DEVELOPMENT OF ULTRASONIC TECHNOLOGY USING MECHATRONIC SYSTEMS IN THE COCOON REELING PROCESS

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Abstract: This article discusses the application of ultrasonic technology in silk production, which enables acceleration of the silk extraction process and obtaining high-quality silk by rapidly decomposing sericin. The use of mechatronic systems allows automation of the production process and increases efficiency through precise control of water temperature and ultrasonic power.

Keywords: mechatronic systems, sericin softening, energy efficiency, automated control, production efficiency, silk quality, low-temperature processing, advanced technologies.

РАЗРАБОТКА УЛЬТРАЗВУКОВОЙ ТЕХНОЛОГИИ С ИСПОЛЬЗОВАНИЕМ МЕХАТРОННЫХ СИСТЕМ В ПРОЦЕССЕ РАЗМАТЫВАНИЯ КОКОНА

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Аннотация

В данной статье рассматривается применение ультразвуковой технологии в производстве шелка, которая позволяет ускорить процесс получения шелковой нити и обеспечить высокое качество шелка за счёт быстрого разложения серицина. Использование мехатронных систем обеспечивает автоматизацию производственного процесса и повышает эффективность за счёт точного контроля температуры воды и мощности ультразвука.

Ключевые слова: мехатронные системы, размягчение серицина, энергоэффективность, автоматизированный контроль, производственная эффективность, качество шелка, обработка при низких температурах, передовые технологии.

Introduction

In the cocoon reeling process, several important parameters significantly affect process efficiency. These include water temperature, reeling speed, and the frequency and power of ultrasonic воздействия. Proper selection of these parameters makes it possible to convert cocoons into silk threads quickly and efficiently.

Water temperature plays a crucial role in the reeling process. The optimal temperature range is 35–40 °C. At higher temperatures, sericin softens more rapidly, facilitating easier separation of silk fibers. This process can be mathematically expressed by the following equation:

$$R_s = k_1 \cdot T_s^n \quad (1)$$

where:

R_s — sericin softening rate,

T_s — water temperature,

k_1 and n — experimental coefficients defining the effect of temperature on sericin.

As water temperature increases, T_s rises, leading to an increase in the sericin softening rate (R_s). Higher temperatures therefore help soften the cocoon more quickly.

Reeling Speed

Reeling speed also has a significant impact on process efficiency. A speed of **178–182 m/min** is considered optimal for the technological process. As speed increases, the softening of sericin and the separation of silk fibers accelerate. This relationship can be expressed by the following equation:

$$V_c = k_2 \cdot \frac{1}{T_s} \quad (2)$$

where:

- V_c — reeling speed,

- T_s — water temperature,
- k_2 — coefficient describing the relationship between water temperature and reeling speed.

At high reeling speeds with low water temperature, efficiency decreases because sericin does not fully soften.

Frequency and Power of Ultrasonic Action

The frequency and power of ultrasonic exposure cause molecular-level vibrations, which accelerate the softening of sericin and facilitate silk fiber separation. The energy of ultrasonic influence can be expressed mathematically as:

$$E_u = k_3 \cdot f \cdot P_u \quad (3)$$

where:

- E_u — ultrasonic energy,
- f — ultrasonic frequency,
- P_u — ultrasonic power,
- k_3 — coefficient influencing energy transfer.

As frequency and power increase, ultrasonic energy also increases, accelerating the sericin softening process in the cocoon.

In the cocoon reeling process, parameters such as water temperature, reeling speed, and ultrasonic frequency and power are of great importance. Optimization of these parameters using mathematical models enables increased process efficiency and improved energy savings.

Mechatronic System Scheme

The application of mechatronic systems is essential for the automatic control of the cocoon reeling process in silk production.

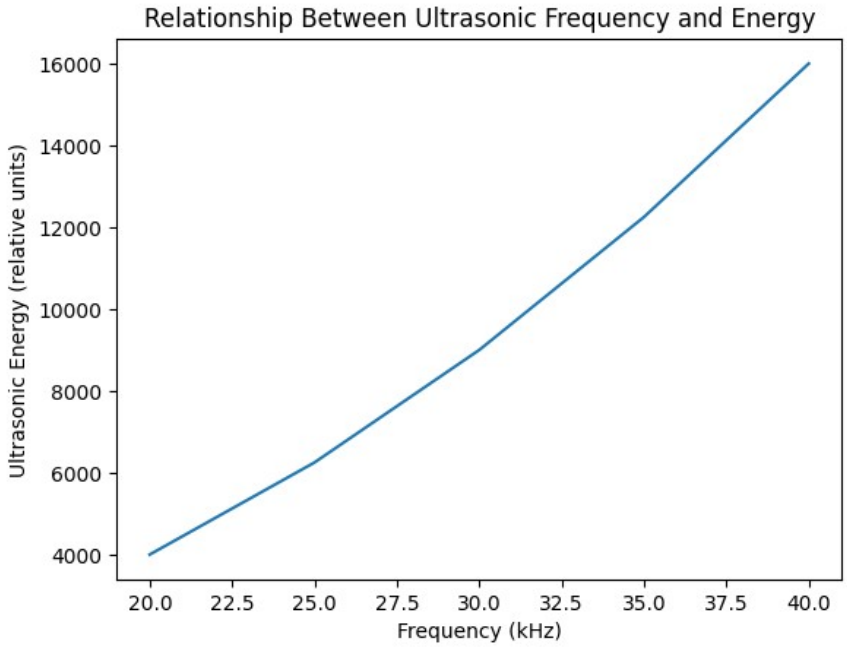

Figure 1. Simplified scheme of the Ultrasonic Frequency and Energy

Such systems precisely and efficiently control water temperature, ultrasonic frequency and power, as well as reeling speed. They enable automation and optimization of the process, which positively affects both energy efficiency and product quality.

Conclusion

The proposed scheme illustrates the operating principle of the mechatronic system: water temperature and ultrasonic frequency sensors transmit data to the controller. Based on this data, the controller manages the process through pumps and power control elements. The system continuously monitors water temperature and ultrasonic frequency, ensuring high efficiency of the reeling process.

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