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The Development of a Carding Machine and a Twisting Silk Machine for Eri Silk

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Abstract

The purpose of this research was to develop a carding machine and twisting machine for produce eri fiber and yarn. A carding machine decomposes degumming cocoons and forms it into cohesiveness silk filament. Silk filament was then spun and twisted in twisting machine. Factors to test machine functionality were teeth of carding head which were aligned in straight and zigzag pattern. Speeds of fiber feeding were 0.24, 0.32, and 0.4 meter per minute. From the experiments of carding machine, it can be found that almost cocoons were decomposed when using zigzag pattern. Speed of cocoon feeder was about 0.24 meter per minute. From twisting machine testing, results pointed out different speed of fiber feeding provided different size of yarn. The properties of eri silk obtained from machine were similar with eri silk produced from traditional method. Therefore, carding machine and twisting machine developed in this research can help farmers to increase production and support the eri silk industry development.

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Keywords: carding machine; twisting machine; eri cocoon; eri yarn

1. Introductions

The distinctive features of eri are a strong, durable and glossy fiber. It can be produced to many products such as fabric for wearing, blanket, bag, etc. The properties of fabrics woven from eri yarn are of light weight, fluffy, absorbent sweat well [1]. Eri worms eat cassava leaves as food. Advantages of eri cocoon are easy to fed, resistant to any disease whereas disadvantages of eri fiber are short and discontinuous fiber [2]. From surveying the price of

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eri, it found that price per kilogram of fresh eri cocoons, yarns and fabrics were 7.5 USD, 35 USD and 127 USD, respectively [3]. Because of eri has short fibers and sticky glue in their cocoon, the spin process as well as cotton production was used to produce eri yarn. Eri yarn production is started from boiled the cocoons with sodium hydroxide dilute to dissolve sticky glue coated cocoons. From the degumming method, cocoons are stick together as a cocoon sheet. Cocoon sheet was dried and combed until cocoon sheet became to eri fiber. Next, fiber is spun by the spinning wheel to produced eri yarn [4,5]. All process requires expertise in producing cocoon sheet fiber and yarn. Moreover, to work all process takes a long time [3]. Therefore, most farmers directly sold fresh eri cocoons to factories even cheaper. From study research related to the eri fiber production, it was found that production have two processes; wet process and dry process. The wet process must be mix eri fiber with other kinds of fiber. In addition, the wet process also causes cocoon rot and stink. By blending with other fibers made the distinctive features such as tensile luster absorb sweat dropped [6-9]. In dry process, it needs to individually crush only one cocoon by hand to make the fiber. Therefore, from the problems mentioned above, the researcher got the idea and objective to design and develop a carding machine and a spinning machine used to produce eri fiber and yarn. The concept of machine design considered to low cost and easy to use. Eri fiber and yarn produced from machines should be flexible, uniform yarn and have properties equivalent to yarn spun by traditional methods. The expectation of machines benefit is to help farmers to increase the productivity of Eri and develop industrial related to eri silk in Thailand.Materials and Methods

1.1. Method of Design and build machine

From study traditional process of eri yarn production [10-15], carding and twisting machine was then designed. A carding machine is used for carding cohesiveness cocoon filament sheet while twisting machine is used to twist eri fiber to make yarn. Carding machine consisted of hopper for input dry cocoon sheet. This hopper was installed at the top of machine. Below the hopper, there has a feeder set for inserting cocoon filament sheet to carding tool which mounted thorns spread around the tool. The lower of machine has a tray to contain cocoon piece which was not stick on thorns in carding tool. A DC motor was utilized for supply power to machine. The user can turn on/off via a switch mounted on the control box. Fig.1.(a) presents drawing of a carding machine, which number 1-6 mean hopper, feeder, carding tool, tray, control box and dc motor, respectively. Overall size of carding machine is 0.6, 1.1 and 0.9 metre in width, length and height. A twisting machine consists of roller 3 sets. This machine gathers fiber together and twists them to form the eri yarn. The first roller presses fiber and sends it to the next roller. Fibers were collected through an aperture which rotated between the first and second set of roller. The third roller set twists fiber gathered from the threaded to make yarn. Drawing of twisting machine is presented in Fig.1 (b). When number 7 to number 11 shown in figure 1 (b) mean roller for pressing fiber, an aperture which rolled to collect fiber, fiber feeder, twisted part, DC motor, respectively. Width of twisting machine is 1.2 m, length 0.6 m and 0.8m in height. Machine operation can be described as following, insert the dry cocoon filament sheet which was degummed already into machine via hopper (no.1). When carding tool was rotated, it will comb cocoon sheet. Eri fiber was then stick on the thorns on the carding tool. The next step, is cutting this fiber and pull out from carding tool as an eri fiber sheet. The eri fiber is inserted to twisting machine through roller (no.7).In this roller, fiber is pressed to small size. Compressed fiber is pulled through an aperture and twisted in the twisting equipment (no.11). The eri yarn is forwarded out from machine by feeder out tool (no.9).

1.2. Design conditions

From review the past research and study practical process of eri yarn producing, it found that eri yarn can produced from only 300 g of eri cocoon per day [5]. Machines developed in this research were designed to work faster than human work about 5 times. Therefore, producing rate of eri yarn is 1.5 kg of eri cocoon per day or 0.1875 kg of cocoon per hour. General size of dry cocoon sheet was 0.3 m in width and length. From size calculation of tools such as length of carding tool, diameter of carding tool, it found that length and diameter of carding tool were 0.3 m and 0.095 m. Torque also was calculated from total weight, friction of machine, it found that machine need at least 597.675 watts of DC motor to drive mechanisms. Hence, DC motor 1 HP was selected to drive machine.

1.3. Experimental design

Experimental conditions of a carding machine were following; cocoon weight inserted to machine per each time was 200 g, angle of thorns which mounted on carding tool were 45 and 90 degree, speeds of carding tool were 2, 3

and 4 rpm (1 rpm meant 0.00265 m/s), thorns patterns were zigzag pattern and direct pattern. For operation conditions of a twisting machine were fiber sheet inserted to machine per each time was 100 g, speeds of twisting set were 400, 500 and 600 rpm (1 rpm meant 0.00265 m/s), speeds of roller used to press fiber were 3 , 4 and 5 rpm (1 rpm meant 0.00265 m/s). Mechanical properties of eri fiber and yarn were inspected by the standard methods for fiber and yarn inspection [16-20].

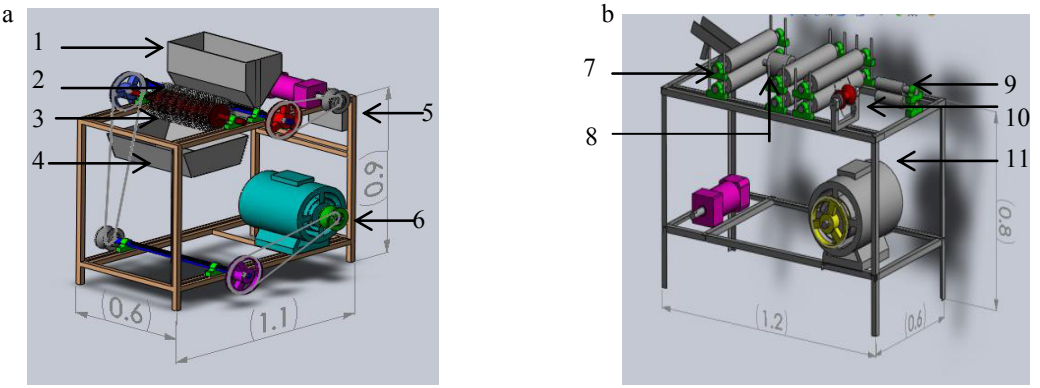

Fig. 1. (a) Drawing of carding machine (m); (b) Drawing of twisting machine (m).

2. Results

A carding machine and a twisting machine were built. Fig.2 (a) and (b) illustrated a carding machine and twisting machine, respectively. Number 1 to 8 in Fig.2 mean control switch, a carding tool, 1 HP DC motor, hopper, rotating aperture, roller collected fiber, twisting head, DC motor. Size of carding machine was 0.6, 1.1 and 0.9 m in width, length and height whereas size of twisting machine was 1.2 m, width, 0.6 m, length and 0.8 m in height.

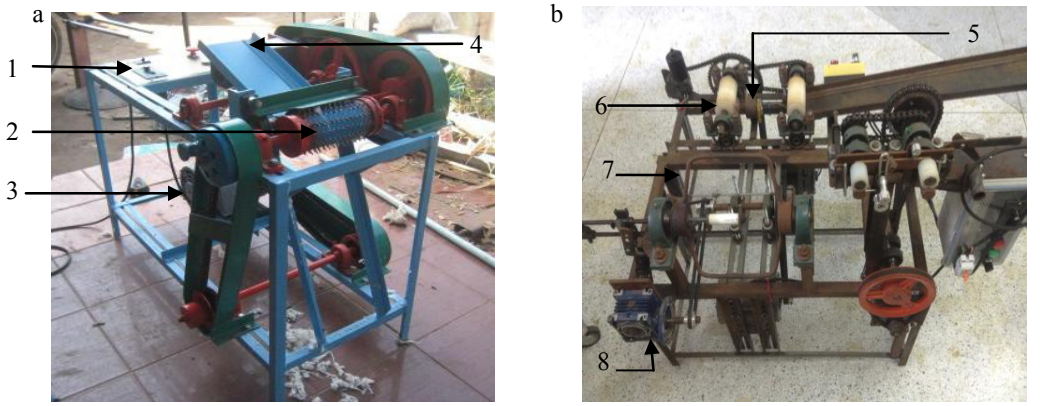

Fig. 2. (a) a carding machine; (b) a twisting machine.

Table 1 presents results of carding machine testing. Percent of distribution or split of cocoon sheet and weight of cocoon waste fallen into tray which installed below of machine were measured and shown in Table 1. The distribution percentage of cocoon sheet was calculated from weight of fine fiber which was thoroughly combed by carding tool was divided by weight of lump fiber which was not thoroughly combed. Table 2 shows results of twisting machine testing. In Table2 percent of yarn consistency, tension force and maximum length of eri yarn produced by a twisting machine were written. Percent of yarn consistency was obtained by measuring size the piece

of yarn sample then calculated standard and variation of value of size for finding percent of yarn consistency.

Table 1. Results of carding machine testing.

Thorn angle (degree)	Speed of carding tool (rpm)	Thorn pattern	Distribution of cocoon sheet (%)	weight of cocoon waste (g)
	2	direct	66.60	34.00
		zigzag	86.60	31.00
45°	3	direct	60.00	35.00
		zigzag	72.00	33.00
	4	direct	41.40	38.00
		zigzag	44.00	36.00
	2	direct	68.00	36.00
		zigzag	84.00	34.00
90°	3	direct	58.60	35.00
		zigzag	77.20	33.00
	4	direct	38.6	39.00
		zigzag	42.2	34.00

Table 2. Results of twisting machine testing.

Speed of pressing roller (rpm)	Speed of twisting set (rpm)	percent of yarn consistency (%)	tension force (N)	maximum length of eri yarn (m)
	400	72.00	5.23	11.45
3	500	79.20	5.26	11.50
	600	66.60	5.35	12.35
	400	78.60	5.55	10.45
4	500	84.00	5.72	10.85
	600	78.60	5.63	11.55
	400	75.20	4.75	8.75
5	500	70.60	4.97	9.35
	600	77.20	4.9	10.85

3. Discussion and conclusions

From testing carding machine, it found that a eri cocoon sheet was finely combed when carding thorns inclined with 45 degree and aligned in zigzag pattern, the operation speed of carding tool was 2 rpm (0.0053 m/s). From above conditions, the cocoon sheet was satisfactory split and distributed to be good fiber sheet which was stick with thorns on the carding tool. Maximum percent of cocoon sheet distribution was 86. The worst conditions for operation carding machine were carding thorns angle 90 degree, thorns were aligned in direct pattern and carding speed was 4 rpm (0.0079 m/s). In this worst condition, cocoon pieces were fallen in tray during carding process because cocoon sheet was not finely combed by carding tool. The speed of carding tool was too high, therefore fiber was not stick and fallen from thorns. Minimum percent of cocoon sheet distribution was 38.6. To find the suitable pattern of thorn alignment, percent distribution of cocoon sheet was compared when machine was operated in the same carding speed. It found that percent of cocoon sheet distribution was higher when combed by carding with zigzag pattern. In addition, carding tool which had thorns angle 45 degree could combed the cocoon sheet better than thorns with angle 90 degree. From testing twisting machine, the results showed that the maximum percent of yarn consistency was obtained when speed of pressing roller and a twisting set were 4 rpm and 500 revolution per minute, respectively. Yarns with highest tension force (5.72 N) were produced when speed of twisted at 500 rpm. Furthermore, speed of a pressing roller of 4 rpm provided higher tension force yarns when compared with others speeds of roller. Minimum tensile force of yarn was 4.75 N, this yarn was produced in speed of pressing roller was of 5 rpm. The tensile force in yarn was lower than standard, it means that yarn easy to broken and low strength. Furthermore, when the inserted rate of fiber sheet to machine was too high, machine was unable to twist yarn in the suitable quantity. Yarns produced with speed of pressing roller of 3 and 4 rpm have tension force similar with standard tension of yarn (5.63 N) whereas tension of yarns produced with speed of pressing roller of 5 rpm lower than standard tension value of eri yarn [21,22]. The optimal condition of operating machine was speed of pressing roller of 1 rpm and speed of twisting set of 500 rpm. From continuously operating a carding machine and a twisting machine 8 hours, it found that carding machine can carding cocoon sheet 1.52 kg or 0.19 kg per hour, twisting machine can produce yarns with have similar quality as standard eri yarn produced in market.

From all experiment, it was observed that to produced yarn with high quality, cocoons should be favorable cleaned before degumming them. If cocoons have dust, fiber will tear or cannot twist between the carding and twisting process.

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