FIRST EXPERIMENTAL PROTOTYPE OF A MECHANISM FOR POULTRY HARVESTING

Ahmed E. Suliman[1] Khaled M. Abdelbary[2] Haytham S. Helmy[2]

ABSTRACT

Recent study aimed to investigate the poultry harvesting period with engineering approach in an attempt to provide a mechanical prototype for moving poultry from the surface and convey it with belts technique to packing facility without any dangerous or injuries. The study also focused on determine some important dimensional, mechanical and physiological properties for birds under investigation to be as assistant data-bases in design, manufacture and test the proposed prototype. Research work was carried out at two poultry farms, farm of Agric. Fac., Cairo Univ., farm of El-Rabie Poultry Company. Proposed prototype's dimensions were 210 (cm) length, 90 (cm) width and 100 (cm) high which fit with the entries dimensions of the farms and also able to work inside the houses and to deal with their obstacles. The general manual clearance rate for the crew (CR_{crew}) was approximately 1540 (bird/hour) and the general manual clearance rate for one man (CR_{man}) was approximately 72 (bird/hour). The bucket's maximum rate was 525 (bird/min) with respect to definite conditions which are the bucket stay in continues and constant forward movement and with full load condition, also the belt's maximum rate was 480 (bird/min) with respect to same conditions. The actual packing rate was indicated by 1.5 (drawer/min) and the prototype's actual overall rate was calculated by an average value of 1350 (bird/hour). The number of heartbeats for birds' sample was measured in several situations; it was 42-55 (beat/min) before the manual harvesting process, 75-90 (beat/min) after the manual harvesting process and finally it was 69-85 (beat/min) after using the suggested automated prototype. The obvious result was the excellence of the automated method according to the physiological point of view which reflects small stress value.

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Finally, the overall prototype's cost (operating and manufacturing cost) indicated by 6450 (LE) and finally the payback period of the investment cost was indicated by approximately 18 (month) depending on savings from labor.

Keywords: Poultry harvest, conveyor belts, general manual clearance rate (CR), packing rate, overall rate, birds' heartbeats and investment payback period.

INTRODUCTION

Poultry harvesting period is one of the important and emergency one, it can be performed manually or mechanically, it must be done in a suitable way to avoid huge losses included losses in the product and losses related to the human resources, economics and management. Commercial catching of broiler chickens and other birds that are headed for the slaughterhouse is often a violent process in which birds are manually caught by workers who carry them upside down by one leg, four or six to a hand, before throwing them forcefully into crates on transport vehicles. Throughout that, birds suffer through great stress, broken bones, bruising and even death (Cem, 2004, Abo Elala, 2007).

Most birds caught by hand. Catchers typically carried birds inverted by a single leg, 3 or 4 birds per hand (Bayliss and Hinton, 1990), and throw them into transport crates. Griffiths (1985) concluded that 40 % of the bruises recorded at the processing plant originated from catching and crating. In addition, catching and placement into containers cause severe stress to broilers shown by increased corticosterone values and prolonged tonic immobility reactions found in broilers after catching and crating.

McGuire (2005) found that this manner causes stress and injuries, which contribute to production losses of 5 to 15 % of carcasses exhibit bruising of the breast, thighs or wings. Large producers harvested all their birds at once (all-in, all-out) whereas, small producers often skimmed by harvesting larger birds and leaving smaller ones to grow (Anne, 2003). Birds are best caught at night or early in the morning when they are calm and far away from any high noise or light.

In Europe, automatic harvesting machinery is increasingly used in large operations, because it is considered more humane than the rough treatment by catchers who handle several birds at once. Mechanical harvesters have been introduced, as alternatives to conventional manual catching ways, to reduce injury losses and decrease labor costs. It can catch, approximately, the same rate as manual catching crews (Scott, 1993; Ekstrand, 1998; Associated Press, 2003; Knierim and Gocke, 2003; Swanson, 2003; HSUS, 2006) without fatigue or slow down at the end of the shift like their human counterparts. It improve welfare for birds during the catching process, it also results in financial savings for the producer (Cem, 2004).

Mechanical poultry catching systems have been investigated for a number of years, (Kilman, 2003). It had the potential to reduce the physical labor demands of catching, the number of personnel and the number of person hours required for catching (labor time requirements) (Babette and Thomas, 1999).

Technology has started to advance to the point where the mechanical catching technology is feasible for poultry integrators. Cem (2004) reported that over the years, automated machines have been developed to capture birds and place them into crates with minimal human interaction. In last 15 years, improvements have been introduced in the mechanical catching of birds, but a satisfactory mechanical catching method had yet to be fully accepted by the industry (Berry *et al.,*1990 and Ramasamy *et al.,* 2004). Many of these machines accomplish this through the use of rotating rubber fingers and conveyor belts.

Kettlewell and Turner (1985) and Ramasamy *et al* (2004) reported that on mechanical catching units used large foam rubber paddles to catch the birds, these paddles rotated down on top of the birds from above and then pushed the birds onto a conveyor belt, which carried them back to a loading platform where they were deposited into crates. The catching unit was a track powered vehicle which made it quite maneuverable and capable of operating on any type of litter.

Lacy and Czarick (1992, 1994) tested a mechanical chicken catcher propelled by a 52 kW diesel engine, catching unit was front wheel drive for increased traction and rear wheels for maneuverability. They reported that the catcher was extremely efficient at picking birds up off the ground, but the caging process damaged birds and was inconsistent. Moreover, the catcher was designed to catch and cage 7000–8000 birds per hour, similar to hand catching rates. They added, also, mechanical catchers should be compatible with a range of house configurations and should operate effectively in pole and clear span houses.

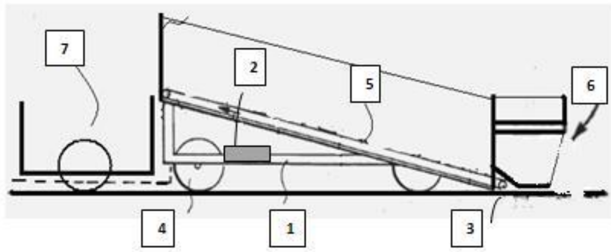
Lacy and Czarick, (1998, 2005) stated that mechanical catcher should be enable rapid mobilization and demobilization to attain high efficiency rates, since most of feasibility studies conducted to test the mechanization are based on the replacement of one hand catcher crew with one mechanical catcher team, the effective catching rate is a function of on-farm performance and the short duration, farm to farm transfer.

Jaiswal *et al* (2005) concluded that mechanical catching operation is organized around the catching team. Their mechanical catching team had a crew of four and operated two catching units, one packing unit and a forklift. Hydraulically driven finger reels are used to pull the birds onto conveyors that lifted the birds (approximately 200 birds) and transported them to onboard storage areas. They added also, that packing unit placed 18–20 birds into each drawer, with approximately 300 birds per module. A forklift was used to exchange the loaded module for an empty module from the waiting tractor-trailer transport. The standard tractor trailer trucks held 20 modules stacked two high for a total of 6000 birds per truck.

Nijdam *et al.,* (2005) used catching machine with three rotating hydraulically driven cylinders (Chicken Cat Harvester, Denmark) in a field trial. Cylinders surface was covered with long flexible rubber fingers, which forced the broilers onto a conveyor belt (up to 20 m length) that moved sideways over a distance of 24 m. Transport containers were standing on a loading platform attached to the rear of the catching machine. They concluded that a machine was suitable for containers with eight compartments (surface area of 1.25 m^2) and could contain a maximum of 85 kg of broilers. A drawer is filled with 32 to 36 broilers, depending on birds mean weight and environmental temperature. A forklift truck removed the loaded containers and replaced them with empty ones, catching machine capacity during this field trial was approximately 7,000 broilers per hour.

MATERIALS AND METHODS

Poultry harvester prototype was manufactured at the workshop of Faculty of Agriculture, Cairo University; its main parts are illustrated in Fig.(1).



1	Main frame.	2	Power source.
3	Transmission tools.	4	Ground wheels.
5	Conveyor belt.	6	Guiding part.
7	Collecting facility.		

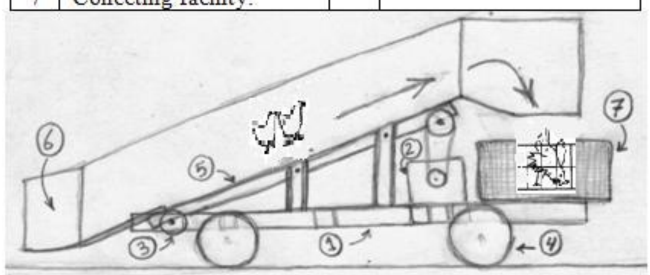


Fig.(1).Prototype's proposed parts.

Precisely, through the birds properties measurements, the values of the maximum space dimensions for the bird were specified that are represented in the bird body's length (BL), the maximum width of the bird's body (TBW), the maximum height of the bird (SBH) beside the bird circumference of chest (BC). Also, value of the maximum space volume (V_{max}) which is occupied by the bird was specified.

The entry's width of collecting the birds were designed to be 80 cm, also the width of the conveyor belt was specified to be 40 cm according to the previous measurements. Also, appropriate space for the passage around the entry opening and also around the conveyor belt until its end were specified. The path's sides high was 50 cm from the prototype front to its middle and 35 cm high from the middle until the end with respect to the horizontal and vertical jumping distances which were indicated also in part two.

A strong frame was designed from thick steel angles (St. 37, 50×50×5 mm) by length of 175 cm and width of 75 cm, frame was loaded on four compact ground wheels (with diameter of 32 cm and 7 cm thick).

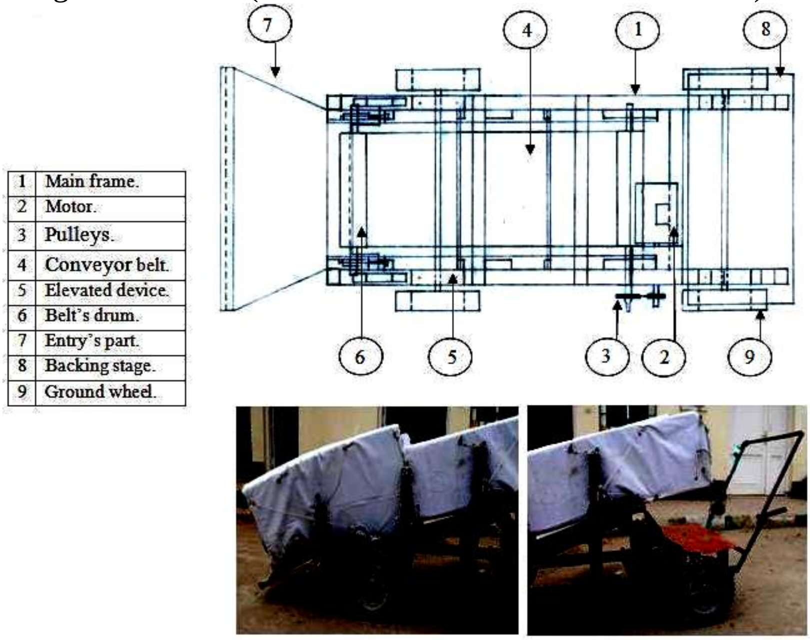


Fig. (2).Top view and final shape of designed prototype.

An elevated device (St. 37, square section, Segal) was fixed between the main frame and the wheels axle (St. 50, 1 inch to allow adjusting, modifying main frame high, packing cages were put at the end of the frame.

Power's supply (electrical motor of 2 HP, 2 Phase, 1200 rpm and 20 m wire cable) was connected with speed's resolute (1/10) to reduce its speed from 1200 to 120. This reduced belt's drum (9 cm diameter) rotating speed to about 100 rev/min (96 rpm) that allowed belt's linear speed about 0.5 m/sec (0.452 m/sec) with working forward speed of 0.36 (m/sec) for whole prototype.

Total belt length can be calculated using the following equation:

$$L = \pi/(d_1 + d_2) + 2x + (d_1 + d_2)/4x \quad \ldots\ldots\ldots(1)$$

Where:

d_1 and d_2	: larger and smaller pulley diameters, cm.
x	: distance between pulleys centers, cm.
L	: total length of the belt, cm.

Calculated total length of the belt (L) was 240 cm with radii of two belt's drums of 9 cm and designed distance (x) of 105 cm. Belt slope angle (friction angle "*α*") and friction coefficient (C_f) between the bird and the belt was calculated using the following equation:

$$C_f = \mu = \tan \alpha \quad \text{.................................} \quad (2)$$

Belt friction angle (α) ranged between 40° to 46°, designed angle of a half of calculated friction angle (20°) was used to insure birds' stability upon the belt calculated friction coefficient (C_f) of 0.933.

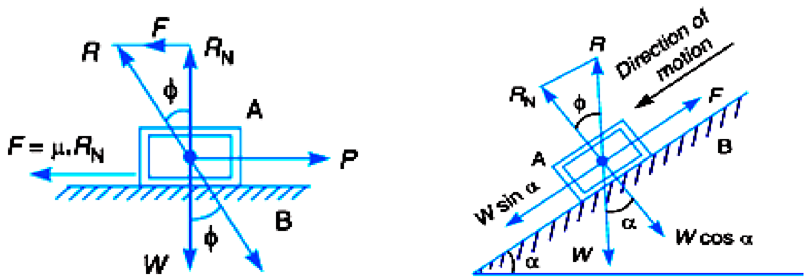


Fig. (3). Limiting angle of friction, adapted to (Khurmi and Cupta, 2004).

Designed prototype was tested at ***El-Rabie Poultry Company***, inside a commercial poultry house (102x12x 2.85 m) with maximum bird capacity of 20,000 birds. Belt's actual elevating rate (*BAER*) (bird/hr) can be calculated using actual bird's density (bird/m^2) as follow:

$$BEAR = (3600).WB.BS.BEBD \quad \text{.............} \quad (3)$$

Where:

WB : Belt's width (m)

BS : Belt's speed (m/s)

BEBD : Belt's birds density (bird/m^2)

Bucket's elevating rate (*BUER*) (bird/hr) also, can be calculated using the following equation through using the bucket actual bird's density (bird/m^2);

$$BUER = (3600).WBU.WS.BBD \quad \text{...............} \quad (4)$$

Where:

WBU : Bucket's width **(m)**

WS : working speed **(m/s)**

BUBD : Bucket's birds density **(bird/m²)**

Packing rate (drawer/min) was measured too and then it was converted to the form of prototype overall operating rate (OOR) (bird/hr) through using the next equation;

$$OOR = (60) . PR. DC \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where:

PR : Packing rate (drawer/min)

DC : Drawer capacity (bird/drawer)

Full time motion study for harvesting process was performed throughout recording the specific time values which document the manufactured prototype efficiency. The efficiency was based on the proportion of time spent harvesting versus performing other tasks (return, pathway setup and packing). 4 workers are required to exchange loaded cage deliver it to the house entrance.

Time values included; set up time, harvesting time, reverse time, movement time, packing time, sequence time and total operating time.

Prototype was financially evaluated; manufacturing cost, operating cost and indicating the economical aspects were established. Cost analysis was performed in two steps, first one was calculating the cost of materials and fabrication, other step was calculating harvesting operating costs (fixed and variable costs). 4 decision rules a firm can be used to help make its decision; (a) Payback Period (PB), (b) Net Present Value (NPV), (c) Profitability Index (PI) and (d) Internal Rate of Return (IRR).

RESULTS AND DISCUSSION

Three consecutive production cycles data are collected, analyzed and illustrated in Figures (4-9); with heavy weights, each worker lift six birds during one operating cycle with average weight of 2 (kg), 10-15 birds are put in one drawer. Each worker is paid 30-50 LE/ working day (approximately 5 hours). Average elevated weight (AEW_{man}) was 12 (kg/man.cycle) and 17 theoretical operation cycles to elevate 1000 birds with a crew of 10 workers and average theoretical birds number was 370 (bird/man). Also, general average of the birds theoretical number for each man from the crew for each house ($BN_{man\text{-}house}$) was approximately 368 (bird/man). Figure (4) illustrates birds theoretical number for three consecutive production cycles individually, Figure (5) represents separately the theoretical number of the operating cycles for each man for the farm ($OCN_{man\text{-}farm}$) and for each house ($OCN_{man\text{-}house}$), for the three consecutive production cycles, general theoretical number for each man for the farm was approximately 62 cycles. Also, the general theoretical number for each man for the house was approximately 62 (cycle).

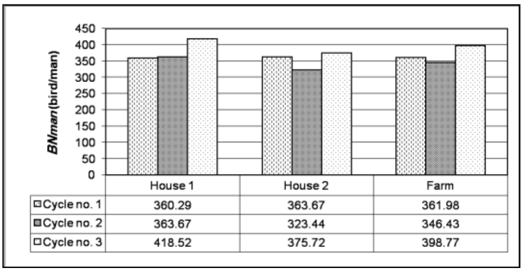


Fig. (4). Birds theoretical number for each man for the farm ($BN_{man\text{-}farm}$) and each house ($BN_{man\text{-}house}$).

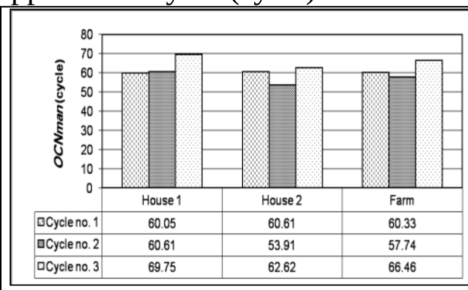


Fig. (5).Operating cycles' theoretical number for each man for the farm ($OCN_{man\text{-}farm}$) and each house ($OCN_{man\text{-}house}$).

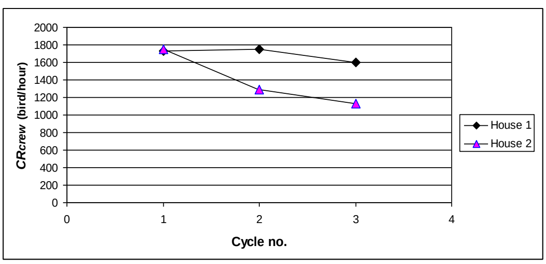


Fig. (6). Clearance rate for the crew for each house ($CR_{crew\text{-}house}$).

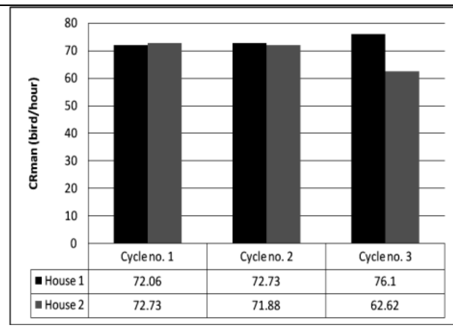


Fig. (7). Clearance rate for one man for each house ($CR_{man\text{-}house}$).

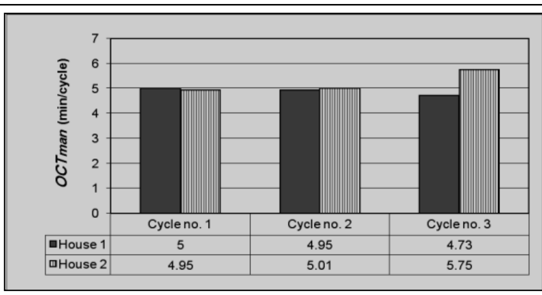


Fig. (8). Operating cycle time for one man of the crew (OCT_{man}).

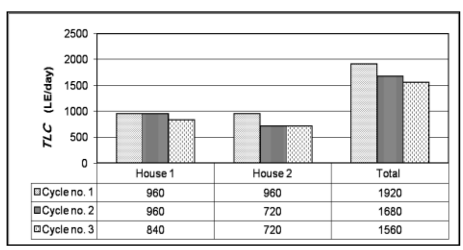


Fig. (9). Total labor cost (*TLC*).

Figure (6) shows the clearance rate for the crew for each house ($CR_{crew\text{-}house}$) for the three consecutive production cycles separately, general clearance rate (*CR*) for the crew for the house ranged between 1127.17 to 1745.6 bird with average of approximately1540 (bird/crew. hour) with average working crew of 21 workers. Figure (7) shows also the clearance rate for one man for each house ($CR_{man\text{-}house}$) for the three consecutive production cycles, general clearance rate for one man for each house ranged between 62.62 to 76.1 birds with average of approximately 72 (bird/man. hour).

Figure (8) shows the operating cycle average time (OCT_{man}) for the three consecutive production cycles, the general average time for one operating cycle ranged between 4.73 to 5.75 minutes with average of approximately 5 minutes. This time for catching and moving six birds and delivers them to the dealer or to the grading men outside the farm's house.

One bird is required a part of the operating cycle time (*BPT*) which was 50.65 (sec/bird). This time was for catching and moving the last bird with the other five birds and delivering it to the grading men outside the house. Finally, figure (9) shows the total labor cost (*TLC*) for the three consecutive production cycles separately. Also the figure indicates that the average labor cost for the farm was 1720 (LE/day) or 333 (LE/hour) and for the house was 860 (LE/day) or 166 (LE/hour).

Furthermore, the actual average of the operating cycle time for one labor was measured during the working day and it was approximately 6 (min). Comparing that value with the calculated time (OCT_{man}) which was 5.06 (min) results that time utilization efficiency reached 84.33 %. Therefore, the working efficiency was assessed to be good compatibility.

Moreover, some of previously values were compared with their manual and automated global counterparts to assess the local condition towards figuring-out the best solution.

The obtained results of the case study showed that the general clearance rate for the crew ($CR_{crew\text{-}house}$) was approximately 1540 (bird/crew. hour), also the general clearance rate for one man for each house ($CR_{man\text{-}house}$) was approximately 72 (bird/man. hour), whereas the previous studies indicated several different factors.

Knierim and Gocke (2005) found that six person manual catching teams loaded 8,000 birds in 40 to 50 minutes, while three person mechanical harvesting teams loaded 8,000 birds in an average of 55 to 60 minutes. Thus, the catch rate per person hour for the mechanical harvester was 2,667 to 2,909 birds per person hour, 33 to 82 percent higher than that for the conventional manual catching team.

Also, Abo Elala (2007) mentioned that with performing catching crew by 8 to 10 workers the rate was 5000-8000 bird per hour. Finally the every 1000 birds need three men to catch and put them into the creating method which take 35 – 40 minute.

Reported mechanical harvesting rates previous research works were ranged between (6400 birds/hr,(harvesting machine, *Berry,1990*; 7000–8000 birds/hr (mechanical catchers, *Lacy and Czarick,1992*); 7,000 (harvesting machine) and 4,200 to 5,000 birds/hr (Mechanical catching system, *Ramasamy et al., 2004*).

Considerable gab between local situation and global manual or mechanical situation can be noticed because of some differences such as crew number of workers and its related cost, also inside working environment. Thus, poultry harvesting process must be considered with new technologies ideas to reduce this gap and achieve to the best.

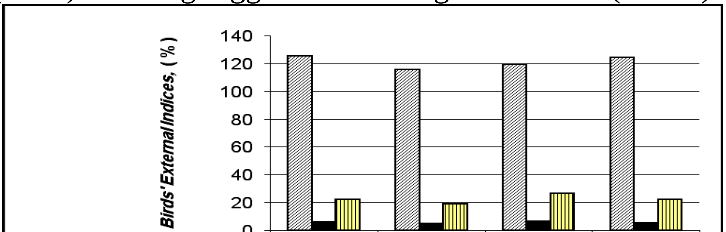
Egyptian birds' production reaches to 800 million birds annually (IDSC, 2008). So, theoretical daily birds' number is approximately 2.19 million birds; about 6576 workers were needed daily with average cost of 40 LE/day/ labor and it needed about 263,040 LE/day or 96.01 million LE/year to harvest all farms. Thus, investment on mechanical solution, reduced huge labor cost and makes superior conditions for both production and industry.

Finally, throughout the previous information and results besides considering the related numerical values, an overview about the harvesting process, values of the manual harvesting parameters and its position with the global ones can be established.

Birds' properties were measured and statistically analyzed using (M-stat.) package, (Suliman, et al., 2010). Bird's space axes were Body Length (BL), Leg Length (LL), Body Height (BH), Stretching Body Height (SBH), Body Width (BW), Total Body Width (TBW), Breast

Circumference (BC), Relax Standing Height (RSH), Sitting Height (SH) beside the Bird's Body Weight (W).

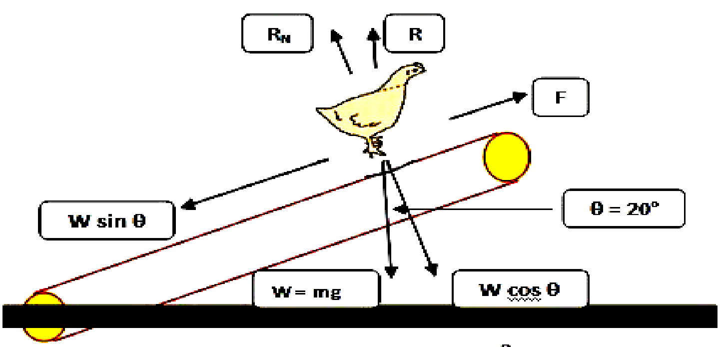
Three important indices (bird's body ratios), Stockiness index links breast circumference (BC) to body length (BL); massiveness index links live body weight (W) to body length (BL) and long-leggedness index links leg length (LL) and body length (BL) were shown in Fig. (10). Stockiness index gives ratio of (1:1.3), while massiveness index gives ratio of (1:5.8) and long-leggedness index gives ratio of (1:0.23).



	Mean	Min	Max	Mode
(Stockiness) %	126	116	120	125
(Massiveness)	5.83	5.1	6.4	5.7
(Long-leggedness) %	22.9	19.4	26.8	22.9

Fig. (10). Birds' External Indices.

Figure (11) illustrates the force and reactions analysis for one bird with average weight of 2 (kg) moving by belt has speed of 0.5 (m/sec) and slope of 20° on the horizontal plan. The analysis values were; 18.79 (N), 20 (N), 6.84 (N) and 0.03 (N.m) for the normal reaction (RN), reaction (R), net pushing force (F) and the bird's kinematic energy (KE) respectively.



$$R = W = mg = 20\ kg.m/sec^2 = 20\ N.$$

$$R_N = W\ \cos\theta = 20\ kg.\frac{m}{sec^2} \times \cos 20 = 18.79\ N.$$

$$F = W\ \sin\theta = 20\ kg.m/sec^2 \times \sin 20 = 6.8\ N.$$

$$KE = \frac{1}{2}\ m v^2 = \frac{1}{2}\ (2\ kg)(0.5\ m/sec)^2 = 0.25\ N.m$$

Fig. (11). Bird's force and reactions analysis with proposed inclined belt.

Maximum power "P" for elevating and transporting one bird from surface to the collecting facility was computed by 0.34 (N.m/sec), (approximately 3.5 W/10 birds). The motion and path analysis of birds, Fig. (12), as projectiles and their range were carried out, obtained results were 0.46(cm), 1.64 (cm), 2.55 (cm) and 0.035 (sec) for maximum vertical distance(S_{max}) depending on the maximum range value, bird's range (R), bird's maximum range (Ramax) and the terminal time (t), respectively. Empty belt power requirements were calculated of 0.23 (hp), where the power for moving loaded belt horizontally was 0.32 (hp) and vertically was 0.074 (hp), so power required was taken as 0.624 (hp).

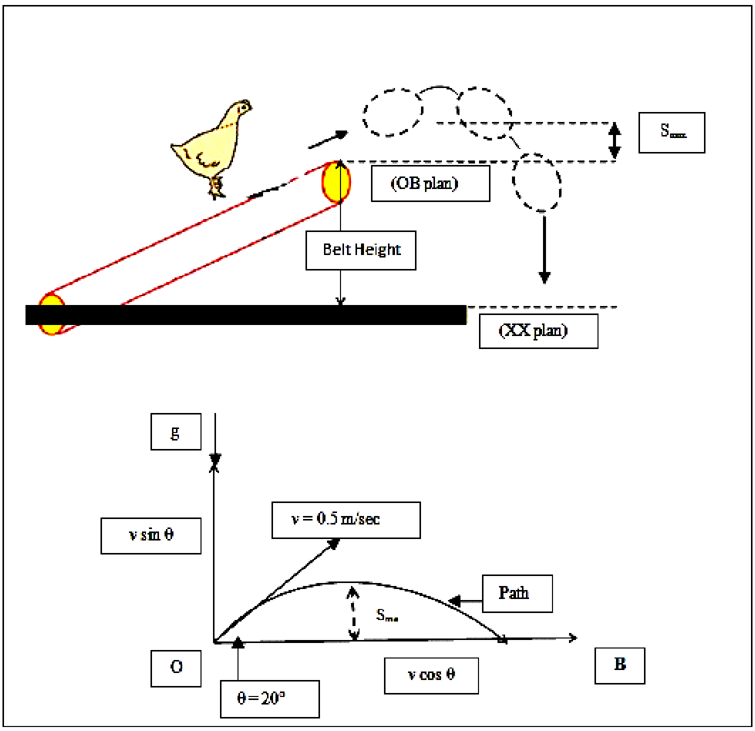


Fig. (12). Motion and path analysis of birds as projectiles.

Harvesting crew of 15 workers, harvested 20,000 birds during three hours, 15 birds were put into the drawer, each worker was paid daily 50 (LE) with 5 hours of work which allow to harvest approximately 2 houses. Normally, labor day cost was 750 (LE/day) for one house, one labor harvests about 1334 birds (considering 7% castoff ratio) hence, 445 (birds/hour.man) for only three hours will be considered with crew general clearance rate of 6200 (birds/hour.crew). For loaded conditions, labor theoretical number of birds was 2480 (bird/man) with harvesting rate of 496 (bird/hour.man) and crew general clearance rate of 7440 (bird/hour.crew).

Examination of manufactured prototype resulted in no injuries, bruises, hurts, scratches, fractures, death carcasses or birds dull and that was checked during and after the loading process. While there was some nuisance or normal fearing with some bruises around the prototype's front in first period of operating, also some birds tried to escape under the bucket in the narrow vertical distance between the bucket circumference and the house's floor.

Bird's heart beating rate (beat/min), describes bird's general status and indicates bird's stress level simply and fast method, was measured, manually, and gave an average value of 30-40 beats/min. Measured heart beating rate, Fig. 13, was (42-55 beats/min.) before manual harvesting and (75-90 beats/min.) after manual harvesting. Stress level of proposed prototype was (69-85 beats/min.), that reflects appropriate of a prototype according to physiological point of view.

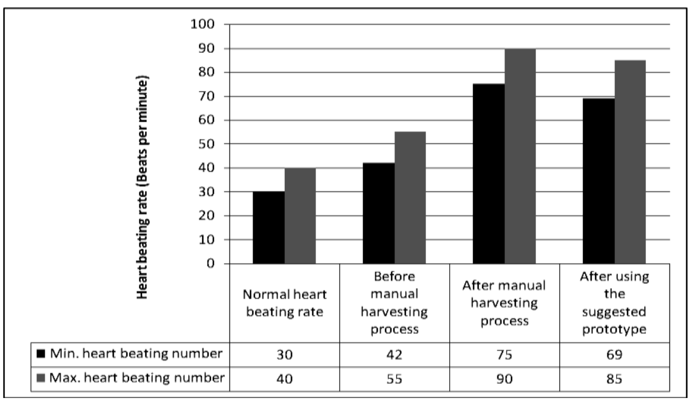


Fig. (13). Birds' heart beating rate.

Sponge sides covered with waterproof material were suitable to absorb bird's impacts and prevent birds escaping. No escaping or injuries events from the prototype's beginning until its end, it can recommend that sides high can be reduced to be equal to rear small one (35cm) high. Birds, under investigation, can't fly and jump over than 10 (cm) vertically or horizontally distance, maximum birds' number can be placed in the belt was 18 birds (with birds' density of 40 birds/m^2 of belt's area), there were no flapping, fearing or others accidental cases occur with belt's designed liner speed.

Belt theoretical maximum rate (*BTER*) was 26,035 birds/hour (434 bird/minute), (if the belt stay in continues move and full loaded), belt actual working width (*BAW*) was 37 cm. Also, belt actual speed (*BAS*) was measured during running using digital tachometer; as 25 (m/sec), calculated belt slippage percentage (*BSP*) was 7.82 (%). Belt actual maximum rate (BAER) was 22,200 birds/ hour (370 bird/min.; actual speed of 0.417 m/sec; 92.5 % of belt's width and birds' density of 40 birds/m^2) with belt's performance efficiency of 85.27 (%).

Bucket theoretical maximum rate (*BUER*) was 31,450 birds/ hour (525 bird/min.) with respect to conditions which are the bucket stay in continues and constant forward movement and with full load condition as cleared similarly for the used belt, bucket width of 0.8 m and birds' density of 30 birds/m^2.

Figure (14) summarize data of trails' time (sec), calculated forward speed (cm/sec) and birds' number caged in each trail individually. These data were 54.9 (sec), 0.36 (m/sec) and 21 (bird) respectively. Average value of 1.5 (drawer/min) was computed from six working strokes, with packing 15 birds/drawer, actual overall rate (OOR) was calculated by 1350 bird/hour. Finally, the actual overall rate (bird/hour) was illustrated in Fig. (15).

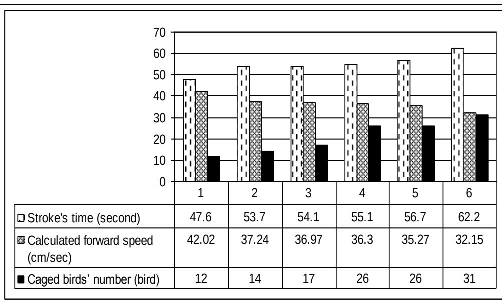


Fig. (14). Trails' summarized data.

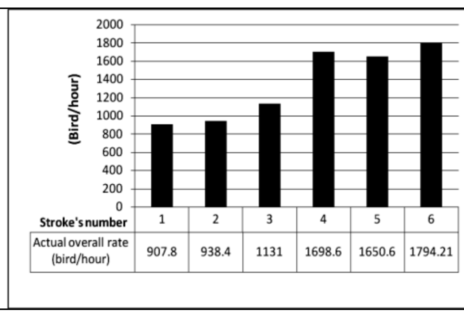


Fig. (15). Prototype's actual overall rate.

Prototype's rate (bird/hour) was compared with manual related rate as shown in table (1); obtained results were as follows; When birds' suffering and labor problems were ignored; the result was the excellence of the manual method, but the crew number of workers and its cost beside insure improved production and finally considering the proposed prototype working rate were important aspects and must be taken into consideration which influence the product and finally the main result is the huge economic losses.

Recent prototype rate (bird/hour) was close to manual rate and reduced the number of workers and its cost, also when considering the prototype's modifications points, improved prototype performance will increase. Finally, the remaining working environment aspects must be modified to increase performance beside decrease the losses and finally gain returns from the processes mechanization.

Table (1). Comparison between the birds harvesting rates.

	Clearance Crew No.	**Harvesting rate**
	Man	**Bird/hour**
Poled houses (manual method)	21	1540
Span houses (manual method)	15	6200
Proposed harvesting prototype	8	1350

Time motion study was performed for whole mechanical harvesting process through recording specific time values which document manufactured prototype efficiency. The efficiency was based on the proportion of time spent harvesting versus performing other tasks (return, pathway setup and packing). Time values were classified and indicated throughout the next table (2).

Total operating time (T_{t}.) was about 21 minutes, sequence time (T_{s}.) was 51 minutes and the total effective time (T_{ef}.) was 13 minutes and 10 seconds. Time values were converted to percentages as shown in table (3) which demonstrate the time items percentage (%) from the sequence time and also from the total operating time. The setup time (T_{st}.) was 30 minutes and confirmed 58.82 % from the sequence time. Finally, the effective time percentage (% T_{ef}) was 62.61 % from the total operating time (T_{t}.).

Table (2). Time motion study obtained values.

Type	Strokes number						Total (min:sec)
	1	2	3	4	5	6	
Set up time ($t_{st.}$), (sec).	900	180	180	180	180	180	**30:00**
Operating time, (sec).							
Harvesting time ($t_{c.}$)	47.6	53.7	54.1	55.1	56.7	62.2	**06:24**
Return time ($t_{r.}$)	38	41	45	45	48	51	**04:28**
Movement time ($t_{m.}$)	20	35	36	41	61	64	**04:17**
Packing time ($t_{p.}$)	30	34	62	76	80	124	**06:46**
Total operating time ($T_{t.}$)	135.6	163.7	197.1	217.1	245.7	301.2	**21:01**
Sequence time ($T_{s.}$), (min:sec).	17:15, 6	05:43, 7	06:17, 1	06:37, 1	07:5,7	08:1, 2	**51:01**
Total effective time ($T_{ef.}$), (sec).	77.6	87.7	116.1	131.1	136.7	186.2	**13:10**

Fabrication costs (materials, purchased parts and assembling cost) and operating cost of the harvesting prototype (fixed and variable costs included management and profit) was carried out. Total fabrication costs were, (year 2011) 6000 LE, operating costs were 9737.5 *LE/year(*162.29 *LE/h)*. Prototype productivity of 1350 (bird/h); cost of harvester per bird equal to 0.122 (LE/bird) and total cost of harvesting process for 1000 birds equals approximately 125 LE.

Table (3). Time motion study obtained percentage.

Type	% from sequence time	% from operating time
Harvesting percentage (% *h*)	12.52	30.4
Packing percentage (% *p*)	13.27	32.22
Return and movement percentage (% *r-m*)	17.16	41.65
Set up percentage (% *s*)	58.82	
Effective time percentage (% T_{ef})	25.78	62.61
Losses time percentage (% T_{lo})	74.22	37.39

Harvesting prototype economical evaluation is performed and based on an inflation rate of 10 % annually and also a discount rate of 10 % annually according to the rates at year 2011. The TSII cost was calculated as 13 % of the (R.V.) at the beginning of the year. Project payback period (PB), net present value (NPV), profitability index (PI) and internal rate of return (IRR) were calculated and illustrated in Table (4) .

Table (4). The economic evaluation input data (LE).

YEAR	R.V.	INV	FC	VC	TC
1	6000	6000	1860.0	5930.000	13790.000
2	4920	0	1719.6	6523.000	8242.600
3	3840	0	1579.2	7175.300	8754.500
4	2760	0	1438.8	7892.830	9331.630
5	1680	0	1298.4	8682.113	9980.513

Harvesting prototype Net percent value (NPV) of 7103.354 LE at 10 % discount rate, net present value of the harvesting project is positive and as a result the project will increase the value of the firm. Prototype Profitability Index (PI) of 3.01. The sum of the discounted cash flows was greater than the cost of the project, PI was greater than 1. Thus, the benefit of the project outweighs its cost. Finally, the prototype PI shows that the investment in this prototype as a project will be economical.

Prototype Internal rate of return (IRR) of 57 %, IRR was greater than the cost of capital. Thus, the IRR parameter shows that the investment in this project will be economical. Table (5) shows values of the different economical parameters and the economical final conclusion which reported that the harvesting prototype project can be accepted.

Table (5). Project economical parameters and final conclusion.

Parameter	Value	
PB (Year)	1.56	< 5 years
NPV (LE)	7103.354	Positive value
PI (ratio)	3.01	> 1
IRR (%)	57	> 10 %
Conclusion	**Project can be accepted**	

Labor energy utilization calculations were also performed for the existing and modern system of harvesting. The effectiveness of man power (Pw) were 146.67 (kg/man.hr) and 337.50 (kg/man.hr) for the previous systems respectively, numerical values indicated that the modern system is superior.

CONCLUSION

Recent poultry harvester design considered and realized important requirements as follows: fits to local conditions and existing buildings; simple and inexpensive; achieves the process without huge escaping or injuries; catch and handle birds in a humane way or at least not adversely affecting compared to normal manual catching systems; operates at rate close to the manual harvesting rate (birds/h) with a possible saving on the normal manual labor costs; quiets and clean in operation to prevent the birds being disturbed and to protect the catching team working environment; reliable and easy to maintain including cleaning and disinfecting; capable of easy transport between farms sites and finally, economical to operate so that users can be assured of a return on their capital outlay through labor savings and reduced down-grading costs.

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الملخص العربي

نموذج تجريبى أولى لآلية لحصاد الدواجن

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هدفت هذه الدراسة إلى استعراض وتحليل واستقصاء فترة الحصاد والإخلاء للدواجن الحية وذلك باستخدام منهج هندسي في محاولة لتقديم نموذج آلي لعملية جمع ورفع طيور التسمين من سطح أرضية العنبر باستخدام وسيلة السيور الميكانيكية الناقلة وذلك دون إحداث اي أضرار أو إصابات أو تدهور للطيور. اهتمت الدراسة أيضا بتقدير بعض الخصائص والقياسات البعدية ، الميكانيكية والفسيولوجية الهامة للطيور محل الدراسة لتكوين قاعدة بيانات لازمة عند التصميم والتصنيع ثم اختبار النموذج الآلي المقترح لإتمام مهمة إخلاء العنابر من الطيور.

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تم عمل دراسة الحالة بداخل مزرعة تسمين الدواجن والتابعة لكلية الزراعة/جامعة القاهرة وذلك لمتابعة فترة الإخلاء للعنابر خلال ثلاث دورات إنتاجية متتابعة خلال أيام الذبح والبيع ، أيضا تم التطبيق والاختبار للنموذج الآلي المقترح بالتعاون مع شركة الربيع للدواجن. وكانت أهم النتائج المتحصل عليها كالتالي: تم دمج البيانات والمعلومات والنتائج المتحصل عليها للوصول إلى تصميم ملائم لتنفيذ مهمة الإخلاء آلياً وبجودة وأيضا كفاءة مناسبين ، بعد إتمام عملية التصنيع أصبح النموذج ذو طول كلي ٢١٠ (سم) ، عرض كلي ٩٠ (سم) وارتفاع أقصى ١٠٠ (سم) وأخيرا تتناسب هذه المقاسات مع أبعاد مداخل المزارع والعنابر وأيضا التعامل مع عوائقها سواء أكانت من النوع ذو الأعمدة أو من النوع المنبسط. قدر المعدل اليدوي العام لرفع الطيور للطاقم وكان ١٥٤٠ (طائر/ ساعة) في حين قدر المعدل العام لرفع الطيور للعامل الواحد وكان ٧٢ (طائر/ ساعة).

قدر معدل العمل الأقصى لجزء الجرف وكان ٥٢٥ (طائر/دقيقة) وهذا مع مراعاة ثبات السرعة التقدمية واستمرارية العمل، في حين قدر معدل عمل السير الفعلي الأقصى وكان ٤٨٠ (طائر/دقيقة) وهذا في حالة بقاء السير محملا بالكامل وفي حالة تشغيل مستمر أيضا. تم تقدير معدل التعبئة الفعلي وكانت قيمته ١,٥ (قفص/دقيقة) وبالتالي أصبح معدل الرفع العام الفعلي للنموذج بمتوسط ١٣٥٠ (طائر/ساعة). تم تقييم الحالة الفسيولوجية لعينة من الطيور في ظروف عدة وذلك بتحديد مدى عدد ضربات القلب والمعبر عن الإجهاد الواقع على الطيور ، أثناء الحالة الطبيعية للطيور وقبل عملية الحصاد اى كان نوعها يدوية أم آلية ، قدر بقيمة ٤٢ ــ ٥٥ (ضربة/دقيقة) ، أما بعد حالة الحصاد بالطريقة اليدوية قدر بقيمة ٧٥ ــ ٩٠ (ضربة/دقيقة) وأخيرا بعد حالة الحصاد الآلي باستخدام النموذج المقترح كانت قيمته ٦٩ ــ ٨٥ (ضربة/دقيقة) وبمقارنة هذه القيم تكون النتيجة الواضحة هي تفوق وأفضلية استخدام طريقة الحصاد الآلية وذلك من وجهة النظر الفسيولوجية نظرا لقيمتها التي تعكس حدوث إجهاد أقل للطيور وذلك عن الطريقة اليدوية. كنقطة أخيرة تم تقييم النموذج الآلى المقترح اقتصاديا بتحديد التكاليف التصنيعية وأيضا التشغيلية وأخيرا تم حساب التكلفة الكلية بقيمة ٦٤٥٠ جنيها مصريا وأيضا تم تقدير فترة استرداد رأس المال المستثمر لإنتاج النموذج المقترح وكانت تقريبا ١٨ (شهر) اعتمادا على الوفر فقط من تكلفة العمالة.

الكلمات الدالة: حصاد الدواجن ، السيور الناقلة ، العمالة ، معدل الرفع اليدوي العام ، معدل الجرف ، معدل الرفع ، معدل التعبئة ، عدد ضربات القلب ، فترة استرداد الاستثمار.