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DEVELOPMENT OF THE MANUAL SOLITARY REELING JAPANESE MACHINE FOR REELING THE MULBERRY SILKWORM BOMBYX MORI L. COCOONS.

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ABSTRACT

The aim of this study is to develop the manual solitary reeling machine which can be used in research studies and can be operated mechanically for reeling cocoons of Bombyx Mori L.. Some parameters were evaluated such as reeling speed, reeling time as indicator for silk yield and reeling efficiency. The obtained results of the developed reeling machine were as follow:

A) Raw silk percentage 41%, floss percentage 3.6%, pelade percentage inside waste silk 9.4%, filament length 8.55 m. and filament weight 0.25 gm.

B) The reeling speed increases from 60 to 160 rpm. the reeling time decreased from 12 to 4 min. this reeling speed tend to increase the productivity from 3.75 to 18.00 gm/h for reeling one cocoon.

C)By increasing the reeling speed from 140 to 160 rpm, the power consumption increased from0.220 to 0.340 kW. While, pelade inside waste silk was decreased from 0.066 to 0.064 gm. The reeling time was decreased from 6 to 4 min. Also, productivity tend to increase from 11.85 to 18.00 gm/h., for reeling cocoon by cocoon.

INTRODUCTION

The present study aimed to improve the reeling efficiency of cocoons reeled by the manual solitary reeling machine using for research work evaluation some parameters affected by reeling process as reeling speed, time of cocoons reeling, length of silk filament, weight of silk filament, number of filament breaks were carried out. Silk is an animal fiber produced by caterpillars belonging to the genus Bombyx. A single silk filament is the product of a series of stages derived from the cultivation of mulberry trees for feed to the propagation of the domesticated silkworm. Bombyx mori L. During the caterpillar phase, the worm wraps itself in a liquid protein secreted by two large glands in its head. This secreted protien hardens upon exposure to the air. The resulting filament is bonded by second secretion, sericin, which forms a solid sheath or cocoon **(Lee 1999)**. Under natural conditions a moth eventualy breaks through the cocoon. In sericulture, the larva is killed in the cocoon by steam or hot air. Silk reeling is the process by which a number of cocoon filaments are reeled together to

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produce a single thread. The yield percentage as well as efficiency could be improved with the temperature adjusting of the reeling part as compared to the conventional cocoon cooking **(Yoo et al, 1990)**.

Ueda (1985) discussed the influence of rearing conditions on the reelability of cocoons of the bombycid Bombyx mori. It is reported that lowering of reelability occurs if the larvae are reared under adverse conditions. The effects of mounting using the Jobarai method and the effects of the interaction of temperature, humidity and air current at the spinning stage on reelability were investigated.

Cappellozza (1988) indicated that the modern 'double cross' silkworms [Bombyx mori] are almost twice as productive as the older varieties when reared at the correct temperature of 21-24°C (294-297 °K) for the 1st to 4th larval instars, 24-25°C (297-298 °K) for the 5th larval instar, humidity (60-70%), light and ventilation, and when fed mulberry leaves of the correct quality and quantity at the different stages of development. Machines, which remove mulberry leaves from the cut branches and shred them are available. Labour costs are thus much less than with traditional methods.

Yoo et al., (1990) found that the yield percentage as well as efficiency could be improved with the temperature adjusting of the reeling part as compared to the conventional cocoon cooking.

Okawa (1992) mentioned that the production costs, price received by producers , trade relations and world prices, and their relationship with the decline in raw silk production. Raw silk price was established as a function of: price of the fibre in the external market; exchange rate; participation in the internal and external markets; taxes and incentives and part of the residue. Some items are considered as a history of disparity between price received by farmers and total operational costs. One of these items was labour used during all phases of production and another was fixed costs.

Hosny (1994) mentioned that three methods were used for drying pupae of Bombyx mori inside their cocoons. They were sunrays, Balady-oven (which is found in Egyptian farmhouses), hot air at 70 and 90°C (343-363 °K) and steam pressure. Certain technological parameters were studied. Sun-drying gave the worst results and is time-consuming and labour-intensive. There were insignificant differences between drying cocoons in the Balady-oven or by hot air. It is recommended to use the Balady-oven for drying cocoons in order to avoid all the disadvantages resulting from the sun-drying method.

Hariraj et al., (1995) mentioned that as treatment time increases from 1 to 5 minutes, the quantity of water absorbed in Indian bivoltine cocoons increase from 1.9 to 3.5 times at up to 50 °C (323 °K). The quantity of water absorbed does not change, but from 50 °C (323 °K) to boiling

temperature, the quantity of water absorbed increases from 1.4 to 4.5 times. Absorbed water increases at boiling temperature. So, the cocoons outer layer come in contact with high temperature suddenly, resulting in over softening of sericin in outer layers.

Tribhuwan and Singh (1997) described the factors influencing the quality of silkworm cocoons, including cocoon formation, environmental conditions, and mounting material and mounting methods. Several types of defective cocoons are also described.

Tsubouchi et al. (1997) stated that in order to obtain a fine filament, silkworms [Bombyx mori] were treated with anti-juvenile hormones and tetramolter silkworms were transformed into trimolter ones. Cocoons of trimolter silkworms were smaller than those of tetramolter silkworms, and the filament size of smaller cocoons was finer and filament strength was higher. Using an automatic reeling machine, super fine raw silk and produced. A cocoon width of 16 mm was found to be suitable for the reeling machine. Among the cocoons with this cocoon width, trimolter race TC14 X MK treated with anti-juvenile hormone was suitable. The cocoon filament size was 1.04 denier and the raw silk size deviation was low (4.59%). The strength of the raw silk was 30% higher than raw silk of the silkworm race Asahi X Tokan.

Du-XunLei and Du-XL (1998) discussed the methods of determining the value of silkworm [Bombyx mori] cocoons. In 1991-93 and 1995 different methods were compared. The fluorescent light method gave higher values than the method of using dry weights. Using the silk reeling count method gave values of 1.86-3.30% higher than the fluorescent light method in 1992-93 and 1995 but in 1991 the value of using silk reeling was 4.44% higher than that using fluorescent light. The values of each technique and the need for the introduction of facilities for the assessment of cocoon value were considered.

Hayashiya and Hamamura (2001) indicated that the quality of coccoons and raw silk produced by silkworms reared on artificial diets are discussed in this chapter. specific topics include the quality of coccoons, based on the fibroin and sericin contents, during the initial stage of artificial rearing; effects of diet composition on coccoon shell weight and reelability percentage; rearing using various artificial diets and the characteristics of the resulting coccoon; and the quality of silk yarn obtained by fresh coccoon reeling using 3 methods, i.e. repeated hot water permeation, reduced pressure permeation method and reduced pressure permeation method combined with supersonic wave treatment.

Kumar et al. (2002) mentioned that from breeders point of view, the filament size deviation test is one of the important characters for evaluation of the breeds/hybrids for commercial exploitation. The reeling was carried out in mono cocoon reeling machine having its reeling circumference of one

meter. There was a decrease in denier from the outermost layer to the innermost layer. The slope of the denier curve was estimated calculated by regression analysis (least square method). The relationship between filament length vs. slope, average filament size vs. slope and maximum filament size vs. slope was calculated based on regression analysis. There was a significantly positive correlation between slope (b) and the average filament length (r=-0.79) and between slope and maximum filament size (r=-0.87).

Objectives.

- The study was carried out to develop the reeling method (manual and motorized reeling methods) for the cocoons of Bombyx moir L. for improving the silk yield and reeling efficiency.
- Studying some parameters affected by reeling as reeling speed, and time of reel cocoons. Also, cocoon, pelade and silk filament weight, length, size of silk and number of breaks for each filament were registed.
- Development of the manual solitary reeling machines to working mechanically with motor and its management.

MATERIAL AND METHODS

Modern rearing of the silkworm Bombyx moril in Egypt are carried out four times a year which are, spring, early summer, early and late autumn while the traditional rearers has only one rearing season during spring. Table (1), shows the average weather condition (temperature and relative humidity) during four seasons of four years.

Table (1): Average weather condition (temperature and relative humidity) through four seasons of four years. (Giza and Kalubia governorate).

Seasons	Temperature , °C							
	Giza				Kalubia			
	Mar	Jun	Oct	Nov	Mar	Jun	Oct	Nov
1999	26.0	36.4	30.8	27.2	23.6	28.9	29.7	23.5
2000	21.6	38	28.9	25.4	21.3	28.1	32.49	29
2001	20	37	27	24	22	36.3	35.5	27
2002	18.68	26.84	24.92	23	22.44	35.65	28.39	25
Ave. 4 years	**20**	**37**	**27**	**23.5**	**22.33**	**32.24**	**31.52**	**25**
	RH,%							
1999	92	92	90	88	83	79	82	76
2000	89	91	83	94	87.1	77.5	83.42	82.7
2001	75	85	75	85	87.9	85.5	85.3	83
2002	56.43	51.96	60.09	75	92	87	95	75
Ave. 4 years	**75**	**85**	**75**	**80**	**87.5**	**82.25**	**86.43**	**75**

Source : paper monthly for weather forecast station, different number , Ministry of Agric., Egypt.

1- Larval stage and requirements:

The requirements of the silkworm larvae during the rearing period are illustrated in fig (1). Larvae are passed through five larval installs viz, first, second, third, fourth and fifth instars respectively. These instars tast for 6, 4.5, 6.5, 7 and 10 days respectively. Also the total areas required are 0.8, 2, 4.5, 10, and 22 m^2 respectively. The second requirement is the quantity of mulberry leave needed for each which are 2, 6, 25, 90 and 475 kg respectively

Rearing of silkworms and production of cocoons:

Larvae of Bombyx mori L. Var 9F7X. were raised on mulberry leaves of Morus alba , var Kokuzo-27 during spring rearing season of 2003-2004 under laboratory conditions at means of 22-25 °C (295-298 °K) and 68-69 % RH at the sericulture Research department at Giza. After pupation, the harvested cocoons were divided into two groups for reeling on the manual and the developing solitary reeling machine. Two treatment of three replicates (30 cocoons each) were used for the experiments, **Souad M. Mahmoud et. al. (1995).**

Features of the manual reeling machine:

1- Required three labor one for cooking, one for operation and one for reeling.
2- Difficulties of speed adjustments manually which increase number of filament break.
3- Difficulties of controlling reeling water temperature which increase the waste silk surrounding the pelade (inside silk).
4- Can only reel one cocoon per time which increase time of operation and decrease the productivity.

2-Machine specification and description.

The machine used in this study is the solitary reeling silkworm machine for reeling solitary cocoon for research purpose. The machine was developed at the workshop of Agricultural Engineering Research Institute (A.En.R.I), Giza, Egypt. The experiments were conducted at Sericulture Research Department (SRD),Giza Plant Protection Research Institute, (PPRI) during spring season of (2003 – 2004).

The developed reeling machine:

For the above mentioned reason the machine was developed as follows:-

1- Using electric engine to develop the machine from manual to mechanical operation, for adjusting the reel speed and decreasing the number of labor.

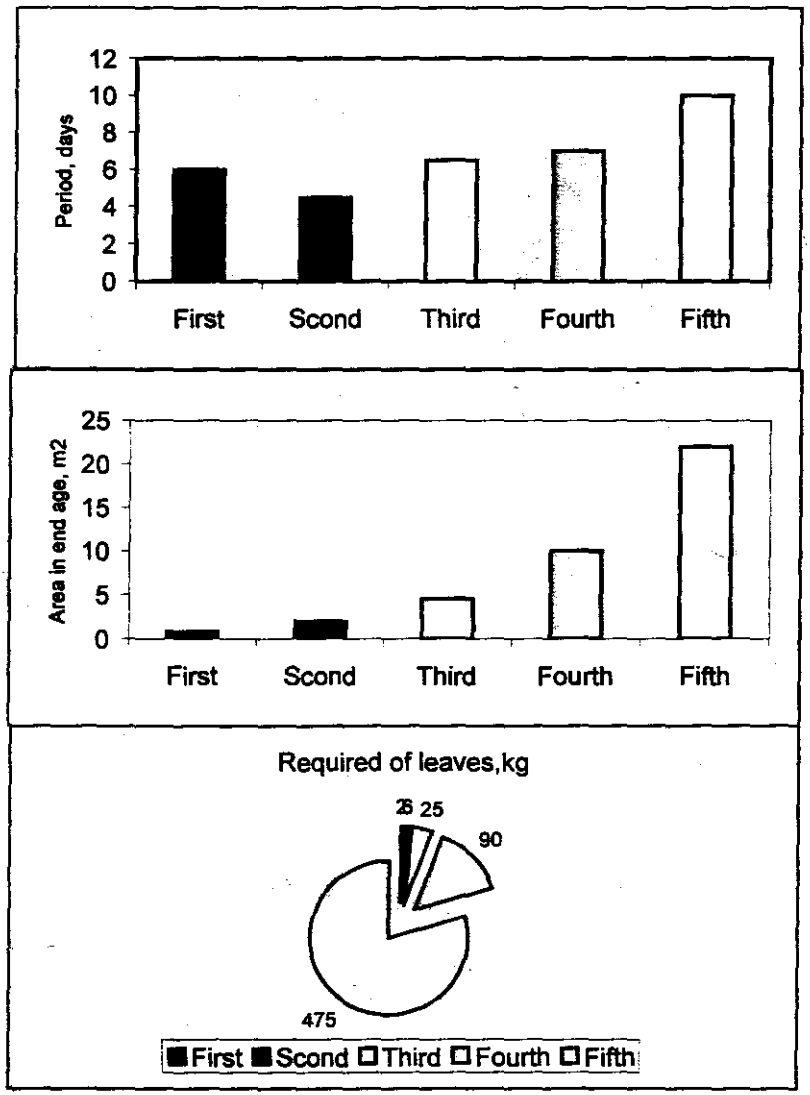


Fig. 1: Requirements of silkworm larval of 1 silkworm egg box through larval ages.

2- Added the heater and thermostat to the reeling basin for keeping the water temperature constant between 35-40 °C (308-313 °K), which lead to decrease the number of filament and number of labor needed.
3- Adding a counter for registering the filament length.
4- Decreasing the reeling time of experiment.
5- Increasing the productivity. (Results to increased reel speed and number of cocoons).

The developed solitary reeling machine consists of frame, reeling basin, heater and thermostat, electric engine, lower shaft which one eyes guide, upper shaft which one wheels, reeling pulley and counter. As shown in fig. 2 (a and b). General specifications of the machine are shown in table (2).

Table (2): General specifications of the developed reeling solitary machine.

ITEM	SPECIFICATION
Over all length, mm.	430
Over all width, mm.	340
Over all height, mm.	1480
Electric power, hp.	0.25
Capacity, cocoon/min.	3 / 3
Labor requirement.	1 man

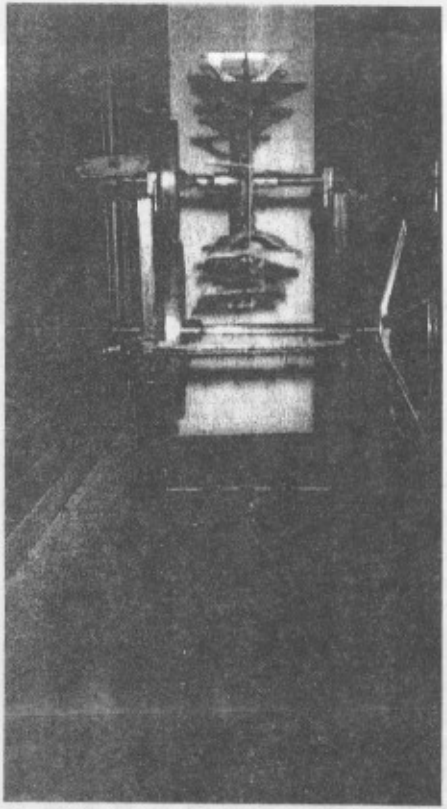
The machine description:

The machine description is as follows: high capacity: up to 60 cocoons /h., low power requirement: 0.25 hp electric motor, low labor requirement: two men. one for cooking and one for operation minimum adjustments reduced repairs and maintenance problems and simple design and highly mobile: can be carried by two men (the machine mass is 100 kg.).

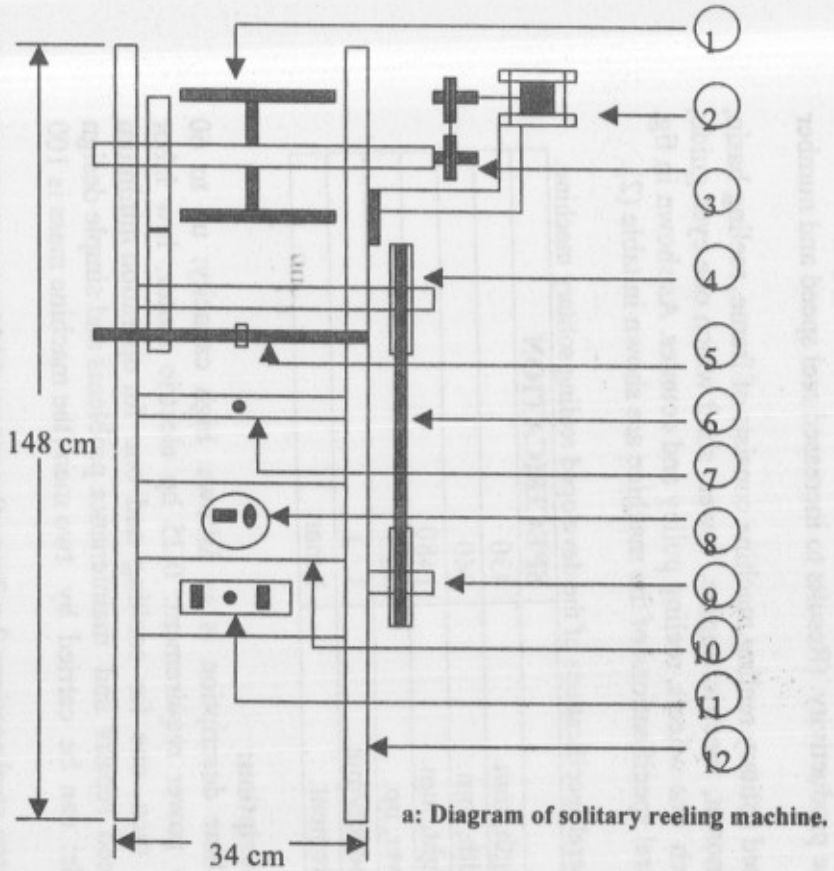
Frame: Made of iron steel sections 2 x 2 cm. (length x width).

Reeling basin: Made of metal sheet of 1.5 mm thickness and dimensions 27.5 x 22.5 cm.

Heater and thermostat: Located at the bottom of reeling basin, they conceited together. The heater used for heating the water, thus saving time and number of labor. As for the manual reeling machine, the reeling basin water need to be changed several times to adjust the temperature. The thermostat is located with heater to control the water temperature and keep the water temperature constant at 35-40 °C (308-313 °K) , it is divided to 4 sections 0, 20, 40, and 80 °C (273, 293, 313 and 353 °K), the temperature can be adjusted by putting the arrow of temperature, so that when the water temperature reached to the desired to heating the water of reeling to separate easy to de solve seriaceen material the thermostat stop the heater.



b: Photo of solitary reeling machine.



a: Diagram of solitary reeling machine.

1-Reeling pulley, 2- Counter , 3- Revaluation group, 4- Motion pulley , 5- Makock , 6- Belt, 7- Guide eye, 8- Heater & thermostat, 9- Motor, 10 - Reeling basin, 11- Switch and 12- Frame

Fig. (2): Diagram and photo of solitary reeling machine to reeling silkworm dray cocoons

Reeling pulley: Made of cooper, diameter of pulley is 220 mm., number of plates are 10 plates, the angle between every plate and the other is 45 degree, can be decreased and increase one of this plates to get out reeling silkworm from reeling pulley.

Counter: Is fixed on the shaft of reeling pulley. For measuring the filament length the next equation is connected and delivered from experiment.

Length of reeling filament, m = reading of counter x 2

Electric motor: An electric motor has power of 0.25 hp (0.175 kW) speed of 1400 r.p.m., 220 V, and 1.5 A. The power is transmitted to the moving parts of the machine by means of pulleys and belts as shown in fig. (1) which decreased the revaluation of motor from 1400 to 160 rpm. By increasing the diameter of pulleys and used reducer speed to control the engine speed, and give different speed (140, 150, and 160 rpm.) instate of constant speed.

3- Instrumentation:

Speedometer: Speedometer was used to measure the rotation speed in three ranges. First range; 40-500 r.p.m., second range; 400-5000 r.p.m. and third range :4000-5000 r.p.m. direct reading. Speedometer specifications are given in table (3).

Table (3): General specifications of speedometer.

Item	Specification
Type	Hand speedometer
Speed	40-50000 r.p.m.
Accuracy	± 1% full scale
Make	Germany
No. of sets	3 diameter dial

Digital dial caliper: Dimensions of cocoons were determined to know length, width and thickness of cocoons. A digital dial caliper reading up to 15 cm was used. Its accuracy is 0.05 mm.

Super clamp meter: A Super clamp meter was used for measuring the A, V and Ω. made in Japan. It was used to measure A in 5 ranges. First range: 0-6, second range: 0-15, third range: 0-60, fourth range 0-300 and fifth range:0-700 direct reading. Type 700 K and 600 V ? AC 50 Hz.

Stop watch: It was used for measuring time during test.

Electronic balance: An electronic balance was used for weighting filament samples after reeling. Its scale ranged from 0 to 50 kg. max., with accuracy of 0.2 g.

4-Cocoons Preparation:

Cocoon cooking was carried out using, the common open-pan system (which is commonly used in Egypt.) under 100 °C (373 °K) for 10 minute. Cocoon cooking is aprocen in which water is made to penetrate from outside to inside the cocoon shell, in order to make the sericin soften to a suitable degree throughout the cocoon shell. Also, to find the first of silk from cocoons to separate easy, after that put this cocoons in the reeling basin which have hot water its temperature about 40 °C (313 °K) by using heater and thermostat to adjust water temperature, take the first silk from cocoon to lower shaft which have three eyes guide, to upper shaft which have three wheels guide, and to reeling pulley to start the reeling operation.

5-Experimental procedures:

Experiments were carried out at different motor speed ranging from 140 to 160 rpm in the reeling processes. Tests were conducted to estimat the length of reeled cocoons filaments, numbers of filament breaks, weight of reeled silk, time of reeling and productivity. The solitary manual reeling machine was developed to operate mechanically by motor for easier operation in the research field to evaluate different cocoon types. The reeling water temperature was maintained at 40 °C (313 °K), the reel speed of 140, 150 and 160 rpm.

RESULTS AND DISCUSSION

Evaluation results for both manual and developed solitary reeling machine are illustrated in table 4.

Table (4): The efficiency of reeling machine.

Type of machine	Amount of cocoon to be reeled (gm/h)	No. of break in filament (No.)	Reeling time (min/one cocoon)	Wt. of filament. (gm/h)	Wt. of filament. (gm/day)
Manually machine	2.5	10	12	3.75	5.25
Mechanical using one lend	7.5	2	4	18.00	26.25

From table (4) reeling results indicates that the amount of reeled cocoons were 2.5 and 7.5 gm/h, resulting weight of filament 3.75 and 18.00 gm/h. (5.25 and 26.25 gm/day considering one work day = 7 hours), for manually and developed reeling machine respectively for reeling one cocoon per time at 160 r.p.m., The reeling time were 12 and 4 min. while number of filament breaks were 10 and 2 for manually and developed machine respectively .It shows that the reeling time of the manually solitary reeling machine were about three times of the developed solitary machine.

The effect of reeling methods and different reeling speed on the raw silk yield are tabulated registered in table 5 and shown in fig.3.

Table (5) Effects of Reeling methods on yield of raw silk.

Reeling methods	Reeling speed (r,p.m.)	Reel time (min)	Length of filament (m)	Energy consumption (kW)	Productivity (g/h)
Manually	60	12	740	2.98	3.750
Machinery	140	6	690	0.220	11.85
	150	5	970	0.264	14.91
	160	4	980	0.340	18.00

From table (5) it can be need that the comparison between manually and developed solitary reeling machine at three different reeling speed showed that, the reel speed of manual reeling machine was 60 r.p.m. the reeling time 12 min. power consumption 2.98 kW and productivity 3.750 gm/h. While by using the reel speed of 160 rpm, at the developed reeling machine, results 4 min. for the reel time, 0.340 kW of power consumption and productivity 18.00 gm/h.

Fig. (3) shows that by increasing the reel speed from 140 to 160 rpm, the power consumption changed from 0.220 to 0.340 kW at reel of one cocoon, while the inside waste silk around the pelade was decreased from 0.066 to 0.064 gm. The time of reel was decreased from 6 to 4 min. Also the productivity of one cocoon was increased from 11.85 to 18.00 gm/h., and the number of labour did not chang at reel one cocoon.

Table (6): some statistic of physical properties of silk thread, reeling by developed solitary reeling machine at 160r.p.m.

Statistical values	Reeling time (min)	Length of filament, m	Size (denier)	Weight of filament (gm)	Weight of plade inside waste silk (gm)
Min.	3	600	2.25	0.15	0.04
Max.	5.5	1080	2.754	0.32	0.7
Mean	4.13	855.00	2.57	0.25	0.11
S. E	0.75	133.97	0.13	0.04	0.16
S.D	0.24	42.39	0.04	0.01	0.05
CV.%	0.18	0.16	0.05	0.18	1.41

Data presented in table (6) indicate that the developed solitary reeling machine to reel cocoons cooked in dry state gave the best results. The average of 4.13 min, 855 m, 2.75 d., 0.25 g. and 0.11 g. for reel time,

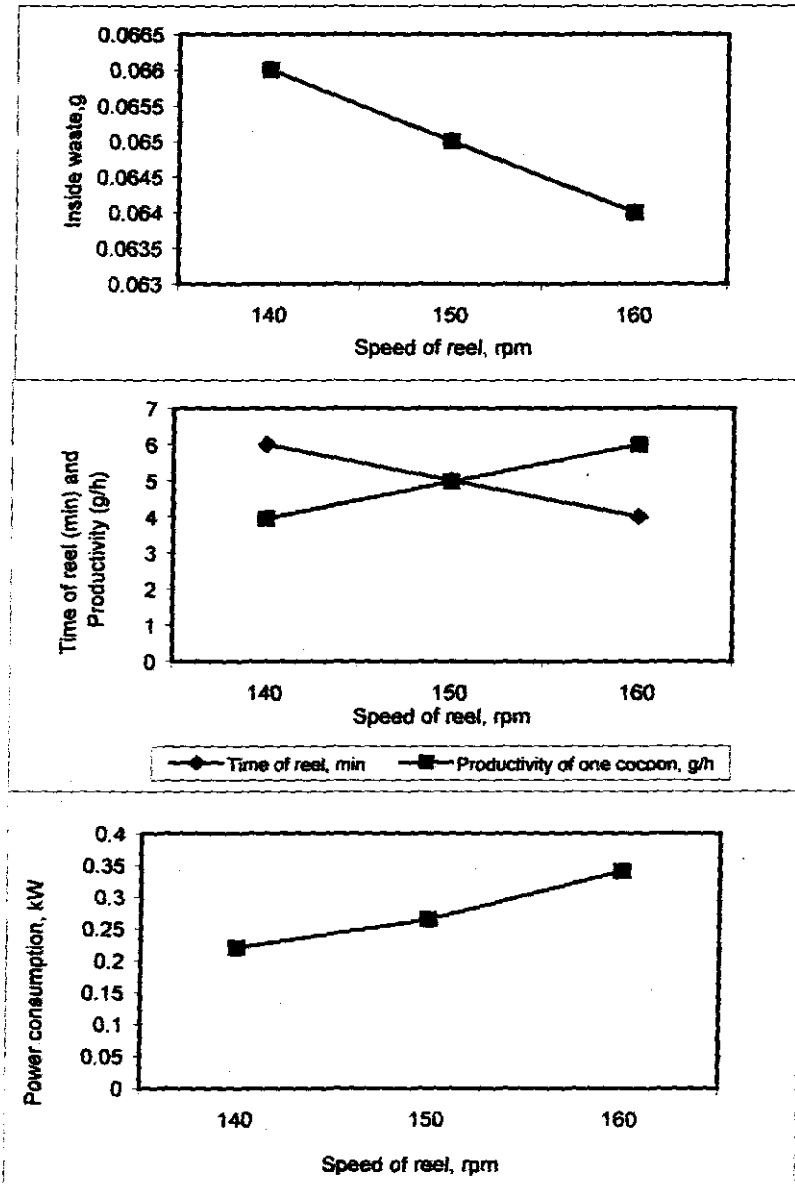


Fig.3: Effect of reel speed on some filament charachters.

length of filament derived, size of filament, weight of filament and weight of plade with inside waste silk, respectively. While, standard division were 0.24 min., 42.39 m, 0.04d., 0.1 g. and 0.05g, and coefficient of variance were 0.18, 0.16, 0.05, 0.18 and 1.41 for reel time, length of filament derived, size of filament, weight of filament and weight of plade, respectively.

Fig (4) shows some operational factors for solitary manual and mechanically of reel silkworm. The manual reeling machine was developed to be mechanically of reel machine. It was noticed that the reel speed increases from 60 to 160 rpm. While, time of reel decreased from 12 to 4 min. This speed of reel tend to increases the productivity from 3.75 to 18 gm/h for reel one cocoon. Also, the same figure shows that the results tend to decrease the number of labour from 3 to 2 labours and the source of power was changed from manual to motor. This change tended to decrease the power consumption from 2.98 to 0.34 kW.

Table (7): Specifications of dry cocoons and characteristics of silk worm for Chinese cocoon variety (Bombyx Mori L) using by developed solitary reeling machine.

Specifications of cocoons.				
Type of silk	Voltinism	Colour	Shape	Av. cocoons weight (gm)
Mulberry –1	Crossbreed	White	Oval	0.52
Characteristics of silk worm.				
Weight of cocoon (g)	Length of filament (m)	Size of filament (d)	Weight of outside waste silk (g)	Weight of inside waste silk (g)
0.574	855	2.75	0.021	0.054
Percentages of reeling results.				
Single cocoon (%)	Outside waste , (%)	Inside waste, (%)	Pupation ratio (%)	Percentage of cocoon shell (%)
100	3.6	9.4	46	41

For dry cocoons and using the manual and mechanically solitary reeling machine, data presented in table (7) and fig.5 show that evaluation of reel dry cocoons by solitary machine. The solitary reel machine was developed better than the manual solitary machine (before developed) for all parameters under study. The characteristics of silk worm revealed the percentage of raw silk (41%) and the percentages of floss (3.6%), pelade (9.4%) and pupa of cocoon (46%).

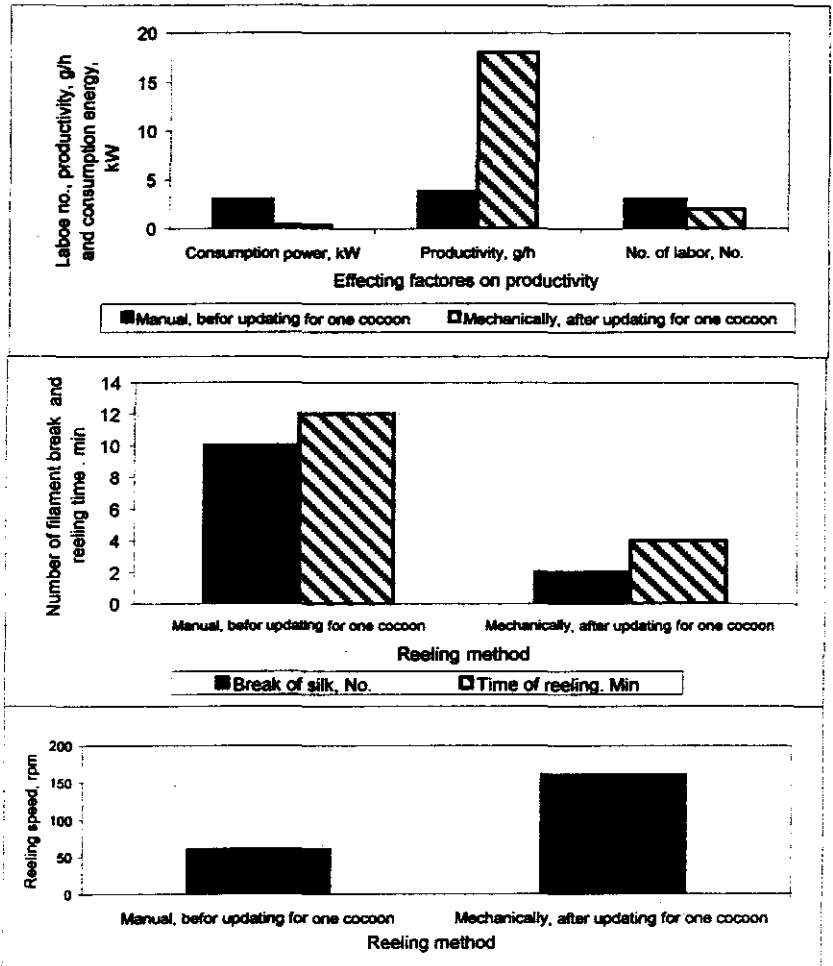


Fig.4: Effect of reel method of some operational factors.

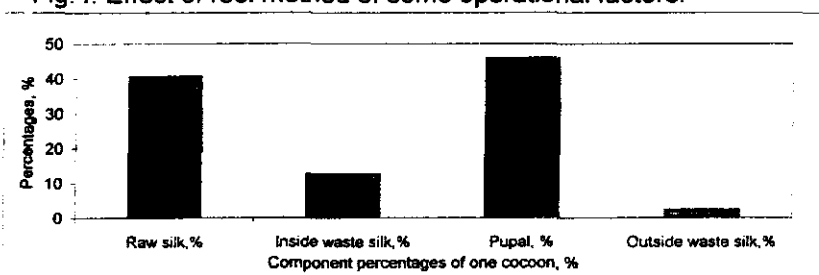


Fig.5: Percentages of different component of dry cocoon.

CONCLUSION

For reeling solitary cocoons, the manual solitary reeling machine was developed for better operation for all the parameters used for the study as followed:

After cooking cocoons for 10 minute at 100 °C, cocoons were transferred to the reeling basin of the solitary reeling machine at water temperature 35-40 °C, as result of adding the thermostat and the heater to the reeling basin. Therefore, best results were obtained for the silk yield percentage as well as reeling efficiency compared to the manual reeling machine. The amount of reeled cocoons increased by three times, also it was 2.5 time of reel speed. While, reeling time decreased about 3 times and number of break about 5 times for manually solitary machine and developed solitary machine to reel one or three cocoons, respectively.

The reeling performance at the developed reeling machine were as followed:

- Raw silk percentage 41%, floss percentage 3.6%, pelade percentage inside waste silk 9.4% filament length 855 m. and filament weight 0.25 gm.
- The reeling speed increased from 60 to 160 rpm. while, the reeling time decreased from 12 to 4 min., this reeling speed tend to increase the productivity from 3.75 to 18.00 gm/h for reeling one cocoon.
- By increasing the reeling speed from 140 to 160 rpm, the power consumption increased from 0.220 to 0.340 kW. while, pelade inside waste silk decreased from 0.066 to 0.064 gm. The reeling time decreased from 6 to 4 min. Also, productivity tend to increase from 11.85 to 18.00 gm/h., for reeling cocoon by cocoon.

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تطوير ماكينة الحل الفردية اليدوية يابانية الصنع لحل شرانق دودة الحرير التوتية بومبكس موراى أل

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الملخص العربي

الغرض من هذة الدرسة هو تطوير ماكينة الحل الفردية والتى تستخدم لتعمل ميكانيكية بموتور لحل شرانق دودة الحرير التوتية بومبكس موراى أل (Bombyx Mori L). والتعديلات التى تمت اضافتها الى الآلة تمت بالورشة الرئيسية بمعهد بحوث الهندسة الزراعية، وتم اجـــراء التجارب على عملية حل الشرانق بقسم بحوث الحرير بمعهد بحوث وقاية النباتات. وقد تم تقييـــم بعض المعايير مثل سرعة الحل، وزمن الحل كمؤشر لكمية الحرير الناتجة وكفاءة الحل.

وكانت معايير الحل الخاص بماكينة الحل المطورة كالآتي:

ا- نسبة الحرير الخام ٤١ %، ونسبة الحرير المشاق ٣,٦ %، نسبة حرير البيلاد (عادم الحريـــر الداخلى) ٩,٤ %، طول الخيط الحريرى ٨٥٥ متر، وزن الخيط الحريرى٠,٢٥ جرام.

ب- بزيادة سرعة الحل من ٦٠ – ١٦٠ لفة/دقيقة (يدوى – ميكانيكى) بينما قل زمن الحل مـــن ١٢ – ٤ دقائق وسرعة الحل هذة ادت الـــى زيـــادة انتاجيـــة الماكينـــة مـــن ٣,٧٥ – ١٨,٠٠ جرام/ساعة وذلك لحل شرنقة واحدة.

ج- بزيادة سرعة الحل من ١٤٠ – ١٦٠ لفة/دقيقة زادت القـــدرة المســـتهلكة مـــن ٠,٢٢٠ – ٠,٣٤٠ كيلووات وزادت الإنتاجية من ١١,٨٥ – ١٨,٠٠ جرام/ساعة بينما قل عـــادم الحريـــر الداخلى (طبقة البيلاد) من ٠,٠٦٦ – ٠,٠٦٤ جرام، وقل زمن الحل من ٦ – ٤ دقائق، وذلـــك لحل شرنقة واحدة.

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