A Development of Knitted Fabric from Thai Silk Waste for Creative Fashion and Lifestyle Products*

การพัฒนาผ้าถักด้วยเส้นด้ายจากเศษไหมไทยเหลือใช้เพื่อสร้างสรรค์งานแฟชั่นและผลิตภัณฑ์ไลฟ์สไตล์

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Abstracts

The aim of this research was develop a knitted fabric from Thai silk waste in order to for creative fashion and lifestyle products. The methodology of this research was related to “practice to design”. It consisted of two parts, the first part involved the collecting of information related to Thai silk waste and its benefits. The second part involved experimenting so as to determine a suitable method and related equipment for the production of knitted fabric through a craft and industrial process. The process required fiber preparation, spinning, dying, knitting, fabric property testing and creating a finished fashion and lifestyle products.

The results of study show that the solid waste produced from Thai silk can be classified into three types: Incomplete cocoons, broken silk yarn and silk fabric waste. Generally, this waste has been re-used in manufacturing for items such as fashion accessories and decorative products. In terms of the experiment, the results suggest fiber preparation through the craft process was superior to the industrial process. Yarn spinning was carried out by using a traditional Thai hand spinner to be single yarn, ply yarn, core yarn. This process was able to created unlimited forms, textures and colors. Moreover, dyeing different types of silk waste, silk hankies, roving and yarn produced a variety of colors. In addition, shade and value was done by mordant. The knitting process was accomplished through hand knitting and a

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บทความนี้เป็นส่วนหนึ่งของดุษฎีบัณฑิต หัวข้อการพัฒนาผ้าถักด้วยเส้นด้ายจากเศษไหมไทยเพื่อสร้างสรรค์งานแฟชั่นและผลิตภัณฑ์ ไลฟ์สไตล์

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domestic knitting machine. The process produced basic and applied fabric structures and was able to create texture and form with thick, thin, three-dimensional, complex and continual structures. The character of fabric was shown to be shiny, sticky, lightweight and flexible. The results obtained from this research can be beneficial and used as a guideline for producing artistic creations and to silk waste. In addition, the information gained from the craft process can be utilized by villagers for small scale production and also by the Thai silk industry. The results from this study can be aid the recognition of the value of waste products from their business and thus assist in the reduction of environment damage.

Keywords: Thai silk waste, Knitted fabric, Creative fashion, Lifestyle products

บทคัดย่อ

การวิจัยนีมีวัตถุประสงค์เพื่อพัฒนาผ้าถักด้วยเส้นด้ายจากเศษไหมไทยเหลือใช้เพื่อนำไปใช้ในการสร้างสรรค์ผลงานแฟชั่นและผลิตภัณฑ์ไลฟ์สไตล์ เครื่องมือที่ใช้ในการวิจัยคือ “การปฏิบัติสู่การออกแบบ”โดยแบ่งออกเป็นสองส่วน คือส่วนแรกเป็นการรวบรวมข้อมูลเกี่ยวกับเศษไหมไทยและการนำมาใช้ประโยชน์ ส่วนที่สอง การทดลองคิดค้นวิธีการและอุปกรณ์ในการผลิตผ้าถักด้วยวิธีหัตถกรรมและอุตสาหกรรม มีขั้นตอนคือการเตรียมเส้นใย การผลิตเส้นด้าย การผลิตผ้าถัก การย้อม การทดสอบสมบัติผ้าถัก และสร้างสรรค์งานแฟชั่นและผลิตภัณฑ์ไลฟ์สไตล์

ผลจากการศึกษาพบว่า ปัจจุบันเศษเหลือใช้จากอุตสาหกรรมไหมไทยแบ่งออกได้ 3 ประเภทคือ รังไหมเสีย เศษด้ายเหลือทิ้งจากกระบวนการทอ และเศษผ้าไหมจากการตัดเย็บ โดยทั่วไปเศษไหมเหล่านี้ถูกนำกลับมาใช้ใหม่ เช่น ผลิตเป็นเครื่องประกอบการแต่งกายเครื่องใช้และของตกแต่งในส่วนของการทดลองพบว่าการเตรียมเส้นใยด้วยวิธีหัตถกรรมทำได้ดีกว่าวิธีอุตสาหกรรม การทำเส้นด้ายทำได้ดีด้วยเครื่องปั่นมือแบบดั้งเดิมของไทยในรูปแบบ เส้นด้ายเดี่ยว (Single yarn) เส้นด้ายควบ (Ply yarn) เส้นด้ายแกน (core yarn) และสามารถสร้างสรรค์ให้มีรูปทรง ผิวสัมผัสและสีตามที่ต้องการได้อย่างไม่มีข้อจำกัดนอกจากนั้นการย้อมสีลงบนเศษไหมเหลือใช้ที่แตกต่างกัน ได้แก่ แผ่นรังไหม แถบเส้นใยและเส้นด้ายจะได้สีสันที่หลากหลายและจะเกิดความเข้มสว่าง เมื่อใช้สารช่วยติดสีในส่วนของการผลิตผ้าถักสามารถถักได้ดีด้วยมือและเครื่องถักกึ่งอัตโนมัติ สามารถถักผ้าลวดลายพื้นฐานและประยุกต์ สร้างสรรค์ให้เกิดผิวสัมผัสและรูปทรง หนา บาง สามมิติ และที่ซับซ้อนและต่อเนื่องได้ ลักษณะเด่นของผ้าที่ได้คือมีความมันวาว น้ำหนักเบา มีความแข็งแรงและยืดหยุ่นดี ประโยชน์ที่ได้รับผลจากงานวิจัยสามารถนำไปเป็นแนวคิดสร้างสรรค์งานงานแฟชั่นและผลิตภัณฑ์ไลฟ์สไตล์ได้หลากหลาย เป็นการสร้างมูลค่าเพิ่มจากเศษไหมไทยเหลือใช้ นอกจากนั้นกรรมวิธีการผลิตแบบหัตถกรรมสามารถนำไปเผยแพร่แก่ชาวบ้านหรือกลุ่มผู้ผลิตไหมไทยให้ให้ตระหนักถึงคุณค่าของสิ่งเหลือใช้จากกิจการที่ทำอยู่และเป็นส่วนหนึ่งของการลดปัญหาสภาพสิ่งแวดล้อม

1. Introduction

Thai silk is a part of the national cultural heritage of the south-east Asian nation of Thailand. Thai Sericulture was founded a long time ago. The recorded evidence shows that in 1903 AD. (2446 BE.) His Majesty King Chulalongkorn founded the "Silk Artisan Department" in Bangkok in order to promote Thai sericulture. Over the course of time, the development of Thai Sericulture has steadily grown. At the present, Her Majesty Queen Sirikit has kindly established the "Foundation for the Promotion of Supplementary Occupations and Related Techniques of Her Majesty Queen Sirikit" so as to sustain this objective (The National Institute of Sericulture Queen Sirikit, 2008: 44-49)

Thai silk is a filament yarn that has very fine and special physical characteristics. Its cross-section is triangular in shape and produces beautiful light refraction. The strength of Thai silk, which is not found in the yellow silk type, is from the 18 kinds of amino acid. The percentage of the amino acid in Thai silk is over 34.5 times higher than silks of other countries (The National Institute of Sericulture Queen Sirikit, 2008: 34-39). This results in the unique characteristics of Thai silk with being gummy, sticky and shiny. Nowadays, Thai silk producers can be found within the household as a village industry and also the factory. Most of these producers can be found in the north-east area of the country.

The Thai silk industry produces a large amount of solid waste which can be classified into three types: incomplete cocoons, broken silk yarn, and silk fabric waste. Among the three types, the first one, incomplete cocoons are imperfect cocoons which cannot be reeled commercially. Examples are double cocoons, feeble cocoons, pierced cocoons, piques, and rates. The second type is broken silk yarn. This is a waste product–from reeling, winding, throwing, and weaving. The last category is silk fabric waste. Silk waste is the waste produced in apparel industries, and decorative product industries (F. R. McGowan, Charles W. Schoffstall, & A. A. Mercier, 1924: 582-583; K. Murugesh Babu, 2013: 48; Thai Textile Institute, n.d.: 52) However, the full amount of this waste cannot be accurately estimated because the factories are under different management (Thai Textile Institute, n.d.: 63). Generally, these waste products are reused by businesses for items such as fashion accessories and decorative products. In the academic field, Thai researchers have conducted studies of waste in several areas in order to achieve high benefit. For example, *Kachamas Tumrongsak* (1994: จ; 5th Thai alphabet) studied how to produce non-woven fabric from silk waste. Furthermore, *Kittisak Ariyakuare* (2010: 369), produced a new mixed fiber from waste cocoon and other plant fibres and *Siriluk Wongkasema and Puripong Aksornpim* (2015: 801-806) developed a carding

machine and a twisting silk machine for Eri Silk. *Pisut Chankum* (2011: ๔; 4th Thai alphabet) also experimented spinning yarn from silk waste in weaving process.

In regards to the production of knitted fabric, it is formed by intermeshing loops of a single yarn or set of yarns together. There are three types of knitting tools: domestic machine, automatic machine and hand knitting tools. Knitted fabric has high flexibility and thus produces comfortable clothing for everyday wear. Whether thick and thin, the fabric produced is soft and is resistant to wrinkles and can easily recover its form and shape. Knitted fabric can be produced by body sizing and it is suitable and convenient for fitted wear (Pornchai Tulpijit, 2009: 2-5). In recent years, knitting has seen a resurgence in popularity. There are various different approaches that have emerged from creative international fashions and from the application of knitting for household interiors in the form of lightshades, cushions, floor coverings, chairs, and blinds. These products are all based on the versatility of the stitch structure. Furthermore, conceptual artists who have exploited the traditional craft of knitting can create installations of all dimensions, from large scale public sculptures to miniatures and wearable art. All of these challenge the publics' preconceptions of knitting (Carol Brown, 2013: 6). The famous artist and designer are as following:

Fashion: *Ramón Gurillo* is a fashion designer from Valencia, Spain. Gurillo's influences are multicultural with elements of traditional Valencian craftsmanship combined with a London sensibility and a 'hint of rock 'n' roll'. The Spanish designer's intricate designs possess recurring open-weave stitches that are often cocoon-like in silhouette and use the finest yarns, refined cottons, linens and crêpes. (Samantha Eliott, 2015: 34)

Clare Tough, is a British designer that rose to fame in knitwear design even before completing an MA (Master of Arts) degree at Central St Matin's College of Art & Design in London. The designer's graduate collection was described by *Vogue* as 'the future of British fashion'. Tough is considered to be visionary in constructed textiles. The collections are characterised by the juxtapositions of oversized, extravagant shapes and streamlined, body-hugging silhouettes embellished with clever detail. Metallic contours are typically stitched around the bust line, while horizontal panels are drawn together to create corseted effects. (Bradley Quinn, 2009: 58)

Design: As a highly regarded textile artist in Japan in the 1970s, *Toshiko Horiuchi* MacAdam wanted to produce works that were designed for children's play rather than for exhibition in galleries and museums. The textile artist's first high- profile plays-pace was created in 1979 and housed at Okinawa Memorial National Park. This was followed by knitted

wonder space at the Hakone Open-Air Museum. Charles MacAdam and Toshiko Horiuchi MacAdam established Interplay Design and Manufacturing in 1990. The company, created and promoted art and play for children in national parks. The artist is currently working on pieces to be installed in northern America.

Annette Bugansky, combines a background in fashion and costume design with a nostalgic appreciation of knitted fabric and skilled slip casting techniques in order to transform soft, tactile surfaces into usable vases, lamps, cups and sculptural pieces. (Samantha Eliott, 2015: 190, 198)

Art: *B-Arbeiten*, are known as German 'guerrilla' knitting group. B-Arbeiten is an adaptation of the German word meaning 'to edit' or 'to alter'. The group is known for using yarn bombing to decorate public objects such as trees and ferries and, more recently, to create tipi structures. (Samantha Eliott, 2015: 116)

In Thailand, the artist *Metta Suwanasorn* produced a project called "Thread of Love from Mother". Suwanasorn, has created a mixed, new style that lies somewhere between soft sculpture and installation art with crochet that was inspired by the artist's autistic son. The crochet knitting technique was chosen because it is seen as a good therapeutic art. Suwanasorn has aimed to show the power of love that is felt for the child. The work aims to assist people in realizing how beautiful a mother can be and show the how the shapes and drawings of the autistic child's artwork can be an inspiration (Metta Suwanasorn, Pisanu Supanimit, and Sutha Leenawat, 2016: 1830).

As previously mentioned, the research shows that Thai silk waste can be utilized to achieve various objectives. For example, knitting has grown-up and expanded into several fields such as art, fashion and design. Therefore, the field should be studied and developed in order to obtain more advantages from Thai silk waste. Furthermore, to add value to the waste, the concepts of recycling and the knit fabric properties should be studied. This can inspire practitioners to produce a more flexible, flat, seamless and three dimensional products to truly present the aesthetics of Thai silk waste through fashion and lifestyle products creations.

2. Objective

2.1 To study the categories of Thai silk waste.

2.2 To conduct an experiment of yarn spinning from Thai silk waste fiber.

2.3 To create a method to produce knitted fabric from the yarn of Thai silk waste.

2.4 To present the aesthetic values of new knitted fabric made from Thai silk waste through textures, colors, structure and pattern and present them as fashion and product creations.

3. Methodology and material

3.1 Methodology

The focus of this study is “practice based research and pure practice”. The methodology consisted of two part. The first part relates to the collection of information regarding Thai silk waste and its benefits. The second part concerns the experiment in order to determine a method and list of equipment for the production of knitted fabric through a craft and industrial process. The steps of the process relate to fiber preparation, spinning, dyeing, knitting, fabric testing and creative fashion and lifestyle products.

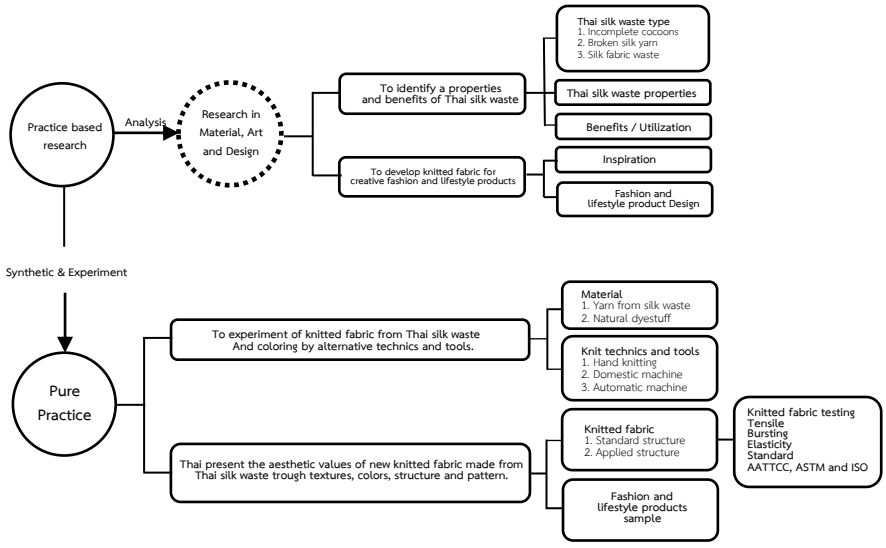

Diagram 1 Research methodology

3.2 Material and equipment

Material required for this study:

1) Thai Silk waste: degummed incomplete cocoons; broken silk yarn; and silk fabric waste (see figure 1).

2) Natural colored dyes: lac, gardenia dulcet leaf, mangosteen leaf and golden shower pod.

Figure 1. A sample of Thai silk waste.

Equipment used in the study:

1) Machine spinning process: MESDAN LAB carding machine serial number 137 and laboratory drawing machine serial number 21 and a tradition Thai hand spinner.

2) Hand knitting process: Hand knitting needle, Brother HK-836 domestic knitting machine (gauge 5.5) and Shima seike SES.122 (multi gauge) (see figure 2).

3) Yarn tensile strength testing machine: Uster 5 tester, Bursting Strength Testing machine and Fryma Fabric Extensometer, pneumatic, elasticity testing machine (see figure 3).

Figure 2. The knitting tools.

Figure 3. The testing tools.

4. Experiment Procedure

4.1 Fiber Preparation:

Two methods for the preparation of Thai silk waste used to produce a suitable fiber for spinning are described as follows:

The first method was conducted through a machine preparation process using the MESDAN LAB laboratory carding machine serial number 137. First, the three sets of raw materials were obtained. Then the degummed cocoons were cut into 3 -5 millimeter pieces and the broken silk yarn and silk thread that separate from the Thai silk fabric waste were cut into 3 centimeter pieces. Next, each waste product was weighed at 15 grams and fed into the carding machine three times. In this step, the fiber was separated and straightened, resulting in fiber lap. Then, after carding had drawn a fiber, each fiber lap was fed into the MESDAN LAB laboratory drawing machine serial number 21. The result was a long bundle of fiber called sliver and roving as presented in figure 4.

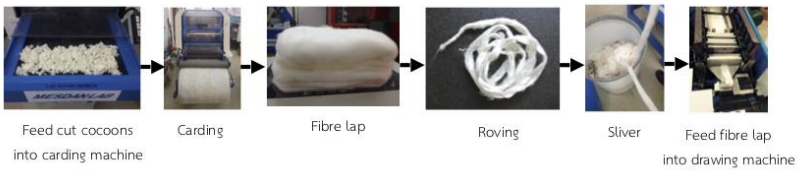

Figure 4. The process of carding and drawing the Thai silk waste into sliver and roving.

The second outlined method is for the hand preparation process. This method was applied only to the cocoons. The process began by degumming the cocoons and then gently stretched into a gossamer film on a square frame by hand. Approximately, ten sheets were overlaid. Next, the silk hanky was removed from a square frame and hung to dry. The dried silk square sheet is known as mawata or silk hankies. The last step, a hole was poked in the center of the silk hankies and the fiber stretched into a large band by hand. The circle was carefully extended and pulled thinner until the size reduced the fiber to the diameter of approximately one centimetre. The out-come was a long band fiber referred to as a roving as presented in figure 5.

Figure 5. The process of turning cocoons into mawata or silk hankies and roving.

4.2. The spinning process:

The objective was to group the fibres and twist them together to form a continuous strand by two methods as outlined below:

A ring spinning and open-ended spinning machine was used in the experiment. Yarn could not be completed by machine because it broke during the spinning phase although a low spinning cycle was used.

A traditional Thai hand spinner was used to produce single yarn. Direct spinning led to the production of both sliver and silk hankies. This process was done by local spinner in the Bann Nong Bau Dang, Chaiyapum Province, Thailand. The number of yarn was not specified, it was controlled by depending on the raw material, spinning tool and spinner as presented in figure 6 and 7. The results from the yarn spinning experiment produced a yarn that was uneven; yarn from broken silk yarn, silk fabric waste, and incomplete cocoon fiber were sticky and softly touch respectively. Figure 8 presents yarn design for single yarn, ply yarn and core yarn from Thai silk waste that was produce by using a traditional Thai hand spinner.

Figure 6. A traditional Thai hand spinner.

Figure 7. Yarn from the cocoons and silk fabric waste (left). Yarn from Thai silk hankies (rigth).

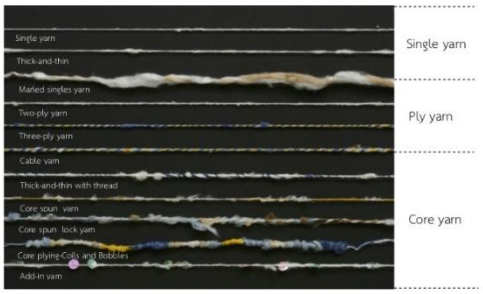

Figure 8. The sample of Single yarn, Ply yarn and Core yarn.

4.3 The coloring process:

The knitted fabric from broken silk yarn and silk fabric waste produces its own color. While the cocoons produce a natural off-white color. Therefor, a concept was devised whereby natural coloured dyestuff was used in experiment process. The natural dyestuff used in this study was lac, gardenia dulcet leaf, mangosteen leaf and golden shower pod. The

dyeing method was applied to incomplete cocoons in the form of yarn, sliver and silk hankies. The process used is as follows:

1) Natural dyestuff was boiled in water about for approximately 1 hour.

2) The liquid was strained and transferred. Dam yarn, silk hankies or sliver was added and simmered for about an hour. It was stirred every fifty minutes to ensure that the object evenly picked up the dye. This step of the process by boiling or not is dependent on raw material of dyestuff.

3) The material was rinsed with water until a clear solution is was obtained and it was then hung to air dry.

4) In addition, it was found that mordant by alum, ferric oxide, tamarind gave a deeper shade and value of color.

The outcomes of the experiment as presented in figures 9 and 10.

Figure 9. The sample of dyeing outcomes from different material and dyestuffs.

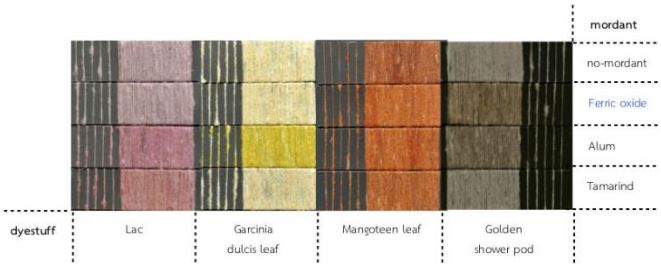

Figure 10 : The sample of yarn-dyed and mordant.

4.4 The knitting process:

This element of the study required the use of three different methods. First was through using a Shima seike automatic knitting machine model number SES.122 (multi gauge). The process of producing yarn from Thai silk waste was not as straightforward as knitting by the automatic machine because of uneven texture and stickiness, the yarn was thus broken during the knitting process. A further method, utilized hand knitting and Brother knitting

machine model HK-836 gauge 5.5. Both process were able to knit fabric from all the silk waste yarn type. The sample as seen in figure 11 was the knitted fabric produced from the silk hankies roving by using hand knitting needle no.8. The fabric produced was thick, soft to the touch and light weight.

Figure 11 : Knitted fabric from silk hankies sliver produce by hand knitting needle no.8.

Figure 12 shows texture of fabric made from the difference materials and equipment. The knitting needle tool produced knit stitch and the domestic knitting machine single Jersey. The results show that the material produced trough the hand knitting method was softer and more flexible than that produced trough the knitting machine. While the surface of the knitting machine produced fabric was smoother than the hand knitting fabric.

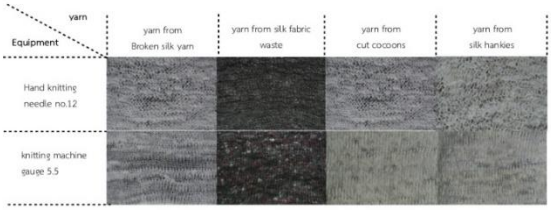

Figure 12 : Knitted fabric produced from Thai silk waste yarn by hand needle and knitting machine.

The experiment in order to created art form was carried out through knitting yarn from silk hankies into different structure such as hold, dimension, fuzzy and color change. This was achieved by use of the domestic knitting machine Brother HK-836 (gauge 5.5). The results showed that the fabric surface was uneven but soft to the touch, slightly shiny and light-weight. The holding stitch, lace and ladder pattern were clearer than rib and cable as shown in figure 13. The embossing pattern, lifting stitch, increasing and decreasing stitch and pile loop produced a stable form as shows in figure 14. Figure 15 reflects colour change of the samples with holding stitch, increasing and decreasing stitch.

Figure 13 : The sample of lace showing ladder,rib and cable pattern

Figure 14 : The sample of lifting stitch, increasing and decreasing stitch and pile loop.

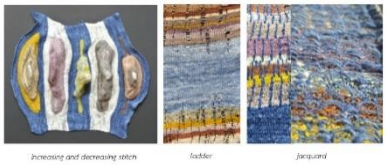

Figure 15 : The sample of the changes in color

4.5 Testing:

This research used yarn and knitted fabrics from silk hankies, produced by a traditional Thai spinner as a case study. The properties of the yarn and knitted fabric were seen as beneficial and correct for selecting as the material to create a pieces of art and design. The process was done in a university testing laboratory. The test was carried out to find the number and strength of the yarn and the durability and flexibility of knitted fabric.

In regards to the yarn testing, the first process was to count the yarn number by indirect system. The result was 7 Nec. Yarn was then taken to its test tensile strength; the results are shown in Table 1.

Table 1 Yarn tensile strength testing[1].

Yarn	Single yarn / No.7 Nec.		
Test speed	200 millimetre per minute		
Sample Length	500 millimetre		
Result (Mean)	Force Peak (N) 7.333	Elongation Peak (mm.) 28.090	Tenacity (cN/Tex) 8.693

1. Standard : ASTM D5035 Standard Test Method of Breaking Strength and Elongation of Textile flexible and strong and suitable for producing products that require high flexibility and strength.

Table 1 shows that at the point of tensile strength at 7.3 Newton at a speed of 200 mm per minute the yarn tears apart. Elongation peak was at 28.090 millimetres and equal to 5.269 percent. Yarn tenacity was found to be 8.7 centi-newton per yarn count. The results of the testing indicate the yarn has fastness and is highly flexible and therefore suitable for products that require high flexibility.

The results of the Knitted fabric bursting strength testing and elasticity testing are shown in tables 2 and 3

Table 2 Bursting fabric testing.

Knitted fabric sample	domestic machine gauge 5.5/ tension 3 /Single yarn no.7		
Temperature	25 deg.C		
Rel Humidity	65%		
Specimen	3		
Test Area (Dia)	10 sq.cm.(35.7 mm.)		
Diaphram Pressure	76.38 psi		
Result (Mean)	Times (sec) 20.0	Distention (mm.) 16.7	Pressure (psi) 13.9

Table 2 shows that at the point of 13.9 pound of pressure per square inch per 20 seconds, the fabric stretched to 16.7 millimeters, the knitted fabric sample of the diameter of 35.7 millimetre then burst. The results of the testing indicate that the fabric is highly

Table 3 Elasticity testing[2].

Knitted fabric sample	domestic machine gauge 5.5/ tension 3 /Single yarn no.7
Loading weigh	3 kg.
Specimens	2 / 3 testing/ time 10 sec.
Test Area	M1(couse) 110x100 mm. / M2 (wale) 100x100 mm.
Result (Mean)	M1: Elongation 102.8% Elasticity 94.41%
	M2: Elongation 64.33% Elasticity 80.9%

2. Standard :BS 4294:1968 Methods of test for the stretch and recovery properties of fabrics

Table 3 explains that within 10 seconds, the course stitch fabric expanded to 102 percent and reverted to its original condition at 94.41 percent. The wale stitch fabricexpanded to 64.33 percent and reverted to its original condition at 80.9 percent. The
results show that the fabric elasticity is related to the knitted fabric properties, the sample had high elasticity and good restorative ability. This indicates that it is suitable for products that require high flexibility.

5. Conclusion and suggestions

Thai silk waste can be reused and recycled through both craft and industrial process. The procedures consist of fiber preparing, spinning, dyeing and knitting. Each step can be used to create a unique artwork that reflects the beauty of Thai silk. It is a relatively easy process to produce knitted fabric into multiple form, textures and colors from a yarn made from Thai silk waste. The resulting knitted fabric is soft to touch, light-weigh, shinny and sticky and keeps the characteristics of Thai silk. The flexibility is related to the properties of the knitted fabric. The results of this study can be applied in order to produce a new knitted fabric from Thai silk waste into fashion and lifestyle products that present aesthetic values through textures, colours, structure and patterns.

In conclusion, the researcher suggests the area should be studied and developed further so as to gain additional benefits from Thai silk waste. The research should focus on reducing the process time, lowering costs and energy consumption and methods of developing easier and quicker ways to respond to the protection of the environment as part of solving the problems caused by pollution.

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