JST: Engineering and Technology for Sustainable Development
Volume 35, Issue 2, April 2025, 058-064

Influencing Factors and Method of Estimating the Pattern Area Designed with Recovered Yarn from Used Shaped Knitted Clothes

Dao Thi Chinh Thuy*, Le Khanh Trang, Vu Thi Thuy,
Nguyen Thi Thanh Thao, Tong Thi Phuong Anh
Hanoi University of Science and Technology, Ha Noi, Vietnam
**Corresponding author email: thuy.daothichinh@hust.edu.vn*

Abstract

Shaped knitted clothes such as sweaters and cardigans are popular and abundant textile products but in the fast fashion trend, their normal life cycle is usually short, about 28 laundry cycles. Therefore, recycling used shaped knitted clothes is of interest to many designers all over the world for a more sustainable environment and development. Sweaters and cardigans are often produced by shaped knitting method. So, an effective recycling process is unravelling continuous yarn from the used clothes to get input for knitting of recycled items. In this way, the longer the length of yarn collected the better, and managing the length of recovered yarn in stock is very important for designers. This study investigated the influence of product construction and knitted structure on the length of continuous yarn unravelling from used shaped knitted clothes. In addition, a method to estimate the pattern area designed from collected yarn was proposed basing on specifications recommended by SDS-One Apex Design system of Shima seiki.

Keywords: SDS-One Apex, shaped knitted products, sweater, uprecycling.

1. Introduction

Nowadays, protecting the environment and natural resources is becoming one of the top priorities of society. In the textile industry, the fast fashion trend has led to a large amount of used clothing becoming waste discharged into the environment. To minimize the negative impact on the environment from this industry, the trend of recycling and reuse has attracted the attention of many researchers.

Sweaters and cardigans are popular types of shaped knitted clothes using in cold season with diverse designs and materials, suitable for all ages and genders. Therefore, the number of sweaters and cardigans consumed worldwide every year is very large. However, with the trend of fast fashion, their life cycle is often short, only about 28 laundry cycles [1]. Most used sweaters and cardigans are discarded into the environment, causing both waste and environmental pollution.

The issue of recycling shaped knitted items has been mentioned in many studies. After consumption, clothes are entered into the reuse/recycling supply chain through methods such as: home collection, donations at clothing banks, donations to charity shops, product take-back programs,... Classified according to the product after recycling, the product recycling process is divided into 2 types: open-loop recycling and closed-loop recycling [2]. In the open-loop recycling process, used clothes will be converted into fibers, thereby creating completely different types of products, no longer fashion products, for example: insulation mattresses, carpets,... In closed-loop recycling, used clothes are typically sent to a fiber or yarn recovery process. At the fiber level, the recovered fibers are then re-blended, possibly combined with other materials to create yarn. At the yarn level, continuous yarn is unraveled from old shaped knitted products and subjected to a few basic processing steps. The collected yarn is then woven or knitted into recycled fashion products [2-5].

Sweaters and cardigans on the market are mainly produced using the shaped knitting technology, in which parts of a product such as the front body, back body, and sleeves will be shaped and knitted directly on the knitting machine from the yarn packages. The shaped panels are then assembled by specialized seams (linking lines) [6]. Therefore, the method of unravelling yarn from used shaped knitted clothes will help to recover almost continuous yarn in the product, minimizing waste and pollution when disposing the product into environment, and create valuable input for re-knitted products. Many designers have proposed methods of unravelling yarn and introducing product designs from collected yarn [7-9]. However, there are few studies that address the factors influencing the

ISSN 2734-9381
https://doi.org/10.51316/jst.181.etsd.2025.35.2.8
Received: Jan 13, 2025; revised: Jan 20, 2025
accepted: Jan 20, 2025

amount of continuous yarn length unraveled from used products. Furthermore, the estimation of yarn length to ensure sufficient material for recycled design has been not mentioned in any reports.

SDS-One Apex design software system of Shima seiki, a Japanese textile company, is well known for design and production of sweaters. The software provides a complete ecosystem including: Yarnbank (database of yarns); Basic functions (simulating the pattern design in terms of shape, color, surface effects corresponding to different woven/knitted structures, and yarn types); Knit - design (simulating the knitted fabric design); Weave - design (simulating the woven fabric design); 3D option (simulating the 3D design of products) [10]. With the Yarnbank and Knit - design modules, the software allows scanning and integrating images of actual yarn bodies into the system, making recommendations for choosing the knitting gauge, fabric structural parameters (the density and loop length). This module can be a useful tool both to visually simulate fabric surface effects and to calculate the pattern area that can be created for a given amount of unraveled yarn length.

This work aims to investigate some factors affecting the ability of unravelling continuous yarn from used shaped knitted clothes and propose a method by utilizing SDS-One Apex design software system to estimate pattern area designed from recovered yarn.

2. Experiment

2.1. Materials

The research materials are old, discarded sweaters and cardigans, collected by the research team from friends and relatives. Most of them are made from 100% acrylic yarn (artificial wool) or the blend of acrylic with some kinds of other fiber such as cotton and viscose.

2.2. Methods

The yarn was unraveled from used clothes by the following steps:

- Step 1: remove any tags from old clothes to make unravelling easier;
- Step 2: check and unravel the linking stitches to get individual shaped panels;
- Step 3: unravel carefully the continuous yarn from each shaped panels, using the yarn reeling equipment.

The SDS-One Apex design software system was applied to estimate the pattern area developed by collected yarn. The estimation was performed as below:

- Step 1: scan the collected yarn and save image to the software;
- Step 2: choose the fabric specifications recommended by the software, including loop length l (mm), wale density W (stitches/10cm), course density C (stitches/10cm);
- Step 3: estimate the pattern area S (cm^2) for a design using total collected yarn length L (m) as below:

$$S = \frac{10^5 \times L}{l \times W \times C} \quad (1)$$

Fig. 1. Old sweater before unravelling yarn

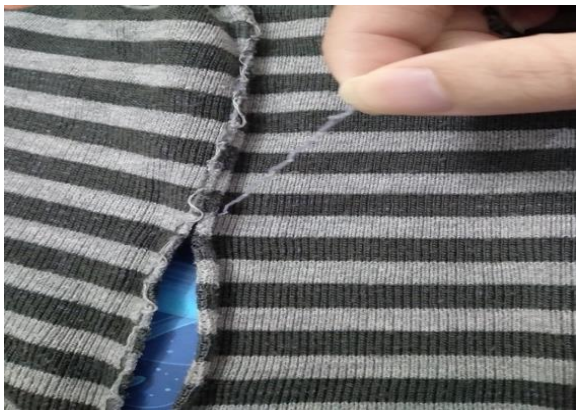


Fig. 2. Unraveling the linking stitches to get panels

Fig. 3. Individual shaped panels

Fig. 4. Yarn reeling equipment and the ball of collected yarn

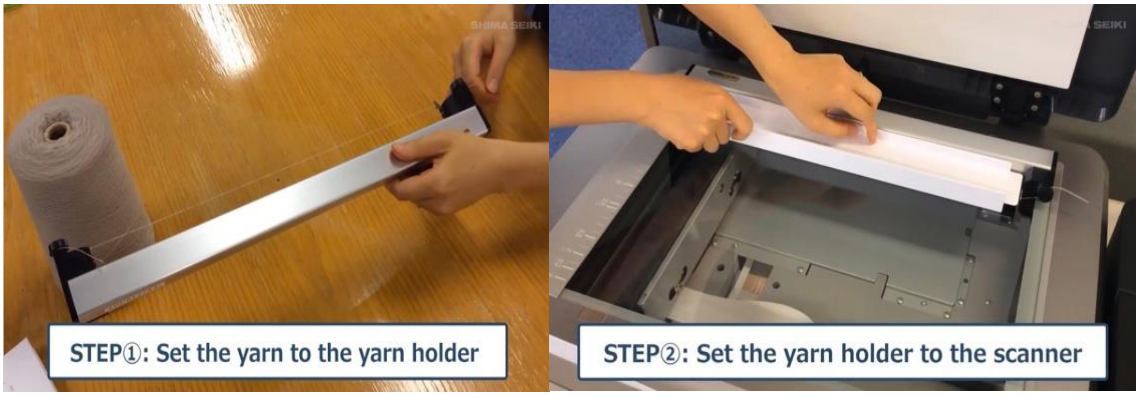


Fig. 5. Scanning the collected yarn

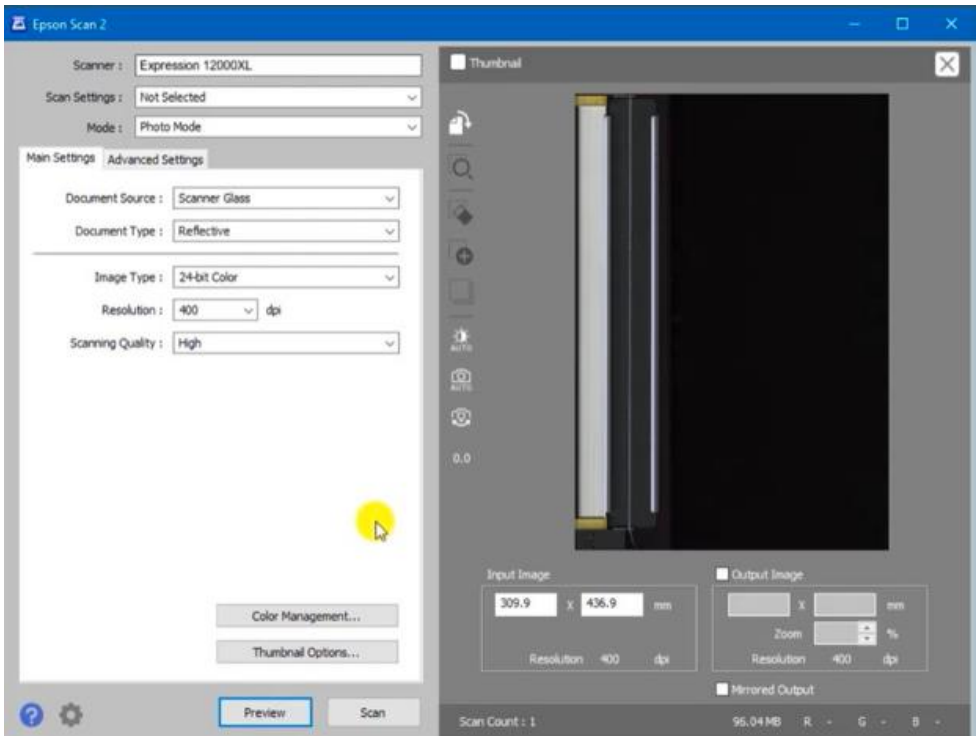


Fig. 6. Saving the yarn image to the software

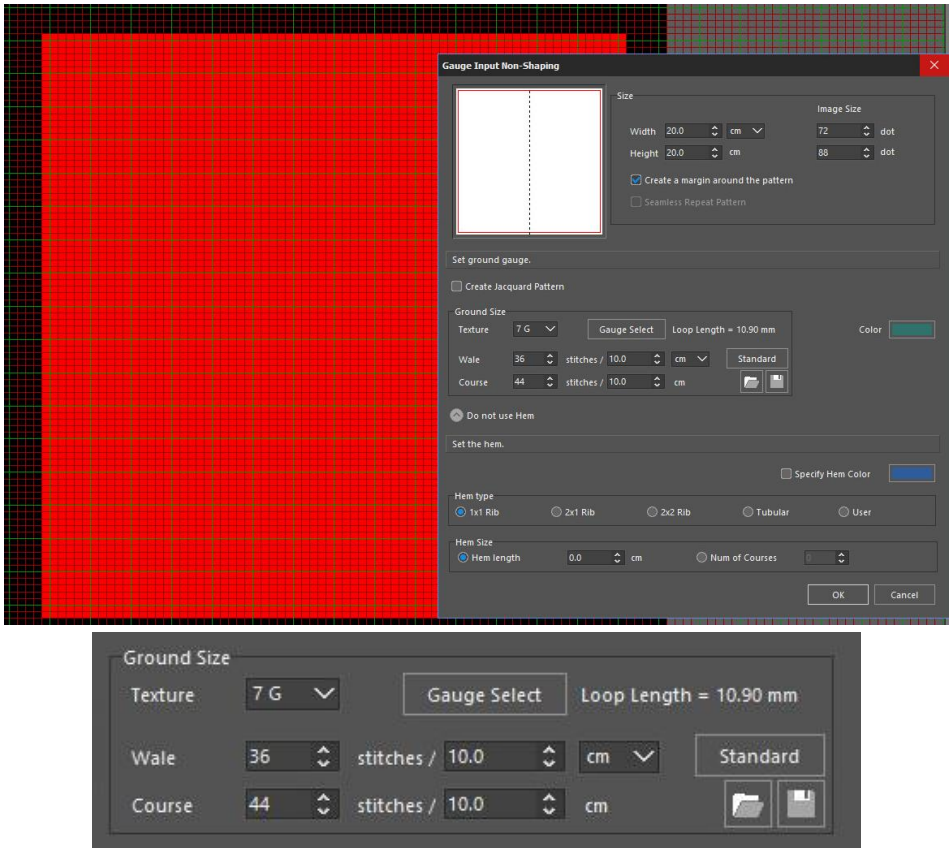


Fig. 7. Choosing fabric specifications recommended by the software

3. Results and Discussion

3.1. Influence of Product Construction on the Length of Continuos Unraveled Yarn

The researchers collected 15 used knitted garments, including two main types: sweaters and cardigans.

The obvious difference between sweaters and cardigans is the construction of the front panels. Cardigans typically have a front closure that can be buttoned or zipped, making them easy to put on and take off, as well as allowing for adjustable ventilation. In contrast, sweaters are pullovers that do not have a front closure, requiring the wearer to pull them over the head. Therefore, at the same size, sweaters provide longer continuous yarn unraveled in comparison to cardigans. However, cardigans by shaped knitting technology are still good candidates for closed-loop recycling process.

3.2. Influence of Knitted Structure on the Ability of Unravelling Continuous Yarn

All the sweaters and cardigans used in this work are of the weft knitted type, so the shaped knitted panels can be unraveled in the opposite direction of the knitting sequence. However, as observed by research members during the unraveling process, the ability of unravelling continuous yarn from used clothes depended on knitted structure as described in Table 1 below.

(A)

(B)

Fig. 8. Old cardigan (A) and sweater (B)

Table 1. Influence of knitted structure on the ability of unravelling continuous yarn

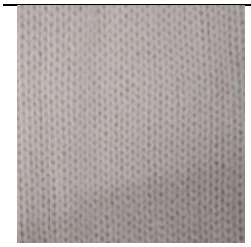
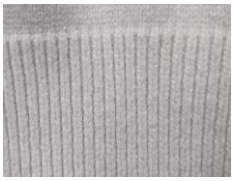
Fabric sample	Knitted structure	Ability of unravelling continuous yarn
	Plain single with conventional yarn	Easy to unravel
	Plain single with fancy yarn	Taking much more time for unravelling, shorter yarn length due to the high friction of fancy yarn
	Horizontal stripes basing on plain single with conventional yarns	Taking much more time for unravelling, shorter yarn length, require two reels for two sets of yarn
	Cable structure basing on plain single with conventional yarn	Taking much more time for unravelling, shorter yarn length due to the high friction of transferred stitches
	Hole structure basing on plain single with conventional yarn	Taking much more time for unravelling, shorter yarn length due to the high friction of transferred stitches
	Plain rib with conventional yarn	Easy to unravel
	Interlock with conventional yarn	Easy to unravel
	Purl with conventional yarn	Easy to unravel

Table 2. Results of design pattern area from recovered yarn

Yarn code	Y1	Y2	Y3	Y4	Y5	Y6	Y7
Total recovered yarn length L (m)	16	19	20	17	15	28	16
Loop length (mm)	11	7.5	6.5	11	11	5.5	11
Wale density W(stitches/10cm)	36	51	61	36	36	72	36
Course density W(stitches/10cm)	44	61	70	44	44	81	44
Design pattern area (cm^2)	93	8036	7318	9846	8687	8890	9266

In general, plain and basic knit structures with regular yarns make it easy to unravel and collect yarns. In contrast, knit structures with patterns such as horizontal stripes or transfer stitches and fancy yarns prevent yarns from unraveling due to high friction between the yarn and the loops in the fabric.

3.3. Estimating Pattern Area for Design with Recovered Yarn

It is very important for designers to confirm whether the amount of recovered yarn in their stock is sufficient for a pattern design or not. Therefore, a method to estimate the pattern area created from recovered yarn should be proposed. The design software system SDS-One Apex of Shima seiki provides useful tools for the estimation, including the suggestion of loop length, wale density, and course density according to real yarn images scanned and put into the system. With the total recovered yarn length in stock (L), which is measured easily by the rotation number of the yarn reeling equipment during unravelling process, along with the value of loop length (l), wale density (W), course density (C) recommended by the software, the pattern area (S) could be calculated by (1).

$$S = \frac{10^5 \times L}{l \times W \times C} \quad (1)$$

The results of pattern area designed from 7 lots of yarn recovered in this work are presented in Table 2.

It should be noted that the fabric specifications recommended by the software were the same for all types of knitted structure, which is a limitation of using the software for estimation of design pattern area.

4. Conclusion

This work focused on the ability of unravelling continuous yarn from used shaped knitted clothes. The results showed that the length of continuous recovered yarn depended on the product construction. Without the closure in front body panels, sweaters provided longer recovered yarn than cardigans at the same size. The ability of unravelling yarn also depended on the knitted structure of the products. Plain structures such as single, rib, interlock, and purl with conventional yarn helped to unravel the continuous yarn easily from used items. In contrast, derivative knitted structures with cables, transferred stitches, and stripes took much more time for unravelling and provided shorter yarn length due to the high friction of the knitted loops. A method of estimation the design pattern area from recovered yarn was also proposed basing on functional tools of SDS-One Apex design software system. The design pattern area could be calculated from the total recovered yarn length and the fabric specifications suggested by the software including the loop length, the wale and course density. This method is easy to understand and perform, but it really helps recycled designers to manage the ability of actualizing a design idea according to the quantity of recovered yarn in the stock.

References

[1] S. Nolimal, Life cycle assessment of four different sweaters, DePaul Discoveries, vol. 7, May. 2018. [Online]. Available: https://via.library.depaul.edu/ depaul-disc/vol7/iss1/9

[2] S. Russell, P. Swan, M. Trebowicz, and A. Ireland, Review of wool recycling and reuse, in conference proceedings Natural Fibres: Advances in Science and Technology Towards Industrial Applications:

From Science to Market, R. Fangueiro and S. Rana, Eds., Dordrecht: Springer Netherlands, Feb. 2016, pp. 415-428. https://doi.org/10.1007/978-94-017-7515-1_33

[3] W. N. I. W. Kamarulbaharin, S. Saidan, H. Saaidin, and M. H. Zakaria, Unravelling discarded second-hand winter knitwear into reusable recycled material, Idealogy Journal, vol. 7, no. 1, Apr. 2022, pp. 94-99. https://doi.org/10.24191/idealogy.v7i1.332

[4] C. Hall, K. Goldsworthy, and R. Earley, Design for sorting knitwear: exploring blended textile wastes and the relationship between sorting, recovery, and recycled blending in yarn manufacture, Materials Open Research, vol. 1, no. 3, Nov. 2022. https://doi.org/ 10.12688/materialsopenres.17478.1

[5] V. Lachner, The sweater work/shop, School of Arts, M. S. thesis, Design and Architecture, AALTO University, Helsinki, 2018. https://aaltodoc.aalto.fi/server/api/core/bitstreams/971cfdac-24d5-4804-a99f-435d8687a836/content

[6] W. Choi, N. Powell, Three dimensional seamless garment knitting on V-bed flat knitting machines, JTATM, vol. 4, no. 3, Mar. 2005, pp. 2-33. https://www.researchgate.net/publication/237482349_Three_dimensional_seamless_garment_knitting_on_V-bed_flat_knitting_machines

[7] Emily Wessel, How to knit with recycled yarn, Tin Can Knits. [Online]. Available: https://blog.tincanknits.com/2021/02/11/how-to-knit-with-recycled-yarn/ Accessed on: Aug. 30, 2024

[8] Emily Wessel, Recycling yarn from second-hand sweaters, Tin Can Knits. [Online]. Available: https://blog.tincanknits.com/2021/02/04/how-to-recycle-yarn-from-second-hand-sweaters/ Accessed on: Aug. 30, 2024

[9] Betsy Strauss, 15 ways to re-use an old sweater, Family Style Schooling. [Online]. Available: https://familystyleschooling.com/2017/11/22/15-ways-to-re-use-an-old-sweater/ Accessed on: Aug. 30, 2024

[10] LTD. Shima seiki Mfg., SDS®-ONE APEX4 All-in-one design system. [Online]. Available: https://www.shimaseiki.com/product/design/system Accessed on: Aug. 30, 2024