Improvement of Textile Waste Sorting Processes

L R Girfanova¹, R R Abdurasulova²

¹Approach Technology and Design, Ufa State Petroleum Technological University, 1 Cosmonatov Str., Ufa, 450062, Russia
²"Drawing, Drawing and Work" department, Osh state university, 331 Lenin Str., Osh, 723500, Kyrgyzstan

E-mail: 321li@mail.ru

Abstract. The transition to digital technologies in industry allows to streamline the processes of production, operation, disposal and processing of products. The recycling and management of raw materials is an important issue for textile industries and is receiving increasing attention. For mechanization and automation of waste sorting, the article proposes an aggregate, and for removal of zippers from clothing - an installation, the use of which allows to reduce their volume of textile waste in landfills, reduce their negative impact on the environment and use as secondary raw materials.

1. Introduction
Ensuring the complete processing of textile wastes of production and consumption into socially useful materials and products is the main task of scientific and technological progress [1]. This will help to eliminate the negative impact on the environment and save primary raw materials with maximum economic impact. Many types of textile waste, namely from chemical fibres, are almost equal in quality to primary raw materials. Waste management can meet needs that are currently limited by insufficient natural resources and production capacity.

Practically all types of waste can be recycled, but for this purpose it is necessary to clean, break and remove dust from them qualitatively. This increases the need for new low-waste and non-waste technologies and equipment [2,3]. The introduction of more productive equipment at enterprises will increase the competitiveness of products with better technical and economic indicators. [4, 5]. Management of waste collection and treatment by the State also helps to solve problems in this area.

2. Relevance
Textile wastes include by-products of production and consumption worn out so that they cannot be used in their original form. Recycling points in Russia focused on collecting products from the population do not cover the class of textile waste, but such programs involve large trademarks and networks [7].

The limited raw material base of the textile industry [8] is becoming a catalyst for finding other resources for the production of clothing and developing new approaches to its design, which allow the rational use of unique raw materials [9-13].

3. Statement of the problem
The systematic approach to research on the emergence and processing of textile waste is aimed at developing technology for their rational processing into secondary raw materials for the production of textile materials or direct casting or printing of finished products in the form of clothing, footwear, accessories. In order to achieve this, it is necessary to carry out an analysis of the existing textile waste processing technology, which includes sorting and preparing the waste for fibre processing or granulation.

4. Theoretical part

Light industry is one of the most important sectors of the economy, bringing together several industries, influencing the stable growth of the economic situation of the country and ensuring social and intellectual levels of society [14]. The light industry sector includes the processing of raw materials (production of fibres, threads, yarns; Treatment of skins and fur); Production of fabrics, knitted fabrics, artificial fur leather and non-woven materials (textile industry); Garment manufacturing (garment industry); Production of leather products (leather industry); Footwear manufacturing (footwear industry) (Table 1). In Russia, the light industry mostly operates on the same raw material base as in the Soviet Union, which is based on cotton, wool, flax, which causes its slow development and dependence on imports.

Table 1. Analysis of the raw material basis of light industry.

| Production | raw materials | Final product | Use in light industry |
|------------|---------------|---------------|-----------------------|
| Fibers, threads, yarn | Cotton, flax, wool, polymers | Fiber, threads, yarn | Fastening materials, fabrics, knitted fabrics, lace fabrics, piece textiles, stockings, socks, gloves, rolls, clothing |
| Skin | Skin of animals, birds, fish | Skin of various excretions, collagen masses | Leather products (bags, folders, gloves, belts, shooting down, etc.); Clothes and shoes, headgear, covers |
| Furs fabrics | Skins of animals | Furs plates, stocking | Clothes, shoes, caps, sleeves, covers |
| Knitted fabrics | Fiber, threads, yarn | Knitted fabrics | Clothing, footwear, accessories, home textiles |

Many of the end products listed in Table 1 are not only consumer goods, but also make up strategically important products used in the aviation and space industries, in the military-space forces. The raw material base of light industry consists of products of chemical industry, livestock and crop production, the development of the latter two requires fertile land and significant investments against the background of low profitability and high risks in these sectors of the national economy.

In order to reduce the amount of waste disposed of in landfills and TBT landfills and to reduce the negative impact on the environment, it is necessary to involve them in material production as secondary raw materials. Preparation of recycling from the population includes the following technological operations [7]: 1 - disinfection; 2 – dust removal; 3 – sorting; 4 – washing; 5 – dry-cleaning; 6 – cutting; 7 – oiling; 8 - razvolokneniye. In the preparation of secondary raw materials coming from the production sector, technological operations such as disinfection, dusting, washing or dry cleaning are not necessary.

Paragraphs 7 of the 8 process operations listed above will not be possible without the use of special types of equipment and units suitable for a particular operation. The only operation that is still carried out at the expense of manual labor is the sorting of textile waste, as small mechanization is used: sorting tables equipped with disk and ribbon knives.

Collected wastes are sorted by composition; on processing; on a state.
4.1. Development of an automated textile waste sorting line

Textile wastes subject to total sorting are household wastes containing a variety of products by raw material composition and design. It is considerably easier to label and apply QR-codes on products during their production, which specify raw material composition and peculiarities of used furniture [15].

In order to mechanize and automate sorting, a textile waste sorting unit is proposed, as shown in Figure 1 (a): after textile waste has undergone disinfection and dusting stages, it is necessary to remove fasteners, buttons, non-textile elements of products by press 1; Then, wastes moving along conveyor 2 pass through spectral lamp 3, which transmits delta signal to robot 4 (Fig. 1-b).

This separation is required because of the different ways in which the products are processed and used. Preparation of synthetic and natural recycling requires different temperature conditions, reagents and technological processes. [3]

As a result, the waste will become a secondary fibre, which is then used in the production of various textile materials: fabrics, knitted fabric, carpets, nonwoven materials, etc.

![Figure 1. Automated textile waste sorting unit: a – process flow diagram; b – delta robot](image)

4.2. Development of an installation for removal of zipper from clothing

Installation for cutting zipper from textile products (Figures 2-4) is characterised by the presence of two parallel-arranged disk knives permanently mounted above the table, equipped with a conveyor belt for the supply of textile products under the knives, having a guide middle chute for fixing the fastener - zipper, and side chutes for the operation of the disk knives and a front pressing roller for the supply of the textile product, and a rear roller for its removal.

The introduction of a second cutting tool, namely a disc knife, reduces the cutting time of the zipper by half, as it is necessary to cut the textile article from at least two sides thereof to remove it.
The introduction of the trough belt conveyor reduces the time required to feed the textile product by simplifying the orientation of the textile product, namely the correct location of the zipper, for proper feeding under the knives.

The introduction of pressure rollers in front of the knives accelerates the advancement of the textile product under the knives due to its fixation in the laid state and the prevention of injury to the person during operation on the plant. Pressure rollers after knives provide continuous removal of textile product and cut zipper, which together reduces time consumption by replacing manual work with mechanized one.

The unit (Figure 2) can be protected by housing (pos. 1) and has two parallel disk knives (pos. 2 and 3) above the table (4). The unit (Figure 3) is equipped with front (pos. 5) and rear (pos.6) pressure rollers, conveyor belt (item 7) is used to move textiles. Conveyor belt (Figure 4) has three parallel chutes of different width (pos. 8,9). Side trenches (poses. 8) to provide working stroke of disk knife are located on two sides from middle chute (pos. 9), which allows to place teeth of zipper in it.

The installation operation procedure is as follows:
- Textile article with zipper aligned with middle chute is laid on conveyor belt (pos. 9);
- At conveyor belt advance (pos. 7), the article is pressed by the front roller (pos. 5);
- Further, when the conveyor belt is advanced, the article falls under the disk blades (2,3), and the article is cut parallel to the zipper by providing the working stroke of the disk knife with lateral flutes (pos. 8);
- After cutting, the article falls under the rear roller (pos. 6) due to conveyor belt advance (pos. 7) and is removed from the table.

![Figure 2. Side view of the zipper cutting installation.](image)

![Figure 3. Front view of the zipper cutting installation.](image)
Figure 4. Top view of the zipper cutting installation.

Such an arrangement can be applied prior to sorting processes for multilayer articles because its use allows the separation of layers representing different materials.

5. Practical importance
Surveys of the population have shown a willingness to join separate garbage collection and purchase secondary raw materials. The developed plants make it possible to increase efficiency and safety of processes of sorting and preparation of textile waste for further processing into raw materials for various industry needs [16, 17].

The application of a systemic approach in the design and production of garments will allow the introduction of additive technologies in the garment industry, in fact, changing its technology fundamentally, turning to methods of clothing production, which are not related to sewing processes. The widespread use of innovative technologies in waste processing plants will increase the attractiveness of these processes to society.

6. Conclusion
Based on theoretical and experimental studies and surveys carried out, shortcomings in the process of sorting textile waste have been identified, primarily related to a large share of manual work, which implies inefficient working format and unsafe working conditions for workers. The low efficiency of sorting processes does not allow to implement the principles of resource saving everywhere and to reduce the cost of processed raw materials in order to increase their competitiveness in the resource market.

Thus, the implementation of the proposed measures is aimed at increasing productivity and reducing the cost of secondary raw materials from textile waste and allows to attract investors and labor resources in waste processing processes.

7. References
[1] Izmailova A R 2019 Connection of Economics and Ecology in the Field of Processing of Secondary Resources *Innovation Science* 4 pp 113-115
[2] Kayumova R F, Girfanov L R 2016 To the issue of waste-free technology of clothing manufacture/In the collection: Topical issues of modern science collection of scientific articles of the International Scientific and Practical Correspondence Conference Ufa State University of *Economics and Service* pp 260-262
[3] Chernasova T S, Ivanov N N 2019 Search for directions of rational use of textile materials *Young scientists - development of the National Technological Initiative (SEARCH)* 1-1 pp 204-207

[4] Volynkin O N, Vinogradova E V, Zarubina E V 2019 Immutable regeneration of waste during production of cotton wool *Young scientists - development of the National Technological Initiative (SEARCH)* 1-1 pp 15-16

[5] Shingisbayeva J A, Abduova A A, Iztleuov G M, Utebayev A A, Baibatyrov B U, Ashitova N J, Dairabayev A J 2019 Peculiarities of waste processing of cotton mill *News of higher educational institutions. Technology of the textile industry* 1(379) pp 319-322

[6] Federal Law dated 24.06.1998 N 89-ФЗ (ed. 07.04.2020) "On Production and Consumption Wastes"

[7] Sharipova R G, Girfanov L R 2019 Prospects of recycling and processing of textile waste in the Republic of Bashkortostan *UGNTU Gazette. Science, education, economy Series: Economy* 4(30) pp 41-49

[8] Quadrikova O G, Girfanov L R 2019 Increasing the efficiency of development of the raw material base of light industry in the Russian Federation *UGNTU Gazette. Science, education, economy. Series: Economy* 2(28) pp 51-59

[9] Girfanova L R, Kayumova R F 2005 Leather Garment Technology. Ufa: Ufa state institute of service 84 p

[10] Minichanov R R, Girfanov L R 2015 Design of light industry products from modern composite materials/In the collection: Science today: Theory and Practice Collection of scientific works of the international correspondence scientific and practical conference (Ufa State University of Economics and service) pp 62-65

[11] Girfanov L R 2004 Development of resource-saving technology of making form-stable clothes: auto-reformate of thesis for the degree of Candidate of Technical Sciences Moscow State University of Design and Technology (Moscow)

[12] Bazayev E M, Rudneva T V, Zaretskaya G P 2014 Design issues of garment products with zone distribution of properties In the collection: Design, technology and innovation in textile and light industry (INNOVATIONS - 2014) the collection of materials of the International Scientific and Technical Conference pp 173-176

[13] Girfanova L R, Teregulova Z S, Krasovsky V O 2019 WAYS TO IMPROVE THE DRILLERS' WORKING CLOTHES AS AN ELEMENT OF THE WORK SAFETY SYSTEM IOP CONFERENCE SERIES: EARTH AND ENVIRONMENTAL SCIENCE The conference proceedings (Far Eastern Federal University) C 022057

[14] Girfanova L R 2011 Methods and methods of improving industrial and consumer properties of garments: monograph (Ufa) 80 p

[15] Girfanov L R 2018 Automated Product and Process Design Systems: Tutorial (Saratov: Ai Pi Air Media) 156 p

[16] Girfanov L R 2013 Improvement of shape stability of clothes using cellular gasket materials *News of higher education institution Technology of the textile industry* 4(346) pp 106-109

[17] Tchernyshev N I, Sysoev O E, Solovev D B, Kiselyov E P 2018 Basic Robotic Platform for Implementation of Accurate Farming Technologies *Bulletin of Electrical Engineering and Informatics (BEEI)* 7(4) 522-528. [Online]. Available: http://dx.doi.org/10.11591/eei.v7i4.920