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Redesign of a High-Capacity Belt Conveyor: Achieving 2000 Tons/Hour Efficiency

[1]Djoeli Satrijo, [2]*Ojo Kurdi, [3]Toni Prahasto, [4]Jeremy Sahat, [5]Ian Yulianti

[1,2,3,4]Mechanical Engineering, Faculty of Engineering, Diponegoro University, Jl. Prof. Sudharto, SH., Tembalang-Semarang 50275, Indonesia

[5]Physics Study Program, Universitas Negeri Semarang, Central Java, Indonesia

*Corresponding Author's E-mail: ojokurdi@ft.undip.ac.id

***Abstract* - Conveyor systems are essential tools in industrial applications, designed to transport objects over fixed distances with specified loads. Among the various types of conveyors, belt conveyors are the most commonly used due to their efficiency and versatility. A belt conveyor typically comprises several critical components, including the belt, pulley, drive system, and idler. This research focuses on the design of a belt conveyor system for coal transportation, employing Computer-Aided Design (CAD) tools to achieve a transport capacity of 2000 tons per hour. The design process produced the following key geometric specifications: the drive pulley has a length of 1600 mm and a diameter of 800 mm, while the tail pulley has the same length but a diameter of 630 mm. The bend/snub pulley measures 1600 mm in length with a diameter of 500 mm, and the shaft pulley is 2180 mm long with a diameter of 130 mm. Additionally, the carrying idler has a length of 530 mm and a diameter of 159 mm, whereas the return idler measures 1600 mm in length with the same diameter of 159 mm. This study offers a robust design framework for industrial belt conveyor systems, emphasizing their operational efficiency and reliability in heavy-duty material handling applications.**

Keywords: Conveyor, Belt, Pulley, Shaft, Cad.

I. INTRODUCTION

In industrial operations, the transportation of materials in large capacities, both externally and internally, is a recurring challenge that requires effective solutions [1]. Industries need reliable tools to facilitate the transfer of goods from one location to another in high volumes while minimizing energy consumption, a task that is impractical to achieve manually [2]. The movement of coal, for example, can be accomplished using various tools such as dump trucks, cranes, and belt conveyors, among others. Among these, belt conveyors are a preferred solution for transporting solids efficiently within industrial settings [3].

Belt conveyors have long been recognized as effective transportation systems for both bulk and unit loads [4][5]. They are widely regarded as simple yet robust equipment capable of handling diverse materials at high rates—often thousands of tons per hour—continuously and uniformly over long distances. Compared to other continuously operating mechanical conveyors, belt conveyors offer superior efficiency and versatility, making them indispensable in modern industrial operations [6].

In light of these advantages, this study focuses on redesigning a belt conveyor for coal transportation within a power plant. The redesigned system is intended to handle a capacity of 2000 tons per hour over a track length of 160 meters. The design process includes meticulous calculations of the primary components, auxiliary elements, and the drive motor, ensuring optimal performance and reliability.

II. MATERIALS AND METHODS OF RESEARCH

This research was conducted in several stages to ensure a systematic and comprehensive approach. The initial stage involved a thorough literature review of belt conveyor systems and their components, utilizing textbooks, journals, and theses as primary sources. Following this, detailed calculations were performed to determine the geometric specifications of the conveyor, based on established references such as Conveyor Belt Technique Design and Calculations and the Dunlop catalogue.

Subsequently, the belt conveyor was modeled using SolidWorks software. The modeling process involved creating detailed representations of key components, including the drive pulley, tail pulley, bend/snub pulley, and take-up pulley. Additionally, the study included the careful selection of essential components such as the idler, belt, motor, and counterweight. This systematic methodology ensured the development of a robust and reliable conveyor design tailored to the specified requirements.

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III. RESULTS AND DISCUSSIONS

3.1 Belt Width

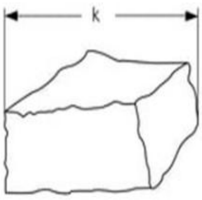
The belt is a critical component of a belt conveyor system, serving as the primary medium for transporting materials. The selection of the belt width is determined based on the size, type, and characteristics of the material to be conveyed, ensuring efficient and safe handling. For instance, larger or irregularly shaped materials typically require wider belts to prevent spillage and maintain smooth operation. Additionally, the belt must be designed to accommodate the load capacity and operating conditions, such as speed, distance, and environmental factors. Proper belt selection is essential to optimize the conveyor's performance and extend its service life.

Figure 1 illustrates the standard and minimum belt width requirements for a belt conveyor based on the size of the material being transported, considering both sized and unsized lump dimensions.

Standard Widths (mm)

300	400	500	650	800	1000
1200	1400	1600	1800	2000	2200

Minimum Belt Widths



Min. Width (mm)	Lump Size K Sized	Lump Size K Unsized
400	50	100
500	80	150
650	130	200
800	200	300
1000	250	400
1200	350	500
1400	400	600
1600	450	650
1800	550	700
2000	600	800

Figure 1: Belt Width for conveyor

The selected belt width (B) for this design is 1400 mm, chosen to ensure optimal performance and accommodate the material size and capacity requirements.

3.2 Belt speed

Figure 2 provides a comprehensive guideline for selecting the appropriate conveyor belt speed based on the material type and application. It categorizes belt speeds into different ranges, highlighting how material properties and operational duties impact the optimal speed.

For example, lighter loads such as unit assembly lines or mobile conveyors require lower speeds (≤1.68 m/s) to ensure precision and control. On the other hand, heavier materials like ores, coal, or sinter require medium to high speeds (1.31–3.35 m/s) to accommodate higher throughput while maintaining efficiency. Long-distance conveying tasks demand higher speeds (2.62–6.60 m/s) to handle bulk material over extended distances.

Standard Values

Speeds V (m/s)						
0.42	0.52	0.66	0.84	1.05	1.31	1.68
2.09	2.62	3.35	4.19	5.20	6.60	8.40

Recommended Velocity (m/s)

Duty	v (m/s)
Unit Loads, Assembly Lines	≤ 1.68
Mobile Conveyors	0.52 - 1.68
Very dusty loads such as Flour, Cement	≤ 1.31
Ash and Refuse	≤ 1.68
Grain, Crushed Limestone Gravel, Sand Readymix	1.05 - 2.09
Ores, Bituminous Coal, Sinter Storage and transhipment, Power Stations	1.31 - 3.35
Long distance conveying, overburden Brown coal	2.62 - 6.60
Thrower belts	≥ 8.40
Steep gradient belts Type CHEVRON and HIGH CHEVRON	0.84 - 2.62

Figure 2: Belt Speed

The selected belt speed of 3 m/s falls within the range recommended for handling ores and coal, indicating that the system is designed for a robust industrial application with moderate to heavy-duty requirements.

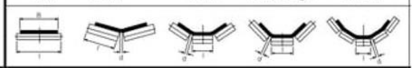
3.3 Idler

The positioning of idlers in belt conveyors is categorized into several types: flat, 2-part, 3-part, deep trough, and garland. Each idler configuration is directly related to the conveyor's capacity, as it determines the belt's ability to support and transport materials efficiently. Figure 3 shows the standard idler for belt conveyor.

Standard Idler Diameter (mm)

Carrying Idlers	51	63.5	88.9	108	133	159	193.7	219
Impact Idlers				156	180	215	250	290
Return Run Support Discs		120	138	150	180	215	250	290

Standard length L (mm) of rollers



Belt Width B (mm)	Troughing Type Flat	2 roll	3 roll	Deeptrough	Garland
300	380	200	-	-	-
400	500	250	160	-	-
500	600	315	200	-	-
600	700	340	250	-	-
650	750	380	250	-	-
800	950	465	315	200	165
1000	1150	600	380	250	205
1200	1400	700	465	315	250
1400	1600	800	530	380	290
1600	1800	900	600	465	340
1800	2000	1000	670	530	380
2000	2200	1100	750	600	420
2200	2500	1250	800	640	460

Figure 3: Idler for conveyor

The idler used is a carrying idler configured with three rollers at a 45° angle, each measuring 530 mm in length and 159 mm in diameter. Additionally, a return idler is employed, featuring a single roller with a length of 1600 mm and a diameter of 159 mm.

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3.4 Conveyor Capacity

Determining conveyor capacity is a critical aspect of belt conveyor design. This calculation is based on the material load stream and belt speed. The effective, or nominal, load stream volume is calculated by considering the effective degree of belt filling. Based on the calculations performed, the conveyor capacity has been determined to be 2132.14 t/h.

3.5 Power Motor

The motor is a crucial component of the belt conveyor system, serving as the primary driving force that powers the entire conveyor circuit. Figure 4 shows the data for calculating the power of motor.

Length Factor C_L

L (m)	3	4	5	6	8	10	12.5	16	20
C_L	667	625	555	526	454	417	370	323	286
L (m)	25	32	40	50	63	80	90	100	150
C_L	250	222	192	167	145	119	109	103	77
L (m)	200	250	300	350	400	450	500	550	600
C_L	63	53	47	41	37	33	31	28	26
L (m)	700	800	900	1000	1500	2000			
C_L	23	20	18	17	12	9			

L (m) Conveying Length

Working Conditions Factor k_f

Working Conditions	k_f
Favourable, good alignment, slow speed	1.17
Normal (Standard Conditions)	1
Unfavourable, dusty, low temperature, overloading, high speed	0.87 - 0.74
Extremely low temperature	0.57

Additional Power Values

	Belt Width B (mm)	P (kW)
Trippers (throw-off carraiges)	≤ 500 ≤ 1000 > 1000	0.8 • v 1.5 • v 2.3 • v
Scrapers (for installations L ≤ 80 m)	**Scraper Type**	
	simple, normal contact	0.3 • B • v
	heavy contact	1.5 • B • v
	multifunctional fac scraper	1.8 • B • v
Material - skirtboard	beyond loading point	0.16 • v • l_f
Discharge plough	Bulk density $\rho \leq 1.2$ Angle α = 30° - 45°	1.5 • B • v

B (m) Belt width
v (m/s) Belt speed
l_f (m) Length of material between skirtboard

Figure 4: Power Motor calculation

Based on the calculations conducted, the selected motor power for the belt conveyor system is 315 kW. This power rating was chosen to ensure sufficient driving force to handle the conveyor's operational demands, including the material load, belt speed, and overall system efficiency. The selection guarantees reliable performance and accommodates potential variations in load conditions, ensuring smooth and uninterrupted operation of the conveyor.

3.6 Belt Type

The type of belt used in the conveyor system is determined based on its breaking strength. The selected belt is S1250/5, with a cover thickness of 8+2 mm, a belt weight of 20.1 kg/m², and a carcass thickness of 7.6 mm. This specification ensures the belt's durability and strength to handle the required load and operational conditions efficiently.

3.7 Pulley Diameters

The diameters of the pulleys used in a conveyor system are determined based on the type of belt employed. The belt type dictates the minimum allowable pulley diameter to ensure proper belt support, minimize stress on the belt, and prevent premature wear or damage. Selecting the appropriate pulley diameter is essential for maintaining the structural integrity of the belt, ensuring smooth operation, and optimizing the conveyor system's performance. By aligning the pulley dimensions with the belt's specifications, the system can achieve greater reliability and an extended operational lifespan. Figure 5 shows the list of standard pulley diameter for conveyor.

Pulley Diameter D_{Tr} (mm)	Diameter Of Pulley Groups (mm) A	B	C
100	100	-	-
125	125	100	-
160	160	125	100
200	200	160	125
250	250	200	160
315	315	250	200
400	400	315	250
500	500	400	315
630	630	500	400
800	800	630	500
1000	1000	800	630
1250	1250	1000	800
1400	1400	1250	1000
1600	1600	1250	1000
1800	1800	1400	1250
2000	2000	1600	1250

Figure 5: Pulley Diameter standard

The conveyor system is equipped with three types of pulleys, each with specific dimensions based on their function. The drive pulley has a diameter of 800 mm, designed to provide the necessary torque and traction to drive the conveyor belt effectively. The tail pulley, located at the opposite end of the conveyor, has a diameter of 650 mm and plays a crucial role in redirecting the belt and maintaining tension. Additionally, the snub/bend pulley, with a diameter of 500 mm, is used to increase the wrap angle of the belt around the drive pulley, enhancing the belt's grip and operational efficiency.

3.8 Take-up Weight

The take-up weight of the belt conveyor is determined based on the tension values at points T3 and T4 along the conveyor system. These tension values are critical for calculating the force required to maintain proper belt tension and ensure smooth operation. After performing the necessary calculations, the take-up weight has been determined to be

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5557 kg. This weight is essential for applying the appropriate tension in the belt, compensating for any slack, and maintaining the correct belt alignment throughout the conveyor's operation.

3.9 Shaft Pulley

Shaft pulley calculations are performed by specifying several key parameters that define the material properties and operating conditions of the system. The material selected for the shaft is AISI 1045 cold drawn steel, known for its strength and durability. The coupling efficiency is considered to be 0.9, reflecting the transmission efficiency between connected components. Additionally, the factors K_f and K_fs are set at 1.5 and 1.0, respectively, accounting for correction factors related to load and safety considerations. The material's ultimate tensile strength (Sut) is 625 MPa, while the modified endurance limit (Se') is 315 MPa. Based on these input data and the resulting calculations, the required shaft diameter is determined to be 140 mm, ensuring that the shaft can safely handle the operational stresses and provide reliable performance in the conveyor system.

3.10 Drive Pulley

The drive pulley is a critical component in the conveyor system, serving as the initial drive element that initiates the movement of the conveyor belt. The pulley has a length of 1600 mm and a diameter of 800 mm, designed to provide the necessary traction and torque to drive the belt efficiently. This pulley is connected to a shaft, which has a length of 2310 mm and a diameter of 140 mm, ensuring robust support and transferring rotational force to the pulley.

Figure 6 illustrates the drive pulley, showcasing its key dimensions and connection to the shaft, highlighting its essential role in the operation of the conveyor system.

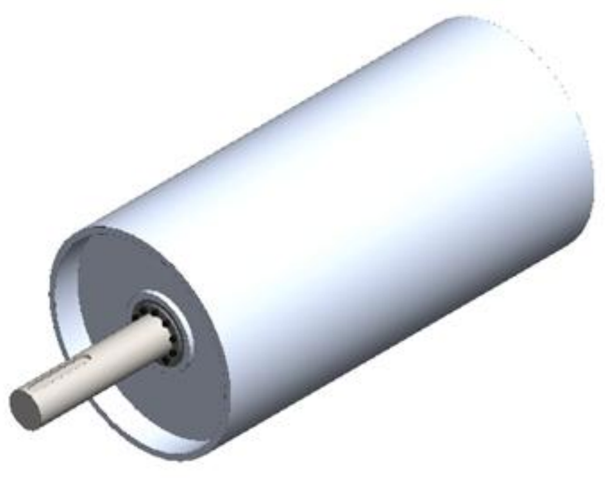

Figure 6: Drive Pulley

3.11 Tail Pulley

The tail pulley is a crucial component located at the end of the conveyor system, responsible for maintaining the tension and directing the conveyor belt back after it has completed its material transport cycle. This pulley has a length of 1600 mm and a diameter of 650 mm, designed to ensure smooth belt movement and effective redirection. The tail pulley is connected to a shaft with a length of 2010 mm and a diameter of 140 mm, providing the necessary support and transmitting the rotational force to the pulley.

Figure 7 shows the tail pulley, emphasizing its key dimensions and its essential role in maintaining belt tension, ensuring that the conveyor operates efficiently by facilitating the continuous loop of the system.

Figure 7: Tail Pulley

3.12 Bend and Snub Pulley

The bend pulley is an important component used to change the direction of the conveyor belt, while the snub pulley plays a key role in increasing the winding angle between the drive pulley and the belt, enhancing belt traction and grip. This pulley has a diameter of 500 mm and a length of 1600 mm, designed to support the belt as it transitions around the pulley. The pulley is connected to a shaft, which has a length of 2010 mm and a diameter of 140 mm, providing the necessary strength and stability to ensure reliable operation.

Figure 8 illustrates the bend and snub pulleys, highlighting their dimensions and their crucial functions in the conveyor system. The bend pulley facilitates belt direction changes, while the snub pulley optimizes the contact angle between the belt and the drive pulley, improving the overall efficiency of the system.

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Figure 8: Bend and Snub Pulley

3.13 Take-up Pulley

The take-up pulley is an essential component designed to maintain proper tension in the conveyor belt, ensuring it remains tight and aligned throughout the system's operation. This pulley has a diameter of 500 mm and a length of 1600 mm, designed to effectively adjust belt tension. The take-up pulley is connected to a shaft with a length of 2200 mm and a diameter of 140 mm, providing the necessary support and stability to maintain the required belt tension.

Figure 9 illustrates the take-up pulley, highlighting its key dimensions and its important role in tightening the conveyor belt. This pulley ensures that the belt remains properly tensioned, preventing slack and maintaining smooth operation of the conveyor system.

Figure 9: Take-up Pulley

IV. CONCLUSION

Based on the research conducted, the following conclusions can be drawn: The geometry of the belt conveyor system components includes a drive pulley with a length of 1600 mm and a diameter of 800 mm, a tail pulley with a length of 1600 mm and a diameter of 630 mm, and a bend/snub pulley with a length of 1600 mm and a diameter of 500 mm. The shaft pulley has a length of 2310 mm and a diameter of 140 mm. The key components that require determination include the carrying idler with a length of 530 mm, a diameter of 159 mm, and a 3-part configuration at a 45° angle, along with the return idler that has a length of 1600 mm and a diameter of 159 mm. The selected belt is a superfort type S1250/5 8+2, and the motor specifications are 315 kW, 400 V, 50 Hz, 1500 rpm, with 4 poles and 3 phases. Lastly, the counterweight weighs 5557 kg, ensuring proper belt tension in the system.

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