

DOI: <https://doi.org/10.36719/2789-6919/57/193-198>

Uzeyir Yunuszadeh

Azerbaijan State University of Oil and Industry

PhD student

<https://orcid.org/0009-0005-9950-5328>

uzeyir.yunuszade1999@gmail.com

Technical Analysis and Optimization of the Gearbox for the SB-10 Drying Drum

Abstract

This article focuses on the drying system, a critical stage in the processing of raw cotton, which is a strategic sector in agriculture, and the primary equipment used in this process. Drying is the initial stage in cotton processing, reducing moisture to the required level and preparing the material for subsequent purification and processing steps. The main drying equipment is analyzed in detail, including its structure and operating principles, as it ensures effective moisture removal and impurity separation. The drying drum contains several mechanisms, among which the gearbox plays a key role. Its current design is technically examined, and major operational drawbacks – such as noise, vibration, energy loss, large size and weight, and sensitivity to industrial conditions – are investigated. The study evaluates the role of individual components, including gears and bearings, in the gearbox's operation, considering their advantages and limitations, and identifies criteria for proper component selection. Potential solutions to these issues are explored, and their impact on the gearbox's subsequent performance is assessed.

The research demonstrates that implementing the suggested improvements can reduce noise levels, increase energy efficiency, enhance operational reliability, and extend service life. Furthermore, accurate calculation of design coefficients ensures long-term operation of the drying drum, maintains energy balance, regulates heat and moisture distribution, and ultimately leads to high-quality processed cotton.

Keywords: *drying process, SB-10 drying drum, gearboxes, theoretical calculations, modernization*

Üzeyir Yunuszadə

Azərbaycan Dövlət Neft və Sənaye Universiteti

doktorant

<https://orcid.org/0009-0005-9950-5328>

uzeyir.yunuszade1999@gmail.com

SB-10 tipli quruducu baraban üçün reduktorun texniki təhlili və optimallaşdırılması

Xülasə

Məqalədə kənd təsərrüfatında strateji sahələrdən olan xam-pambığın emal prosesinin əsas mərhələlərindən olan qurudulma sistemindən və bu işi aparan əsas avadanlığa diqqət yetirilir, buna səbəb emaldan alınan məhsulların sənayenin bir çox yerlərində tətbiqinə ehtiyac duyulur. Xam-pambığın emalı prosesində ilkin mərhələ qurudulma prosesidir, bu rejimdə tətbiq edilən əsas quruducu avadanlıq detallı formada (quruluşu, işləmə prinsipi) analiz edilir, çünki bu qurğu xam-pambığın nəmliyinin tələb olunan səviyyəyə gətirilib, tərkibində olan zibillərdən təmizlənməsi üçün digər mərhələyə yönləndirilir.

Quruducu cihazda bir çox mexanizmlər mövcud olub, əsas mexanizmlərindən biri olan quruducu barabanın reduktorunun mövcud konstruksiyası texniki baxımdan təhlil edilmiş və istismar zamanı yaranan əsas çatışmazlıqlar (səs-küy, vibrasiya, enerji itkisi, böyük ölçü və çəki, sənaye mühitinə həssaslıq) araşdırılmışdır. Bu mexanizm avadanlığın davamlı və etibarlı olaraq işləməsində mühümdür. Reduktoru təşkil edən hissələrin (dişli çarxlar, yastıqlar və s.) onun işləmə prinsipindəki rolu, mənfi və müsbət tərəflərinə baxılır və bu hissələrin düzgün seçilməsində bir sıra parametrlərə və şərtlərə fikir verilir. Yarana biləcək problemlərin həlli yolu üçün bir sıra təbiiqlərə nəzər yetirilir və bu həll üsullarının reduktorun daha sonra işləməsində ola biləcək təsirlərə baxılır. Ümumilikdə aparılan tədqiqat göstərir ki, təklif edilən dəyişikliklərin tətbiqi reduktorun səs-küy səviyyəsinin azalmasına, enerji səmərəliliyinin yüksəlməsinə, istismar etibarlılığının və xidmət müddətinin artırılmasına şərait yaradır, bundan əlavə hesablamalarda tələb olunan əmsallar avadanlıq üçün dəqiq hesablanarsa, quruducu barabanın daha uzunmüddətli işləməsi təmin edilər, enerji balansını tənzimləyər, istilik mübadiləsi nəmlik üçün müntəzəm nizamlanar və sonda keyfiyyətli məhsul əldə olunar.

Açar sözlər: qurutma prosesi, SB-10 quruducu baraban, reduktorlar, nəzəri hesablamalar, modernləşdirmə

Introduction

When raw cotton enters processing, its moisture content is usually 15-25%, which must be reduced to around 8-10% for high-quality products. Drying is one of the most energy-intensive and critical stages in cotton processing. Both mechanical and thermal energy are applied to remove excess moisture, with mechanical power transmitted to components such as the drum, conveyors, and fans. Gearbox transmission systems are essential in this context, ensuring the coordinated motion of all components and maintaining uniform heat and mass transfer (Rakhmonov & Fayziev, 2020). Proper selection and adaptation of these mechanisms significantly enhance the energy efficiency, reliability, and effectiveness of the drying process (Ismayilov, 2019). Various equipment types are used for drying raw cotton, generally consisting of a rotating cylindrical drum, drive mechanism, and support structure. Dryers are typically classified as drum-type, vertical, or belt-type, with drum-type being the most common due to higher productivity, uniform drying, energy efficiency, and ease of maintenance. Among these, the 2SB-10 drying unit (Figure 1) is widely applied in industrial cotton processing (Gulyaev, 2017; Jamolov et al., 2020; Jamolov & Shodmonkulov, 2022). Its operation involves feeding material into the drum, where it is lifted by internal flights and exposed to hot air. The heat evaporates the moisture, achieving the desired level, after which the material proceeds to the next stage of processing.



Figure 1. Drying equipment (2SB-10)

Drying equipment is generally equipped with six main mechanisms:

- Gas burner (burner unit) – generates the hot air flow required for the drying process;
- Drum – one of the principal components where the drying process takes place;
- Fan or ventilation system – ensures the controlled circulation of hot air inside the system;
- Belt drive and gearbox systems – transmit motion from the motor to the drum;
- Sensors – regulate temperature and moisture levels during the drying process;
- Filtration unit – removes fine impurities contained in the cotton.

The main technical specifications of the SB-10 drying drum are presented in

Table 1. Main parameters of the SB-10 drying unit.

| No | Parameter | Unit | Value |
|----|----------------------------|------|-------|
| 1 | Drum diameter | Mm | 3200 |
| 2 | Drum length | Mm | 13000 |
| 3 | Rotational speed | Rpm | 10 |
| 4 | Maximum drying temperature | °C | 250 |
| 5 | Total capacity | kg/h | 700 |

It should be noted that these values may vary for other types of drying equipment depending on process requirements. However, for the SB-10 drying system, these parameters are considered standard and fundamental (Rahimov, 2022).

Research

A gearbox is primarily a mechanical system designed to transmit rotational motion through various mechanisms. In general, its main function is to reduce angular velocity while simultaneously increasing torque. In drying drums, the gearbox operates as an integral part of the transmission system, ensuring the continuous and stable operation of the equipment. Within such systems, gearboxes are typically installed in two possible configurations: either after the belt transmission or directly between the motor and the drum (Figure 2) (Gulyaev, 2017; Norton, 1999; Budynas & Nisbett, 2015).

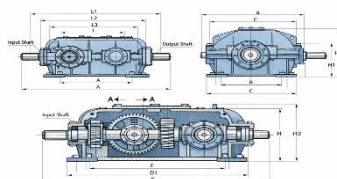


Figure 2. Gearbox of the 2SB-10 Drying Drum

Here, L denotes the length; A, B, and C represent the width parameters; and H indicates the height. The main functions of the gearbox in this process are as follows:

- To reduce the high rotational speed generated by the motor;
- To increase the torque required for the process;
- To minimize energy losses and suppress vibrations during operation.

It should be noted that, in the SB-10 drying drum, the gearbox is used to rotate the heavy cylindrical drum continuously and uniformly at the required speed. This directly affects both the drying time and the quality of the final product (Budynas & Nisbett, 2015).

As can be seen from the technical drawing, the gearbox consists of six main components, each performing a specific function:

1. Input shaft – receives rotational energy from the motor and transfers motion to the gear system, as the motor operates at high speed.
2. Output shaft – transmits the increased torque to the drum, initiating its rotation. At this stage, speed decreases while torque increases.
3. Gears – may be spur or helical; their primary function is to reduce rotational speed and amplify torque.
4. Housing – encloses all gearbox components and protects internal parts, particularly gears, from dust and moisture present in the working environment.
5. Bearings – support both input and output shafts, ensuring stable and accurate rotation.

6. Lubrication system – provides lubrication to critical components such as gears and bearings, reducing friction and facilitating uniform heat dissipation.

The operating principle of the gearbox in drying equipment follows a sequential process. Initially, the motor rotates the input shaft of the gearbox. The input shaft then drives the internal gear system. During this transmission, rotational speed is reduced while torque is increased. The amplified torque is subsequently transmitted to the output shaft, causing the drum to rotate. This rotation ensures uniform heat distribution within the drum and contributes to efficient drying of the material (Norton, 1999; Rahimov, 2022).

Gearbox systems used in drying processes exhibit both advantages and disadvantages, which in turn reveal certain limitations of the system.

Advantages:

1. High torque transmission – as rotational speed decreases within the gearbox, torque increases, enabling stable rotation of the drum.
2. Speed regulation – when the motor operates at high speed, the gearbox ensures a controlled and constant rotational speed of the drum.
3. Durability and reliability – with proper selection of gears and bearings, the equipment can operate efficiently over an extended period.
4. Low maintenance requirements – the use of robust housing materials and timely lubrication contributes to the long service life of gear components.
5. Stable and safe operation – ensures uniform heat distribution and improves the overall effectiveness of the drying process.

Disadvantages:

1. High initial cost – gearboxes used in industrial drying systems are relatively expensive, and their installation also involves significant costs.
2. Large size and weight – gearboxes are typically heavy and bulky, which complicates installation and maintenance procedures.
3. Noise generation – due to high torque transmission and gear interaction, considerable noise may occur during operation.
4. Energy losses – minor energy losses are inevitable during the drying process.
5. Sensitivity to industrial environment – high temperatures, dust, humidity, and harsh operating conditions can negatively affect the performance and service life of the gearbox (Geareducer Repair Manual SERIES 22.2/22.3).

The primary parameters characterizing a gearbox are the transmission ratio, torque, and rotational speed.

The transmission ratio of the gearbox is defined as:

$$i_r = \frac{n_{in}}{n_{out}}$$

The increase in torque is expressed as:

$$M_{out} = M_{in} \cdot i_r \cdot \eta_r$$

where

η_r – represents the efficiency of the gearbox (typically within the range of 0.92–0.97) (Reduktor IQ2Y-355H i 1IQ2Y-355H, n.d.).

To eliminate the identified drawbacks in the gearbox of the SB-10 drying drum, several design improvements should be considered.

One of the main issues is the reduction of noise and vibration. This problem primarily arises from the interaction of gear teeth under high torque conditions. In this regard, replacing spur gears with helical gears can significantly reduce noise levels, as helical gears provide smoother engagement.

Regarding energy losses, the key factor is friction reduction (Leyu et al., 2023). Applying specialized surface coatings (e.g., nitrided coatings) to gear teeth and ensuring effective lubrication can substantially minimize energy losses. Another critical issue is the large size and complexity of gearbox installation (Repairing Gears, 2022). Designing the gearbox in a modular configuration would allow individual components to be assembled separately, simplifying maintenance and installation procedures. Furthermore, the use of lightweight materials such as aluminum alloys or advanced polymer composites for certain components can reduce overall weight.

The implementation of these improvements would decrease operational interruptions in the gearbox system and ensure more reliable performance of the equipment. As a result, product quality would improve, while maintenance and operational costs would be reduced (Budynas & Nisbett, 2015).

Conclusion

As discussed above, the negative factors associated with gearbox operation directly influence the performance of the equipment. This, in turn, may lead to delays in the processing stage and a reduction in product quality. If the necessary design considerations are properly addressed and an optimized gearbox is developed, both the service life of the equipment and the efficiency of the processing operation can be significantly improved.

The obtained results indicate that:

1. Heat generated during the drying process is distributed more uniformly and consistently;
2. Energy consumption is minimized;
3. Mechanical reliability and durability of the drying equipment are enhanced;
4. The overall quality of the final product is improved.

In addition, gearbox calculations must be carefully considered during the design phase, particularly in relation to its interaction with other components of the drying system, such as the belt drive. Key parameters – including motor power, torque, transmission ratios, and energy losses – should be comprehensively determined. This is important because, during operation and especially under heavy load conditions, stress concentrations may occur within the gearbox. Excessive loading can lead to wear or even failure of gear elements. Therefore, detailed engineering calculations are essential during the design process.

References

1. Budynas, R.G. & Nisbett, J.K. (2015). *Mechanical Engineering Design (tenth edition)*.
2. *Geareducer Repair Manual SERIES*. (2022). Handbook.
3. Gulyaev, R.A. (2017). Advanced Equipment and Technology of Primary Processing of Cotton and Estimation of its Quality. *International Journal*, 2–5.
4. Ismayilov, E. (2019). *Ways to increase the energy efficiency of cotton processing equipment*. Elm.
5. Jamolov, R. et al. (2020). *Development of resource-saving drying technology and its implementation in production*. NTO, Paxtasanoatilmiy-markazi (cotton industry scientific center) JSC.
6. Jamolov, R.K., Shodmonkulov, A.M. (2022). Improvement of the Drive of the Dryer 2SB-10 in order to Reduce its Energy Consumption. *American Journal of Interdisciplinary Research and Development*, 64–67.
7. Leyu, W., Xinmeng, L., Yang, J., Shangguan, L., Wang, X., Mao, J. (2023). Failure analysis and optimization design of suspension support holes for gearbox cases. *Journal of theoretical and applied mechanics*, 61(3), 533–544.
8. Norton, R.L. (1999). *Design of Machinery (an introduction to the synthesis and analysis of mechanisms and machines)*. Worcester Polytechnic Institute Worcester.
9. Rahimov, T. (2022). Application of gearboxes and belt drives in cotton drying machines. *Journal of Technical Sciences*, 4(2), 56–63.

10. Rakhmonov, K. & Fayziev, S. (2020). Study of Effect of Speed and Temperature of the Drying. *International Journal of Emerging Trends in Engineering Research*, 8(10), 7008–7013.
11. *Repairing Gears*. (2022, 17 iyun). <https://illinoispulleyandgear.com/blogs/blog/repairing-gears>
12. *Reduktor U2V-355H i 1U2V-355Hmym*. (n.d.). <https://slemz.com.ua/reduktory/cylindricheskie/reductor-c2y/reductor-c2u-355n>

Daxil oldu: 04.01.2026

Qəbul edildi: 07.04.2026