DEVELOPMENT OF A GRANULAR PROCESSING MACHINE

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ABSTRACT.

The aim of this study was to develop and testing of granular-processing machine for poultry fodder. The tested parameters were: (1) die speeds of 160, 180, 200, 220, 240 and 260 rpm, the die speeds were 80, 90, 100, 110, 120 and 130 rpm (2) hole diameters of 3, 4 and 5 mm (3) Die thickness of 8, 12, 15, 20 and 25 mm. and (4) Moisture content of fodder mixture 5 %, 10% and 15%.

The optimum conditions of developed machine were: (1) Die-hole diameter of 3, 4 and 5 mm, (2) Die thickness of 8 mm, (3) Die speed of 220 rpm, (4) Fodder moisture-content of 10 % and (4) Granular dry-duration of 69 h. The obtained results in optimum conditions can be summarized as follows: Granular productivity ranged between 185 – 276 kg/h, Granular losses ranged between 3.03 – 3.78 %, real density ranged between 1.1469 – 1.1491 g / cm^3, Granular durability ranged between 88.9 – 90.7 and Machine power ranged between 8.89 – 10.05 kW.

The variables affecting the granular productivity, total losses, density were combined into dimensionless groups. The general equations were formulated inside the paper.

The production costs at optimum conditions were 12 to 11.71 64.84, 54.17 and 43.84 L.E./ton for die-hole diameters 3 and 4 and 5 mm respectively.

1 - INTRODUCTION.

The shortage in traditional feedstuffs is one of the most important problems challenging the poultry production industry in Egypt. The cost of feeding constitutes about 60 – 70 % of total poultry production **(El-Derey, 2005)**. In addition, the feed materials increase continuously and consequently of poultry product prices (meat and eggs).   For this reason, many attempts have been carried

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out to look for alternative the sources such as agricultural residues to overcome this problem.

Awady (1989) mentioned that appropriate mechanization technologies should fulfill the three following parameters: (1) Proper functioning in handling the job for which it is designed, (2) Economical aspects, and (3) Matching with the present technological status while maintaining sustainability and safety requirements. So, various agricultural machines must be designed and manufactured to save time and work, and to protect the environment. The designed machine must not be expensive, simple in construction and operation in all environmental conditions.

Packaging technology of voluminous forage or fodder materials into dense stable units is presently widely spreading throughout the farmworld due to its versatile benefits. This technique prevents segregation of the feed components and facilitates handling and feeding conditions associated with increasing production of animals fed in compact units.

El-Attar (2010) designed, and tested of pelleting machine that produce to feed the cattle and sheep (This machine was developed in this study for granular for poultry feed) used agricultural residues recycling to conserve the environment. The tested factors were: (1) die hole-diameters of 5 (for rabbit), 8, 10 (for cheep) and 12 mm (for cattle). (2) Die speeds of 100, 180, 250 and 320 rpm (3) Clearnce between die and rollers of 0, 0.5, 1.0 and 1.5 mm. (4) Moisture content of fodder of 5, 10 and 15 %. (5) Molasses content of 5, 10 and 15. The tested cheep and cattle rations consist of 50 % rice straw (treated by urea), 15 % barseem hay, 10 % wheat bran, 10 soybean meals, and 15 % yellow corn. The maximum machine pellet-productivity of 247 kg/h was obtained with die speed of 250 rpm, die-hole diameter of 12 mm and clearance between rollers and die of 0.5 mm. Meanwhile, the minimum machine pellet-productivity of 95 kg/h was obtained with die speed of 320 rpm, die-hole diameter of 5 mm and clearance between rollers and die of 1.5 mm. This machine (designed by El-Attar, 2010) was developed in this study to produce granular for poultry. The feed unit was added to this machine to give feed rate acceptable with die-hole diameter. The tested factors to produce granular were: (1) Die-hole diameter ranged between 3 – 5 mm, (2) Die

thickness ranged between 8 – 25 mm, (3) Die speed ranged between 160 – 260 rpm, the die speed ranged between 80- 120 rpm and (4) Moisture content of fodder mixture ranged between 5 – 15 %.

The objectives of this study are to develop and test of granular-processing machine for poultry fodder. In addition, some factors affecting the performance and power consumed such as die speed, die-hole diameter, die thickness and fodder moisture-content were studied.

2 - MATERIALS AND METHODS.

2-1- Materials:

2-1-1 Designed granular processing-machine:

The developed granular-machine is shown in Figs. 1 and 2. The machine consists of the following parts:

a) Frame: The frame was made of steel sheet of overall length, width and height of 1010, 705 and 1478 mm respectively.

(b) Feeding unit: The granular feeding-unit consists of the following parts:

(1) The trapezoidal feeding-hopper was made of steel sheet of 2 mm thickness, base dimensions of 350 x 350 mm, top dimensions of 50 x 200 mm and height of 250 mm.

(2) Feeding chamber consists of a feeding housing with 90 mm diameter and 5 mm thickness and an auger of 80 mm diameter and 300 mm length. The overall dimensions of feeding unit are shown in Fig. 1.

(c) Granular forming-unit: The granular forming-unit consists of the following parts:

(1) Granular forming-chamber. The granular forming-chamber (fig. 2) consists of four parts as follows:

(a) Agitator housing: made of steel pipe with 200 mm diameter and 5 mm thickness this closed from the top. The agitator housing was assembled with the top of upper part of forming unit by 4 bolts with 8 mm diameter.

(b) Agitator: consists of 6 fingers with 20 mm width, 5 mm thickness and 50 mm height which welded on steel pipe with 15 mm
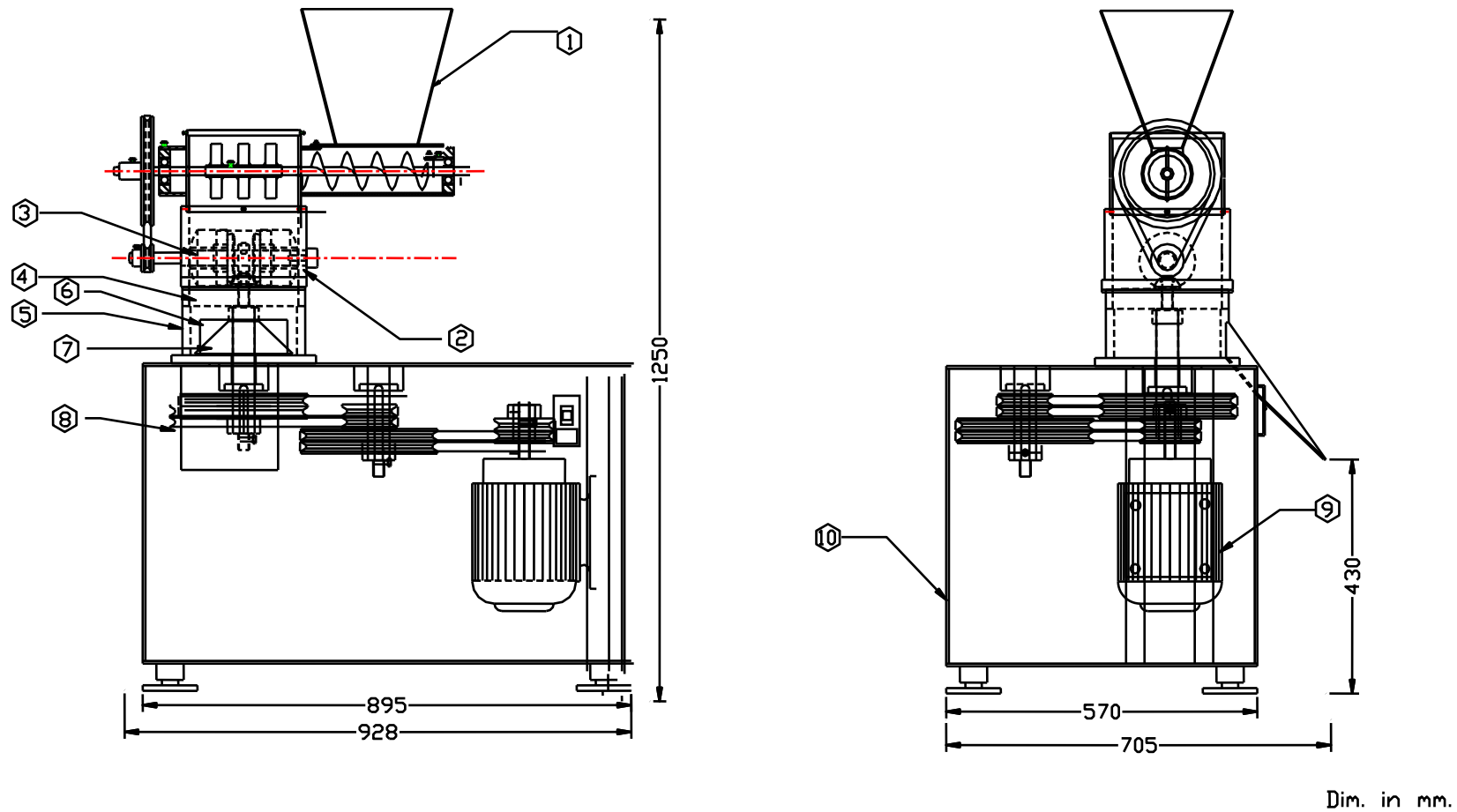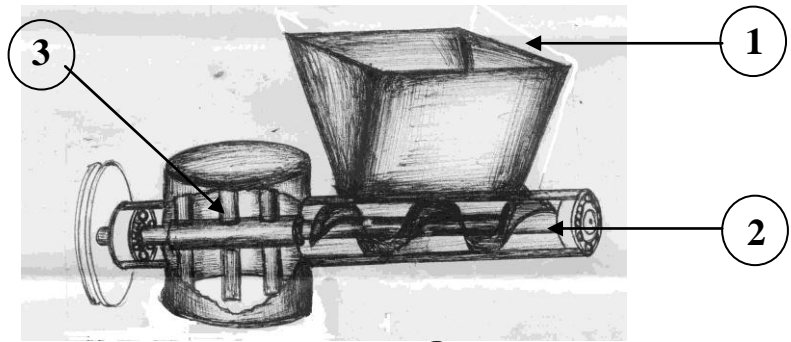
Fig. 1: View of developed granular-machine.

(1) Feeding unit, (2) Pressing chamber, (3) Pressing rollers with bevel gears, (4) Die, (5) Upper part of pressing chamber, (6) Knife (7) cone,   (8) Outlet of granular, (9) Motor, (10) Frame.

Fig. 2: Assembly of the designed granulating-machine.

(1) Fodder hopper, (2) Auger, (3) Agitator, (4) Pressing rollers with bevel gears, (5) Upper part of pressing chamber, (6) Rollers shaft, (7) Bevel gear of main shaft, (8) Die, (9) Main shaft, (10) Outlet cone, (11) Conical bearing, (12) Lower part of pressing chamber, (13) Outlet of granular, (14) Round bearing, and (15) Pulley of main shaft.
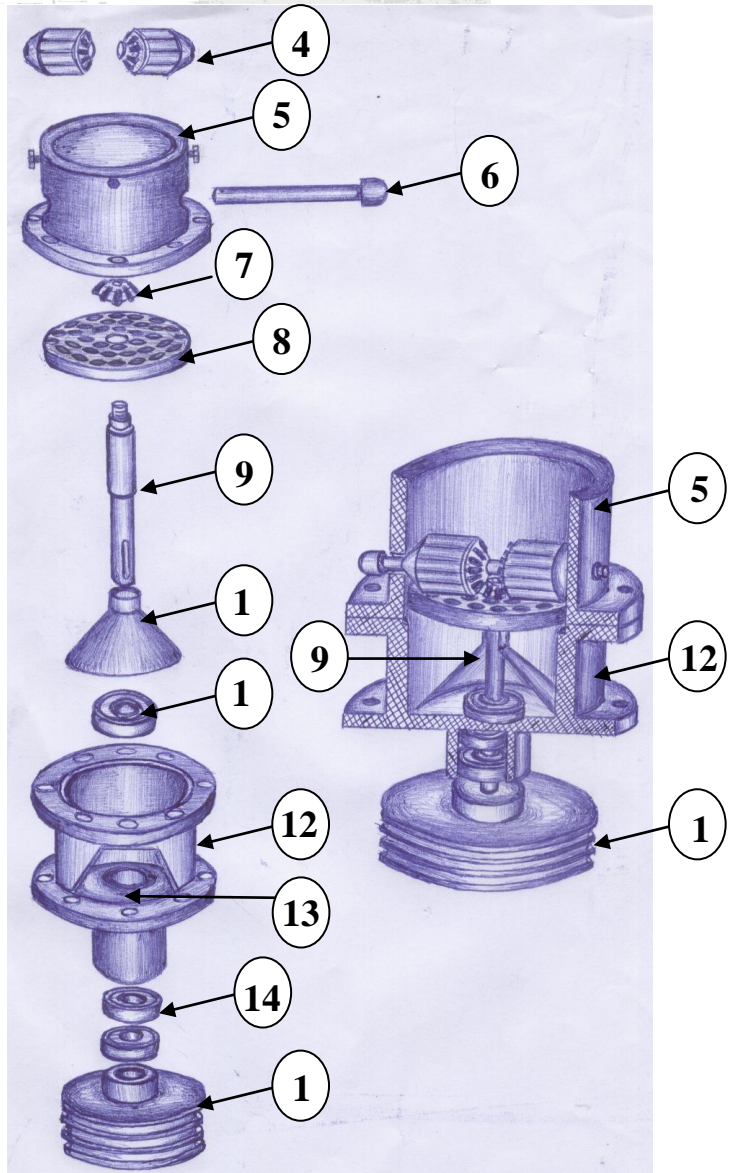
diameter and 200 mm length. The power is transmitted to agitator from forming rollers by two pulleys and belt. The forming-rollers pulley has mm diameter and agitator pulley has mm diameter.

(c) The upper part of pressing camper: made of steel pipe with thickness of 20 mm, diameter of 200 mm and height of 141.5 mm. Two forming rollers are assembled inside the upper part.

(d) The lower part pressing camper: made of steel pipe with the same thickness and diameter of upper part, and 131.5 mm height. Die was assembled on the top of lower part. And granular cutting-knife and exit cone were assembled under the die.

(2) Forming rollers. The forming rollers were made of steel 37. The two forming-rollers are attached with the upper part of forming chamber by a shaft crossed through the chamber by two holes. The power is transmitted to the forming rollers by main shaft through bevel gears. Every roller made of steel bar with diameter of 103 mm and length of 70 mm. A copper ring with diameter of 38 mm, length 55 mm and 5 mm thickness of 10 mm was inserted inside every roller. Bevel gear of 90 mm diameter, total length 38 mm and number of teeth of 18 was inserted with every roller. The inserted part of bevel gear was 25 mm. The rollers were rotated by a bevel gear with 9 teeth, 50 mm diameter and 20 mm width connected to the main shaft as shown in Fig. 2. Clearance between forming rollers and die was 0.2 mm. The clearance was adjusted by putting rings in the bottom of die.

(3) Die: Die was made of alloyed steel plate of 200 mm diameter and 8, 12, 15, 20 and 25 mm tested thicknesses. The tested dies were perforated by different hole-diameters of 3, 4 and 5 mm. The die-hole configuration consists of two levels: the first level is a conical shape named "entry" has diameter bigger than straight hole output diameter named "land length". The die geometrical dimensions are shown in table 1 and Figs. 3 and 4.

(4) Knife: Knife was made of spring steel with 3 mm thickness, 70 mm width and 170 mm length. The knife has two slots assembled with the outlet gate by two bolts and nuts at clearance between knife and die bottom 2 mm. The recommended granular length for poultry of 12 – 22 weeks age ranged between 2 and 5 mm Culpin (1986).

Table 1: Die hole-geometry for different tested die-hole diameters.

Die Thickness, mm.	d, mm	L, mm	L/d	D, mm	I, mm	No. of holes	Working area, cm^2
8	3	5	1.67	7	3	440	31.07
	4	5	1.25	8	3	264	33.16
	5	5	1.00	9	3	200	39.25
12	3	9	3.00	7	3	440	31.07
	4	9	2.25	8	3	264	33.16
	5	9	1.80	9	3	200	39.25
15	3	12	4.00	7	3	440	31.07
	4	12	3.00	8	3	264	33.16
	5	12	2.40	9	3	200	39.25
20	3	17	5.67	7	3	440	31.07
	4	17	4.25	8	3	264	33.16
	5	17	3.40	9	3	200	39.25
25	3	22	7.33	7	3	440	31.07
	4	22	5.50	8	3	264	33.16
	5	22	4.40	9	3	200	39.25

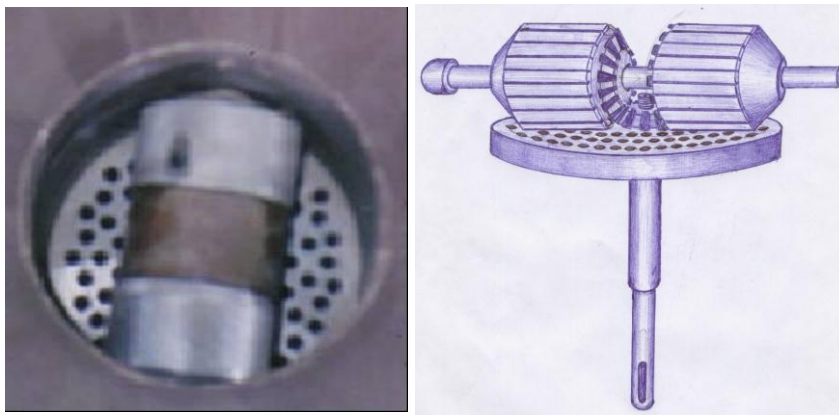d = die hole diameter, L = land length, I = cone height and D= entry diameter.

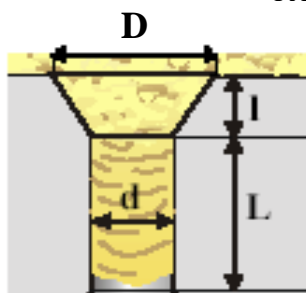
Fig. 3: Sketch and photograph of pressing rollers and die.

Fig. 4**:** Die-hole geometry**.**

(5) The main shaft. The vertical main shaft was made of hard steel 52 carbon. The main shaft has three level diameters of 20, 40 and 20 mm and total length of 295 mm. The main shaft passed through the forming chamber by central hole of 45 mm diameter in the bottom of body chamber. The main shaft was inserted inside the forming chamber by conical bearing and two round bearings in the bottom of forming chamber as shown in Figs. 1 and 2.

(d) Electrical motor and power transmission: Electric motor of 20 hp (15.4 kW) and 1350 rpm was sorted on the frame of granular machine. The power was transmitted from the electrical motor by pulleys and v-belts. The tested motor pulley transmits power to double grooves pulley. The diameter of the pulley on the motor shaft was 10 cm. The Pulley of motor shaft transmitted with the pulley with first groove diameter of 25 cm. The second groove with diameter of 10 cm was connected with the pulley of main shaft (die shaft). The four tested main shaft pulleys with diameters of 20.5, 22.5, 24.5, 27, 30 and 33.5 cm gave various speeds of the main shaft of 160, 180, 200, 220, 240 and 260 rpm (Fig. 2). The horizontal bevel gear with 9 teeth was connected with the main shaft upper the die. This gear transmitted the power to the forming rollers by connected two 18-teeth bevel gears fixed with two rollers.

2-1-3 Instrumentations:

(1) Speedometer, stop watch, digital caliper with vernier, digital balance and graduated cylinder.

A speedometer was used to measure the auger speed and die speed. Stop watch was used for measuring the consumed time for each treatment. Digital caliper with accuracy of 0.01 mm, to measure different dimensions of granular. Digital balance with accuracy of 0.2 g, to measure mass of granular. Graduated cylinder of 1000 ml with accuracy of 25 ml to determine the bulk density and volume of granular.

(2) Durability tester.: A durability (tumbling box) tester was constructed in Ag. Eng. Res. Inst. according to ASAE standards, 1996. It is fitted with a 23 cm baffle fixed symmetrically to a diagonal of 30 cm dimensions box side for tumbling. It is hand rotated about an axis placed inside friction bearings fixed on a stand. A speed indicator at 50 r/min is connected with the shaft. A 500 g. sieved sample of granular are placed in the box and tumbled for 10min. Durability index is defined as:

Durability % = Intact or undamaged granular mass x 100
Granular mass before tumbling

2-2 Methods:

The granular-machine was developed in Production Sector of Agricultural Mechanization in Tookh Station and tested in Agricultural Engineering Research Institute and Animal Production Research Station (Poultry Department) in Gemmiza at years from 2007 and 2010.

2-2-1 Studied factors: Experiments were conducted to study some factors affecting the design and performance of a granular machine. The tested parameters were:

(1) Die speeds: 160, 180, 200, 220, 240 and 260 rpm.

(2) Hole diameters: 3, 4 and 5 mm

(3) Die thickness: 8, 12, 15, 20 and 25 mm.

 (4) Rollers speeds: 80, 90, 100, 110, 120 and 130 rpm.

(5) Moisture content of fodder mixture was 5, 10 and 15 %.

2-2-2 Measurements:

(1) Granular productivity, (2) Total losses of granular, (3) Granular real-density, (4) Granular durability, and (5) Machine power.

2-2-3 Equations and calculations:

(1) Granular productivity, kg/h = (Wp / T) x 3.6

Where: Wp = granular mass (g) and T = consumed time (s).

The variables affecting the granular productivity, total losses and density (table 3) were combined into dimensionless groups according to (Khurmi, 1978 and Awady, 1995).

2-1-2 Poultry ration formulations:

Table 2 shows the components of poultry-finishing diets (12-22 wks of age) ration formulations used in this study.

The meal was prepared using a hammer mill and mixed in a forage mixture with 5, 10 and 15 % of its total mass with water at 50 C$^{\circ}$ and 2 % molasses.

Table 2: The components of poultry-finishing diets (age of 12 - 22 weeks) ration formulations used in this study (**El-Derey**, 2005).

	Ingredients	**%**
1	Yellow corn	54.00
2	Soybean meal (44 %)	22.94
3	Date stone	12.50
4	Dicalcium phosphate	1.55
5	Limestone	0.80
6	NaC1	0.30
7	Vit+Min Mix. [1]	0.30
8	D1-methionine	0.01
9	Washed and dried sand	7.60
	Total	100.00

 * Vit+Min mixture provides per kilogram of diet.

 * Particle size of mixture components is less than about 1 mm.

The resulting dimensionless functional relation is:

$$P / (D^2_{th} \ S_r \ \rho_m) = f \ [\ (D_h/ D_{th} \ ), M_c, \ (S_d / S_r)]$$
$$P = (D^2_{th} \ S_r \ \rho_m) \ K_1(D_h/ D_{th})^{K_2} . (M_c)^{K_3} . \ (S_d / S_r)^{K_4}]$$

(2) Total losses = {(W_t - W_P) / W_t} x 100

Where: W_P = granular yield mass (kg) and W_t = sample mass (kg).

The resulting dimensionless functional relation (according table 3) is:

$$L_t = f \ (D_h , D_{th} , M_c . S_d , S_r , \rho_m)$$
$$L_t = f \ (D_h / D_{th} , S_d /S_r , M_c)$$
$$L_t = K_1 \ (D_h / D_{th})^{K_2} (S_d / S_r)^{K_3} . M_c^{K_4})$$

(3) Granular real-density = (W_d/ V_d) x 100

Where: W_d = granular mass (g) and V_d = granular real-volume (cm^3).

The resulting dimensionless functional relation (according table 3) is:

$$\rho_g = f \ (D_h , D_{th} , M_c . S_d , S_r , \rho_m)$$
$$\rho_g / \rho_m = f(D_h / D_{th}) , M_c (S_d / S_r)$$

Table 3: The variables affecting the granular productivity, total losses and density.

No.	Variables	Symbol	Dimension
1	Granular productivity.	P	M/T
2	Density of fodder mixture.	ρ_m	M / L^3
3	Density of granular	ρ_g	M / L^3
4	Die-hole diameter	D_h	L
5	Die thickness.	D_{th}	L
6	Die speed.	S_d	L / T
7	Rollers speed.	S_r	L / T
8	Moisture content of granular.	M_c	%

(M, L, T are principals of mass, length, and time resp.)

(4) Estimation of power requirements:

Total consumed power (kW) under machine working load was estimated by using Wattmeter (700-k type) having an accuracy of $\pm$ 1%. Then, the power was estimated from the knowledge of line current strength in Amperes (I) and potential difference values. Then the actual power of the machine (P) was then estimated according to (Kurt, 1979) as follow:

$$P = \sqrt{3} . I. V. \eta . \cos \Theta / 1000 \qquad kW$$

Where:

I = line current strength in Amperes; V = potential difference (voltage) being equal to 380 V; η = mechanical efficiency (assumed to be 95 %); Cos Θ = power factor (was taken as 85%).

Specific energy requirements in (kWh/ton) were calculated using the following equation:

(6) Estimating the costs of using the machines: Cost of operation was calculated according to the equation given by Awady (1978), in the following form:

$$C = p/h (1/a + i + t/2 + r) + (Ec * Ep) + m/144,$$

Where: C = hourly cost, p = price of machine, h = yearly working hours, a = life expectancy of the machine, i = interest rate/year, t = taxes, r = overheads and indirect cost ratio, Ec = Electricity consumption kW, Ep = Electricity price L.E/kW.h, "144" are estimated monthly

working hours. Notice that all units have to be consistent to result in L.E/h.

Production cost, L.E./ton = Operation cost, L.E./h / Machine productivity, ton/h

RESULTS AND DISCUSSION

1 Effect of die speed, thickness, hole diameter, and fodder moisture-content on machine granular-productivity.

Fig. 5 shows the effect of die speed, thickness and hole-diameter, and fodder moisture-content on machine granular-productivity.

The maximum machine granular-productivity of 267 kg/h was obtained with die speed of 220 rpm, die-hole diameter of 5 mm, die thickness of 8 mm and fodder moisture-content of 10 %. Meanwhile, the minimum machine granular-productivity of 76 kg/h was obtained with die speed of 160 rpm, die-hole diameter of 3 mm, die thickness of 25 mm and fodder moisture-content of 5 %.

Increasing the productivity of granular by increasing die speed and die-hole diameter is due to decreasing the consumed time of granular processing and decreasing the dead area of die respectively. Meanwhile, the decreasing of granular productivity by increasing of die thickness is due increasing the consumed time of granular processing. The decreasing of productivity by increasing fodder moisture-content from 5 to 10 % is due to sliding the fodder-mixture layers between rollers and die

The variables affecting the granular productivity were combined into dimensionless groups. The general equation of the granular productivity was formulated to follow:

$$P = [D_h{}^{1.14} \ M_c{}^{0.06} \ S_d{}^7 \ \rho_m] \ / \ [8103 \ (\ D_{th}{}^{0.4} \ . \ S_r{}^6)] \qquad R^2 = 0.93.$$

Where: P = Granular productivity,

D_h = Die-hole diameter, m, (ranged between 0.003 – 0.003 m),

M_c = Moisture content of granular, (ranged between 5 – 15 %).

S_d = Die speed, m/s, (ranged between 1.67 and 2.72 m/s),
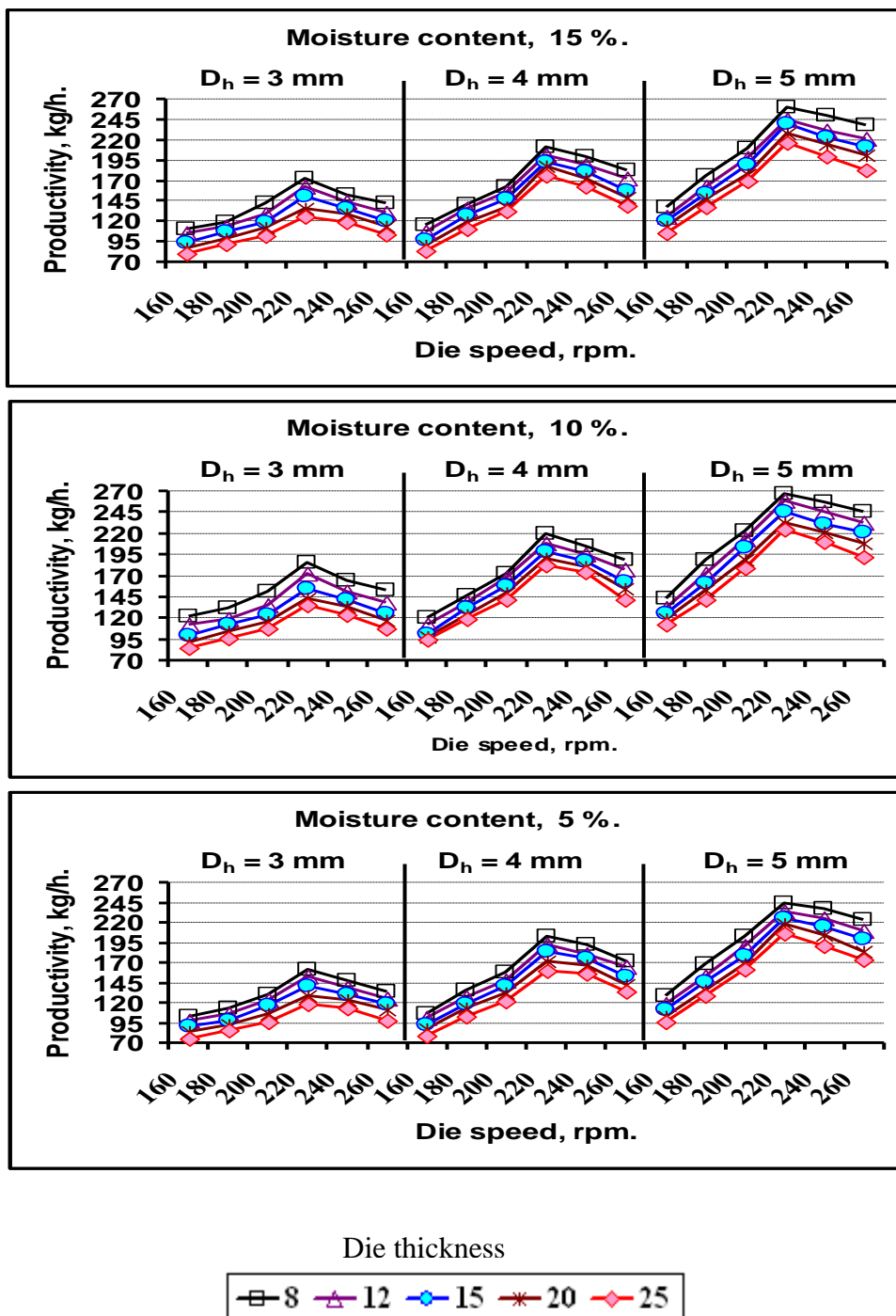
Fig. 5: Effect of die speed, thickness, hole diameter, and fodder moisture-content on machine granular-productivity.

ρ_m = Density of fodder mixture., kg / m^3 (654 kg / m^3),

D_{th} = Die thickness, m, (ranged between 0.008 – 0.025 m) and

S_r = Rollers speed, m/s, (ranged between 0.84 and 1.36 m/s).

2 Effect of die speed, thickness, hole diameter and fodder moisture-content on granular-losses.

Fig. 6 shows the effect of die speed, thickness and hole-diameter, and fodder moisture-content on machine granular-losses.

The maximum range of granular-losses of 3.56 – 4.71 % was obtained with die thickness of 8 mm for all tested die-speeds and diameters. Meanwhile, the minimum range of granular-losses of 2.85 – 4.03 % was obtained with die thickness of 25 mm for all tested die-speeds and diameters, an\d fodder moisture-contents.

Decreasing the total losses of granular by decreasing die speed and hole-diameter and by increasing die thickness and fodder moisture-content is due to increasing of compaction of granular particles and stability.

The variables affecting the granular total-losses were combined into dimensionless groups. The general equation of the total losses was formulated to follow:

$$L_t = [D_h^{0.17} . S_d^{15.4}] / [8103 (M_c^{0.13} . D_{th}^{0.17} . S_r^{15.4})] \qquad R^2 = 0.38.$$

Where: L_t = Granular total-losses,

D_h = Die-hole diameter, m, (ranged between 0.003 – 0.003 m),

M_c = Moisture content of granular, (ranged between 5 – 15 %).

S_d = Die speed, m/s, (ranged between 1.67 and 2.72 m/s),

ρ_m = Density of fodder mixture., kg / m^3 (ranged between 654 kg / m^3),

D_{th} = Die thickness, m, (ranged between 0.008 – 0.025 m) and

S_r = Rollers speed, m/s, (ranged between 0.84 and 1.36 m/s).

3 Effect of die speed, thickness, hole diameter and fodder moisture-content, drying duration on granular real-density.

Fig. 7 shows the effect of die speed, thickness, hole diameter and fodder moisture-content on granular real-density. The granular real-density increased by decreasing die hole-diameter increasing die thickness, fodder moisture-content and die speed from 160 to 220 rpm.
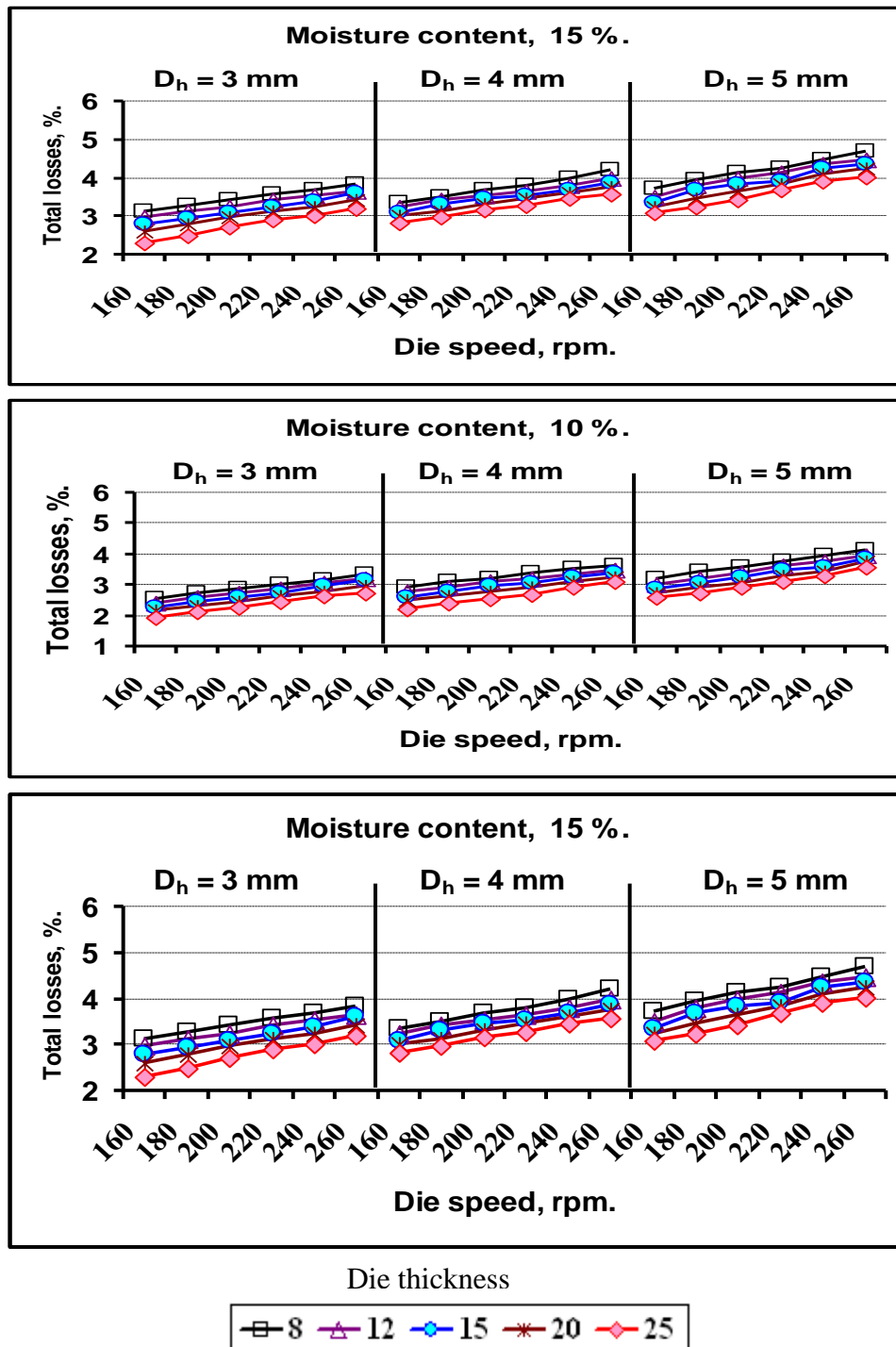
Fig. 6: Effect of die speed, thickness, hole diameter and fodder moisture-content on machine granular-losses.

The maximum real-density of 1.1634 g/cm^3 was obtained with die speed of 220 rpm, die thickness of 25 mm, die hole-diameter of 3 mm, fodder moisture-content of 15 % and drying duration of 96 hours. Meanwhile, the minimum real-density of 1.0983 g/cm^3 was obtained with die speed of 160 rpm, die thickness of 8 mm, die hole-diameter of 5 mm, fodder moisture-content of 5 % and drying duration of 96 hours.

The variables affecting the granular density were combined into dimensionless groups. The general equation of the granular density was formulated to follow:

$$\rho_g = [\ \rho_m\ D_{th}^{0.009}\ .\ M_c^{0.01}\ .\ S_d^{0.73}] / [1.107\ (D_h^{0.009}\ .\ S_r^{0.73})]\quad R^2 = 0.59.$$

Where: ρ_g = Granular density,

       D_h = Die-hole diameter, m, (ranged between 0.003 – 0.003 m),

       M_c = Moisture content of granular, (ranged between 5 – 15 %).

       S_d = Die speed, m/s, (ranged between 1.67 and 2.72 m/s),

       ρ_m = Density of fodder mixture., kg / m^3 (654 kg / m^3),

       S_r = Rollers speed, m/s, (ranged between 0.84 and 1.36 m/s).

4 Effect of die speed, thickness, hole diameter, and fodder moisture-content on granular durability.

Fig. 8 shows the effect of die speed, thickness and hole diameter, and fodder moisture-content on granular durability. The durability increased by decreasing die speed and hole-diameter, and increased by die thickness and fodder moisture-content.

The maximum durability of 96.3 % was obtained with die speed of 160 rpm, die thickness of 25 mm, die hole-diameter of 3 mm and fodder moisture-content of 10 %. Meanwhile, the minimum durability of 86.7 % was obtained with die speed of 260 rpm, die thickness of 8 mm, die hole-diameter of 5 mm and fodder moisture-content of 5 %.

Increasing granular durability by decreasing die speed and hole-diameter and by increasing die thickness and fodder moisture-content is due to increasing of compaction of granular particles and stability.

5 Effect of die speed, thickness, hole diameter, and fodder moisture-content on machine power.

Fig. 9 shows the effect of die speed, thickness and hole diameter, and fodder moisture – content on machine power. The machine power increased by
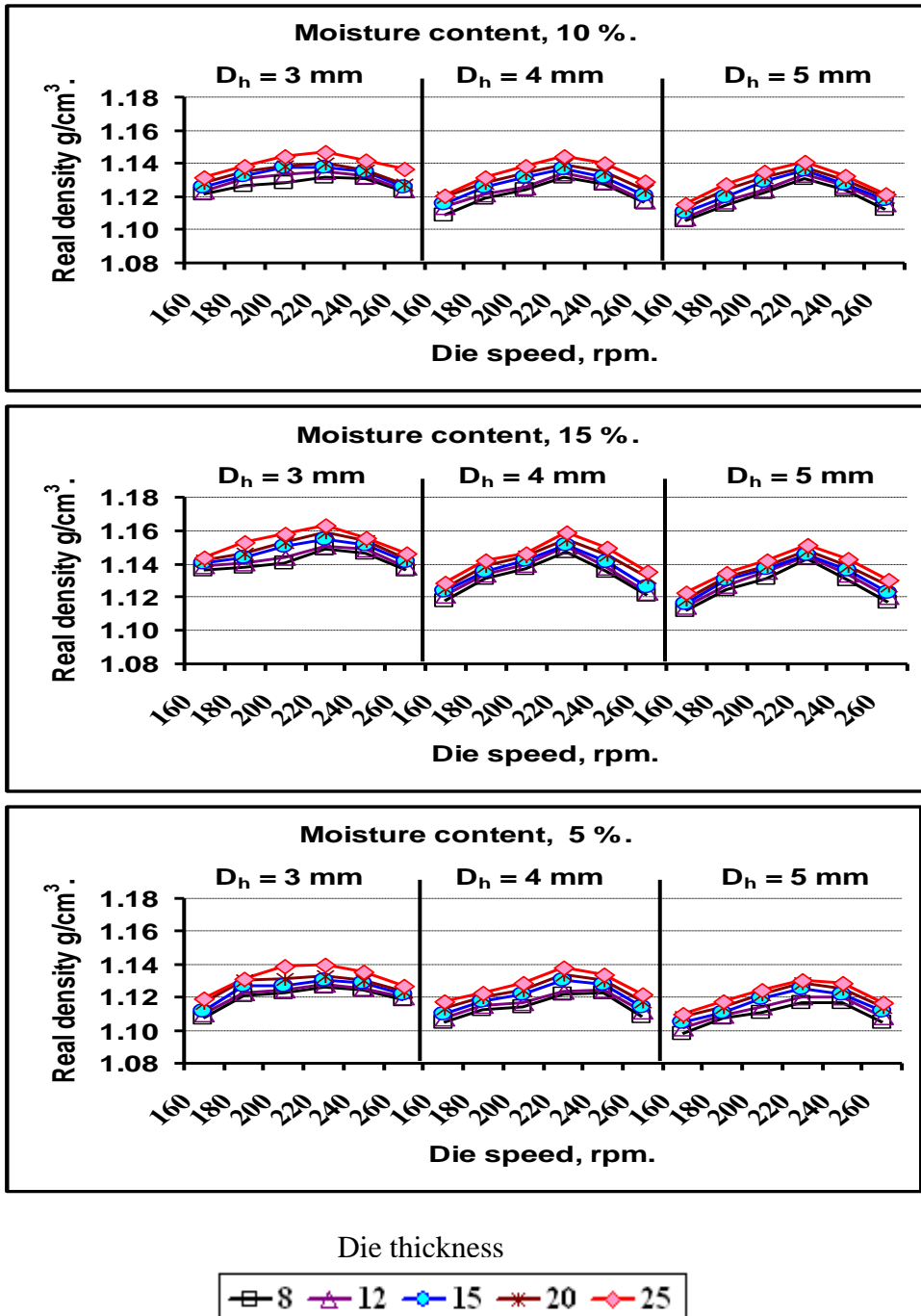
Die thickness

Fig. 7: Effect of die speed, thickness, hole diameter and fodder moisture-content on granular real-density.

increasing die speed, thickness and decreasing die hole-diameter and fodder moisture-content.

The maximum machine power of 12.32 kW was obtained with die speed of 260 rpm, die thickness of 25 mm, die hole-diameter of 3 mm and fodder moisture-content of 5 %. Meanwhile, the minimum granular-stiffness of 7.61 kW was obtained with die speed of 160 rpm, die thickness of 8 mm, die hole-diameter of 5 mm and fodder moisture-content of 15 %.

Increasing machine power by decreasing hole-diameter and fodder moisture-content and increasing die thickness is due to increasing friction between granular and die hole-walls

6 Cost of using the designed granular processing-machine.

Tables 4 and 5 show the components of the Awady equation and operation and production costs of using the designed granular processing-machine.

Table 4: The components of Awady equation.

p, L.E.	h, h	a, year	i	t	r	Ec, kW.h/h	Ep, L.E.	m, L.E
10000	2000	10	0.075	0.05	0.03	7.61 – 12.32	0.25	1200

C = 10000 / 2000 {(1 / 10) + 0.075 + (0.05 / 2) + 0.03} + (10.05 * 0.25) + (1200 / 144)

= 0.075+(0.05/2)+0.03}+(7.92*0.25)+(1200/144)

= 11.46 L.E./h for die hole-diameter of 3 mm.

The operation and production costs were 12, 11.86 and 11.71 L.E./h and 64.84, 54.17 and 43.84 L.E./ton for die-hole diameters of 3, 4 and 5 mm respectively at optimum condition (die speed of 220 rpm, die thickness of 8 mm and fodder moisture-content of 10 %).

Table 5: Operation and production costs of different die hole diameters at optimum condition (die speed of 220 rpm, die thickness of 8 mm and fodder moisture-content of 10 %).

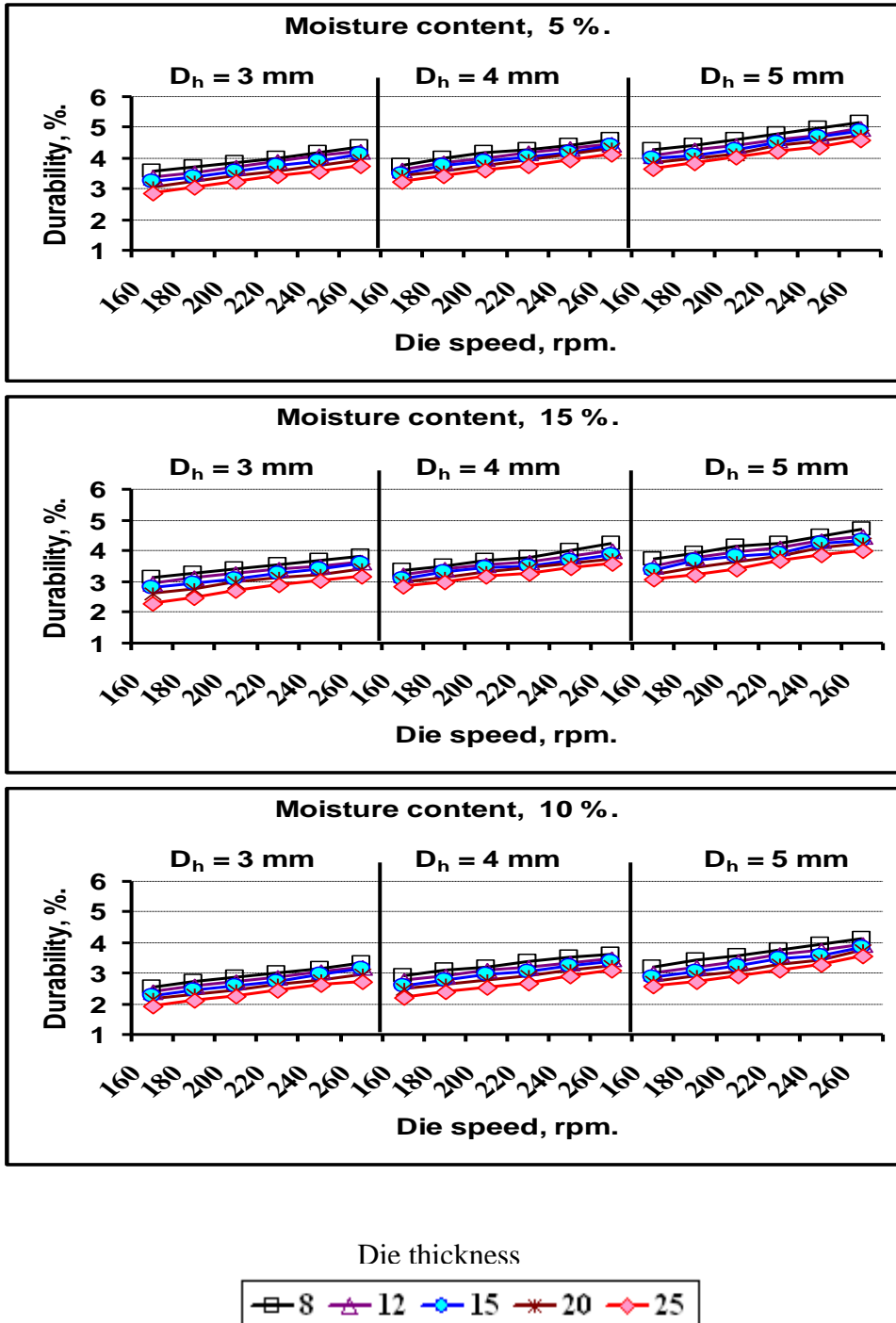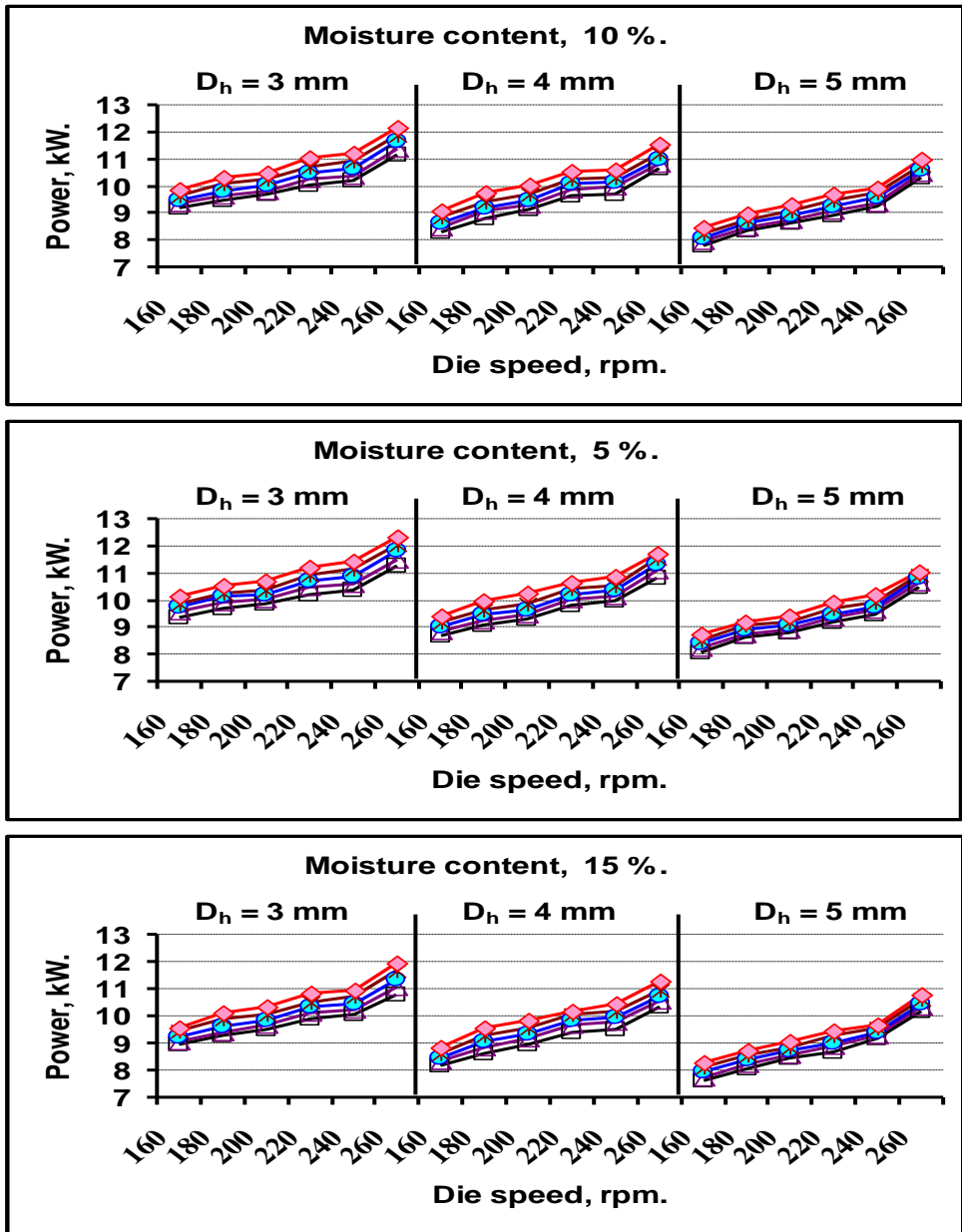| Die hole, mm	Power, kW	Operation cost, L.E./h	Machine productivity, ton/h	Production cost, L.E./ton
3	10.05	12.00	0.185	64.84
4	9.52	11.86	0.219	54.17
5	8.89	11.71	0.267	43.84

Fig. 8: Effect of die speed, thickness, hole diameter and fodder moisture-content on granular durability.
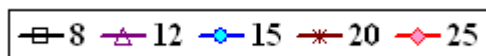
Die thickness

Fig. 9: Effect of die speed, thickness, hole diameter, and fodder moisture-content on machine power.

SUMMARY AND CONCLUSION

The optimum conditions of developed machine were: (1) Die-hole diameter of 3, 4 and 5 mm, (2) Die thickness of 8 mm, (3) Die speed of 220 rpm, (4) Fodder moisture-content of 10 % and (4) Granular dry-duration of 69 h. The obtained results in optimum conditions can be summarized as follows: Granular productivity ranged between 185 – 276 kg/h, Granular losses ranged between 3.03 – 3.78 %, real density ranged between 1.1469 – 1.1491 g / cm^3, Granular durability ranged between 88.9 – 90.7 and Machine power ranged between 8.89 – 10.05 kW.

The operation and production costs ranged between 12 to 11.71 L.E./h and 64.84 to 43.84 L.E./ton for die-hole diameters ranged between 3 and 5

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الملخص العربى
تطوير آلة لتصنيع المحببات
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يهدف البحث إلى تطوير واختبار آلة لتصنيع محببات علف الدواجن. وفكرة عمل الآلة هى نزول خليط العلف من صندوق أسفله بريمة تغذية إلى غرفة الكبس بداخلها قلاب بكرتين تقوم بكبس العلف بينها وبين مشكل العلف الموجود أسفل البكرتين وهو عبارة عن قرص مثقب، فيخرج العلف من أسفل مشكل العلف على هيئة محببات عن طريق سكينة وقمع أسفل مشكل العلف. وتم أختبار ثلاثة أقطار لفتحات مشكل العلف (٣، ٤، ٥ مم)، ست سرعات لمشكل العلف (١٦٠، ١٨٠، ٢٠٠، ٢٢٠، ٢٤٠، ٢٦٠ ل/د)، خمسة سمك لمشكل العلف (٨، ١٢، ١٥، ٢٠، ٢٥ مم)، وثلاثة نسب رطوبة (٥، ١٠، ١٥ %). وتم الحصول على النتائج التالية:

(١) أنتاجية المحببات: وجد أن أعلى إنتاجية تم الحصول عليها هى ٢٦٧ كج/س عند استخدام مشكل علف بقطر ثقوب 5 مم وسمك ٨ مم وسرعة ٢٢٠ ل/د ونسبة رطوبة ١٠ %. بينما وجد أن أقل إنتاجية تم الحصول عليها هى ٧٦ كج/س عند استخدام مشكل علف بقطر ثقوب ٣ مم وسمك ٢٥ مم وسرعة ١٦٠ ل/د ونسبة رطوبة ٥ %.

(٢) الكثافة الحقيقة للمحببات: تم الحصول على أعلى كثافة حقيقة للمحببات ١.١٦٣٤ ج/سم³ عند استخدام مشكل علف بقطر ثقوب ٣ مم وسمك ٢٥ مم وسرعة ٢٢٠ ل/د ونسبة رطوبة ١٥ % وفترة تجفيف طبيعى ٩٦ ساعة. بينما تم الحصول على أقل كثافة ظاهرية للمحببات ١.٠٩٨٣ كج/سم³ عند استخدام مشكل علف بقطر ثقوب ٥ مم وسمك ٨ مم وسرعة ١٦٠ لفة/د ونسبة رطوبة ٥ % وفترة تجفيف طبيعى ٩٦ ساعة.

(٣) تحمل المحببات: تم الحصول على أعلى متانة للمحببات ٩٦.٣ % عند استخدام مشكل علف بقطر ثقوب ٣ مم وسمك ٢٥ مم وسرعة ١٦٠ ل/د ونسبة رطوبة ١٠ %. بينما تم الحصول على أقل تحمل للمحببات ٨٦.٧ % عند استخدام مشكل علف بقطر ثقوب ٥ مم وسمك ٨ مم وسرعة ٢٦٠ ل/د ونسبة رطوبة ٥ % وذلك باستخدام العلف بعد فترة تجفيف طبيعى ٩٦ ساعة.

(٤) أستهلاك القدرة: وجد أن أعلى قدرة مستهلكة لآلة المحببات ١٢.٣٢ ك وات عند استخدام مشكل علف بقطر ثقوب ٣ مم وسمك ٢٥ مم وسرعة ٢٦٠ ل/د ونسبة رطوبة ٥ %. بينما تم الحصول على أقل قدرة مستهلكة لآلة المحببات ٧.٦١ ك وات عند استخدام مشكل علف بقطر ثقوب ٥ مم وسمك ٨ مم وسرعة ١٦٠ ل/د ونسبة رطوبة ١٥ %.

(٥) تكاليف استخدام الآلة: أقل تكاليف تشغيل للآلة ١١.٧١ جنيه/س، ٤٣.٨٤ جنيه/طن تم الحصول عليها باستخدام مشكل علف قطر فتحاته ٥ مم. بينما تم الحصول على اعلى تكاليف تشغيل للآلة ١٢جنيه/س، ٦٤.٨٤ جنيه/طن باستخدام مشكل علف قطر فتحاته ٣ مم. وذلك عند أفضل ظروف تشغيل للآلة وهى: قطر ثقوب مشكل علف ٥ مم وسمك ٨ مم وسرعة ١٦٠ ل/د ونسبة رطوبة ١٠ %.

ويوصى باستخدام آلة تصنيع المحببات المطورة لتناسب المزارع الصغيرة بأقطار ثقوب لمشكل الأعلاف ٣، ٤، ٥ مم لتغذية الدواجن ، وسمك ٨ مم وسرعة ٢٢٠ ل/د ونسبة رطوبة ١٠ % وفترة تجفيف ٩٦ س.

(١) ، (٢) أستاذ الهندسة الزراعية، كلية الزراعة جامعة الازهر،
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