New Device and Technology for Primary Processing of Silkworm Cocoons Obtained During Different Feeding Seasons

Alimova Kh., Gulamov A., Avazov K., Umurzakova Kh., Eshmirzaev A.

***Abstract**: the article presents the developed device for mortification a silkworm pupa inside a cocoon by exposing it to infrared radiation and the technology for its use. The schemes of temperature changes in the structural bonds of a live cocoon pupa during its mortification under the influence of infrared radiation on cocoons obtained in different seasons of the year and the corresponding results of practical research are presented and analyzed. Studies have shown that the distance between the cocoon and the infrared lamp affects the temperature of the structural connections of the pupa and the cocoon. It was found that the treatment of cocoons with infrared radiation for a short period of time can cause an increase in the temperature of the pupa to an average of 79°C, and the temperature of the cocoon shell in comparison with the pupa decreases to 27°C. It was also found that when processing with distances between cocoons and infrared lamps equal to 10cm, 15cm and 20cm-the temperature of the pupa and the cocoon shell obtained in different seasons of the year may differ and the temperature difference of the pupa reaches 4°C, and the temperature difference of the cocoon shell is up to 9°C. In this regard, the process of mortification the pupa cocoons, obtained in spring, can be performed in a short time, resulting in saved technological parameters of the shell cocoons at a high level, which leads to improving the efficiency of unwinding cocoons enterprises, as well as to acquire high quality raw silk.*

***Keywords**: device, technology, live cocoon, pupa, mortification, drying, infrared ray, temperature, dry cocoon, raw silk.*

I. INTRODUCTION

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The measures provided by the Program of the Republican Association "Uzbekipaksanoat", established in accordance with the Resolution of the President of the Republic of Uzbekistan dated March 29, 2017, under No DP-2856, "On measures to organize the activities of the Uzbekipaksanoat Association" are being embodied in practice. In particular, in order to implement the Resolution of the Ministers Cabinet of the Republic of Uzbekistan under No. 616 dated on August 11, 2017 "On the Program for complex development of the silk industry in 2017-2021", there have been defined the main target indicators of further development of the silk industry in the Republic for 2017-2021, and also there have been approved the major targets for the development of feeding base of the cocoon industry in 2017-2021, and significant works are being carried out in this regard [1].

These decisions are directed to grant of a number of benefits and preferences for existing businesses, approval of major investment projects, gradual transition to cluster method of production, as well as encouraging the creation of new intensive mulberry plantations and mulberry rows, attracting foreign direct investment in the sector, wide introduction of advanced technologies, innovative ideas, scientific developments and scientific achievements, deep processing of raw cocoon, further support of producing the competitive ready silk products with highly added value and to multiply their types. Widespread implementation of the silk cluster system in the Republic and the task of increasing their export potential impose the high requirements on the quality of cocoons produced from primary cocoon processing bases. At present, by means of modern silk worming machines in silk factories we can achieve through the production of raw silk that meets international standards and production of competitive finished products, mainly through the processing of high quality cocoons.

It is known that, for functioning of silk worming enterprises all year round, the cocoons are pre-treated so that the pupa inside the cocoons are mortification and dried. Only then cocoon will be stored for a long time. Otherwise, the living pupa will turn into a butterfly, pierce the shell, and make it unusable for unwinding, or if the pupa is mortification, but not dried, the wet cocoon will quickly mold and degrade [2-4].

Although there are a number of methods for primary cocoon processing in our country, only one hot air method has been widely used in production for many years. In the current method, hot air with high-temperature, which has long-term effects on cocoon processing, adversely affects the technological properties of the cocoon shell, reducing the amount of raw silk.

As majority of the equipment used in it are physically and morally obsolete and increasing the production costs, which necessitates the scientific research to upgrade or modernize them [5, 6]. Despite of the fact that there have been conducted a number of other scientific studies they are still technically and technologically incompatible due to their low efficiency.

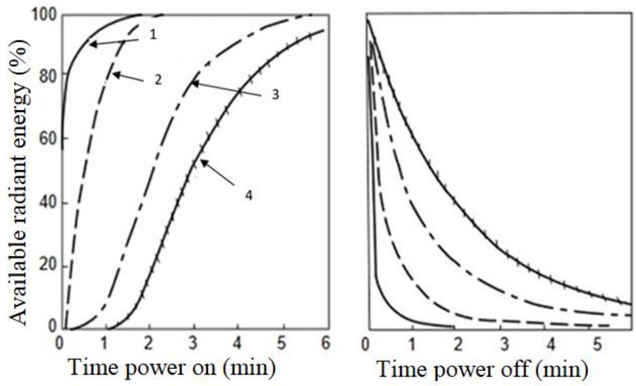
II. MATERIAL AND METHODS

Scientists of SRIS have created a device for evaporation of cocoon shell under the influence of sunlight [6]. In this case, the device is proposed to inactivate the living cocoon pupa and then dry it in the shade dryer to air humidity. According to it, the temperature in the chamber of the device to fully deactivate the pupa with the help of solar radiation is 60^{o}C, with the cocoons placed on it not exceeding 8-10cm, and total solar radiation of 515 W / m2 and the processing time is at least 60 minutes. This method can only be used during the daytime, with no cloudy days, and low performance of the device (work efficiency for 1 sqm., of drying area makes - 2.1 kg / hrs, coefficient of total heat consumption-50 %) and the duration of the pupa inactivation under sunlight is 60 minutes.

Some authors have defined that under the influence of sunlight for 100 hours, raw silk strength increased by 19.8% and stretching properties by 24.6%, and after 200 hours - raw silk strength reaches up to 26.7% and elongation is decreased by 60.3%. Cocoons, which remain in the sunlight for a long time, are poorly drained. Therefore, this method has been used lately in some cases [3].

Currently, there are available units such as SK-150K, KSK-4.5, Yamato-Sanko, steam stain and simplex, proposed for inactivation and drying the alive cocoon pupa in the primary cocoon processing bases of our republic, SK-150K conveying units make their main share in 82.1 %. As it is known, these units are pre-treated on cocoons with high air temperature of 110÷120^{0}C. The amount of heat consumed for the process is 837kJ/hrs, and the air volume is 15,000m3/hrs, with an electric motor power of 43kW. Unit also consumes 120l of fuel and 70 kW of electricity to process 1 ton of live cocoon [4].

Practical studies show that, because the aggregate is full-metal, it takes a long time (2-3 hours) to heat the drying chamber before it reaches the set temperature. Also, because the inner walls of the drying chamber are made of metal surfaces, the heat that affects the cocoons increases and the unevenness of the conveyor surface increases. This in turn increases production costs and has a negative impact on the natural properties of cocoon shells and pupa.



Here: 1-infrared lamp, 2-quartz tube, 3-metal tube, 4-ceramic tube.

Fig.1. Time dependence of heat retention for infrared radiation sources (With permit of Fostoria Industries, Ins., Fostoria, State of Ohio)

When the live cocoon pupa is dehydrated and dehydrated, it takes into account the ability of its white and porous body to penetrate rapidly and be absorbed into aqueous moisture content. According to the foregoing, heat is transferred to the humid part of the beam due to the passage of light energy from the cocoon shell under the influence of infrared light. This process facilitates short-term intensive moisture evaporation and inactivation of cocoon pupa by intense heat [7-15]. It also shows that energy saving can be achieved when preparing and using the device (Figure-1). The obtained data demonstrate that the heat retention time for different types of infrared radiation sources is different, and the most efficient are infrared lamps [16].

With consideration of the above, scientists of the Department of “Silk Technology” offered a new improved device. The function of the device is to allow the inactivation of the cocoon pupa for a short period of time (2-5 minutes) to maintain the technological properties of the cocoon shell. As a result, the moisture separating the cocoons will prevent the lamps from affecting their performance, replace the defective lamps, allow to control the cocoon over the conveyor, and effectively use the light energy between the cocoons. The authors have filed an application with the Agency for Intellectual Property under the Ministry of Justice of the Republic of Uzbekistan for the new device and method [14].

It is well-known that the quality of the finished product requires a sequence of properly selected raw materials and technological processes. Today, joint ventures for the production of silk are established and are equipped with modern machines. However, it is known that the technical level of the units on the cocoon primary processing bases (CPP) is physically and culturally obsolete, and their long-term exposure to high temperature during the primary processing of the cocoon will partly affect the technological properties of the shell. Taking this into consideration, the technology of primary processing of cocoons was studied.

A main process of cocoon processing technology is to inactivate and dry the living cocoon pupa. Due to the high moisture content of the living cocoon pupa, the pupa is inactivated but not dried, the wet cocoon quickly molds and worsens the quality of shell. Therefore, the initial moisture content of the cocoons should be dried to air conditioning. At present, at the bases of cocoon processing, this process is carried out in high-temperature hot air. Initial processing of live cocoons is a complex process, where intensive moisture and heat exchange occurs between the drying agent, the shell and pupa [7-9]. Therefore, the direct involvement of the cocoon shell in the process of inactivating the pupa and removing moisture from it, requiring them to investigate preprocessing processes based on the techniques of heat engineering, to choose their modes, or to find the best methods, to use their technological properties naturally. [15]. This will further increase the efficiency of the existing silk industry enterprises.

Results of the initial research show that the distinctive features of the Guzal and Marvarid breeds in comparison with other breeds are that they have high metric number, which is one of the technological features of silk fiber, despite having a large, lightweight silk shell. “Oltin vodiy2” industrial hybrid with these breeds has shown that the average yield of 65-70 kg of cocoons can be obtained from one pack of seeds if they are breeding according to the established agricultural techniques.

III. RESULT AND DISCUSSION

Taking into account the above, in order to determine the technological modes of cocoon primary processing, during the cocoon season, has been carried out in Silk worm breeding enterprise “Kumush tola” in Kattakurgan district, Samarkand region and Silk technology laboratories of “Silk Technology” chair. The studies were conducted on existing SK-150K units and the newly created live cocoon pupa inactivation devices. For the experiment, Oltin vodiy-2 hybrid alive cocoons, grown in similar conditions, in each economy were divided into equal control and experimental variants.

In the course of the experiments, samples of identical caliber cocoons were sampled for experiment and control, and the thermocouple sensors were measured again and the shell was repeatedly cut, there were installed the proper thermocouple sensors into their corresponding parts (Fig. 2).

At the thermocouple of the 1st cylinder, the second thermocouple was punctured with a needle and inserted into the working chamber of the 3rd thermocouple according to the functional diagram shown in Figure 3.

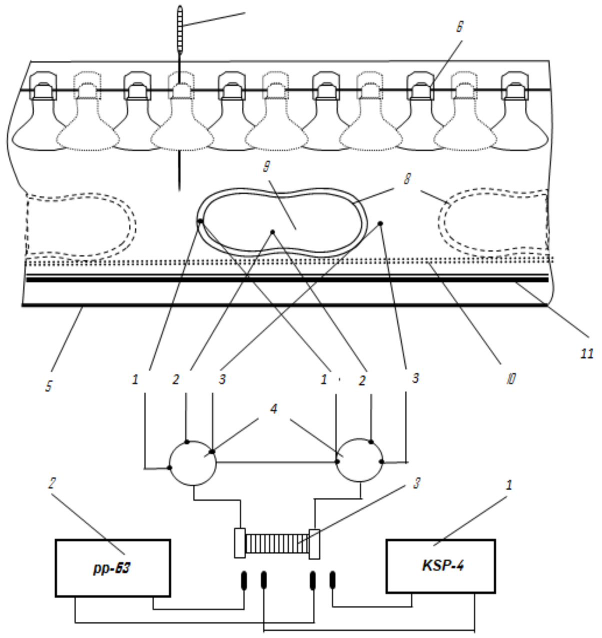


Fig. 2. Functional scheme for determining the temperature changes in the components of living cocoon pupa.

Here: 1-KSP-4-type self-propelled device which transmits temperature change; 2-PP-63-Patentometer with constant current for measuring temperature changes; 3-P2T-7 power switch; 4-10 P4N-coated welding machine; 5-working chamber; 6-Infrared lamp; 7-thermometer; 8-subjected cocoons; 9-pupa in the cocoon; 10-conveyor belt; 11-horizontally located mirror window.

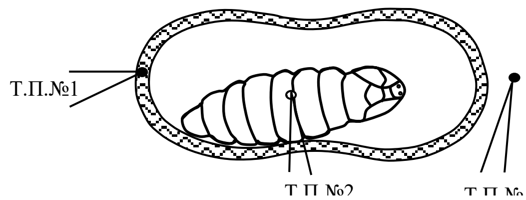


Fig.3. Principal scheme of location of thermocouples into structural pattenrs of alive cocoons.

intervals of cocoon and lamp in 10cm, 15cm, and 20cm, the temperature of their structural patterns were recorded using a specially designed devices [17].

Fig. 4. The adjustment of the distance between the lamp and the cocoon in the process of dehydration of the living cocoon.

Fig. 5. A study of the determination of temperature changes in the components of living cocoon pupa during its inactivation.

Fig.6. The process of detecting the inactivation of the pupa as a result of infrared light treatment of live cocoons.

IV. ANALYSIS OF RESULTS.

During the study, the temperature of the live cocoon pupa, which was grown in spring and repeated seasons, was determined and correlated at different intervals under the influence of infrared light.

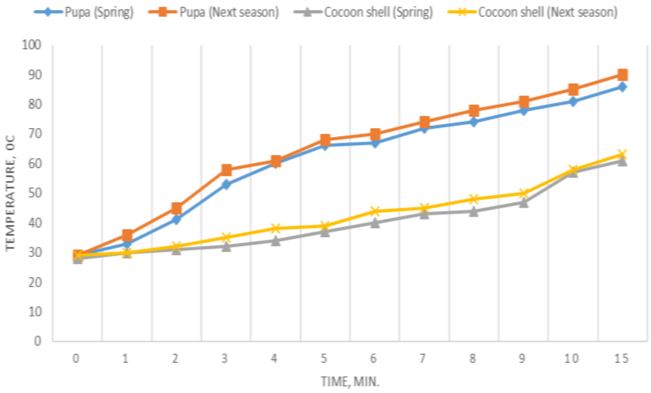


Fig.7. Changes in cocoon shell and bulb temperature when the distance between the cocoon shell and the pupa is 10 cm.

Results obtained in Fig. 7 show that in the infrared light treatment of live cocoon pupa when the distance between the cocoon and the pupa is 10 cm, the temperature of the spring cocoons can be increased to 81^0C in 10 minutes and 57^0C in the next season and 85^0C and 58^0C in the next season. During this time, the difference between the temperature of the pupa and the cocoon shell was 24^0C in the spring, and 27^0C in the cocoon grown in the repeated season.

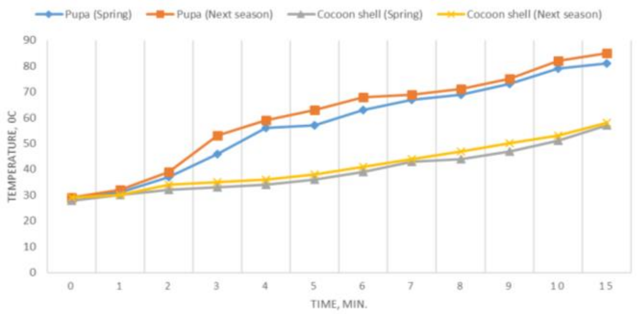


Fig.8. Changes in the temperature of the pupa and cocoon shells when the distance between the cocoon and the lamp is 15 cm.

Results obtained in Fig. 8 show that in the infrared light treatment of live cocoon pupa at 15 cm between the cocoon and the lamp, the temperature of the spring cocoons can be increased to 79^0C in 10 minutes and 51^0C in the seasonal cocoons at 82^0C and 53^0C. During this time, the difference between the temperature of pupa and the cocoon shell was 28^0C in the spring cocoons and 29^0C in the cocoons in the spring.

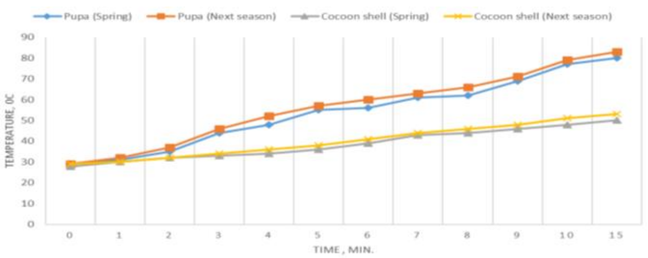


Fig.9. Changes in the temperature of the pupa and cocoon shells when the distance between the cocoon and the lamp is 20 cm.

Results obtained in Figure 9 show that in the infrared light treatment of living cocoons at 20 cm between the cocoon and the lamp, the temperature of the spring cocoons can be increased to 77^0C in 10 minutes, and in the seasonal cocoons at 79^0C and 49^0C. During this time, the difference between the temperature of the pupa and the cocoon shell was 29^0C in the spring cocoons and 30^0C in the seasonal cocoons.

Analysis of the results has shown that infrared light treatment of cocoons can increase the temperature of the pupa by 79^0C in a short period of time, while the cocoon shell temperature is below 27^0C. In addition, during all three variants, cocoon shells and pupa temperatures were higher in the seasonal cocoons than in the spring cocoons. The difference between the cocoons and the lamps of spring pupa was 4^0C, while the temperature of the cocoons was 9^0C. In the cocoons grown in the next season, the rate was 6^0C and 7^0C, respectively. The difference between the temperature of the cocoons grown in the spring during the breeding season is on average 30C, and the difference between the temperature of the cocoon shell is 1.3^0C. This means that cocoons grown in different seasons vary in size of pupa and shell thickness. Therefore, it is necessary to apply special technological regimes for the initial processing of spring and repeated cocoons, which is to activate and dry the cocoons.

V. CONCLUSION

1. The results of applied research have shown that the distance between the cocoon and the lamp depends on the temperature of the cocoon and the temperature supplied by the infrared emitter.
2. Infrared light processing of cocoons shows that in a short period of time the temperature of the pupa can be raised to an average of 79^0C, while the temperature of the cocoon shell is 27^0C.
3. The distances between the cocoon and the lamp were set at 10cm, 15cm and 20cm, while the heating time of the pupa in the cocoons obtained in the spring season was less than in the cocoons obtained in the autumn.
4. The difference between the temperature of the cocoons of the spring season at these distances between the cocoon and the lamp was 4^0C, and the temperature of the cocoon shell was 9^0C. in cocoons grown in subsequent seasons, the difference was 6^0C and 7^0C, respectively.
5. Processing of local cocoon hybrids "Oltin vodiy-2" with short-term infrared radiation ensures the death of the pupa and preserves their high technological performance, which will further improve the efficiency of existing silk industry enterprises.

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Alimova Halimakhon, graduated from the Tashkent Institute of textile and light industry in 1961, doctor of technical Sciences (DSc), Professor of the Department of "Silk technology", Tashkent Institute of textile and light industry. She has published more than 300 scientific papers, including: 5 monographs, 2 textbooks, 48 patents. Currently, she is conducting research on the development of multicomponent yarn with useful properties based on "Silk nanotechnology", developing methods and technologies for the production of new types of silk products.

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