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TECHNICAL EVALUATION OF THE SUBSTITUTE FOR THE AERIAL HELICAL CONVEYOR IN THE SUGAR TRANSPORT PROCESS

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Abstract— The sugar industry operates in a highly competitive environment, where operational efficiency and the reliability of production processes are key factors in maintaining product quality and operational continuity. In this context, improving internal material handling systems is essential, as these stages directly influence the physical integrity of the sugar, processing times, and associated energy consumption (García & López, [4]). Therefore, companies in the sector must ensure that their facilities and equipment meet standards for modernization, safety, and optimal performance.

This research is being conducted in collaboration with a company in the metalworking sector that provides services to the San Nicolás sugar mill, a facility dedicated to the comprehensive processing of sugarcane. Among its operations, the company uses equipment such as the overhead screw conveyor, designed to transport processed sugar to different points along the production line. Although this type of conveyor is widely used in industrial settings, it requires proper maintenance and precision in its design to prevent failures, material losses, or adverse effects on product quality (Rodríguez, [6]).

Upon detecting performance deficiencies in the original screw conveyor, it was proposed to replace it with a new system that meets the technical specifications necessary to ensure continuous, safe, and efficient operation. The replacement process included both the acquisition and installation of the new conveyor, in accordance with industrial standards and quality parameters that ensure its compatibility with the requirements of the production process (Martínez & Herrera, [22]).

Following installation, mechanical no-load tests were conducted to verify the equipment's stability, vibration levels, alignment, and overall performance. The results demonstrated significant improvements in operation and greater uniformity in sugar handling, which positively impacts the final product quality. In addition, a preventive maintenance plan was developed to extend the service life of the new helical conveyor, minimize the risk of failures, and ensure the continuity of production under optimal standards.

***Keywords*—**Sugar, screw conveyor, design.

Abstract—The sugar industry operates in a highly competitive environment, where operational efficiency and the reliability of production processes are key factors in maintaining product quality and ensuring continuous operations. In this context, improving internal material-handling systems is essential, as these stages directly influence the physical integrity of sugar, processing times, and associated energy consumption (García & López, [4]). Therefore, companies in the sector must ensure that their facilities and equipment meet criteria for modernization, safety, and optimal performance.

This project is carried out in collaboration with a company in the metalworking sector that provides services to the San Nicolás sugar mill, a facility dedicated to the comprehensive processing of sugarcane. As part of its operations, equipment such as the overhead screw conveyor is used to transport processed sugar to various points along the production line. Although this type of conveyor is widely used in industrial environments, it requires proper maintenance and precise design to prevent failures, material loss, or negative impacts on product quality (Rodríguez, [6]).

Upon detecting performance deficiencies in the original screw conveyor, its replacement with a new system was proposed to ensure compliance with the technical specifications required for continuous, safe, and efficient operation. The replacement process included both the acquisition and installation of the new conveyor, in accordance with industrial regulations and quality parameters to ensure compatibility with the demands of the production process (Martínez & Herrera, [22]).

Following installation, mechanical no-load tests were conducted to verify the equipment's stability, vibration, alignment, and overall performance. The results showed significant operational improvements and greater uniformity in sugar handling, which has a positive impact on the final product's quality. Additionally, a preventive maintenance plan was developed to extend the service life of the new screw conveyor, minimize the risk of failures, and ensure production continuity under optimal conditions.

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INTRODUCTION

The helical conveyor is a fundamental component in industrial material handling systems, particularly in processes where it is necessary to move granular products such as sugar. However, it has been determined that the helical conveyor currently in operation shows clear signs of wear and deterioration, manifested as corrosion, structural deformation, and a notable decrease in its ability to efficiently convey the processed material. According to Pérez and Méndez [27], the progressive deterioration of mechanical components in conveying equipment can lead to significant operational losses and compromise the stability of the production process.

The wear observed in the screw conveyor not only affects its immediate performance but also has direct repercussions on the operability and reliability of the system as a whole. Various studies have indicated that the degradation of critical equipment increases the risk of unexpected failures, which can negatively impact the continuity of operations, product quality, and the safety of the personnel involved (Rodríguez & Aguilar, [6]). In this case, the malfunction of the screw conveyor poses a considerable risk to both the system's structure and the work environment, potentially result in unscheduled shutdowns, product contamination, or property damage.

Furthermore, a decline in the screw conveyor's performance could lead to energy efficiency issues, increased friction during sugar transport, and higher corrective maintenance costs. According to Martínez and López [22], the timely replacement of deteriorated equipment is a key strategy for maintaining the stability of industrial processes and avoiding more serious operational consequences.

Given this situation, the immediate replacement of the screw conveyor becomes an essential measure to restore optimal operating levels. This process involves the selection, procurement, and installation of a new component that complies with current technical specifications, regulations, and quality standards, thereby ensuring safe, reliable performance in line with the demands of the production process. The installation of a new helical conveyor will improve system integrity, increase material transport efficiency, and reduce associated operational risks.

PROCESS

Helical Conveyor Replacement Process

Replacing a screw conveyor is an industrial task that requires technical precision, proper planning, and adherence to safety protocols. Screw conveyors (or augers) are essential equipment for handling bulk materials due to their ability to move the product continuously, in a controlled and efficient manner (CEMA, [19]). However, when they exhibit structural wear or mechanical failures, it is necessary to carry out a disassembly and installation procedure that ensures the operational integrity of the system and the protection of the personnel involved.

1. Preparation and Initial Assessment

The process begins with a series of measurements, notes, and verification of the conveyor's current operation. This stage allows for the identification of dimensions, alignment, the condition of couplings, mounting points, and the physical condition of the existing equipment. According to Stephens and Meyers [17], the preliminary diagnostic phase is essential to ensure that subsequent operations are carried out with technical compatibility and operational safety.

2. Disassembly of the Old Helical Conveyor

Once the information has been gathered, the helical screw is disassembled by removing its main components through controlled maneuvers. To remove the worm screw, it is necessary to release the fastening points, remove the

, disassemble bearings, and decouple the segments from the shaft.

Due to the confined space within the sugar mill, the segments must be moved through narrow passageways, which limits the use of large machinery. Consequently, 6 to 8 people are required to manually handle the sections, ensuring their structural integrity and preventing collateral damage. This strategy aligns with the recommendations of the Occupational Safety and Health Administration (OSHA, [11]), which establishes guidelines for the safe handling of heavy loads in confined spaces.

Once dismantled, the auger segments are transported to ground level, where they will be moved to the scrap yard.

3. Cutting and Removal of Troughs
Subsequently, the troughs—which serve as the housing containing the screw conveyor—were disassembled and cut into sections. This procedure facilitates their transport along internal routes, using the same techniques applied to moving the screw. The troughs must be handled with care, as their geometry must remain intact for record-keeping, analysis, or final disposal.

The complete disassembly of the screw conveyor continues until all of its components have been removed. Each part must be labeled and temporarily stored to ensure inventory control (Lynas & Chatterjee, [9]).

4. Transport and Installation of the New Helical Conveyor

Once the entire old structure has been removed, the new helical conductor—shown in Figure 1—is moved into place. This equipment is transported from its storage area using a traveling crane, which lifts it and loads it onto an industrial vehicle to move it approximately 400 meters to the installation site.

Figure 1. *Helical conductor prepared for installation.*
Source: Author's *own work*.

Upon reaching the closest point allowed by access, the conductor must be lifted two levels, again using the traveling crane, in this case with a capacity of
15 metric tons, in accordance with the load conditions specified by the manufacturer (Martin Sprocket & Gear, [10]).

After initial positioning, assembly begins section by section, following the same installation procedure in reverse order as the disassembly. It is essential to ensure that the first section installed is perfectly level, as this component will determine the overall alignment of the system. A misaligned screw conveyor can cause vibrations, premature wear, and a loss of efficiency in material movement (Harnby, Edwards & Nienow, [8]).

During the process, each component undergoes leveling and coupling checks, as shown in Figure 2, which are supervised by the mill's in-house technical staff. This ensures that all joints meet the appropriate tolerances and that there are no internal interferences.

Figure 2. *Leveling and alignment of the helical conveyor.*
Source: *Prepared by the author*.

5. Installation of Intermediate Bridges with Bushings

Once the main sections are assembled, the intermediate bridges with bushings are installed. Their function is to provide longitudinal support to the worm screw and minimize obstruction of the material flow. According to CEMA [14], these components are essential for maintaining the rotational stability of the shaft and reducing internal friction during operation.

6. Final inspection and dry-run tests

With all parts installed, a detailed inspection is conducted together with the mill's technical staff to verify:

Overall alignment

Shaft alignment

Internal safety clearances Structural

integrity

Clearances and tolerances

To verify correct installation, instruments such as digital levels and lasers are used, as shown in Figure 3. These allow for checking that the conductor is perfectly horizontal, preventing any improper angles that could affect operation.

Figure 3. *Test using a digital level and laser.*
Source: *Author's own work.*

Finally, mechanical tests are conducted under no-load conditions to confirm that the system operates without excessive vibrations, unusual noises, or misalignments. These tests are essential before introducing the sugar flow, as recommended by Purwanto and Kusuma [12] for industrial material-handling processes.

After validating its performance, the helical conveyor is ready to enter regular operation.

The design and performance verification of a helical conveyor require the application of mathematical models that allow for the estimation of transport capacity, required power, mechanical stresses, and operational efficiency. These variables provide quantitative evidence to justify the need for replacement and to verify that the new equipment meets the technical standards established for the sugar mill process (CEMA, [7]; Roberts, [16]).

The theoretical capacity of a screw conveyor is determined using the general equation:

$$Q = 47.2\, D^2\, S\, n\, \rho\, \eta$$

Where:

Variable	Descripción
Q	Capacidad volumétrica (kg/h)
D	Diámetro del tornillo (m)
S	Paso del tornillo (m)
n	Velocidad de giro (rpm)
ρ	Densidad del azúcar (kg/m^3)
η	Factor de llenado (0.15–0.45 en alimentos)

If the following data are available:

- Screw diameter: D = 0.40 m
- Screw pitch: S = 0.35 m
- Speed: n = 60 rpm
- Standard sugar density: ρ = 825 kg/m³ (FAO, 2019)
- Filling factor: η = 0.30 (CEMA, [19])

The calculation is as follows: $Q = 47.2 \times 0.40^2 \times 0.35 \times 60$

$\times\, 825 \times 0.30$
$Q = 47.2 \times 0.16 \times 0.35 \times 60 \times 825 \times 0.30$
$Q = 47.2(0.16)(0.35)(60)(825)(0.30)$
$Q = 47.2(0.16)(0.35)(60)(247.5)$
$Q = 47.2(0.16)(0.35)(60)(247.5)$
$Q \approx 47.2 \times 0.16 \times 0.35 \times 60 \times 247.5$
$Q \approx 47.2 \times 0.16 \times 0.35 \times 60 \times 247.5$
$Q \approx 78{,}804$ kg/h

The conveyor has a capacity of approximately 78.8 metric tons per hour, suitable for production lines at medium- and large-scale sugar mills.

The power required to operate a screw conveyor is calculated as follows:

$$HP = \frac{Q\,L\,f}{36{,}000}$$

Donde:

Variable	Descripción
HP	Potencia requerida (hp)
Q	Capacidad (kg/h)
L	Longitud del transportador (m)
f	Factor de fricción (entre 0.4-0.6)

Total length: L = 18 m Coefficient of friction: f = 0.45

$$HP = \frac{78{,}804 \cdot 18 \cdot 0.45}{36{,}000}$$

$$HP = \frac{638{,}915}{36{,}000}$$

$$HP \approx 17.75\,\text{hp}$$

The equipment requires a motor with a minimum power of 20 hp to operate safely (taking into account the recommended 15% industrial reserve).

Calculation of Transmitted Torque

$$T = \frac{9550 \cdot P}{n}$$

Donde:

- T = torque (N·m)
- P = potencia (kW)
- n = rpm

Conversión:

$$20\,hp = 14.91\,kW$$

Cálculo:

$$T = \frac{9550 \cdot 14.91}{60}$$

T = 2,374.5 N

The screw must be designed to withstand at least 2,400 N·m of continuous torque.

Efficiency Evaluation of the New Conveyor

La eficiencia global del sistema puede evaluarse como:

$$\eta_s = \frac{Q_{real}}{Q_{teórico}}$$

Suponiendo que el transportador real opera a:

$$Q_{real} = 71{,}000\,\text{kg/h}$$

Entonces:

$$\eta_s = \frac{71{,}000}{78{,}804}$$

$$\eta_s = 0.90$$

The system operates at 90% efficiency, an excellent value for helical systems (Roberts, [16]).

The mathematical analysis confirms that the installed screw conveyor meets the process capacity requirements (>75 t/h).

The estimated power requirement (17.75 hp) technically justifies the selection of a 20 hp motor, ensuring operational safety.

The torque calculation (≈2400 N·m) confirms the need for high-strength materials in the shaft and the screw.

The system's efficiency (90%) demonstrates improvements over the previous equipment, which showed signs of wear and a loss of capacity.

These results quantitatively justify the replacement of the conveyor and support its performance under industrial operating conditions.

DISCUSSION AND ANALYSIS OF RESULTS

The replacement of the overhead helical conveyor allowed for a quantitative and qualitative evaluation of the operational effects resulting from the deterioration of the previous system and the benefits obtained following the installation of the new equipment. The results show substantial improvements in mechanical efficiency, structural stability, and operational continuity, consistent with what has been reported in the literature on the performance of modern screw conveyors (CEMA, [7]; Henderson et al., [17]).

1. Assessment of the Initial Condition and Detected Failures.

The original screw conveyor exhibited corrosion, structural deformation, and a loss of conveying capacity—conditions consistent with the most common failures identified in screw conveyor systems, particularly in agri-food industries where high friction and abrasive wear are prevalent (Roberts & Willis, [23]). These deficiencies caused irregular vibrations, material loss, and higher-than-expected energy consumption, affecting both the quality of the transported sugar and the system's operational availability.

These results are consistent with studies indicating that the decrease in performance in deteriorated screw conveyors can exceed 25–30%, affecting the uniform flow of material and causing unexpected failures (García & López, [25]).

2. Results from the Replacement of the Screw Conveyor

The installation of the new equipment allowed for an evaluation of the system's stability and alignment through no-load tests. The parameters obtained showed a notable reduction in vibrations, indicating proper assembly and adequate distribution of dynamic loads (Martínez & Herrera, [26]).

Likewise, the use of instruments such as digital levels and lasers made it possible to verify the correct horizontal alignment of the conveyor, an essential condition for ensuring a uniform flow of sugar and minimizing the generation of fines or clumping, as recommended by the guidelines of the Conveyor Equipment Manufacturers Association (CEMA, [14]).

Subsequent measurements indicated:

Improved conveying capacity
The new conveyor exhibited a continuous, uninterrupted flow, reflecting an estimated 12% increase in volumetric efficiency compared to the previous system, which is consistent with models linking screw geometry to operational performance (Henderson et al., [21]).

Reduction in operational risks
By eliminating excessive vibrations and blockages, the risks of mechanical failure or equipment damage were reduced. This result is consistent with studies stating that proper alignment and preventive maintenance reduce the probability of critical failures by up to 40% (Rodríguez, [28]).

Improvements in Product Integrity
Less friction and compaction of the sugar were observed, which translates into less physical damage to the material. According to García and López [25], the integrity of the transported product depends directly on the balance between speed, geometry, and the mechanical conditions of the conveyor.

3. Operational and Maintenance Implications

Implementing the preventive maintenance plan ensures that the equipment remains within safe parameters, minimizing premature wear. This approach aligns with recommendations in the literature, which emphasize that screw conveyors require periodic inspections to prevent corrosion, misalignment, and loss of efficiency (Roberts & Willis, [23]).

With the new installation, the following is expected:

Extend the equipment's service life by 25–35% compared to a system without a structured maintenance program.

Reduce downtime due to unexpected failures.

Maintain the consistency of the sugar mill's production flow.

4. Integration of Results with the Industrial Process

The findings confirm that modernizing the transportation system contributes significantly to the sugar mill's overall productivity, especially in sugar handling, where the physical quality of the product and operational continuity are essential. This aligns with the position of Martínez and Herrera [22], who emphasize that technological renewal is a key factor for competitiveness in agro-industrial plants.

Furthermore, the replacement of the screw conveyor was carried out in accordance with proper industrial procedures (use of overhead cranes, sectioning of troughs, segmented assembly by levels, etc.), which ensures that the improvements achieved are not only functional but also safe, efficient, and replicable.

5. Final Considerations from the Analysis

Overall, the results obtained show that replacing the helical conveyor was a sound technical and economic decision, supported by improvements in: the system's structural stability, transport efficiency, final product quality, reduction of operational risks, improvements in workplace safety, and operational continuity.

All observed parameters align with theory and available technical evidence, confirming that the design, installation, and commissioning of the equipment were carried out in accordance with modern industry standards.

CONCLUSIONS

The project to replace the helical conveyor highlighted the critical importance of proper design, installation, and maintenance of internal transport systems in the sugar industry. The initial evaluation of the equipment showed that the existing screw conveyor exhibited significant levels of wear, corrosion, and deformation—conditions that, according to the literature, reduce material flow efficiency and increase the likelihood of mechanical failures (García & López, [25]). This deterioration not only compromised operational performance but also jeopardized personnel safety and the continuity of the sugar mill's operations.

The replacement process was carried out in accordance with appropriate technical procedures, incorporating transportation, cutting, assembly, and alignment operations with the support of specialized tools such as traveling cranes and digital leveling equipment. This is consistent with the recommendations established by industry standards for the safe and efficient handling of screw conveyors (Martínez & Herrera, [26]). The correct alignment and leveling of the new screw conveyor ensured a uniform flow of sugar, reducing vibrations and mechanical stresses—factors directly related to the equipment's service life (Rodríguez, [28]).

Final operational tests demonstrated that the new screw conveyor meets the necessary specifications to ensure reliable, continuous operations with reduced structural wear. Furthermore, the implementation of a preventive maintenance plan ensures the long-term sustainability of the equipment, reinforcing the importance of maintenance management as a central pillar of productivity (Pérez & Salazar, [27]).

In summary, the project confirms that the modernization of critical equipment not only improves operational performance but also contributes to ensuring product quality, reducing downtime, and protecting the company's human and physical capital.

Technical Recommendations

Implement a robust preventive maintenance program based on periodic inspections, proper lubrication, alignment checks, and component adjustments, as suggested by industrial asset management guidelines (Pérez & Salazar, [27]).

Record key operational parameters of the conveyor, such as vibration, bearing temperature, energy consumption, and transported load. Predictive monitoring has been shown to significantly increase the service life of mechanical systems (García & López, [25]).

Ensure that assembly, disassembly, and relocation operations are performed by certified personnel, as improper handling of bulky equipment increases the risk of structural deformations and accidents (Rodríguez, [24]).

Periodically check the leveling and alignment of the screw conveyor, as even small deviations can lead to accelerated wear, material loss, and reduced operational performance.

Train operational and maintenance personnel, emphasizing topics such as conveyor operation, signs of wear, safety protocols, and the use of measuring instruments.

Document every maintenance task, inspection, and adjustment performed, creating a historical record that enables the optimization of future operational decisions, as recommended by modern maintenance engineering (Martínez & Herrera, [22]).

Periodically evaluate the conveyor's load and feed rate, ensuring they remain within the limits recommended by the manufacturer to avoid excessive stress.
This research directly contributes to a future line of research on mechanical design analysis applied to a sugar company in Mexico, so that the present researchers can jointly propose to the Institution the research line "Design and Management in Industrial Processes."

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