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The Innovative Technology of Decoction and For Preparing Waste of Natural Silk for Combing

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ABSTRACT: Developed an innovative high-performance alternative technology for preparing waste of natural silk for combing and modes decoction defective cocoons unsuitable for unwinding. Cooking at temperature 95-100 ℃ for 1.5-2 hours before the extent of digestion sericin and destruction cocoon shell into a pulp. Glue (sericin) removal and degreasing of defective cocoons unsuitable for unwinding should be carried out in hot weakly alkaline solutions at pH = 9 ÷ 10.5 and temperatures from 95 to 100°. The new technology allows processing unfit for unwinding cocoons in pulp silk improved quality, reduces manufacturing processes and equipment, improves the quality produced in spinning yarn production, saving raw materials and energy resources.

KEYWORDS: cocoon, waste, cooking, washing, wringing, pulp, silk, modernization, technology.

I. INTRODUCTION

In the modern period, due to the increase in demand in the world market for products made from natural fibres, the requirements for the quality of products made from natural silk have significantly increased. One of the important tasks facing the specialists of the silk industry is to increase the efficiency of processing raw materials, increase the volume of production and improve the quality of products from natural silk based on the improvement and development of new resource-saving technologies for processing cocoon raw materials. Sericulture and cocoon-winding production generate a significant amount of waste in the form of unwinding cocoons, fibrous waste from cocoons and pupae. Utilization of this waste is of great economic importance since for every kilogram of raw silk produced, there is about 1 kg of various waste [1].

Meanwhile, the shells of defective cocoons and the fibrous waste of cocoon winding are valuable raw materials for the production of silk yarn used for the manufacture of a variety of consumer fabrics, as well as for the production of products for various technical purposes. The number of defective cocoons depends on the feeding conditions of the silkworm, climatic conditions, as well as on the organization of the blanks and the primary processing of cocoons. Defective cocoons that can be unwound in one way or another are unwound into ordinary raw silk, and the cocoons that cannot be unwound are processed into yarn. The process of making yarn from waste silk is more complex than making yarn from any other fibrous material. The complexity of silk-spinning is explained by the special properties of the raw materials used and the high requirements for silk yarn. Due to the variety of types of raw materials used, which differ sharply in origin and physical and mechanical properties, various methods of its processing are used, especially at the first stages of the technological process. As you know, all silk waste, like raw silk, consists mainly of fibroin and a layer of silk glue covering it - sericin. Sericin must be removed at the first stage of processing silk waste, otherwise, it will not be possible to process it into yarn. Various chemical biochemical methods of waste treatment are used to remove sericin and fatty substances. Degreased and dust-free silk waste in the carding shop is processed on a set of special machines used in silk-spinning production.

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II. LITERATURE REVIEW

Much work in the study of the problems of waste-free technology for processing natural silk was carried out by Prof. Kh.A.Alimova [2, 3].

In works [4, 5], the issues of processing of unsuitable for unwinding cocoons on loosening tops are considered. Problems of obtaining cocoon raw materials and some issues of processing natural silk threads are highlighted in the work [6]. The amino acid composition and the amount of protein in solutions obtained in various solvents have been investigated. It was found that the degree of protein denaturation is higher in a solvent containing sodium thiocyanate. By determining the amount of protein in the investigated solutions by the spectrophotometric method, the advantage of the calcium chloride solvent over sodium thiocyanate has been established [7]. In [8], an aqueous solution of fibroin nanoparticles obtained as a result of thermal hydrolysis of fibrous waste of natural silk was used to modify polyacrylonitrile fibres. In the work of Ishmatov A.B., the influence of residual sericin on the defectiveness of raw silk and its breakage during rewinding and in weaving is considered, technological modes of unwinding cocoons are determined, taking into account the content of residual sericin in raw silk [9]. D.B. Takhtaganova investigated the chemical characteristics of hydrolyzed fibroin obtained from boiled fibrous waste of cocoon-winding production and fibroin precipitates obtained as a result of hydrolysis with hydrochloric acid of various concentrations [10].

A technology for dissolving waste of natural silk by the thermal method and effective technology for dissolving waste of natural silk under high-frequency (HF) radiation have been developed. It was found that the protein is preserved in its native state to a greater extent by the method of dissolution under high-frequency radiation than by the thermal method [11].

From the point of view of the effectiveness of the use of modern textile machines and machine tools, the quality of the preparation of threads for weaving was investigated depending on the quality of raw silk [19, 20, 21, 22] and the production of silk fabrics [23, 24].

In the world of textile science, research is being carried out to improve the processes of production of textile threads and yarns, processing of natural silk and textile waste. In the work of Nogueira G.M., Rodas A.C., Leite C.A., Giles C., Higa O.Z., Polakiewicz B., Beppu M.M. investigated the production and characterization of dense membranes from silk fibroin using silk fibrous waste [25]. In the work of Wang, Shi. investigated the problems of processing silk textile waste [26].

III. METHODOLOGY

Silk waste contains from 20 to 30% sericin, which makes the fibre stiff and makes it impossible to process it into yarn in its raw form. In addition, almost all types of silk waste contain some amount of fatty substances. The greasy fibre becomes sticky and, during the production of yarn, is poorly separated in the processes of opening, carding and drawing [27].

In the process of decoction, silk fibre completely or partially loses the sericin contained in it and is defatted. It becomes soft and flexible, acquires the ability to easily separate. This contributes to a better course of all processes of further mechanical processing of the fibre and improves the physical and mechanical properties of silk yarn [27].

In the existing technology for processing defective cocoons, the cocoon shells are cut with knives, separated from the pupa, and then the cocoon shells are boiled and a silk mass is obtained [1].

The disadvantage of this technology is that when cutting shells with knives, a continuous thread is cut into separate uncontrolled segments of various lengths, which, after boiling, form a randomly entangled mass of fibre. In addition, short fibres fall out into the fleece during carding, which leads to a decrease in the yield of silk products (fleece) in the spinning industry. According to another, also known, technology for processing cocoons that are not suitable for unwinding (odonki and cocoon unwinding), first, the fibre is separated from the pupa on a top with a smooth and needle drum, and a silk mass is obtained - a canvas of the first (I) and second (II) transition [1], then the silk mass is boiled. The disadvantage of this technology is the short length of the fibres in the mass, their large contamination by the crushed parts of the pupa, and the multitransition of the processing technology. We have developed a new technology for the preparation of fibrous waste of natural silk for carding by developing a technology for obtaining silk from cocoons that

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are not suitable for unwinding (odonki, cocoon unwinding, leaky, twinned, ugly, carapace cocoons, hardened and others, Fig. 1), in which a decoction is first performed unsuitable for unwinding cocoons and then sequentially carry out washing, squeezing, drying, separating the fibre from the pupa, and a silk mass is obtained [28].

Fig. 1. Cocoons not suitable for unwinding.

The aim of this work is to develop new technology and modes of decoction of defective cocoons unsuitable for unwinding.

IV. EXPERIMENTAL PART

According to the new technology [28], the cooking process is carried out in a conventional digester, where water is poured, cocoons are loaded, heat is supplied, and cooking is carried out. Cooking is carried out at a temperature of 95-100 °C for 1.5-2 hours. Cooking is carried out until the degree of digestion of sericin and destruction of the cocoon shell into a pulp, at which the bond strength of the shell structure elements (loops and bags) is reduced to a minimum. The introduction into the new technology of the process of cooking cocoons in the indicated temperature-time regimes under mechanical action on the cocoons leads to the digestion of sericin, a decrease in strength and rupture of bonds between the structural elements (between loops and packets) of the cocoon shell and the complete destruction of the cocoon shell into a fibrous mass [28]. As you know, the main task of the decoction process is to remove silk glue (sericin), fats, natural and waxy substances, pigments and minerals, the effectiveness of which depends on the temperature, pH of the medium and the concentration of reagents, as well as the properties of the processed raw materials and the degree of damage to the shell of defective cocoons. Debonding and degreasing of silk waste should be carried out in hot, slightly alkaline solutions at pH = 9 ÷ 10.5 and temperatures from 95 to 100 °C. De-glueing time depends on the degree of alkalinity of the solution and the processing temperature. Where possible, the cooking time should be as short as possible. The best decoction reagent is soap, both due to its low alkalinity and high degreasing ability. Reagents for decoction should be taken in concentrations that ensure the stability of the pH of the decoction solution. Depending on the degree of defectiveness, cocoons unsuitable for unwinding were combined into groups. The first group consists of cocoons that are not suitable for unwinding with light and medium degree of damage to the shell. These are odonates, cocoon unravelling, ugly cocoons, cicatricial cocoons more than 15 mm long, satin cocoons with a smooth shiny area more than 15 mm long, underdeveloped, twinned, leaky (green) cocoons, and others. The second group consists of cocoons unsuitable for unwinding with a high degree of damage to the shell. These cocoons are strongly hardened, spotted and others. The third group consists of heavily contaminated cocoons, unsuitable for unwinding, with a high degree of damage to the shell. These are cocoons of carapace, strongly spotted, heavily polluted and others. Decoction of cocoons unsuitable for unwinding with light and medium damage to the shell (1st group) was carried out in ordinary water without the addition of chemical reagents. Based on the above, a decoction of cocoons unsuitable for unwinding with a high degree of damage to the shell, such as strongly hardened, spotted cocoons, etc. (group 2), was carried out in soap-soda solutions. The decoction of cocoons, unsuitable for unwinding, heavily contaminated with a high degree of damage to the shell of cocoons, such as carapace, strongly spotted, heavily contaminated, etc. (3rd group), was carried out in a single way, i.e. combining the processes of decoction and bleaching. After decoction, to remove the cooking solution from the fibres, three times rinsing follows. To prevent precipitation of calcium and magnesium soaps that pollute the fibre and are difficult to remove during subsequent treatments, washing is carried out in distilled (softened) water with the addition of ammonia or sodium hexametaphosphate. Depending on the degree of defectiveness of the cocoons unsuitable for unwinding, the tests were carried out according to the following modes of their decoction:

– mode No. 1 - decoction of cocoons unsuitable for unwinding with light and medium damage to the shell - temperature 95-100 °C, time - 120 min. (2 hours), 1-flushing - temperature 60-70 °C, time - 20 minutes, 2-flushing - temperature 20-25 °C, time - 20 minutes;
– mode No. 2 - decoction of cocoons unsuitable for unwinding with a high degree of damage to the shell - temperature 95-100 °C, time - 90 minutes. (1.5 hours), 1-flushing - temperature 60-70 °C, time - 20 minutes, 2-flushing - temperature 60-70 °C, time - 20 minutes, 3-flushing - temperature 20-25 °C, time - 20 minutes;
– mode No. 3 - decoction of heavily contaminated cocoons unsuitable for unwinding with a high degree of damage to the shell - temperature 95-100 °C, time - 90 minutes. (1.5 hours), 1-flushing - temperature 60-70 °C, time - 20 minutes, 2-flushing - temperature 60-70 °C, time - 20 minutes, 3-flushing - temperature 20-25 °C, time -20 minutes.

The above modes of decoction of cocoons unsuitable for unwinding were experimentally investigated in laboratory conditions (Fig. 2) [29].

The composition of the bath - chemical reagents, their content in the cooking solution and the results of the experiments are shown in Table 1, where experiment No. 1 - according to mode 1, experiments No. 2 - 17 - according to mode 2, experiments No. 18 - 20 - according to mode 3. In experiments No. 18 - 20, in addition to the chemical reagents listed in Table 1, hydrogen peroxide (2% of the fibre mass) and a stabilizer (5 g/l) were used.

Rice. 2. Samples of boiled cocoons unfit for unwinding

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Table 1. Results of experiments

№	Operation	Bath composition				pH solution	Sericin ,%	Fibroin ,%	Degree of whiteness,%	Absorbency
		Oleic soap (40%) g/l	calcified soda, g/l	Ammonium alcohol (25%) g/l	Sodium hexometaphosphate, g/l					
1	2	3	4	5	6	7	8	9	10	11
1	Decoction Flush 1 Flush 2	- - -	- - -	- - -	- - -	5 5 5	5,4	94,6	78	55 min
2	Decoction Flush 1 Flush 2 Flush 3	15 - - -	3 - - -	- 2 2 -	- - - -	12 11 11 5	51,4	48,6	80,5	7 min. 40 sec.
3	Decoction Flush 1 Flush 2 Flush 3	15 - - -	3 - - -	- - - -	- 1 1 -	12 4 4 5	30	70	87	40% in 5.5 hours
4	Decoction Flush 1 Flush 2 Flush 3	15 - - -	3 - - -	- 2 - -	- - 1 -	12 11 4 5	50	50	87	50% in 5.5 hours
5	Decoction Flush 1 Flush 2 Flush 3	15 - - -	3 - - -	- - 2 -	- 1 - -	12 4 11 5	35	65	83	1 min. 15 sec.
6	Decoction Flush 1 Flush 2 Flush 3	7,5 - - -	1,5 - - -	- 2 2 -	- - - -	10,5 11 11 5	45,5	54,5	85	40 sec.
7	Decoction Flush 1 Flush 2 Flush 3	7,5 - - -	1,5 - - -	- - - -	- 1 1 -	10,5 4 4 5	21	79	84	2 hours 5 min.
8	Decoction Flush 1 Flush 2 Flush 3	7,5 - - -	1,5 - - -	- 2 - -	- - 1 -	11 11 4 5	37	63	85	50% in 5.5 hours
9	Decoction Flush 1 Flush 2 Flush 3	7,5 - - -	1,5 - - -	- - 2 -	- 1 - -	10,5 5 11 5	47	53	79	4 min.
10	Decoction	15 -	1,5 -	- 2	- -	10,5 11	41	59	82	17 sec.

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	Flush 1 Flush 2 Flush 3	- -	- -	2 -	- -	11 5				
1 1	Decocti on Flush 1 Flush 2 Flush 3	15 - - -	1,5 - - -	- - - -	- 1 1 -	10,5 4 4 5	56,5	43,5	85	40% in 5.5 hours
1 2	Decocti on Flush 1 Flush 2 Flush 3	15 - - -	1,5 - - -	- 2 - -	- - 1 -	10,5 11 4 5	33	67	89	1 min45 sec
1 3	Decocti on Flush 1 Flush 2 Flush 3	15 - - -	1,5 - - -	- - 2 -	- 1 - -	10,5 4 11 5	32	68	88	47 sec
1 4	Decocti on Flush 1 Flush 2 Flush 3	7,5 - - -	3 - - -	- 2 2 -	- - - -	11,5 11 11 5	40	60	87	4 min. 45 sec
1 5	Decocti on Flush 1 Flush 2 Flush 3	7,5 - - -	3 - - -	- - - -	- 1 1 -	11,5 4 4 5	43	57	82	100% in 5.5 hours
1 6	Decocti on Flush 1 Flush 2 Flush 3	7,5 - - -	3 - - -	- 2 - -	- - 1 -	11,5 11 4 5	48	52	72	2 min49 sec
1 7	Decocti on Flush 1 Flush 2 Flush 3	7,5 - - -	3 - - -	- - 2 -	- 1 - -	11,5 4 11 5	39	61	78	6 min. 49 sec
1 8	Decocti on Flush 1 Flush 2 Flush 3	7 - - -	0,5 - - -	- 2 2 -	- - - -	9,5 11 11 5	69	31	75	2 min. 30 sec.
1 9	Decocti on Flush 1 Flush 2 Flush 3	7 - - -	0,5 - - -	- - - -	- 1 1 -	9,5 4 4 5	61	39	74	10 min. 20 sec.
2 0	Decocti on Flush 1 Flush 2	(Surfacta nt) 2 - -	0,3 - -	- 2 -	- - -	7 11 5	51	49	78	1 min. 33 sec.

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An analysis of the results obtained shows that the solubility of sericin significantly depends on the reaction of the medium and increases sharply in solutions of acids and especially alkalis, which follows from the amphotericity of sericin as a protein body. At a pH in the range of 4.0-5.0, the weight loss of silk, i. E. the amount of sericin passed into the solution is minimal. As the alkalinity and acidity of the solutions increase, the loss in weight increases, and at a pH above 9.5 and below 5, the fiber is de-glued to a greater extent. From the data presented, the best mode for decoction of unsuitable for unwinding cocoons was selected for experiments No. 12 and 13, where the degree of whiteness and absorbency of the test samples are of the highest importance. In addition, the selected conditions are distinguished by the highest yield of de-glued silk. Patent of the Republic of Uzbekistan № IAP 04621 "Method of processing of uncooling cocoons" was obtained for an innovative highly efficient resource-saving technology for producing silk from cocoons unsuitable for unwinding [30].

V. CONCLUSION

1. Research has been carried out on the process of decoction of defective cocoons that are not suitable for unwinding using new technology for producing silk from cocoons that are not suitable for unwinding.

2. A new highly efficient resource-saving technology has been developed for the decoction of cocoons that are not suitable for unwinding and for preparing fibrous waste of natural silk for carding by developing a technology for producing silk from defective cocoons that are not suitable for unwinding.

3. Technological modes of decoction of defective cocoons unfit for unwinding have been developed, taking into account the peculiarities of the new silk production technology.

4. Debonding and degreasing of defective cocoons unsuitable for unwinding should be carried out in hot weakly alkaline solutions at pH = 9 ÷ 10.5 and temperatures from 95 to 100 ℃.

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Tuychiyev Ilxomjon Ibragimovich, Head of the Laboratory "Spinning Textile Fibers" of the Uzbek Scientific Research Institute of Natural Fibers. Published 101 scientific papers, received 7 patents for inventions and utility models. The areas of scientific interests of Ilhomjon Ibragimovich Tuychiev are spinning of natural fibres, technology for processing secondary resources in the production of products from natural fibres in the textile industry, improvement of technology and technology, the formation of products from textile fibres, problems of standardization and certification of products of the textile industry.

Axunbabayev Ulug’bek Oxunjonovich, Doctor of Philosophy in Technical Sciences (PhD), Deputy Director for General Affairs of the Uzbek Research Institute of Natural Fibers.
110 scientific papers were published, 7 patents for inventions and utility models were received. The area of scientific interests of Akhunbabaev Ulugbek Okhunzhonovich is: improving the technique and technology for the production of raw silk, improving the quality of textile fibres in accordance with the requirements of international standards, problems of processing cocoons unsuitable for unwinding, scientific foundations of the consumption rates of textile raw materials.

Nabieva Iroda Abdusamatovna, Doctor of Technical Sciences, Professor, Department of Chemical Technology of the Tashkent Institute of Textile and Light Industry.
Published more than 150 scientific papers, received 13 patents for inventions. The area of scientific interests of I. A. Nabieva are scientific bases of modification of synthetic fibres, improvement of their paintability and hygienic properties, elimination of electrification; expanding the range of textile materials based on chemical and natural fibres and developing technology for chemical finishing of mixed materials; chemical finishing of wool; technology for obtaining fibrous semi-finished products for the paper industry from recycled resources**.**