STUDY ON SOME ENGINEERING PARAMETERS AFFECTING THE PERFORMANCE OF FISH FEED PELLETING MACHINE

Morad, M. M. , [*] M. K. Afify[**], O. A. Kaddour[***], V. M. Daood[****]

ABSTRACT

The main experiments were carried out in a local animal feed factory in El-Alawaia village, Sharkia Governorate to study the effect of some engineering parameters (screw speed, feed rate, number of die holes and effective hole thickness) on the performance of fish pelleting machine to produce high quality fish pellets. Evaluation of the fish pelleting machine performance was carried out taking into consideration extruder productivity, pelleting efficiency, pellets bulk density, pellets durability, energy requirements and pelleting cost.

The obtained results revealed that pelleting machine has a high efficiency and minimum production cost and conditions of screw speed of 2.11 m/s. and feed rate of 432kg/h. In order to minimize pelleting energy and high quality fish pellets, effective hole thickness of 15 mm. and 31 die holes were used.

***Key words*: Pelleting, machines, screw speed, durability, effective hole**

INTRODUCTION

Extrusion processing is considered one of the new processes of high technology in food and feed industry. Floating and sinking extruded fish feed industry is used as a new technology in a large scale all over the world to optimize the quantity of fish feed meal in agricultural farms. Both the geometrical dimensions of die and ration components are the most important parameters influencing the efficiency of extrusion machine and pellets quality .

Singh (1996) used a wheel tire as a pelleting machine , by rotating it in a vertical plane. The dry soil-seed mixture is put in the tire concave. The tire

* Prof. of Ag. Eng. Dept., Fac. of Ag., Zagazig Univ., Egypt.
** Associate Prof. of Ag. Eng. Dept., Fac. of Ag., Zagazig Univ. Egypt.
*** Research, Agric. Eng. Res. Inst. (AEnRI), Dokki, Giza, Egypt
**** Post graduate student of Ag. Eng. Dept., Fac. of Ag., Zagazig Univ. Egypt.

is rotated while sprinkling the water on the mixture. In this process the mixture goes up and rolls back and as a result of continued cascading action for a period, the mixture is transformed into balls.

Blass and Wisman (1998) suggested the length of pellets to be in normally between 0.8 and 1 cm. If longer, there is a higher risk of breaking during handling while losses of single pellets or parts of them are more frequent.

Jannasch *et al.* (2001) stated that a reduction in screen size from 0.32 cm to 0.28 cm for the fine grinding process appeared to produce a modest increase in pellet hardness. Pellet throughout was approximately 2 Mg/h. The bending quality of the feedstock and pellet durability could be improved by changes to the die configuration, steam temperature or natural additives.

Adapa *et al.* (2002) mentioned that understanding the terminology used to describe dies is important when choosing die specifications. Different feeds and ingredients require specific amounts of time in the die hole – die retention time – to be able to bind together to form a pellet. Larger die working areas provide more retention time to form pellets, reduce power consumption per Mg of feed pelleted and improve production efficiencies. They found that the bulk density of a dried straw is as low as 40 kg/m^3, whereas the bulk density of palletized grasses can reach as high as 1250 kg/m3.

Booth *et al.* (2002) studied the effect of processing techniques on digestibility coefficients, thee diets treatments by thee processing methods (cold pelleted, steam pelleted and extruded). They found that feed conversation and diets protein efficiency was better in fish feed by extruded diets than steam-pelleted diets. The cold-pelleted diet reduced performance of fish feed.

Robutti *et al.* (2002) found that important aspect of cereal extrusion and the extruded product properties would depend on the raw material structure characteristics. For example. corn endosperm hardness and amylase content of rice affect both expansion and cooking degree of extruded.

Kaddour (2003) stated that when extruder screw speed increased from 1.01 to 1.4 and up to 1.81 m/s. the energy requirements decreased by 12.72 and 16.20% and fineness level of 2 mm. and number of holes of 22 using effective hole diameter of 25.5mm.Also energy requirements increased by increasing the effective hole from 19.5 to 25.5 mm. by 8.89, 11.72 and

17.80% at screw speed of 1.81 m/s. and number of holes of 22 using fineness level of 1, 2, and 3 mm., respectively. He added that by increasing number of holes from 16 to 22 and up to 30 holes the energy requirements decreased by 42.37 and 75.23% at screw speed of 1.81 m/s. and effective hole of 25.5 mm. using milling fineness level of 2 mm.

Yucheng Feng *et al* (2004) stated that there was a slight decrease in bulk density as the moisture content of the litter increased. The amount of storage space that will be required per unit mass of material will therefore increase with the increase in moisture content . In contrast , particle density of the pellets increased with increase in moisture content .

Nehu *et al.* (2005) stated that the extruders used in the feed industry can be generally divided into two types. Single screw and twin screw. There are several factors which contribute to the production of high quality feeds in the extrusion process These factors include various feed parameters aquaculture and extrusion processing parameters.

Kaddour *et al.*(2006) decided that both the geometrical dimensions of die and rations components are the most important parameters influencing the efficiency of extrusion machine and the quality of pellets. The extrusion machine with different dies was evaluated for the two previously kinds of ration and taken into account the effective design parameters such as; [four levels of L/D ratio (1.42, 1.67, 1.92 and 2.17),thee hole entry diameter (16, 18 and 20 mm),thee percentage of die opening area (2.66, 5.33, and 7.99 %), and two thickness values of die (30 and 35 mm)], while the evaluation parameters were specified into two groups such as; a) machine evaluation parameters (productivity, energy requirements and total losses), b) pellets quality parameters (pellets durability, pellets bulk density, and pellets hardness). The results indicated that the optimum conditions for producing a good quality of pellets from standard ration were 1.92 L/D ratio, 18 mm hole entry diameter, 5.33 % die opening area, and 30 mm thickness of die, when the evaluated parameters (machine productivity, energy requirements, total losses, pellets durability, pellets bulk density, and pellets hardness) were 0.399 Mg/ h., 114.04 kW .h. /Mg, 5.21%, 86.72%, 1.190 g/cm3, and 184.80 N, respectively.

So, the objectives of the present study may be summarized as follows::

1-Evaluate the performance of fish pelleting machine to produce high quality of fish pellets.
2-Optimize some operating and engineering parameters (extruder screw speed, feed rate, die effective hole thickness and number of die holes) affecting the performance of fish pelleting machine .
3-Evaluate the performance of fish pelleting machine from the cost point of view.

MATERIALS AND METHODS

The main experiments were carried out during the summer season(2005/2006) in a local animal feed factory in El-Alawaia village , Sharkia Governorate to study the effect of some operating and engineering parameters on the performance of fish pelleting machine.

Materials:

1-Experimental ration: The experimental ration prepared by a hammer mill and mixed in forage mixer at 16% total mass moisture content for the mixture . The composition of the experimental ration is shown in **Table 1**.

Table 1. Composition of experimental ration

Composition	Percentage, %
Corn (yellow grain)	47.5
Soy-bean meal	27.5
Wheat bran	7.5
Fish meal	12
Fish oil	5
Premix	0.3
DL.methionine	0.2

*Taken from Amria for fish feed meal company.

2-Extrusion pelleting machine:

The extrusion pelleting machine is local manufactured and it consists of the following main parts:-

Main frame:

The main frame is a the base which carrying the feed unit, extrusion unit and main electric power motor. It was made of iron steel L-sections with 2000 mm length , 1050 mm width and 98 mm height (**Fig.1)** .

2-1-Feed unit: Feed unit consists of feed hopper, feed screw and feed mixer.

• **Feed hopper**: It is the part in which the ration prepared before extrusion stage .It constructed of iron sheet metal (2 mm. thickness), with 360 mm length,280 mm width and 620 mm height. Maximum capacity of feed hopper is about 30 kg, There is a gate at the bottom of the hopper to allow ration to flow to the extrusion unit.

• **Feed screw** :A screw was fixed in the bottom of the feed hopper to transmit ration from feed unit to extrusion unit. The feed screw dimensions of 550 mm length, 49 mm diameter and 35 mm pitch, feed screw is powered by an electrical variable speed motor by means of two gears and sprocket , The motor gear is of 18 teeth, while the screw shaft gear is of 16 teeth. Feed screw is powered by speed. It can be controlled by means of a key

• **Feed mixer**: It is working inside the middle of feed hopper to mix and turn the ration. It consists of a shaft which has dimensions of 22 mm diameter and 360 mm lengths. Six blades are fixed on the shaft to re-mix ration before feed. Feeder shaft mixer takes the power from feeding screw shaft by two gears 1 :1 .

2-2- Extrusion unit : This unit is responsible for compressing and cooking the ration before the forming zone.

• **Main pressing shaft**: Itt is carried on the machine from one end, on which all extrusion units were assembled. It having made of hard steel 52 carbons. It has dimensions of 1250 mm length and 50 mm diameter. Also the main shaft is supported by two tapered bearings inside oil-house On another hand the shaft connected from behind to a drawing pulley having diameter of 660 mm, to transmit the power from main motor to main shaft by five (V) belts. There is an incision in the surface of the shaft to assemble as a keyway, to prevent slipping of extruder screw on the main shaft .

• **Extruder screw**: It consists of five parts . The first thee parts are single screws and each part has dimensions of 150 mm length,95 mm. diameter and pitch of 35 mm, The next two parts are twin screws. Each part having dimensions of 150 mm length ,95 mm diameter and pitch of 17.5 mm .At the front of the screws there is a bolt assembled on the last screw to hold all screws parts with main shaft. Also the key on the main shaft is passing in

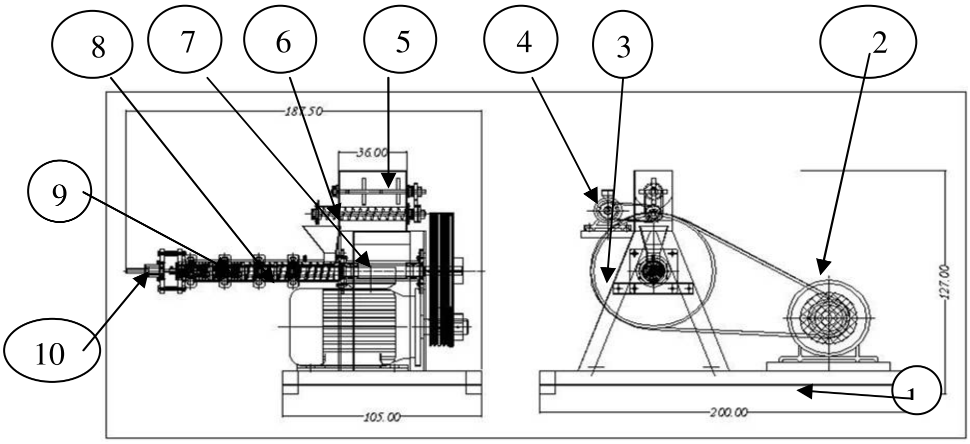

Fig. 1 : Extruder pelleting machine.

Part No.	Name	Part No.	Name
1	Main frame base	6	Feeding screw
2	Main electric motor	7	Main pressing shaft
3	Operating pulley	8	Extruder screw
4	Variable speed feeding motor	9	Cylinder clumps
5	Feeding mixer	10	Cutter shaft

the screws throw an internal incision. 10.4 mm diameter .There is a square hole in feed cylinder and equal parts. Each one of them having dimensions of 159 mm length, 104 mm diameters and 12 mm thickness, and they have the same incisions from internal surface. The last part of extruder cylinder named die-house, as the die is fixed in a hole on the front of this part by a screw key and also there is a edge which prevent die movement during forming process, Die house has dimensions of 70 mm length,10.4 mm diameter, and 1.2 mm thickness. Each two parts of the cylinder are assembled together by a couple of clumps of 50 mm thickness, each couple is holding by two bolts

• **Forming unit (die)**: It is the part which blocked the last cylinder from the end of extruder screw. It is assembled in die house by screw bolt 8 mm diameter. Clearance between the die and extruder screw about 3 mm. The die dimensions are 104 and 100 mm diameter exterior and interior, respectively, and 25 mm total thicknesses. On the surface of the die there are holes on die surface having diameter of 3 mm. Each hole consists of

Die hole entry: The entry is of conical shape to help ration to flow easily inside the effective hole.

Die effective hole thickness:- It's a straight distance which press and form ration though the hole to get the final product (pellets). Dimensions of entry and effective hole thickness can be changed to adapt the experimental ration treatment to control specification of the obtained pellets.

- **Cutter knife** : It turns in a circular motion on die surface was used to cut the final product into small parts. It consists of four sharp blades, It having diameter of 95 mm. Obtained pellets length are controlled by changing knife speed by means of digital inverter, which controls cutting motor shaft speed.

2-3-Power transmission and electric control:

- **Main motor**: The machine is powered by an electrical motor of 37.3 kW, 43 A, the power is transmitted to the extruder shaft by a pulley (diameter of 224mm) and 5 (v) belts.
- **Feeder motor**: It has variable mechanical gearbox is used to control motor shaft speed, output power 1.5 kW and 18 A. It is operated by a manual key to change feed rate. Motor shaft speed ranged from 28 rpm to 160 rpm Power transmitted to feeder screw shaft and feeder mixer shaft by gears and sprockets.
- **Cutter motor**: It connected to cutter knife by a shaft having dimensions of 180 mm length and 15 mm diameter .It is output power 0.746 kW,12 A . The cutting speed can be controlled by inverter which change motor shaft speed from zero to 28 rpm.

Methods

Experiments were conducted to optimize some operating and engineering parameters affecting the performance of fish pelleting machine. The experiments were carried out and replicated thee times in a completely randomized block design .

The tests were run and the following treatments:

1-Four different extruder screw speeds of 325, 375, 425 and 450 rpm (Corresponding to 1.62, 1. 86, 2.11 and 2.24 m/s) with thee different feed rates of 6000, 7200 and 9000 g/min.

2-Thee different effective holes of 10, 15 and 20 mm with thee different feed rates of 6000 , 7200 and 9000 g/min (Corresponding to 360,432 and 540 kg/h)

3-Four different die hole numbers of 19, 24, 31 and 36 hole/die with thee different feed rates of 6000, 7200 and 9000 g/min.

Evaluation of the machine performance was carried out taking into consideration the following indicators:-

- Extruder productivity: It was calculated from the following relation:

Extruder productivity = W_p / T ×3.6, kg/h…………..(1)

Where: W_p: pellets mass ,g , **T**: consumed time, s.

- Pelleting efficiency: It was calculated from the following relation:

Pelleting efficiency =W_p / W_m ×100, %................................ (2)

Where: W_p: pellets mass, g, W_m: ration sample mass, g.

- Pellets bulk density: It was calculated by using the following relation:

pellets bulk density = W_d / V_d, gm/cm^3 ……………......…… (3)

Where: W_d: pellets sample mass, g, V_d: pellets sample volume, cm^3.

- Durability of pellets

A shaker model California pellet mill (CPM). was used for measuring pellets durability. It was calculated using the following relation:

Durability =W_a / W_b x100, %... (4)

Where: W_a: Pellets mass after shaker treatment , g ,

W_b: Pellets mass before shaker treatment, g.

Energy requirements(ER): They were obtained using the following equation:

ER =Power / Extruder productivity , kW.h/Mg…….………..(5)

- Pelleting Cost (PC): It was estimated according to the conventional method of estimating both fixed and variable costs. While pelleting cost was calculated using the following formula:

PC = Machine cost / Extruder productivity, L.E./Mg……..(6)

RESULTS AND DISCUSSION

The discussion will handle the obtained results and the following headings :

1- Effect of different operating parameters on extruder productivity

Extruder productivity is affected greatly by many factors such as: feed rate, die effective hole thickness, number of die holes (output area) and screw speed

Results obtained in (**Fig. 2**) show that increasing screw speed from 1.62 to 2.36 m/s at constant feed rate of 360 kg/h. increased the extruder productivity by 1.38, 1.29, 1.16 and 0.82% using effective hole thickness of 10mm., by 1.40 , 1.30, 1.17 and 0.83 % using effective hole thickness of 15 mm, and by 1.49, 1.48, 1.47 and 0.84% using effective hole thickness of 20mm and number of holes of 19, 24, 31 and 36, respectively.

The same trend was noticed with the feed rate of 432kg/h, it is noticed that , by increasing screw speed from 1.62 to 2.36 m/s the productivity increased by 1.49, 1.48, 1.47 and 1.46 % and by 1.50, 1.50, 1.48 and 1.48 % and by 1.52, 1.51, 1.49 and 1.49 % using effective hole thicknesses of 10, 15and 20mm, and number of holes of 19, 24, 31 and 36 holes respectively. On the other hand, when the feed rate increased to 540 kg/h., increasing screw speed from 1.62 to 2.11 m/s increased the productivity by 0.52, 0.51, 0.51 and 0.51 %,
and by 0.52, 0.52, 0.51 and 0.51% ,and by 0.52, 0.52, 0.52 and 0.51% using effective hole thicknesses of 10, 15 and 20 mm and number of holes of 19, 24, 31and 36 respectively. While increasing screw speed more than 2.11 m/s up to 2.36 m/s sharply decreased the productivity by 15.45, 7.97, 3.17 and 3.16 %, and by 16.39, 10.19, 3.19 and 3.18% and by 17.47, 12.13, 3.22 and 3.20% using effective hole thicknesses of 10, 15 and 20mm and number of holes of 19, 24, 31 and 36 respectively.

The decrease of extruder productivity by increasing the screw speed from 2.11 to 2.36 m/s using feed rate of 540 kg/h could be due to high screw speed which transfer the experimental ration from the screws feed zone to the die zone quickly though constant output area that tend to block extruder cylinder ,resulting in over load in the extruder main motor so time is required to remove the blocked ration to reproducing the extruder .

The increase of extruder productivity by increasing feed rate may be due to the increase of ration quantities which passed though the extrusion unit and expelled from the die holes at the same time .

The increase in extruder productivity by increasing the number of holes on the die surface could be due to the increase of the output area that help the ration to move out the die holes quickly, resulting in remarkable decrease in treatment consumed time.

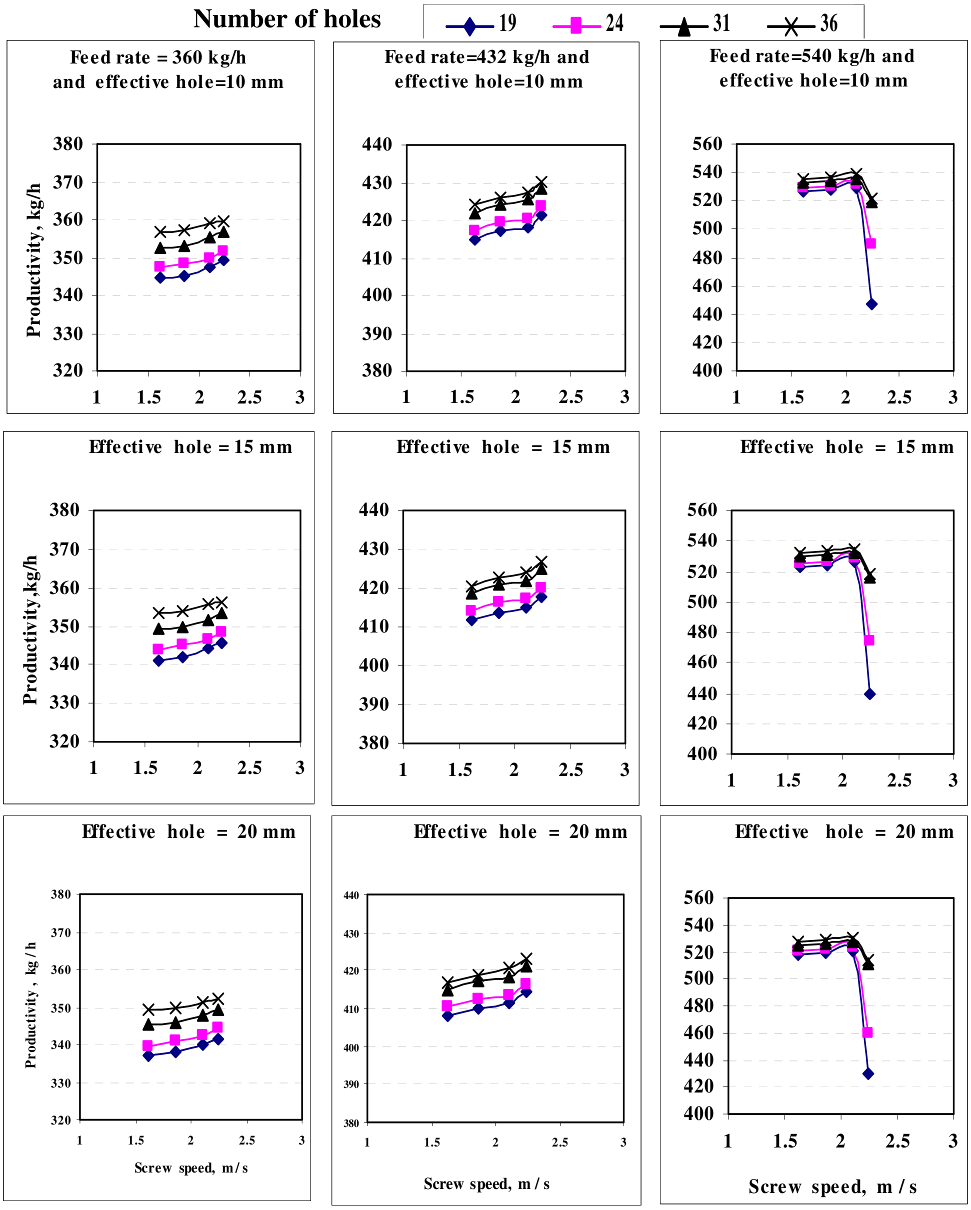

Fig. 2 : Effect of screw speed on extruder productivity at different numbers of die holes, effective hole thicknesses and feeding rates .

While the decrease in extruder productivity by increasing the die hole thickness could be due to the increase in treatment consumed time as the ration passed a long distance inside the die hole.

2-Effect of different operating parameters on extruder pelleting efficiency

Pelleting efficiency is affected by many factors such as screw speed, number of die holes, feed rate, and die effective hole thickness (**Fig.3**).

Regarding the effect of screw speed on pelleting efficiency result show that increasing screw speed from 1.62 to 2.36 m/s, with number of holes of 19 increased pelleting efficiency by14.99, 13.59 and 12.60% at feed rate of 360kg/h, and by 14.66, 13.16 and 12.46% at feed rate of 432 kg/h, and by13.90, 12.68 and 11.93 % at feed rate of 540 kg/h, and die effective hole thicknesses of 10,15and 20 mm, respectively. The increase of pelleting efficiency by increasing screw speed could be due to the increase in both compressing pressure and temperature, that is make the granules mixture in high bulking, and coming out the extruder as good pellets, without any cracking.

The slow increase of pelleting efficiency by increasing feed rates could be due to the increase in the quantities of mixture resulting in more compression that increased the ration temperature that is enough to change the moisture profile from water into steam to make the mixture has bulking structure.

As to the effect of die hole number on pelleting efficiency ,data show that increasing die hole numbers from 19 to 36 at screw speed of 2.36 m/s, the pelleting efficiency decreased by 25.76, 23.48, and 22.16 % at feed rate of 360kg/h., and by 24.96, 22.84, and 21.11% at feed rate of 432 kg/h, and by 23.82, 21.86,and 20.69% at feed rate of 540 kg/h, and effective hole thickness of10,15 and 20 mm, respectively.

The reason of decreasing the pelleting efficiency by increasing numbers of die hole, can be due to the increase of the die output area that tend to decrease pressure in extrusion unit, which caused decreasing in granules bulking. So a high percentage of broken pellets are expected.

Increasing the working thickness of die hole forced the mixture to st more time in die zone which is the hottest zone in extrusion unit, added to that the effective hole thickness has a less diameter than the hole entry diameter that tend to

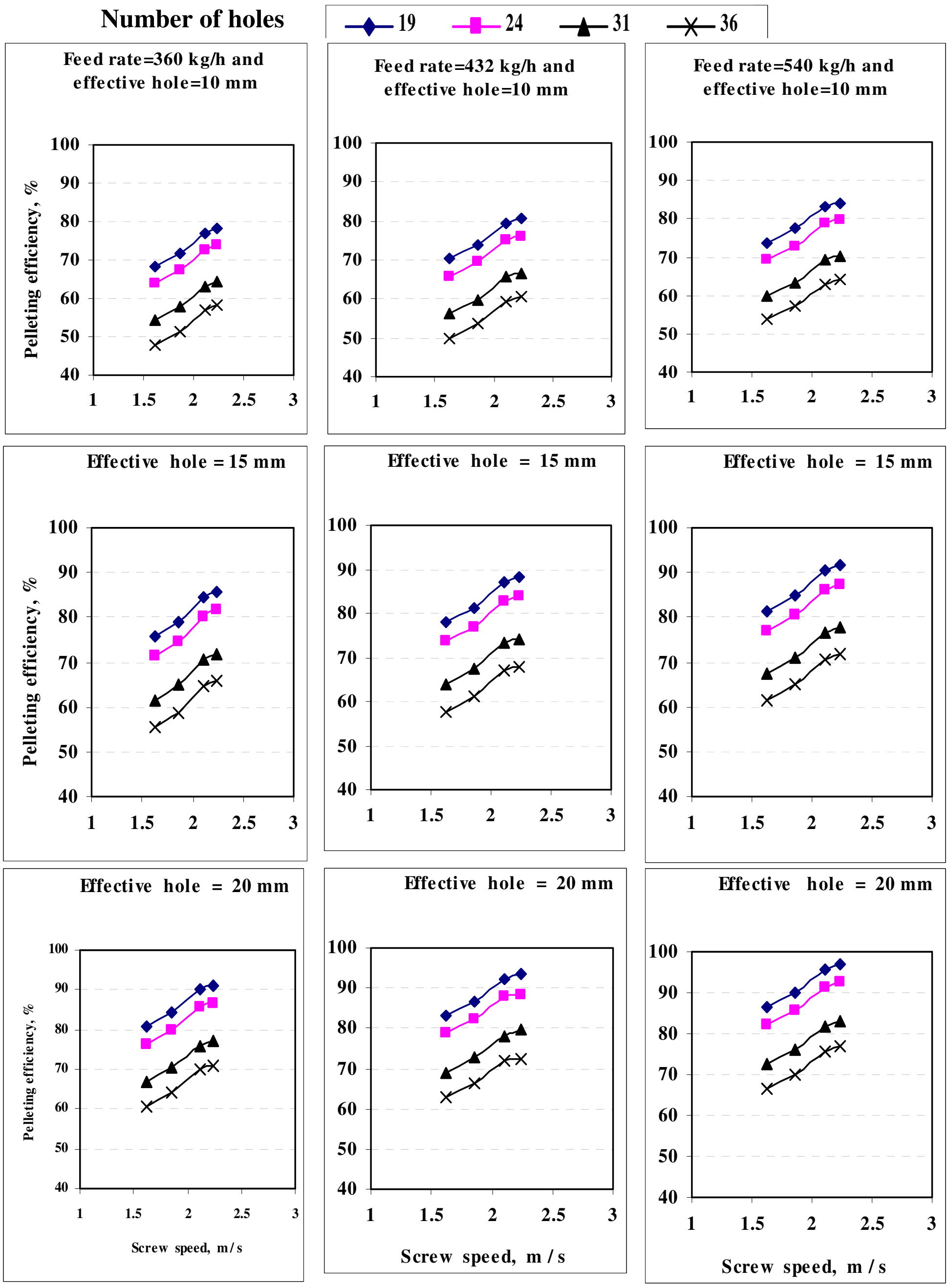

Fig. 3 : Effect of screw speed on pelleting efficiency at different numbers of die holes , effective hole thicknesses and feeding rates .

increase temperature to 140 C, it caused burning by plastic film on the pellets surface, that decreased the mash mixture and broken pellets were expected.

3- Effect of different operating parameters on pellets bulk density

Pellets bulk density is the major aquatic feed pellets quality controller, it attending the kind of producing aquatic feed. There is a lot of factors affecting the bulk density, such as screw speed, feed rate, die holes number (opening area) and die effective hole thickness(**Fig. 4**) .

Referring to the effect of screw speed on pellets bulk density, results show that increasing screw speed from 1.62 to 2.11 m/s with number of holes 19, increased bulk density by 10.61, 12.60, and 12.15 % at feed rate of 360 kg/h, and by 12.39, 12.40 ,and 12.56 % at feed rate of 432 kg/h, and by 12.31,12.09, and 12.23 % at feed rate of 540 kg/h, and effective hole thicknesses of 10,15,and 20mm, respectively.

The increase in bulk density by increasing screw speed from 1.62 to 2.11m/s, attributed to be due to the increase in homogeneity of ration granules with moisture and steam, causing more compaction to the raw materials in the die zone, that means increasing in granules mass in the same volume of die holes for the obtained pellets.

While increasing screw speed more than 2.11 up to 2.36m/s., with number of holes 19 decreased bulk density by 24.20, 25.33,and 30.29 % at feed rate of 360 kg/h, by 32.11, 29.35,and 35.45 % at feed rate of 432 kg/h, and by 37.29, 33.43, and 44.73 % at feed rate of 540 kg/h, and effective hole thicknesses of 10,15,and 20 mm respectively.

The significant decrease in bulk density by increasing the screw speed from 2.11 to 2.36m/s, due to the high increase in mechanical energy inside the extruder barrel, by the fraction, pressure and temperature, that caused high cooking of the raw materials and increase in starch gelatinization by the high temperature around (150C^o), all of this reasons make the produced pellets to be expanded, that is mean increasing of pellets volume with constant mass.

Feed rate affects positively pellets bulk density at limit of screw speed around 2.11m/s that may be due to the more quantity of raw materials on the die zone which increase the compaction of materials granules and fore sure increase the ration mass in the constant volume of die holes.

The different effect of increasing feed rate from 360 to 540 kg/h on pellets bulk density at screw speed of 2.36m/s could be due to the differences in die opening area, using die holes number of 19 and 24 the output area decreased with high feed rate and high screw speed . That means high raw materials pressure on the die surface causing to high of increase in ration temperature, This effect causes the expansion of ration starch and increases the pellets volume at the same pellets mass. While increasing feed rate using die holes number of 31and 36 holes increases the pellets bulk density by increasing the output area cause of decreasing the pressure .

Referring to the effect of number of holes on pellets bulk density, data show that increasing number of holes on the die surface (opening area) from 19 to 36 at screw speed of 2.11 m/s decreased the pellets bulk density by 13.74, 13.70 and 13.52 % at die effective hole thickness of 10 mm, and by 15.15, 13.36 and 13.70 % at die effective hole thickness of 15 mm ,and by 15.09, 13.41 and 14.00 % at die effective hole thickness of 20 mm and feed rates of 360, 432 and 540 kg/h, respectively .

The reason of negative effect of increasing die output area on pellets bulk density could be due to the decrease in raw materials compacted inside the die zone caused by the low compacting pressure .

Meanwhile there is a different effect of increasing the die number of holes on pellets bulk density at a speed of 2.36 m/s, the same figures showed that there is positive effect of increasing die opening area from 19 to 36 it increased the pellets bulk density by11.36, 23.81 and 35.29 % at die effective hole thickness of 10 mm, and by 10.49, 16.61 and 24.37 % at die effective hole thickness of 15mm and by 15.69, 22.91 and 43.87 % at die effective hole thickness of 20mm using feed rates of 360, 432 and 540 kg/h respectively .

Theoretically, the increase in opening area decreased the pellets bulk density, but practically with the high screw speed of 2.36 m/s.It increased the pellets bulk density, which could be due to the decrease in mechanical energy less than the expanding limit .

The increase in extruded pellets bulk density by increasing die effective hole thickness from 10 to 20 mm, could be due to the increase in raw

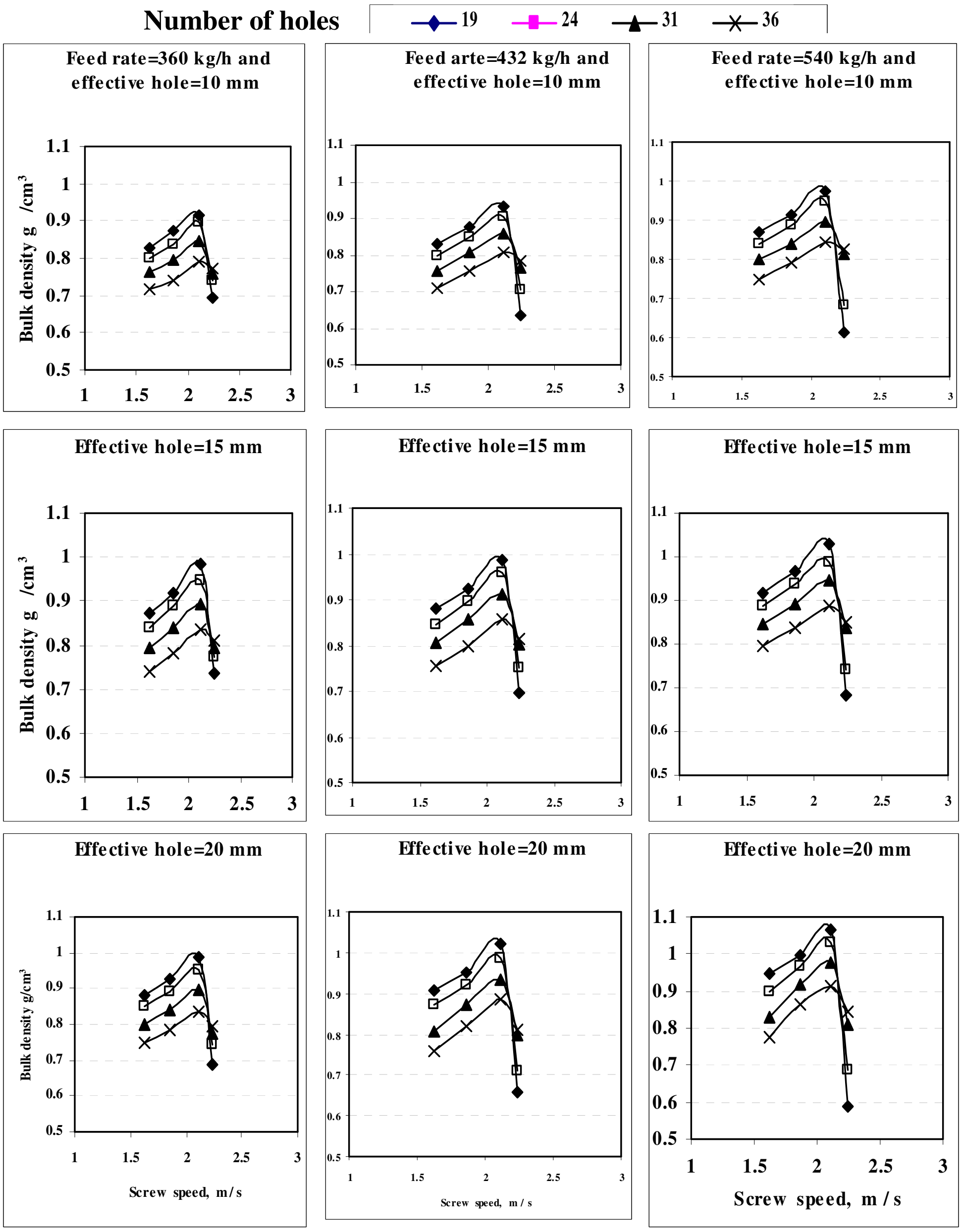

Fig. 4 : Effect of screw speed on pellet bulk density at different numbers of die holes , effective hole thicknesses and feeding

materials retention time in die holes that means more compaction to the ration granules, caused increase in materials mass in the constant die holes volume.

This effect of die effective hole thickness is not constant with all the screw speeds, actually at 2.36m/s screw speed the increase of die effective hole thickness from 15 to 20 mm decreased slowly the extruded pellets bulk density by 6.26, 3.75, 2.26 and 1.84 % at feed rate of 360 kg/h, and by 5.58, 5.19, 0.24 and 0.49 % at feed rate of 432 kg/h ,and by 14.61, 7.28, 3.34 and 0.70 % at feed rate of 540 kg/h, using die holes number of 19, 24, 31, and 36 respectively .

The little decrease in extruded pellets bulk density by increasing the die effective hole from15 to 20 mm, using screw speed of 2.36m/s could be due to the increase in retention time of raw materials in die holes which increased the temperature of die zone more than starch expansion limit, and that caused increase in pellets dimensions and volume with constant material mass flow though the die holes.

4- Effect of different operating parameters on pellets durability

Pellets durability is considered one of the most important indicators of pellets quality. All the operation parameters such as, screw speed , number of holes on the die surface ,feed rate ,and die effective hole thickness have a great influence on pellets durability (**Fig. 5**).

Considering the effect of screw speed on pellets durability, results show that increasing screw speed from 1.62 to 2.36 m/s with number of holes of 19, increased pellets durability by 12.98, 12.31 and 11.90% at feed rate of 360 kg/h, and by 12.81, 12.00 and 11.73% at feed rate of 432 kg/h., and by 12.36, 11.67, and 11.39% at feed rate of 540 kg/h, and effective hole thicknesses of 10,15, and 20 mm respectively.

The increase of pellets durability by increasing screw speed could be due to the increase in pellets compression in the die zone, as well as increasing the temperature ,which remove the moisture from the cells between the granules, that make the pellets too hard with high resistance against cracking and breakage. The increase in durability by increasing feed rate could be due to increasing quantity of the ration which reaches the die zone in the same time

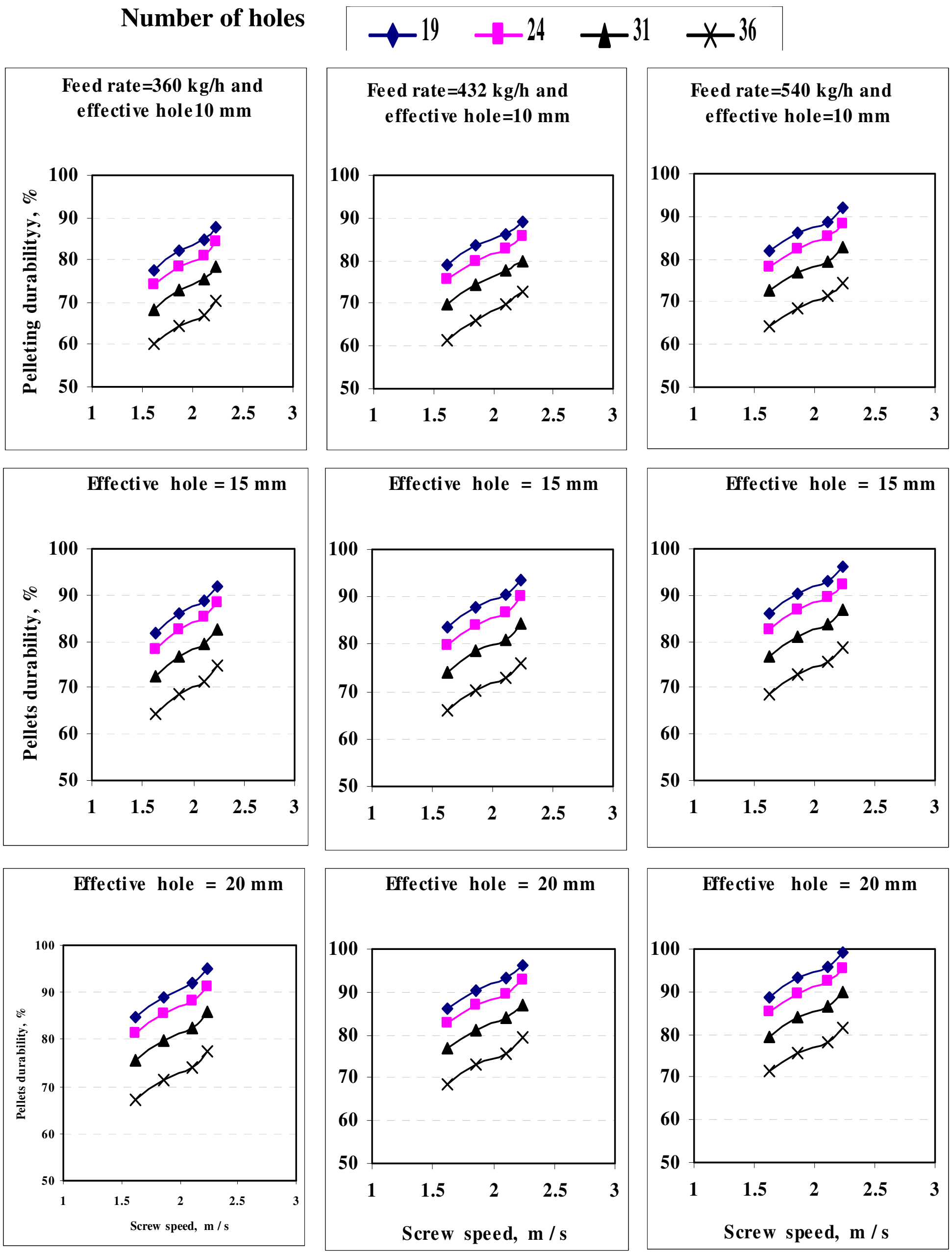

Fig. 5: Effect of screw speed on pellets durability at different numbers of die holes , effective hole thicknesses and feeding rates

unit. It means increasing pressure and temperature inside the die and more compaction for the pellets is expected. Referring to the effect of number of holes on pellets durability, results show that ,increasing number of holes from 19 to 36 cause a decrease in pellets durability by 29.15, 27.26, and 26.21% at feed rate of 360kg/h., and by 28.61, 26.66 and 25.62 % at feed rate of 432 kg/h, and by 27.29, 25.29 and24.60% at feed rate of 540 kg/h and effective hole thicknesses of 10,15, and 20 mm, respectively.

This decrease of pellets durability by increasing number of holes from 19 to 36 holes/die could be due to increasing the out put area which decreases pressure in die zone extrusion, it means low level of pellets compaction and high amount of air between the ration granules. While increasing pellets durability by increasing effective hole thickness could be due to increasing the retention time of the ration in the effective hole thickness which form hard pellets and increase the pellets resistance for durability test.

5 - Effect of different operating parameters on extruder energy requirements

The extruded aquatic feed pellets energy requirements depend theoretically on consumed power and productivity ,also depend practically on the effect of the different operating parameters such as, screw speed, effective hole thickness, die hole numbers ,and feed rate **(Fig. 6)** .

Recording the effect of screw speed on the energy requirements ,results show that increasing screw speed from 1.62 to 2.36 m/s, increased the energy requirements by 34.02, 34.54, and 36.70 % at feed rate of 360 kg/h, and by 27.70, 27.67,and 29.88 % at feed rate of 432 kg/h, and by 18.40, 20.99,and 28.38 %at feed rate of 540 kg/h and at die hole number of 36 and effective hole thicknesses of 10,15 and 20 mm, respectively.

The increase in energy requirements by increasing screw speed could be due to the high increase in the required power and at the same time insignificant increase in production rate was occurred.

While the decrease in energy requirements by increasing feed rate, could be due to the increase in extruder productivity in the same time unit more than the increase of the required power. On the other hand increase in energy requirements by increasing the feed rate more than 432 up to 540 kg/h could be due to the sharply decrease in extruder productivity addition to the high

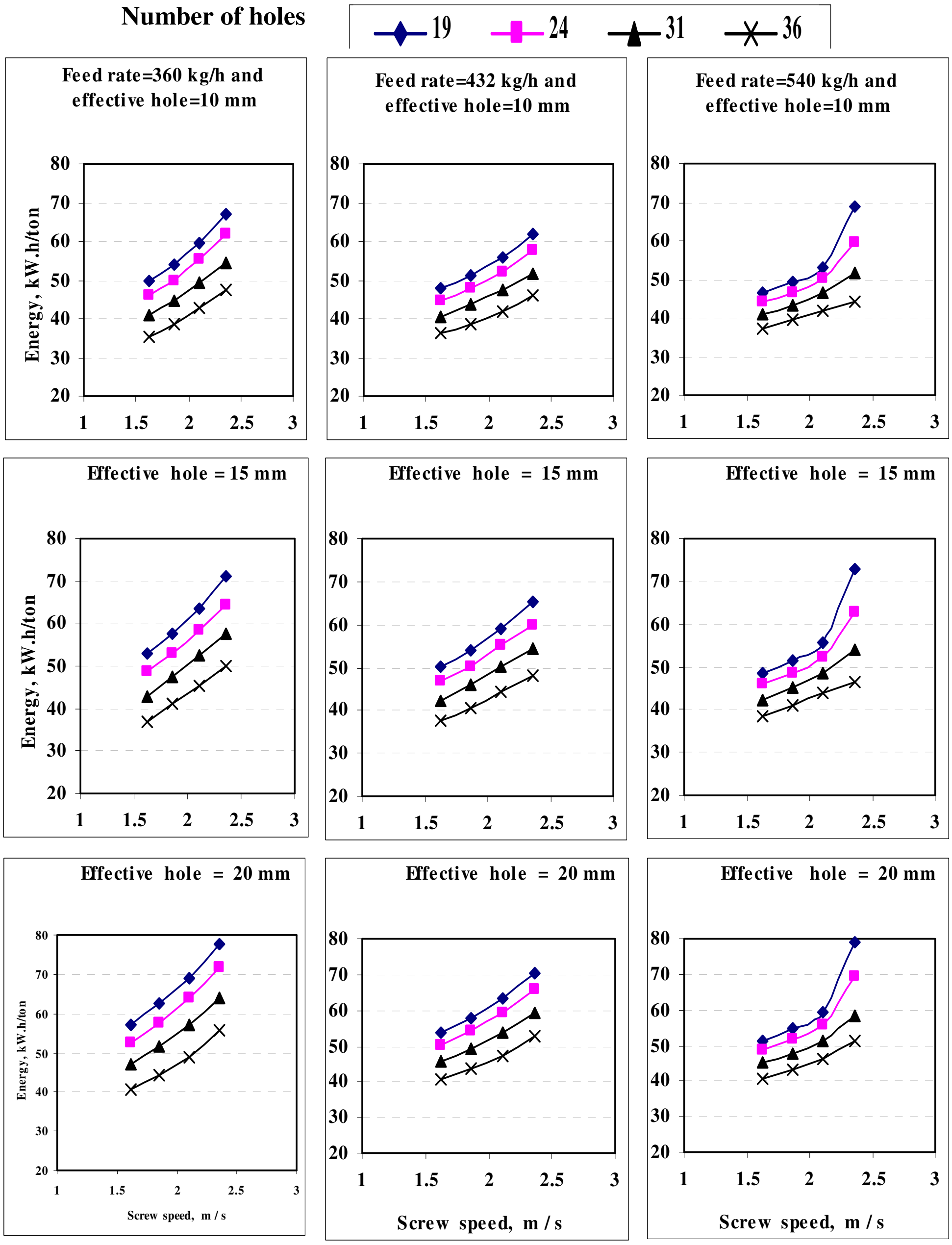

Fig. 6 : Effect of screw speed on consumed energy at different numbers of die holes, effecive hole thicknesses and feeding rates .

increase of power consumed in this treatment. That means high power consumed with low production rate at the same time.

Regarding the effect of increasing the die holes number on energy requirements, results show that increasing die holes number from 19 to 36 at screw speed of 2.11 m/s decreases the energy requirements by 28.68, 28.62, and 29.52 % at feed rate of 360 kg/h, by 24.98, 25.04, and 26.03% at feed rate of 432 kg/h, and by 20.78, 21.62 ,and 22.00% at feed rate of 540 kg/h, and effective hole thicknesses of 10,15, and 20 mm respectively .

The decrease of energy requirements by increasing number of holes could be due to the increase in output area that caused a decrease in the pressure load and the required power, and increases the treatment production rate in the same time While the increase of energy requirement by increasing the effective hole thickness could be due to the decrease in extruder production rate by the increase in treatment consumed time.

6 - Effect of different operating parameters on extruder pelleting cost

Decreasing the industrial cost is considered one of the most important aims of any company. The selection of operating parameters which decreases operating cost with high quality product still very difficult question in animals feed industry field. In the present study the effect of some operating parameters on pelleting costs of extruded aquatic feed pellets were described **(Fig. 7)**.

Concerning the effect of screw speed on pelleting cost , the data show that increasing the screw speed from 1.62 to 2.36m/s with die hole number of 19, increased the pelleting cost by 0.86, 0.92, and 1.01 % at feed rate of 360 kg/h, and by 0.96, 0.78, and 0.85 % at feed rate of 432 kg/h, and by 1.39, 1.51, and 1.69 % at feed rate of 540 kg/h and effective hole thicknesses of 10,15,and 20 mm respectively. Pelleting cost increased by increasing the screw speed because of increase in power consumed is accompanied by insignificant increase in extruder productivity.

While the high decrease of pelleting costs by increasing feed rate could be due to the high increase in extruder productivity with low increase in extruder power consumed.

Referring to the effect of number of die holes on pelleting cost, it is noticed that, increasing the die holes number from 19 to 36 at screw speed of 2.11

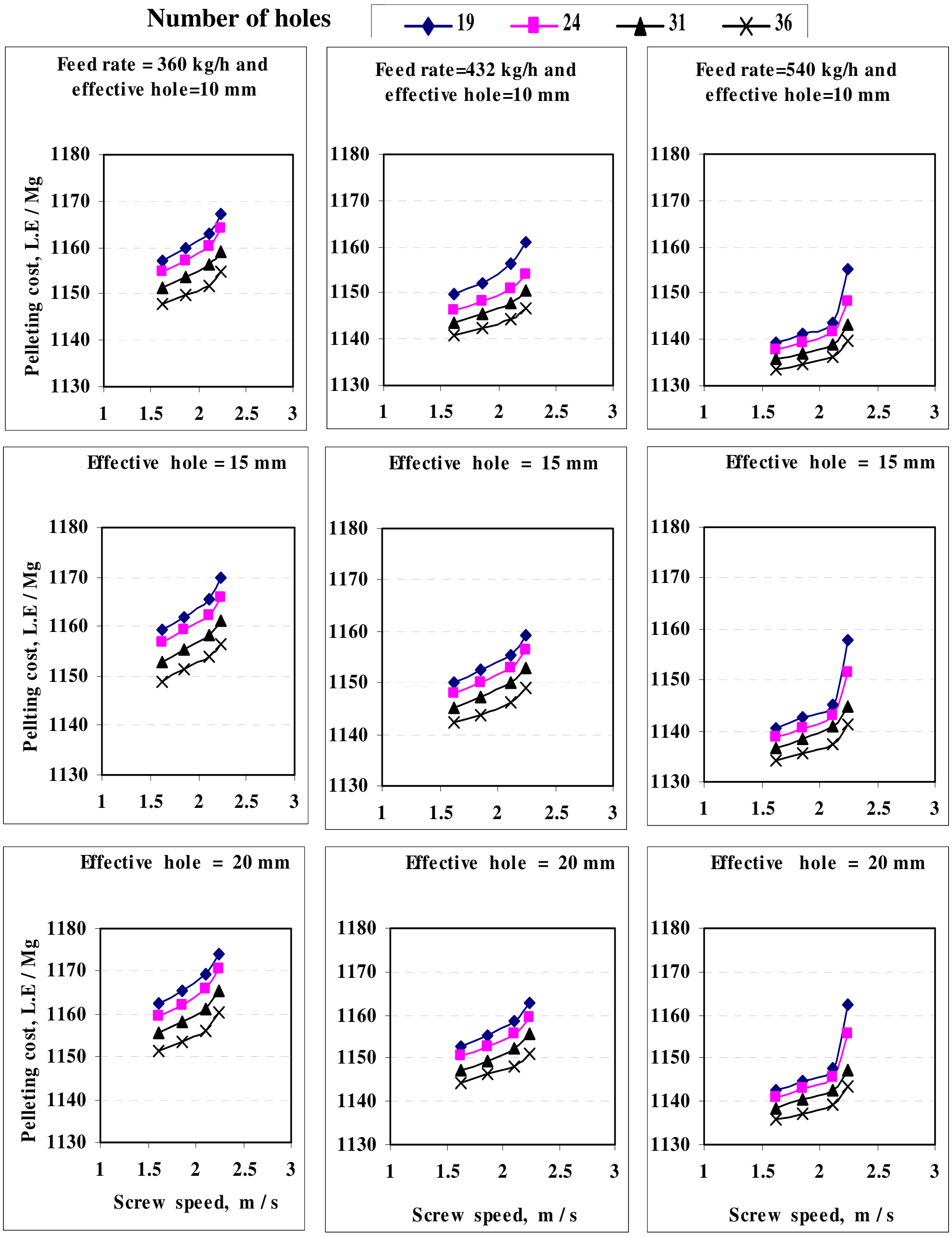

Fig. 7 : Effect of screw speed on pelleting cost at different numbers of die holes , effective hole thicknesses and feeding rates .

m/s, decreased the pelleting cost by 0.95 % , 1.01 % and 1.12 % at feed rate of 360 kg/h, by 1.04 %, 0.79 %, and 0.89 % at feed rate of 432 kg/h, and by 0.63 %, 0.66 %, and 0.72 % at feed rate of 540 kg/h, and effective hole thickness of 10,15,and 20 mm respectively. The sharply decrease in pelleting costs by increasing the number of die holes from 19 to 36 holes could be due to the increase in die opening area, it caused more increase in extruder productivity and decreased the load on extruder motor caused high decrease in extruder power consumed .While the insignificant increase in pelleting costs by increasing the die effective hole thickness could be due to the low decrease in extruder productivity caused by increasing the raw materials retention time in die holes, and the low increase in the required power , caused by increasing the load on the extruder main motor.

CONCLUSION

1. The extrusion pelleting machine is recommended to be used for producing fish pellets because of its maximum efficiency and minimum production costs .
2. It is recommended to operate the extrusion pelleting machine of screw speed of 2.11 m/s. at feed rate of432 kg/h in order to minimize pelleting energy .
3. It is recommended to adjust the effective hole thickness at 15mm and number of die holes a 31 in order to produce high quality fish pellets .

REFERENCES

Adapa, P.K.; L.G. Tabil; G.J. Schoenau; B. Crerar and S. Sokhansanj (2002). Compression characteristics of fractionated alfalfa grinds. International Journal of Powder Handling and Processing., 14(4): 252-259.

Blass, C.D. and J. Wisman (1998). The nutrition of the rabbit CAPT publishing, C A B International, Ch. 12 and 14, 215-239 and 255-271.

Booth, M.A.; G.L. Allan.; A.J. Evans and V.P. Glesson (2002). The Effects of steam pelleting or extrusion on digestibility and performance of silver perchbidyanus. Aquaculture Research., 33. 1163-1173.

Jannasch R., Y. Quan, and R. Samson (2001). A process and energy analysis of pelletizing switch grass. Final report prepared for natural resources Canada, Alternative Energy Division, Resource Efficient Agricultural Production (REAP-Canada), 14 (4): 252-259.

Kaddour, U.A.K. (2003). Development of a local pelleting machine to produce fish feed meal cook pellets. The 11th Annual Conference of Misr Society of Agricultural Engineering. Meet El Deeba, Kafr El-Sheihk, 15-16 October . 538-556.

Kaddour, U.A.K.; T.R. Awes and M.K Afify (2006). Influencing of geometric dimension of extrusion die holes on machine efficiency and pellets quality. ,Conference of Mansoura University, Journal of Agricultural Science. 31 (7) : 337-359.

Nehu, C.; A.R. Kurt and K. Muthukmarappan (2005). Utilization of distillers dried grains for fish feed by extrusion technology. A review ASAE Annual International Meeting Spocnsored by ASAE. Tampa Convention Center, Tampa, Florida.17-20 July.

Robutti, J.L.; F.S. Borras; R.J. Gonzalez; R.L. Torres and D. M. De Greef (2002). Endosperm behavior of maize cultivars., Food Science and Technology / LWT., 35: 663-669.

Singh, J. (1996). Design construction and performance evaluation of feed pelleting machine., Agric. Mechanization Asia, Africa, and Latin, America. 27 (1): 27.

Yucheng, F.; M. German; W. Wood and O. Fasina (2004). Physical Characteristics of pellets from poultry litter., ASAEL CSAE. An Annual International Meeting. The Westin Government Center. Ottawa, Ontario, Canada. 1-4 August.

<u>الملخص العربى</u>

دراسة بعض العوامل الهندسية المؤثرة على أداء ماكينة تصنيع علف الأسماك

محمد محمد مراد* ،محمود خطاب عفيفى ،أسامةاحمد خليل قدور،***
فيكتورميخائيل داؤد*****

تعتبر الأسماك من أهم مصادر البروتين اللازمة لسد الفجوة الغذائية فى إنتاج البروتين الحيوانى ،ومن أهم الصعوبات التي تواجه التوسع في مجال الثروة السمكية هى التغذية و ارتفاع أسعار آلات تصنيع الأعلاف السمكية لذلك أجريت الدراسة على آلة أعلاف محلية الصنع تعمل بنظام بريمة الضغط لتصنيع المصبعات بغرض دراسة تأثير بعض العوامل الهندسية المؤثرة على تشغيلها وكانت كالتالى :

1. سرعة بريمة الضغط
2. معدل التغذية
3. عدد ثقوب مشكل العلف (الداى)
4. السمك الفعال لمشكل العلف

و قد تم تقييم أداء الآلة المستخدمة أخذا في الاعتبار كل من المؤشرات التالية إنتاجية الآلة و كفاءة تكعيب الآلة وكثافة العلف و مقاومة العلف للنقل و الصدمات و كذلك كل من الطاقة اللازمة و تكاليف الإنتاج.
و قد تم تحديد أفضل نسب للعوامل الهندسية التي تم دراستها و هى استخدام سرعة بريمة التغذية 2.11 م/ث مع معدل تغذية 432 كجم /ساعة و عدد ثقوب مشكل العلف 31 مع سمك فعال قدره 15 مم.حيث أوضحت النتائج أنه عند استخدام هذه القيم تم التوصل إلى أعلى إنتاجية و هى 422 كجم /ساعة مع أفضل نسبة مقاومة علفية للنقل و الصدمات وهى 81.08% ،و كانت كفاءة التكعيب 73.15% ،وكثافة العلف 0.911 كجم/سم^3، و كانت احتياجات الطاقة اللازمة لعملية التكعيب تساوى 50.03 كيلووات/ميجا جرام ، و أقل تكلفة إنتاج كانت 1150 جنية / ميجا جرام.

*أستاذ الهندسة الزراعية - قسم الهندسة الزراعية – كلية الزراعة – جامعة الزقازيق-مصر.
** أستاذ مساعد الهندسة الزراعية - قسم الهندسة الزراعية – كلية الزراعة – جامعة الزقازيق- مصر.
*** باحث- معهد بحوث الهندسة الزراعية – مركز البحوث الزراعية – الدقى – الجيزة- مصر.
**** طالب دراسات عليا - - قسم الهندسة الزراعية – كلية الزراعة – جامعة الزقازيق-مصر.