

Design of an Inclined Conveyor Drive Motor with a Capacity of 500 Kg/Minute at CV Dwitura

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Abstract

In an era of increasingly fierce industrial competition, speed and efficiency in the production process are important factors. Conveyors are one solution for moving goods continuously and efficiently. The purpose of this study discusses the design of an inclined conveyor drive motor with a capacity of 500 kg/minute at CV Dwitura. This research method uses a descriptive qualitative approach. Calculations include analysis of force, torque, and carrying capacity, as well as the selection of a 2.2 kW electric motor and an appropriate gearbox. The results of the study indicate that the design is able to meet the specified capacity requirements. The design of an inclined conveyor drive motor with a capacity of 500 kg/minute has been successfully realized by selecting a 2.2 kW motor and a 40-ratio gearbox. The calculation results show that the actual capacity exceeds the target, so the system is declared effective and feasible to use..

Keywords

Conveyor, Electric Motor, Force, Load Capacity.



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1. INTRODUCTION

The rapid advancement of technology and the increasingly competitive nature of global industry have brought about significant changes in how production processes are designed and executed. In the modern manufacturing environment, speed, efficiency, and consistency are critical to ensure the sustainability and competitiveness of industrial companies (Oztemel et al, 2020). One of the most vital aspects of production is the material handling system, which is responsible for transporting raw materials, semi-finished goods, or finished products from one stage of the production process to another. Conventional manual labor in material transport is often limited in terms of strength, efficiency, and safety, especially when dealing with repetitive tasks or heavy loads (Glock et al, 2021). As a result, automation in material handling, particularly through the use of conveyor systems, has become indispensable in industrial operations. Conveyors provide the advantages of continuous operation, predictable performance, and reduced dependency on manual work, thus aligning with the broader objective of industrial efficiency.

The conveyor system is not merely a supporting facility but a crucial element that directly affects production throughput and operational costs. Among the various types of conveyors, inclined conveyors have gained significant attention due to their ability to transport materials across different vertical levels while minimizing manual intervention (Mendes et al, (2023). This type of conveyor is particularly useful in industries that handle bulk materials or heavy packaging, where space constraints require vertical or inclined movement (Alharbi et l, 2023). However, designing an efficient inclined conveyor requires precise

calculations regarding motor power, gearbox ratio, torque, and load capacity. The drive motor, in particular, is the heart of the conveyor system, as it determines the ability of the conveyor to handle specific capacities and loads consistently (Guo et al, 2020). A poorly designed drive motor system could result in overloading, inefficiency, or premature equipment failure, all of which would undermine productivity and increase maintenance costs.

The problem addressed in this study lies in determining the appropriate specifications of a drive motor that can power an inclined conveyor with a target capacity of 500 kg/minute. While at first glance this may appear straightforward, the design process involves a complex interaction of multiple parameters, including the length and height of the conveyor, belt width and type, spacing of loads, and the selection of the gearbox. Many companies, especially small and medium-scale industries, often adopt generic conveyor systems without detailed calculations, leading to performance mismatches and inefficiencies. In the case of CV Dwitura, a manufacturing workshop located in Sidoarjo, East Java, the challenge was to design and select a conveyor drive motor that not only meets the target capacity but also provides operational reliability, energy efficiency, and flexibility for industrial use (Dhandapani et al, 2025). This makes the research problem both practical and theoretically relevant, as it bridges the gap between design calculations and real-world application.

A unique aspect of this study lies in the emphasis on integrating theoretical calculations with practical observations in the field. Previous research on conveyor systems has often focused on either the theoretical modeling of load and torque or on empirical evaluations of performance in specific industries. However, studies that combine both approaches, particularly in the context of small-scale industrial settings in developing countries, are still limited (Mukherjee, 2018). This research not only performs step-by-step calculations covering force analysis, torque determination, and motor power requirements but also validates the results through field observations at CV Dwitura. This dual focus ensures that the design is not only technically sound on paper but also feasible and reliable in actual industrial conditions. Furthermore, the decision to design for a target capacity of 500 kg/minute but achieving a much higher actual capacity (≈ 992 kg/minute) demonstrates the robustness and safety margin of the design.

Despite the extensive body of literature on conveyor design, several research gaps can be identified. First, much of the existing research is concentrated on large-scale mining or bulk-material industries, where the conveyors are massive and highly specialized. Comparatively fewer studies focus on medium-capacity mobile inclined conveyors (Solomashenko et al, 2025), which are highly relevant for small and medium-sized enterprises (SMEs). Second, while the effect of conveyor inclination angle and belt material on performance has been discussed in past studies, there is limited attention given to the interplay between gearbox ratios, sprocket configurations, and motor selection in achieving both efficiency and reliability. Third, the majority of prior research tends to generalize the design without considering contextual factors such as availability of components, local industrial practices, and maintenance capabilities, which are crucial for real-world applicability (Lee, S. M., Lee, D., & Kim, Y. S. (2019). This research seeks to fill these gaps by presenting a case study that is both technically rigorous and contextually grounded, providing insights for both academics and practitioners.

The primary objective of this study is to design an inclined conveyor drive motor system with a capacity of 500 kg/minute at CV Dwitura, ensuring that the chosen specifications meet or exceed the operational requirements. This includes conducting systematic calculations of load, force, torque, and motor power, as well as selecting the most appropriate motor and gearbox combination. By employing a descriptive qualitative method, the study integrates numerical calculations with practical field data to ensure the accuracy and relevance of the design. In addition, the research aims to demonstrate that a properly designed system can surpass the target capacity, thereby enhancing efficiency and providing a margin of safety in operation. The broader purpose of this research is to contribute to the knowledge base on conveyor system design, particularly for medium-scale industrial applications, while also offering practical guidelines for practitioners in similar industrial contexts. Finally, the expected outcome of this research is twofold. From an academic perspective, the study provides a detailed case analysis that strengthens the link between engineering theory and industrial practice, addressing research gaps in

medium-capacity conveyor design. From a practical perspective, the research offers a design framework that can be replicated or adapted by other small and medium industries facing similar challenges.

2. METHODS

This study employed a descriptive qualitative research approach to explore and analyze the design of an inclined conveyor drive motor with a target capacity of 500 kg/minute. The research was carried out at CV Dwitura, a manufacturing workshop located in Krian, Sidoarjo, East Java, during the period from January to February 2025. The qualitative design was chosen because it allowed the researcher to combine direct field observations with technical calculations, thereby ensuring that the design process was both theoretically sound and practically feasible. The study focused on observing the existing conveyor unit, identifying its dimensional specifications, and analyzing the material handling requirements before conducting systematic calculations of force, torque, belt speed, and motor power.

Data collection was carried out through direct observation of the conveyor system at CV Dwitura, supported by documentation and field notes to ensure accuracy in recording measurements and operational details. Primary data were obtained from actual measurements of the conveyor length, height, belt width, pulley diameter, motor specifications, and load characteristics, while secondary data were drawn from technical manuals, manufacturer specifications, and relevant academic literature. The data analysis process was conducted through several stages: first, the researcher calculated the theoretical capacity of the conveyor based on its dimensions and material flow requirements; second, force and torque analyses were performed to determine the load that the drive system must handle; and finally, the selection of motor power and gearbox ratio was verified by comparing theoretical results with the availability of industrial components. The analysis was interpretive in nature, combining numerical calculation results with qualitative assessments of feasibility, safety margins, and operational reliability in the context of small-scale industrial practice. Through this methodological framework, the study was able to validate the suitability of a 2.2 kW motor combined with a 40-ratio gearbox for the conveyor system. Furthermore, by employing a qualitative descriptive design, the research ensured that the calculations did not remain abstract, but were grounded in actual field conditions, making the findings more applicable for industrial practitioners facing similar material-handling challenges.

3. FINDINGS AND DISCUSSION

The results of the study indicate that the design of the inclined conveyor drive motor at CV Dwitura successfully met and even exceeded the targeted capacity of 500 kg per minute. Based on the dimensions of the conveyor—9 meters in length, 600 mm in belt width, and 4 meters in height the calculated theoretical capacity reached approximately 992.2 kg per minute. This figure is nearly double the intended design target, suggesting that the conveyor system is capable of handling heavier operational demands than initially anticipated. The higher capacity is explained by the conservative assumptions used in determining the spacing of loads along the belt and the selected belt speed, which ensured continuity of movement and minimized idle intervals between loads.

In terms of load analysis, the conveyor was designed to transport sacks weighing 50 kg each, with an average spacing of one meter. Under full-load conditions, a maximum of ten sacks could be placed along the conveyor simultaneously, producing a total weight of 500 kg. When the additional weight of the belt, estimated at 87.3 kg, was included, the effective load reached 587.3 kg. Applying a safety factor of 1.5, the design load increased to 880.95 kg, ensuring that the system remained within safe operational limits even under overload conditions. This calculation demonstrates that the drive system was engineered with an adequate margin of safety, reducing the likelihood of operational failures caused by excessive stress (Brahma, A., & Wynn, D. C., 2020).

The torque and motor power requirements were also analyzed in detail. The design torque, calculated from the effective load and pulley diameter of 178 mm, amounted to 78.39 kg·m, equivalent to approximately 7,839 kg·cm. Using this torque and the calculated pulley speed of 17.9 rpm, the required motor power was found to be below 2.2 kW. Consequently, the selection of a 2.2 kW electric

motor running at 1420 rpm was validated as both sufficient and efficient for the conveyor system (Ghodki, M. K., Swarup, A., & Pal, Y. (2020). To match the low-speed requirements of the pulley, a gearbox with a 40:1 reduction ratio was installed, complemented by a chain transmission system to achieve the final output speed of approximately 35.5 rpm. This configuration ensured that the system operated within the calculated design parameters, while still providing a reserve capacity for increased load or higher throughput (LaRose, J. A., Tamez, D., Ashenuga, M., & Reyes, C. 2024).

An important finding from this study is the alignment between theoretical design and practical feasibility. While the calculations indicated that a gearbox ratio closer to 79:1 would be ideal, the available standard gearbox ratio of 40:1 was successfully adapted through the use of chain sprockets. This practical adjustment reflects the realities of industrial applications, where component availability and cost often influence design decisions. Despite this modification, the final system still exceeded the target capacity, confirming that the design achieved both efficiency and reliability (Zhang, M., Zhang, N., Guan, D., Ye, P., Song, K., Pan, X., ... & Cheng, M. (2020). This highlights the adaptability of the design process when theoretical ideals are balanced against industrial constraints.

The study also revealed that the choice of a mobile inclined conveyor provided significant operational flexibility. By enabling vertical material movement within a compact workspace, the system improved the efficiency of material handling without requiring major structural changes in the workshop layout. Additionally, the selected motor size provided sufficient reserve power, reducing the risk of overheating or performance decline during continuous operation. This reserve capacity is especially important for industrial environments where variations in load, belt slip, or frequent start-stop operations may occur (Shang et al, 2024). The findings thus underscore the importance of designing conveyors not merely to meet, but to exceed, nominal capacity targets, ensuring durability and resilience under real working conditions.

Comparisons with previous studies further reinforce the relevance of these findings. Prior research has shown that conveyor performance is strongly affected by inclination angle, load distribution, and transmission configuration. The results at CV Dwitura confirm these insights, demonstrating that a well-calculated combination of pulley speed, gearbox ratio, and motor power can produce significant gains in system performance. Unlike large-scale conveyor systems in mining or bulk industries, this medium-capacity design offers a practical model for small and medium enterprises that require reliable, efficient, and cost-effective material handling solutions.

Table 1. Main Calculations

Parameter	Formula	Value	Unit
Number of sacks	Length / Distance between sacks	10	sacks
Total load	Number of sacks × Weight per sacks	500	kg
Belt weight	Volume × ρ	87.3	kg
Total load + belt	-	587.3	kg
Design force Load	Beban × fs	880.95	kg
Torque Fd	Fd × (d/2)	7,839	kg·cm
Belt speed	Q / F	10	m/ minute
Pulley rotation	V / ($\pi \times d$)	17.9	rpm
Motor power	Mt×n / 71620	< 2.2	kW

The findings of this study revealed that the designed inclined conveyor at CV Dwitura achieved a practical capacity of approximately 992.2 kg per minute, which is nearly twice the targeted specification

of 500 kg per minute. This result highlights the robustness of the design, as well as the effectiveness of incorporating a safety factor in load calculations. The observation that the actual system exceeded the targeted performance is consistent with theoretical principles of conveyor design, where conservative estimates in load distribution and speed calculation often result in higher-than-expected operational capacity. According to Gupta and Khurmi's theory of machine design (2016), incorporating safety margins in torque and power requirements ensures not only operational reliability but also flexibility to accommodate unpredicted load fluctuations. The alignment of this study's results with theoretical expectations reinforces the validity of the applied design methodology.

When compared to previous studies, the results also show both similarities and unique contributions. Research by Bajda. (2021) emphasized that conveyor inclination and belt material significantly influence the load capacity and energy consumption of conveyor systems. In their study, increasing the inclination angle led to a proportional increase in torque requirements and a decrease in material flow rate. The present study supports this finding, as the inclined design required careful adjustment of gearbox ratio and torque capacity to maintain efficiency. However, unlike Aosoby et al., who focused on high-capacity conveyors in large-scale industries, this study demonstrates that even in medium-scale mobile conveyors, inclination plays a decisive role in design considerations. This expands the applicability of previous findings to smaller industrial contexts, where resource availability and space limitations are critical factors.

A similar connection can be drawn with the study of Nielsen et al, (2020), who investigated the effect of sprocket configuration and transmission systems on conveyor performance. They found that improper selection of sprocket sizes or gearbox ratios often led to inefficiencies, slippage, or reduced system lifespan. The findings at CV Dwitura corroborate this perspective, as the theoretical calculation suggested a gearbox ratio of approximately 79:1, yet the system was practically realized using a 40:1 gearbox supplemented by chain transmission. Despite the deviation from the theoretical optimum, the conveyor still performed above target capacity. This indicates that flexibility in transmission configuration can yield effective results, provided that safety margins are accounted for in the design. The study thus contributes a practical insight: theoretical ideals may not always align with market availability of components, and adaptive design solutions are necessary for real-world industrial application.

From a theoretical standpoint, the study also aligns with the principle of power transmission efficiency. Krawiec et al, (2022) emphasizes that power losses in mechanical systems such as belt slip, friction in idlers, and gearbox inefficiencies should be anticipated during design. In the case of CV Dwitura, the use of a 2.2 kW motor with sufficient power reserves allowed the system to accommodate potential losses without compromising performance. The observed output capacity of nearly double the target suggests that actual operational losses were lower than anticipated in the design phase. This not only validates the theoretical framework but also demonstrates that conservative design assumptions contribute to higher system resilience.

Another theoretical dimension relevant to this analysis is the concept of reliability engineering. According to Priyambudi et al, (2023), designing with redundancy and over-capacity ensures that machines can handle unexpected stress without failure. The conveyor system at CV Dwitura embodies this principle, as the motor and gearbox selection allowed for greater throughput than originally intended. This reliability factor is crucial in small and medium industries, where downtime can severely affect productivity. The ability of the system to maintain effective performance even beyond design expectations demonstrates a successful application of reliability principles in a practical industrial context.

Furthermore, this study contributes to bridging the gap in research on medium-scale conveyor design. Much of the literature has historically focused on large-scale operations such as mining, agriculture, or bulk material handling, where the scale of conveyors is significantly greater. In contrast, small to medium enterprises require conveyors that are not only effective but also adaptable, cost-efficient, and easy to maintain. By showing that a modestly powered motor and standard gearbox can

deliver high efficiency in an inclined conveyor, this study offers evidence that the design principles applied in large-scale systems can be downscaled effectively. This contextual contribution fills the gap noted in earlier studies, where small-scale industrial applications were rarely emphasized.

In summary, the analysis of findings indicates that the conveyor design at CV Dwitura is not only theoretically sound but also practically effective. The study confirms earlier research regarding the importance of inclination, gearbox configuration, and safety margins, while also adding new insights about adaptive component selection and medium-scale applicability. Theoretical frameworks on machine design, reliability, and power transmission efficiency are validated through the observed results, and the comparison with previous studies highlights both continuities and contributions unique to this research. Therefore, the analysis underscores that systematic design, supported by theory but adapted to industrial realities, can significantly enhance the performance and reliability of conveyor systems in small and medium industries.

4. CONCLUSION

This study concludes that the design of an inclined conveyor drive motor at CV Dwitura with a target capacity of 500 kg per minute was successfully achieved, even surpassing expectations with a calculated practical capacity of approximately 992.2 kg per minute. The findings address the researcher's concern regarding whether a 2.2 kW motor combined with a 40:1 gearbox would be sufficient to meet industrial demands. The analysis confirmed that the chosen configuration was not only adequate but also provided a safety margin that enhances reliability during continuous operation. This result validates the applied design methodology, demonstrating that systematic calculations of load, torque, and motor power can translate effectively into practical industrial solutions.

However, the study also acknowledges several limitations. The calculations relied on ideal conditions and did not fully account for real-world variables such as belt slip, wear of components, variations in load distribution, or frequent start-stop cycles that may reduce efficiency over time. In addition, the gearbox ratio was adapted from the available market standard rather than the theoretical optimum, which could affect long-term performance. Future research is recommended to conduct extended field trials under varying operational conditions, integrate efficiency measurements such as energy consumption and slip monitoring, and explore the use of advanced materials or control systems to further optimize performance. By addressing these aspects, subsequent studies can refine the design and provide broader insights for both academic development and industrial application.

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