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# Enhancing Conveyor Belt Performance: Evaluating the Impact of Increased Capacity Using Belt Analyst Software

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**Abstract**

This study investigates the effects of increasing conveyor belt capacity from 148.5 tons per hour (t/h) to 180 t/h on the overall system performance, employing both manual measurements and simulations using Belt Analyst software. The research aims to evaluate critical parameters such as effective pulling force, motor power requirements, structural load, and belt deflection, which are essential for determining the feasibility and impact of such an upgrade. The analysis reveals that with the capacity increase, the effective pulling force required rises to 14,072 N, while the motor power usage escalates to 15 kW. Concurrently, the structural load experiences a significant increase from 46.144 kg/m to 56.238 kg/m, and belt deflection intensifies from 22 mm to 27 mm. These findings suggest that increasing the conveyor belt capacity to 180 t/h, may lead to increased stress on the structure and belt, which could potentially affect the lifespan and performance of the conveyor system. Furthermore, while the conveyor system's performance enhances at the higher capacity, it also places additional stress on the system's components. The study further examines the implications of these changes, emphasizing the potential risks to the conveyor belt's structural integrity and the possible reduction in its lifespan due to the increased mechanical stress. It is highlighted that careful consideration and precise engineering adjustments are necessary when planning capacity enhancements to avoid adverse effects on the system's longevity and reliability.

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## 1. Introduction

Conveyor belts play a critical role in the production processes of various heavy industries, such as steel, fertilizer, chemical, and cement manufacturing. These industries rely heavily on conveyor systems to transport bulk materials efficiently from one location to another, making them indispensable for maintaining continuous operations. In construction projects, conveyor belts are also essential for material handling, ensuring that resources are moved smoothly and reliably across the site.

A typical conveyor system consists of two pulleys that loop continuously over a belt, which carries the material along a defined path. This belt is supported by a series of rollers that maintain its stability and alignment [1]. The performance of conveyor belts in bulk material handling is crucial for optimizing production capacity, as even minor inefficiencies can lead to significant operational delays and increased costs.

The use of advanced software tools, such as Belt Analyst, has revolutionized the analysis and simulation of conveyor systems [2]. These tools enable detailed examination of the system's performance, allowing for precise adjustments that can lead to significant improvements in both efficiency and reliability. Understanding the mechanical properties of the materials used in conveyor belts, particularly the rubbers, is vital for ensuring smooth operation. These properties influence key factors such as friction between the belt and driving drum, which in turn affects power consumption and overall system efficiency [3], [4].

One of the primary challenges in conveyor belt operations is managing material flowability to prevent spillage, which can disrupt production and create environmental concerns. Modeling and simulation are essential for addressing these challenges, as they allow for the virtual testing of

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dynamic performance under various conditions. For instance, virtual prototyping can help engineers identify potential issues in material transfer and optimize the conveyor design before physical implementation, thereby reducing design cycles and development costs [5].

Moreover, the capacity of a conveyor belt is directly influenced by its geometrical configuration and the load it carries [6]. Research indicates that maintaining conveyor belt operation at less than 80% of its capacity is crucial for ensuring durability and long-term performance [7]. Dynamic analysis tools are indispensable for modernizing conveyor systems to accommodate larger loads and higher speeds while maintaining operational stability.

The use of Belt Analyst software for simulating belt conveyor systems is well-documented in the literature, particularly regarding its application in dynamic analysis and design optimization. conducted a dynamic analysis of an inclined belt conveyor system using Belt Analyst, focusing on improving reliability and design levels within the detergent industry. Their findings underscore the software's capability to enhance the performance of conveyor systems through detailed dynamic modeling [8]. Similarly, emphasizes the necessity of dynamic analysis in large belt conveyor operations, noting that such analysis is complex and requires specialized software like Belt Analyst to achieve accurate results [9]. This highlights the importance of using advanced simulation tools to ensure operational efficiency and reliability in conveyor systems.

One of the primary concerns in conveyor belt operations is the control of material flowability to prevent spillage, which can disrupt production and lead to environmental issues. emphasize the importance of modeling and simulation in managing coal flowability to mitigate spillage and enhance conveyor performance [10]. This aligns with the findings of Du et al., who advocate for the use of virtual prototyping to analyze the dynamic performance of belt conveyors, thereby reducing design cycles and development costs [11]. Such virtual modeling techniques enable engineers to identify potential issues in material transfer and optimize the design before physical implementation. Moreover, the capacity of a conveyor belt can be directly influenced by its geometrical configuration and the actual load it carries. Research indicates that maintaining the operational capacity of a conveyor belt below 80% is crucial for ensuring durability and performance [12]. This is supported by Guo & Wang, who discuss the advantages of belt conveyors in terms of conveying capacity and operational stability [13]. The integration of dynamic analysis tools, as highlighted by Feng et al., is essential for modernizing conveyor systems to handle larger loads and higher speeds effectively [14].

In addition to performance optimization, the detection and management of conveyor belt failures, such as longitudinal tears, are critical for maintaining operational efficiency. Advanced detection methods, like multispectral visual techniques, enhance the identification of such failures, significantly reducing downtime and repair costs. This is particularly relevant in industries such as coal mining, where conveyor belts are integral to production.

This study aims to analyze the performance of a conveyor belt system under increased capacity, focusing on key parameters such as effective pulling force, motor power consumption, belt tension, deflection, and structural loads. As industries strive to increase production, understanding the capabilities and limitations of their conveyor systems becomes essential for ensuring sustained operational efficiency.

**Figure 1.** The conveyor belt system analyzed in this study, with a total length of 223 meters and a belt width of 750 mm

## 2. Methods

To meet the increased production demands, the conveyor system's capacity needs to be upgraded from 148.5 tons per hour (t/h) to 180 t/h. The following are the specifications and requirements for the conveyor system:

- **Conveyor Belt Length**: The total length of the conveyor belt is 223 meters, which ensures the system can cover the required distance for material transportation.
- **Belt Width**: The width of the conveyor belt is 750 mm, which is suitable for handling the specified material load.
- **Displacement Distance**: The horizontal distance covered by the conveyor system is 101 meters, indicating the span of material movement from the loading to the unloading point.
- **Height Difference**: The vertical elevation change in the conveyor path is 19.4 meters, requiring the system to lift the material over this height.
- **Idler Configuration**: The conveyor system uses a 3-roller-idler configuration for the carry side and a 1-roller-idler configuration for the return side. This configuration is critical for supporting the belt and maintaining stability under load.
- **Angle of Repose**: The angle of repose for the material is 30°, which is important for understanding how the material will settle on the belt and affects the load distribution.
- **Angle of Surcharge**: The angle of surcharge is set at 25°, reflecting the angle at which the material naturally rests when loaded on the conveyor belt.
- **Idler Spacing**: The distance between consecutive idlers is 1.3 meters, which is optimized for balancing support and minimizing belt sag.
- **Motor Power**: The actual motor power used is 22 kW, which drives the conveyor belt and ensures consistent material movement.
- **Belt Speed**: The conveyor belt operates at a speed of 0.9 m/s, which is calibrated to balance throughput with system stability.
- **Maximum Belt Tension**: The maximum tension experienced by the belt is 29,302 N, a critical parameter for assessing the belt's durability under increased load conditions.
- **Transported Material**: The material being transported is limestone, with a density of 1,442 kg/m$^3$. This density affects both the load on the conveyor belt and the required energy for transportation.

### *2.1. Calculation*

To assess the impact of increasing the conveyor capacity from 148.5 tons per hour (t/h) to 180 t/h, specific calculations were conducted to determine the effective tensile force and material weight. These parameters are critical for understanding the stress on the conveyor system under the new operating conditions.

The effective tensile force, which represents the force required to move the conveyor belt and the material, and the material weight per unit length of the conveyor were calculated using the following equation [15].

$$F_e = W_m \times H + 0.04\,(2 \times W_b + W_m) \times L \quad (1)$$

$$W_m = \frac{Q}{V} \quad (2)$$

where:

$F_e$ : Effective tensile force (N)
$W_m$ : Material weight per unit length (Kg/m)
$Q$ : Conveyor capacity (t/h)
$V$ : Belt speed (fpm)
$W_b$ : Belt weight (Kg/m)
$L$ : Displacement distance (m)
$H$ : Altitude difference (m)

### *2.2. Belt deflection measurement*

Belt deflection was measured manually to evaluate the degree of bending that occurs under different load conditions. Measurements were conducted under three specific scenarios: no-load conditions, a load capacity of 148.5 tons per hour, and a load capacity of 180 tons per hour. This method allows for a direct comparison of the belt's behavior as the load increases, providing crucial data for assessing the structural integrity and durability of the conveyor system under varying operational stresses.

### *2.3. Simulation using Belt Analyst software*

To comprehensively analyze the conveyor system's performance and structural integrity when operating at increased capacity, simulations were carried out using Belt Analyst 16 software. This software automates the calculations for essential parameters such as structural strength, dynamic load, belt tension, and motor power [16]. As parameters are adjusted, the software dynamically recalculates associated values, ensuring a thorough and accurate analysis of the system's performance. The simulation process using Belt Analyst 16 software was carried out in the following steps:

1. **Basic Conveyor Specifications:** Initial data entered into the software included a belt width of 750 mm, an operational belt speed of 0.9 m/s, and a material capacity of 180 tons per hour. The material handled was limestone, characterized by a surcharge angle of 25°.
2. **Conveyor System Components:** The simulation modeled the system with carry idlers configured in a 3-roller arrangement, set at a 35° angle. The idlers were spaced 1.3 meters apart, necessitating approximately 79 carry idlers to adequately support the conveyor belt along its length. The return side of the conveyor employed a 1-roller configuration, with idlers spaced 3 meters apart, requiring around 29 return idlers in total.
3. **Motor Power:** The motor utilized in the simulation was specified with a power output of 22 kW and an efficiency rating of 0.92. This input is critical for determining the energy requirements of the conveyor system under the simulated load conditions.
4. **Pulleys:** The pulley setup included the drive (head) pulley, tail pulley, bend pulley, and take-up pulley. These components were modeled based on their roles in maintaining the belt's movement and tension.
5. **Belt Specifications:** The belt used in the simulation was modeled with a steel carcass, featuring covers each with a thickness of 6.4 mm. These details are essential for assessing the belt's strength and durability under increased operational loads.

**Table 1.** Specification data input

| Input Parameters | Values |
|---|---|
| Width (mm) | 750 |
| Speed (m/s) | 0.9 |
| Load (mtph) | 180 |
| Ambient Temperature (°C) | 30 |

**Table 2.** Material data input

| Description | Values |
|---|---|
| Material Type | Limestone Crushed |
| Material Density (kg/m$^3$) | 1442 |
| Surcharge Angle (degrees) | 25 |
| Maximum Area (m$^2$) | 0.095 |
| CEMA Area Available (m$^2$) | 0.063 |
| Actual Area (m$^2$) | 0.039 |
| Percent Loaded (%) | 61 |
| Material Weight (kg/m) | 55.5 |
| Edge Distance (mm) | 120 |
| Bed Depth (mm) | 109 |
| Lump Size (mm) | 100 |
| Chute Drop (m) | 3 |
| Impact Energy (N-m) | 53 |
| Stopping Length (m) | 0.7 |
| Stopping Discharge (kg) | 31 |

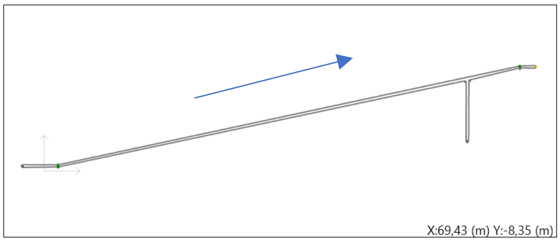


**Figure 2.** Conveyor belt profile

**Table 3.** Idler's data input to the software

| Parameter | Carry Default | Return Default |
|---|---|---|
| Idler Name | Carry | Return |
| Specification | DIN-6200 | DIN-6200 |
| Description | 6204-102-3 | 6204-102-1 |
| Type | Fixed | Fixed |
| Estimated No of Idlers | 79 | 29 |
| For Belt Width (mm) | 800 | 800 |
| No of Rolls | 3 | 1 |
| Angle (degrees) | 35° | 0° |
| Bearing Type | Ball | Ball |
| Roll Diameter (mm) | 102 | 102 |
| Roll Material | Steel | Steel |
| Rotating Weight (kg) | 8.7 | 7.5 |
| Load Rating (N) | 3237 | 1028 |
| Max Actual Load (N) | 897 | 437 |
| Max Calc. Idler Load - CIL (N) | 1007 | 486 |
| RPM | 169 | 169 |
| Min L10 Life (Hr) | 1,968,684 | 1,364,828 |
| L10 Average (Hr) | 2,004,426 | 1,368,525 |
| % Reliability for 50,000 Hrs | 99.96% | 97.73% |

**Table 4.** Motor specification data input

| Parameter | Value |
|---|---|
| Drive No. | 1 |
| Location | 4 |
| Number of Motors | 1 |
| Total Nameplate Power | 22 |
| Running Power (kW) | 11 |
| Running Te (kN) | 11.5 |
| Power Ratio | 1 |
| Efficiency | 0.92 |
| Synchronous RPM | 1450 |
| HS Inertia (kg-m$^2$) | 0 |
| Wrap Angle (Degrees) | 183 |
| Lagging | Herringbone |
| Friction Factor - Run | 0.35 |
| Wrap Factor - Run | 0.49 |
| Slip Ratio - Run | 3.05 |
| Actual T1/T2 Ratio - Run | 2.01 |

**Table 5.** Pulley data input

| Parameter | Dr/Head | Bend | Bend | Takeup | Bend | Tail |
|---|---|---|---|---|---|---|
| Pulley No. | 1 | 2 | 3 | 4 | 5 | 6 |
| Flight Description | Dr/Head | Bend | Bend | Takeup | Bend | Tail |
| Location | 4 | 6 | 8 | 10 | 12 | 15 |
| Same As (Pulley No.) | auto | auto | auto | auto | auto | auto |
| Tension (T1) (kN) | 22.5 | 11.2 | 11 | 9.4 | 11.4 | 11.3 |
| Tension (T2) (kN) | 11.2 | 8.4 | 8.4 | 7.8 | 8.4 | 8.5 |
| T1 Incoming Angle (de- | 346.6 | 314.2 | 314.6 | 92.7 | 30.5 | 92.7 |
| Wrap Direction | Counter | Counter | Clock- | Clock- | Clock- | Clock- |
| Wrap Angle (degrees) | 183 | 144.6 | 110.8 | 90 | 92.6 | 183 |
| T2 Outgoing Angle (de- | 183 | 144.6 | 110.8 | 90 | 92.6 | 183 |
| Pulley Weight (kN) | 12.8 | 22.7 | 23.1 | 22.8 | 24.1 | 26.1 |
| Resultant Force (kN) | 272.24 | 164.25 | 268.14 | 206.32 | 382.45 | 164.14 |
| Resultant Force Angle (de- | 314.6 | 270.3 | 270.7 | 207.7 | 227.5 | 172.4 |
| Pulley Diameter (mm) | 510 | 407 | 407 | 407 | 407 | 407 |
| Lagging Gauge (mm) | 12.7 | 0 | 0 | 0 | 0 | 0 |
| Lagging Type | Herringbone | None | None | None | None | None |
| Face Width (mm) | 800 | 800 | 800 | 800 | 800 | 800 |
| Pulley RPM | 1055 | 423 | 423 | 423 | 423 | 423 |
| Bearing Centers (mm) | 1096 | 1004 | 1004 | 1004 | 1004 | 1004 |
| Overhung Load (N) | auto | auto | auto | auto | auto | auto |
| Backstop Required? | Yes (Click to Move) | - | - | - | - | - |
| Min Backstop Rating (N-m) | 4317 | - | - | - | - | - |
| Backstop Torque (N-m) | 1818 | - | - | - | - | - |

**Table 6.** Belt data input

| Parameter | Value |
|---|---|
| Specification | Steel |
| Carcass | ST630 |
| Rating (N/mm) | 94 |
| Safety/Design Factor | 6.7 |
| Breaking Strength (N/mm) | - |
| Maximum Belt Width (mm) | 3048 |
| Minimum Belt Width (mm) | 610 |
| Top Cover Gauge (mm) | 6 |
| Bottom Cover Gauge (mm) | 6 |
| Top Cover Rubber Type | Good |
| Bottom Cover Rubber Type | Good |
| Top Cover Deformation | 1 |
| Bottom Cover Deformation | 1 |
| Weight (kg/m) | 14.8 |
| Elastic Modulus (N/mm$^2$) | 45,325 |
| Apparent Length (m) | 232 |
| Acceleration Rating (%) | - |
| Max Tension (kN / N/mm / | 22.5 / - / 30 / 32 |
| Average Tensions (kN / | 12.7 / 17 / 17 |
| Min Tensions (kN / N/mm / | 9.1 / 12 / 13 |

The conveyor belt profile was drawn to reflect the actual system, with a total length of 223 meters, a belt width of 750 mm, a horizontal distance of 101 meters, and a height difference of 19.4 meters. The angle of repose was set at 30°, and the angle of surcharge at 25°, representing the typical operational conditions for this conveyor system.

## 3. Results and Discussion

### *3.1. Result of calculations*

The material weight per unit length of the conveyor was calculated for both the initial and increased capacities.

For capacity 148.5 t/h:

$$W_m = \frac{Q}{V} = \frac{148.5\ t/h}{0.9\ m/s}$$

$$W_m = 45.833 \text{ kg/m}$$

For capacity 180 t/h

$$W_m = \frac{Q}{V} = \frac{180\ t/h}{0.9\ m/s}$$

$$W_m = 55.555 \text{ kg/m}$$

The effective tensile force (Fe) required to move the material was calculated based on the material weight, belt dimensions, and operational parameters.

For capacity 148.5 t/h:

$$F_e = W_m \times H + (0{,}04\ (2 \times W_b + W_m) \times L)$$

$$F_e = 45.833 \times 19.4 + (0.04\ (2 \times 13 + 45.833) \times 101)$$

$$F_e = 1364.5 \text{ kg} = 13645 \text{ N}$$

For capacity 180 t/h

$$F_e = Wm \times H + (0{,}04\ (2 \times Wb + Wm) \times L)$$

$$F_e = 55{,}555 \times 19{,}4 + (0{,}04\ (2 \times 13 + 55{,}555) \times 101)$$

$$F_e = 1407.2 \text{ kg} = 14072 \text{ N}$$

### *3.2. Result of belt deflection measurement*

Figure 3 illustrates the belt deflection across various idler spacing distances under three different load conditions: no load, a capacity of 148.5 t/h, and a capacity of 180 t/h. Under no load conditions, the belt deflection remains relatively constant at around 33.5 mm. This deflection occurs due to the inherent sag of the belt when not subjected to any material load. The deflection is primarily influenced by the belt's weight and the spacing between the idlers. When the conveyor operates at a capacity of 148.5 t/h, the belt deflection decreases compared to the no-load condition, reaching a minimum of approximately 32 mm at the optimal idler spacing of around 650 mm. This reduction in deflection occurs because the material weight helps stabilize the belt, reducing sag. However, as the idler spacing increases beyond this point, the deflection gradually increases again, highlighting the importance of optimal idler spacing to minimize belt sag under load. At the increased capacity of 180 t/h, the belt deflection further decreases, reaching a minimum of about 31.5 mm at the same idler spacing of approximately 650 mm. The heavier load exerts more force on the belt, reducing deflection more significantly at shorter idler spacings. However, similar to the other conditions, the deflection increases as the idler spacing exceeds 650 mm, although it remains lower than the deflection observed under the 148.5 t/h capacity.

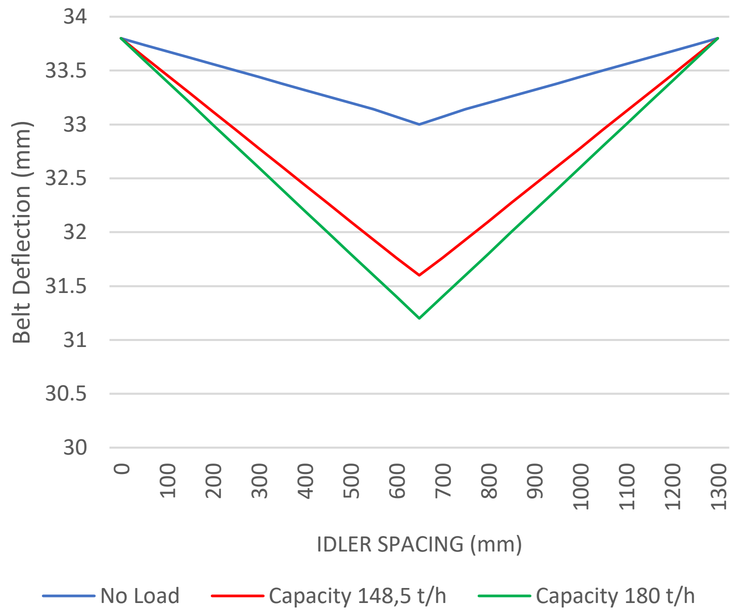


**Figure 3.** Belt deflection calculation result graphs.

*3.3. Result of simulation*

The simulation conducted with Belt Analyst 16 software provides a detailed assessment of the structural strength and dynamic load behavior of the conveyor system when operating at an increased capacity of 180 t/h, as the result presented in Figure 4.

| | Carry Default | Return Default |
|---|---|---|
| Idler Name | Carry | Return |
| Specification | DIN-6200 | DIN-6200 |
| Description | 6204-102-3 | 6204-102-1 |
| Type | Fixed | Fixed |
| Estimated No of Idlers | 79 | 29 |
| For Belt Width (mm) | 800 | 800 |
| No of Rolls | 3 | 1 |
| Angle (degrees) | 35 | 0 |
| Bearing Type | Ball | Ball |
| Roll Diameter (mm) | 102 | 102 |
| Roll Material | Steel | Steel |
| Rotating Weight (kg) | 8,7 | 7,5 |
| Load Rating (N) | 3237 | 608 |
| Max Actual Load (N) | 897 | 437 |
| Max Calc. Idler Load - CIL (N) | 1018 | 461 |
| RPM | 169 | 169 |

**Figure 4.** The strength of the structure and the load rating for belt conveyor capacity of 180 t/h

The volume of material per meter at a capacity of 180 t/h results in a load of 555.55 N/m. This load is distributed across the carry idlers in the conveyor system. The conveyor system is equipped with 79 carry idlers, each capable of withstanding a load of 3,237 N. Therefore, the total load-bearing capacity of the structure, considering all carry idlers, is 255,723 N. The results show that the structural strength of the conveyor is adequate, with the load rating comfortably below the threshold specified for the carry idlers. This suggests that the conveyor system is capable of handling the increased load capacity without compromising its structural integrity or safety.

The dynamic load, which fluctuates due to the moving nature of the conveyor, was also evaluated. The simulation results indicated that maximum dynamic load is 34 N/mm, and minimum dynamic load is 12 N/mm.

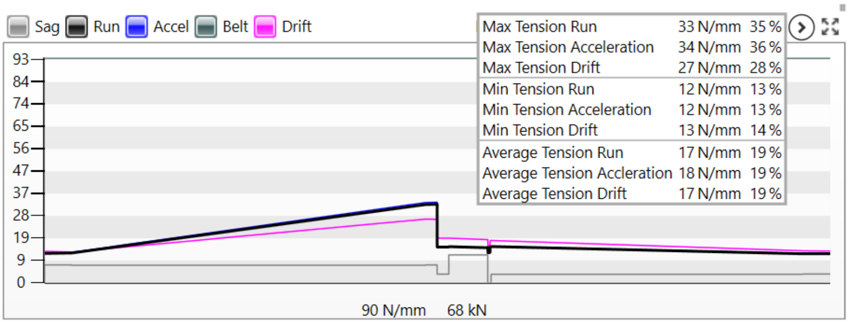


**Figure 5.** Dynamic load on the conveyor belt structure

Based on the simulation results, the belt tension at various points along the conveyor system has been determined. The maximum tension recorded is 25.2 kN, typically occurring at locations where the conveyor handles the heaviest material load or where the belt experiences the greatest pulling force, such as near the drive pulley. The minimum tension observed is 9.1 kN, which is characteristic of the belt's slack phase, where the belt is less taut. The belt is designed to withstand a maximum tension of 29.2 kN, ensuring that even under peak loads, the system operates within safe limits.

The maximum tension values, as shown in Table 7, indicate the peak load experienced by the belt in different scenarios. The highest tension of 25.2 kN occurs when the belt is under the most significant stress, likely near the drive pulley where the pulling force is greatest. This tension is 36% of the belt's maximum capacity, which is safely below the belt's maximum tension limit of 29.2 kN.

**Table 7.** Belt tension prediction

| Tension Type | Value 1 (kN / N/mm / %) | Value 2 (kN / N/mm / %) | Value 3 (kN / N/mm / %) |
|---|---|---|---|
| Max Tension | 24.6 / 33 / 35 | 25.2 / 34 / 36 | 19.9 / 27 / 28 |
| Average Tensions | 13.1 / 17 / 19 | 13.3 / 18 / 19 | 13.1 / 17 / 19 |
| Min Tensions | 9.1 / 12 / 13 | 9.2 / 12 / 13 | 9.6 / 13 / 14 |

The simulation results indicate that to transport materials at a capacity of 180 t/h, the conveyor system requires only 60.4% of the available motor power, which equates to 15 kW out of a total 22 kW. This demonstrates that the system is operating efficiently, utilizing just over half of its potential power capacity to achieve the desired throughput. This efficiency not only suggests that the system is well-designed for its current load but also implies that there is sufficient power reserve available to accommodate potential increases in load or other operational demands without overtaxing the motor.

## 4. Conclusions

The belt performance analysis indicates that increasing the conveyor belt capacity to 180 t/h results in an effective pulling force of 14,072 N, with a maximum belt tension of 25,200 N. The motor power required for this increased capacity is 13.28 kW. Additionally, the structure experiences an increased load from 45.833 kg/m to 55.555 kg/m, and the belt deflection rises from 22 mm to 27 mm. Despite these increases, the structural integrity remains secure, as the system is designed to withstand loads up to 255,723 N, supported by 79 carry idlers, each capable of bearing 3,237 N. The capacity increase utilizes only 60.4% of the total available power, demonstrating that the system is operating efficiently and has sufficient reserve capacity to handle additional demands. These findings affirm that the conveyor system can safely and effectively manage the enhanced load without compromising performance or safety.

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