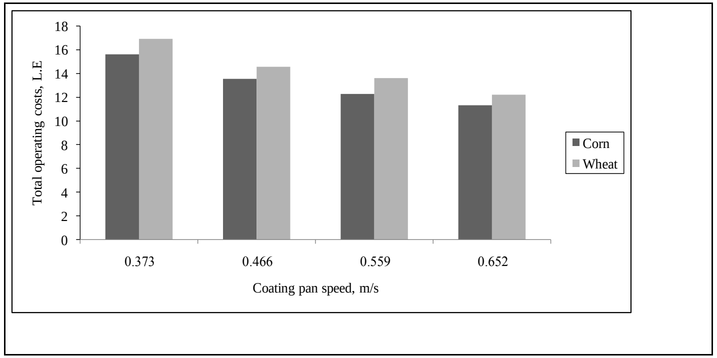

Fig.4: The effect of coating pan speed on Productivity and costs

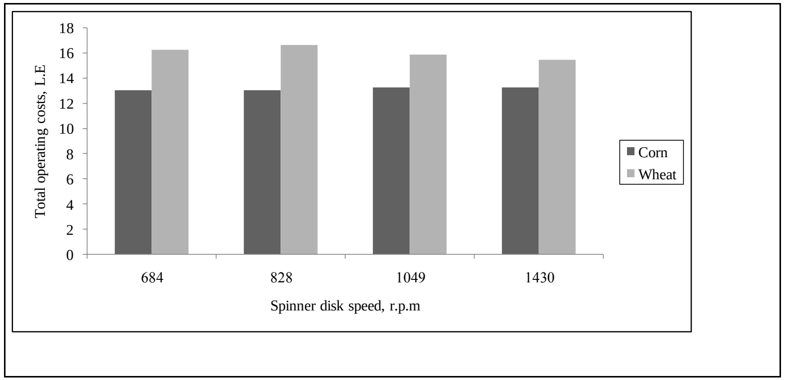

Fig.5: The effect of spinner disk speed on Productivity and

With respect to the speed of pan rotation, it is observed that, decreasing the speed from usual one i.e., (0.466 m/s) down to (0.372 m/s), the time of operation increased and by the way the productivity of the machine decreased and the cost increased by 13.13 % for corn and by 16.21 % for wheat.

With respect to the diameter and spinning speed of spinner disk, the differences between different spinning disk diameter i.e.(13.5, 16.5,18 and 15 cm) spinning disk speed i.e. (1430, 1049, 828, and 684 r.p.m) and were not clear.

These results may leads to recommend the highest angle of coating pan slope and the highest speed of pan rotating. But this is not an absolute right because, in spite of the highest angle of coating pan slope and the highest speed of pan rotating saved more time and costs, the coating efficiency was decreased. So, from the economical point of view, θ_3 (27.66×10^{-3} rad.) and V_3 (0.5592 m/s) could be recommended as the highest coating efficiency (CE) was achieved.

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<u>**الملخص العربى**</u>

تأثير بعض عوامل التشغيل على تكاليف التشغيل فى عمليات تغطية البذور

ممدوح عباس حلمى* ، أسعد عبدالقادردربالة ، سامى السعيد بدر*** ، مى محمد عامر****

أجريت هذه الدراسة بمحطة إعداد وتجهيز التقاوى بمحطة بحوث الجميزة بوسط الدلتا - محافظة الغربية - ج .م.ع. حيث تمت دراسة تأثير كل من زاوية ميل اسطوانة الخلط وسرعة اسطوانة الخلط وقطر القرص الدوار وسرعة القرص الدوار وتهدف دراسة وتقييم تأثير هذه العوامل على على تكاليف التشغيل فى عمليات تغطية كل من الذرة والقمح بمبيد فطرى (سومى – ايت 2 %) .

تعتبر عملية معالجة التقاوى من العمليات التى تمثل تكلفة تضاف إلى قيمة التقاوى لذلك فإن دراسة تكاليفها تعطى مؤشرا على كفاءة أدائها ، وقد أجريت دراسة لتقدير تكاليف عملية تغطية التقاوى لمحصولى الذرة والقمح تحت مختلف العوامل الهندسية تحت الدراسة ، وقد أظهرت النتائج ما يلى:

- أدت زيادة كل من زاوية ميل أسطوانة الخلط وسرعة دورانها إلى تقليل زمن التشغيل اللازم لمعاملة طن واحد من كل من حبوب الذرة والقمح على السواء.
- أدى نقص زاوية ميل أسطوانة الخلط من (18.086×10-3 rad) إلى (9.043×10-3 rad) إلى خفض الإنتاجية وبالتالى زيادة التكلفة بمقدار 13.45% لتقاوى محصول الذرة وبمقدار 12.22% لتقاوى محصول القمح.
- أدت زيادة زاوية ميل أسطوانة الخلط من (18.086×10-3 rad.) إلى (27.66×10-3 rad.) إلى زيادة الإنتاجية وبالتالى خفض التكاليف بنسبة 16.80 % لتقاوى محصول الذرة وبنسبة 6.27 % لتقاوى محصول القمح.
- أدت زيادة زاوية ميل أسطوانة الخلط إلى (36.71×10^{-3} rad.) إلى زيادة الإنتاجية وبالتالى خفض التكاليف بنسبة 25.05% لتقاوى محصول الذرة وبنسبة 18.03% لتقاوى محصول القمح ومع ذلك لا يوصى بهذه المعاملة حيث أنها أدت الى خفض معدل لكفاءة التغطية.
- بالنظرإلى تأثيرسرعة الأسطوانة فقد أدى نقص سرعة دوران الأسطوانة من(0.466 m/s) إلى (0.372 m/s) أدى إلى زيادة الزمن اللازم لتشغيل طن واحد وبالتالى زيادة التكلفة بنسبة 13.1 % لتقاوى الذرة و بنسبة 16.21 % التقاوى محصول القمح.
- أدت زيادة سرعة الأسطوانة إلى (0.6524 m/s) إلى زيادة الإنتاجية وبالتالى خفض التكاليف بنسبة 14.05% لتقاوى الذرة ، 12.21% لتقاوى القمح .
- يوصى باستخدام زاوية ميل الأسطوانة (27.66×10^{-3} rad.[1º 35´ 5.9″]) وسرعة دوران الأسطوانة (0.5592 m/s) وسرعة القرص (1430 r.p.m) حيث أعطت هذه العوامل أعلى كفاءة تغطية وأعلى إنتاجية وبالتالى أقل تكلفة لمعاملة طن من تقاوى المحصولين تحت الدراسة .

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