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Design And Verification Of The Strength Level Of The Proposed New Type Of Columns

Tokhirova Maftuna Umidjon kizi
Doctoral student of Namangan State Technical University, Namangan, Uzbekistan
Salomova Mashkhura Arabboy qizi
PhD, Namangan State Technical University, Namangan, Uzbekistan
Muradov Rustam Muradovich
Professor, Namangan State Technical University, Namangan, Uzbekistan

Abstract
In the article, work was carried out on improving the grate, which is the main part of cleaning machines used to separate impurities from cotton during the primary processing of cotton, and design and strength calculations were carried out using modern programs. According to the design results, the proposed hexagonal grate bars can be used in practice, i.e., they fully meet the requirements for strength and durability. As a result, the introduction of such structures into production not only increases the efficiency of cleaning devices but also ensures their reliability.
Keywords: cotton, fibre, seed, lint, cleaner, stove, mesh surface, pipe.

Introduction

Studies conducted in the small impurity cleaning section of the UHK unit showed that the raw cotton caught by the spikes of the spiked drum hits the surface of the grate bars and, at the same time, moves along their surface, as a result of which small impurities are released and fall into a special bunker for impurities. An in-depth study of this process showed that the geometric shape, surface structure, and movement mechanism of the grate bars involved in cotton cleaning directly affect the cleaning efficiency. As a result of practical research, it was established that these factors significantly influence the quality of the cleaning process. Therefore, special attention was paid to the role of rotating hexagonal grate bars of the proposed new design in increasing cleaning efficiency.

Materials and methods

Taking into account the influence of various forces during the cleaning process, carried out with the help of these grates, i.e., the impact, pressure, and traction of raw cotton, their structure was designed and strength calculations were performed. These design and computational works were carried out using modern computer technologies, in particular, using the Simulation module of the SolidWorks program. High-strength alloy stainless steel was chosen as the material for the grate bars, and the forces acting on it were calculated. The influence of forces arising during the collision of raw cotton caught by the spiked drum with rotating grates was modelled separately. The productivity of the cleaning device was assumed to be 7.0 tons/hour for cotton of grades I and II, and 5.0 tons/hour for cotton of grades III, IV, and V, and the amount of force applied to the rotating grate bars was theoretically calculated as F = 100 N.

Considering that the new rotating grate bars are hexagonal with a total diameter of 18 mm, the grate base is made of a solid material with a diameter of 17.5 mm, the height of the edges is 0.5 mm, and the total number of edges is 6, based on the forces acting on it, its displacement, mechanical stress, deformation, and safety factor were determined.

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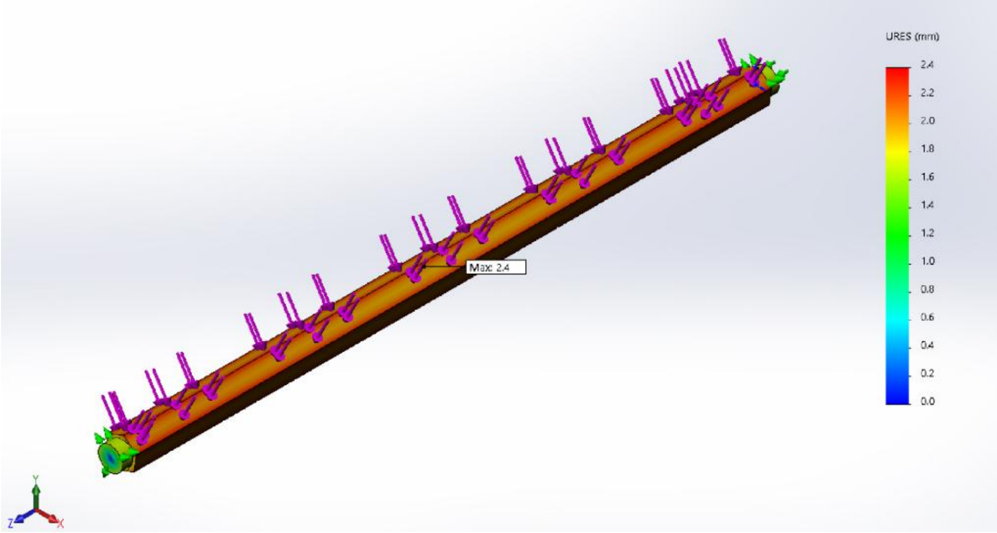

Figure 1. Displacement due to the force acting on hexagonal rotating grates

The strength and deformation properties of the proposed hexagonal grate bars were analyzed using the SolidWorks Simulation module. In this modelling process, an external force F was applied to the grates, and as a result, their deformation, i.e., displacement states, were determined. The analysis results were expressed using colours, which allows one to clearly see the degree of deformation. According to the results obtained during modelling, the maximum displacement was observed in the areas depicted in red, and its value was determined to be equal to 2.4 mm. This is the part of the grate that moves the most under the influence of force. This maximum displacement occurs mainly in the part of the grate bars fixed to the body of the UHK unit.

On the contrary, the minimal displacements were depicted in blue, and almost no deformation was observed in these areas. According to the modelling results, the displacement value in these areas is equal to 0 mm, which means that they are used as relatively stable, stationary points. Also, the average displacements formed on other parts of the grate surface are shown in green. These values represent the real deformation zone of the grate in the working state. These colour indicators (gradient) clearly show the degree of displacement under the action of force at each point of the device, which allows one to form a complete picture of the overall mechanical stability of the structure (Fig. 1).

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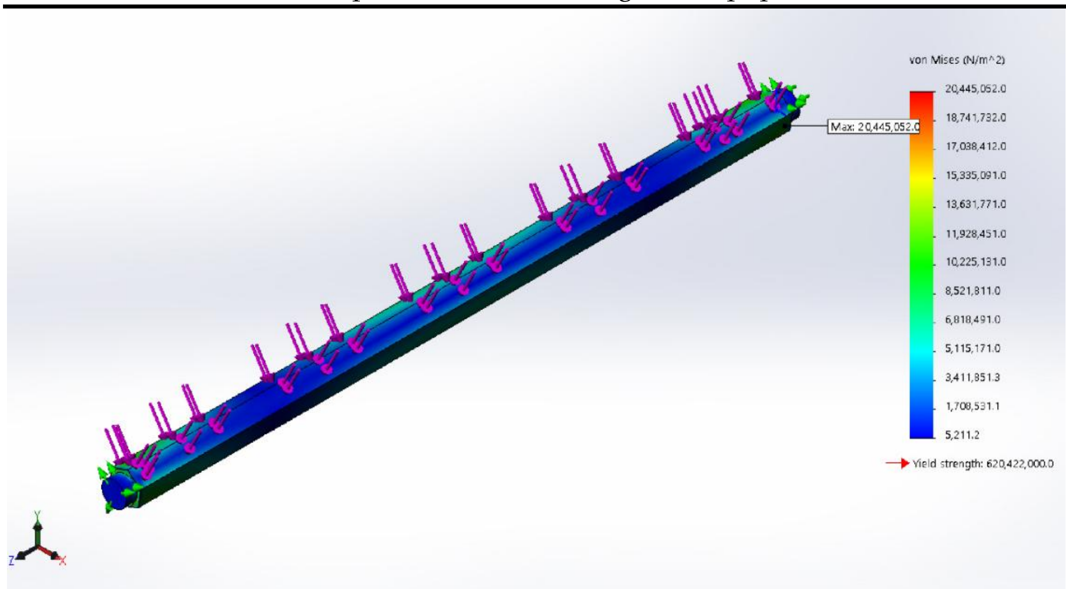

Figure 2. Mechanical stress arising from the force acting on hexagonal rotating grates

These analyses show that hexagonal grates undergo deformation within specified limits even under high loads, and these deformations are at a safe level, which does not have a serious negative impact on the operation of the structure. As a result, the possibility of reliable operation of this type of grate in real conditions was scientifically substantiated.

As a result of the modelling analysis conducted using the SolidWorks Simulation module, the mechanical stress states arising on the surfaces of the proposed hexagonal rotating grates when an external force F is applied were determined. These stresses are the main cause of deformations and are an important indicator in assessing the strength and reliability of the material. The simulation results were represented graphically - by colour. Calculations showed that the maximum mechanical stress of the grate bars is equal to 20.44 N/mm2, which is located in the middle part of the hexagonal grate bars.

These areas are marked in red on the graph and are considered the highest-risk zones in terms of stress. This means that the middle part is the one that receives more external loads and accumulates stress. On the contrary, the areas of the grate bars that are least susceptible to deformation are depicted in blue, which indicates the minimum degree of mechanical stress. It was established that these minimum stresses were observed on the outer surface of the grate bars with a large diameter. Due to the fact that the load was less effective in these areas, the voltage was practically zero. Also, in the remaining parts of the grate surface, the stress values are moderate, which are depicted in the colour gradient in the range from yellow to green. (Fig. 2). Based on these analyses, it can be concluded that the design of hexagonal rotating grates is sufficiently resistant to external loads, and the critical level of mechanical stress does not exceed the permissible limits of the material. Consequently, such grate bars can serve for a long time in real production conditions and operate with high efficiency. This is an important technical basis necessary for the practical implementation of the improved form of the structure.

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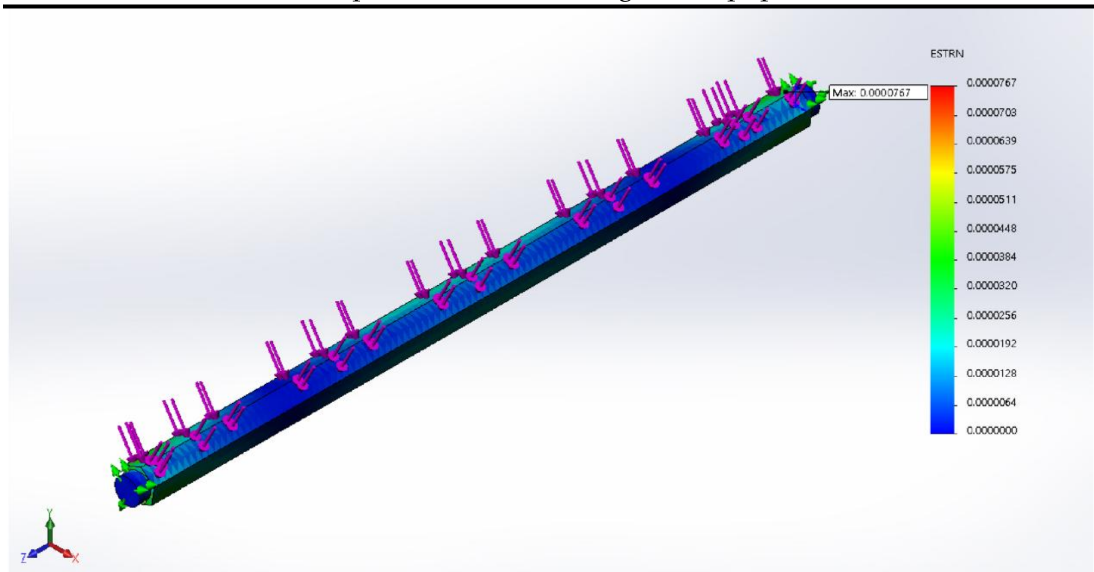

Figure 3. Deformation caused by the force acting on hexagonal rotating grates

In the next analytical work, conducted using the Simulation module of the SolidWorks program, the deformation states arising under the influence of external forces on the surface of the proposed hexagonal grate bars were studied in depth. In this process, it was modelled and assessed what elastic deformations the grate bars undergo under working conditions, i.e., how much the structure bends or shifts. According to the simulation results, the state of maximum deformation was observed precisely on the surface of the hexagonal grate bars, and the value of this deformation was determined to be equal to 0.00007 mm. This value indicates that the strength of the grates is high, and the degree of their deformation is very small, i.e., practically insignificant from a practical point of view.

This deformation is shown on the graph by the red colour, which indicates the zone of greatest force. At the same time, it was established that in other parts of the grate bars, deformations are absent or at an absolutely minimal level. Especially on surfaces depicted in blue, the deformation value is equal to 0 mm, and these areas serve as static points completely protected from force or not subjected to bending. This indicator means that the structural design of the grate is optimally designed - that is, the stresses and deformations are distributed correctly when necessary. In general, this analysis confirms the high mechanical and deformation stability of the proposed hexagonal grate bars. This makes it possible to use them effectively and reliably in the technological processes of cotton cleaning.

In the design work, the loads acting on the surface of the proposed hexagonal grate bars, i.e., mechanical stresses arising under the action of external forces, were analyzed. In this case, in order to assess the deformation resistance and stability of the grate bars, their safety factor was calculated. As a result of calculations, the safety factor of the grate bars was 30.3 units (Fig. 4). This indicator means that they have a very high level of structural reliability. In other words, grate bars provide a safety level of about 30 times the maximum working forces arising during operation.

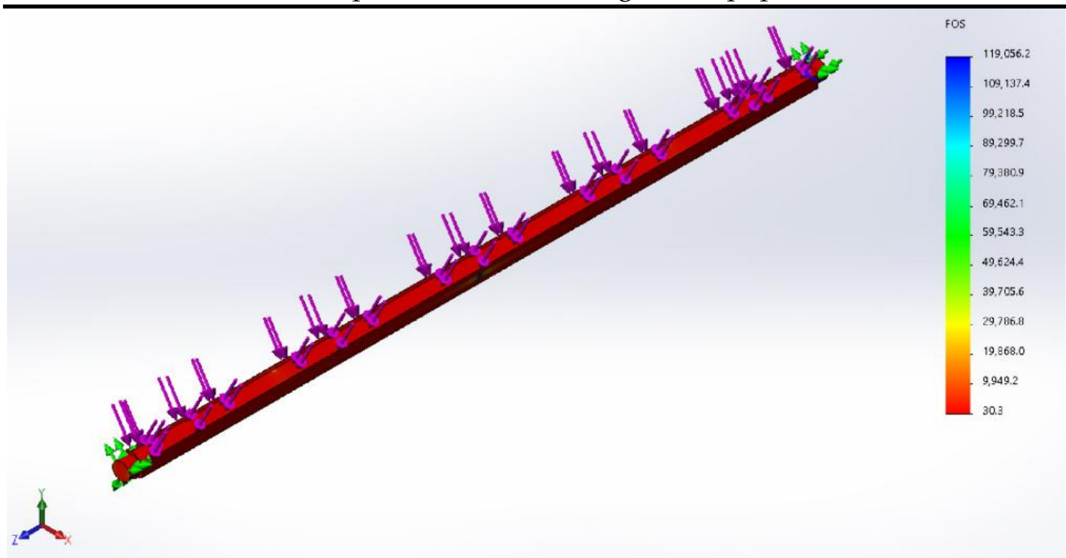

Figure 4. Safety factor of hexagonal rotating grates as a result of the force acting on them

Conclusion

The proposed hexagonal grate bars show that they can be used in practice, that is, they fully meet the requirements for strength and durability. As a result, the introduction of such structures into production not only increases the efficiency of cleaning devices but also ensures their reliability.

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