LAB University of Applied Sciences

# Design A Movable Inclined Conveyor

LAB University of Applied Sciences
Bachelor of Engineering, Mechanical Engineering and Production Technology
2023
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**Abstract**

| Author(s) | Publication type | Completion year |
|---|---|---|
| Hau, Tran | Thesis, UAS | 2023 |
| | Number of pages<br>61 (thesis), 20 (appendices) | |

Title of the thesis

**Design A Movable Inclined Conveyor**

Possible subtitle(s)

Degree, Field of Study

Bachelor of Engineering, Mechanical Engineering and Production Technology

Organisation of the client


Abstract

In an age when the industry is continuously developing, the incorporation of production chains into manufacturing is not surprising. The conveyor system is one of the most visible systems that may be seen almost anyplace. Conveyor Belt is a prominent product in this category.

A Movable Inclined Conveyor is also regarded as a notable product type in the Conveyor Belt Category. Because of its popularity in the industry, this research focuses on investigate the essential characteristics and feasibility to self-designing A Movable Inclined Conveyor based on specified product qualities and original specifications. The Movable Inclined Conveyor would be served for loading products to transport vehicles and also use in a limited area like a warehouse.

The article includes equations, statistics, a tension diagram, a shear force diagram, and a bending moment diagram to bring the research process to life. The final outcome demonstrates the fundamental construction of a Movable Inclined Conveyor in practice. At the same time, it completely depicts the process of developing a design concept from start to finish.



Keywords

Conveyor system, belt, equations.

Contents

**List of symbol and units:**

| | | |
|---|---|---|
| $a_0$ | Idler spacing on the carrying side of the conveyor | m |
| $a_u$ | Idler spacing on the reverse side of the conveyor | m |
| i | Number of plies | - |
| d | Belt Thickness | m |
| $d_{ply}$ | Thickness of the ply | m |
| $d_1$ | Thickness of the top rubber layer | m |
| $d_2$ | Thickness of the bottom rubber layer | m |
| b | The usable width of the belt | m |
| B | Belt width | m |
| $F_T$ | Total load of one idler | N |
| Q | Conveyor capacity | t/h |
| v | Belt speed | m/s |
| G | Belt weight | kg/m |
| $F_r$ | Bearing load rating | N |
| k | Lifetime coefficient | |
| $q_G$ | Mass per unit length due to cargo weight | kg/m |
| q | Mass per unit length due to the mass of the belt | kg/m |
| $q_{RO}$ | Mass per meter of the revolving idler parts along the carrying side of the conveyor | kg/m |
| $q_{RU}$ | Mass per meter of the revolving idler parts along the return side of the conveyor | kg/m |
| $q_B$ | Mass per meter of the belt along the carrying side and along the return side | kg/m |
| α | Elevator angle | degrees |

| | | |
|---|---|---|
| w | Idler total weight | kg |
| $w_r$ | Weight of rotating parts | kg |
| $F_n$ | Tension forces at point n | N |
| $F_{n+1}$ | Tension forces at point n + 1 | N |
| $Fs_n$ | Resistance force at point between point n and n+1 | N |
| H | Elevator height | m |
| L | Length from centre to centre | m |
| ч | Friction coefficient between the driving pulley(s) and the belt | - |
| $F_{min}$ | Minimum belt tension | N |
| $\sigma$ | Tensile stress at screw cross-section | $N/mm^2$ |
| $F_{cr}$ | Traction force in one screw | N |
| $F_t$ | Total traction force | N |
| $F_A$ | External force | N |
| F | The force acting on the conveyor | N |
| Ks | Service factors | - |
| i (gear) | Gear ratio | - |
| $F_{rc}$ | Load acting on roller chain | kgf |
| $C_p$ | Distance between the Drive and Driven shafts (centre-to-centre) | mm |
| $L_p$ | Overall chain length | mm |

## 1 Introduction:

Conveyor belts are no longer unfamiliar to people living in an age where businesses are rapidly increasing. The problem of safely moving items across levels is becoming more pressing as the need to safeguard human health grows.

Conveyor belts capable of delivering items to a particular height are increasingly becoming more frequently used in a variety of developing nations, including moving commodities in manufacturers, construction, and harbours. The initial illustration portrays a commonly employed belt conveyor in the construction industry.

Image 1 .Portable Conveyor (Portable Conveyors - Vale Industries, 2020)

Conveyor belts are primarily used by conveyor shaft rollers, chain conveyors, and conveyor systems in enterprises that use manufacturing and packing chains. Airports, supermarkets, and small manufacturing facilities are also using more mobile conveyors. These points demonstrate that the conveyor sector in particular and mobile conveyors in general, are fast evolving. (The Introduction of Portable Belt Conveyor—Henan Excellent Machinery Co.,Ltd., 2018)

A Movable Conveyor Belt frequently referred as A Portable Belt Conveyor. A portable conveyor is a sort of transportable conveyor that has supports that allow it to move. (Portable Conveyors - SolidsWiki, 2023)

This is a versatile equipment that is used in a variety of sectors, including the light industry of food, medicine, textile, construction and so on. It is the primary method of industrial production due to a number of benefits of short-distance transportation. The portable belt conveyor offers superior mobility as compared to standard belt conveyors, thanks to the redirection system. With such a little gadget, the whole belt conveyor seems to be alive; it can travel immediately to the material site and instantly connect with both sides; it also eliminates the time that the belt conveyor must be fixed at one location to transmit materials, which considerably reduces production costs. (The Introduction of Portable Belt Conveyor—Henan Excellent Machinery Co.,Ltd., 2018)

This thesis focuses on proving the versatility of the conveyor belt structure that would be used for loading things into transport trucks as well as in limited locations such as a warehouse, as well as answering the issue of whether it is feasible to create a mobile conveyor yourself. The second issue that must be addressed is: what are the procedures involved in creating a portable conveyor? Are the costs of current mobile conveyors on the market reasonable? Because this article focuses on self-fabrication, the conveyor structure chosen is likely to be the most basic.

## 1.1 History:

The first conveyor had been seen in 1795, used in ports to move agricultural products from shore to ship. In this very first design, the conveyor frame was a basic flat wooden bed with a belt running over it. They were powered by hand cranks and a pulley system. The belt themselves were made of leather, canvas, or rubber, with leather being the most common. (Bailey, 2020)

With the birth of the steam engines in the 18th century, hand cranks or human work were no longer required to keep belt conveyors running. In the 1804, British Navy started consuming biscuits made using the first steam-powered conveyors, as depicted in image 2. (Bailey, 2020)

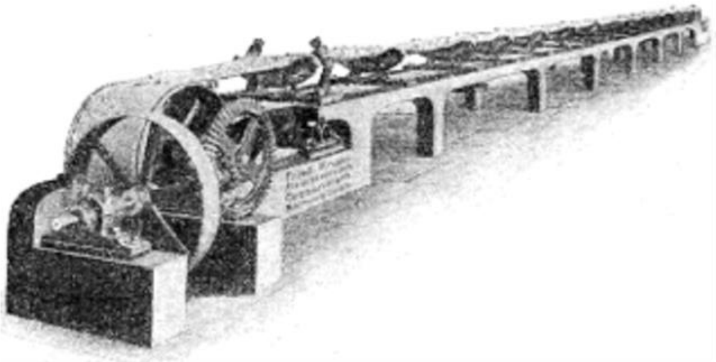

Image 2. First Steam-operated Belt (The History of Conveyors, LAC Conveyors, 3 Nov. 2022)

Until 1892, an American inventor, Thomas Robins created a conveyor belt system for transporting coal and ore for Thomas Edison’s Ore-Milling Company. His invention had been considered as the first primitive and basic conveyor belts and won the grand prize at the Paris Exposition World Fair in 1900. (LAC Logistics Automation, 2022)

In 1901, the Swedish engineering firm Sandvik began mass producing steel conveyor belts, and in 1905, the Irish-born Yorkshire-based engineer Richard Sutcliffe designed the first underground conveyor belts specifically for use in coal mines. No longer after, in 1908, an inventor Hymle Goddard patented the first roller conveyor. (SEMCOR, 2020)

In 1913, Henry Ford implemented conveyor-belt assembly lines at Ford Motor Company's Highland Park, Michigan facility. Image 3 provides a clear presentation of the conveyor that was utilised. (SEMCOR, 2020)

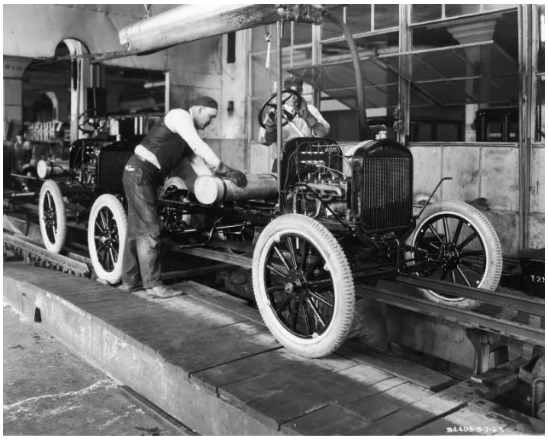

Image 3. The creation of the assembly line by Henry Ford at his Highland Park plant, introduced on December 1, 1913 (Alamy Limited, 2020).

In 1957, the B.F. Goodrich Company patented a particular kind of conveyor belt, which they then began manufacturing and marketing as the Turnover Conveyor Belt System. The half-twist design made it more durable and hence more effective than regular belts. (SEMCOR, 2020)

In 1970 Conveyors with improved noise suppression and wear resistance were developed. Until 1980, Internally driven conveyor rollers and motorised pulleys were created to reduce the need for expensive maintenance. (Bailey, 2020)

Other conveyor belt varieties, such as Portable Conveyor Belt, were developed as science and technology advanced through various periods and based on different needs. Simultaneously, numerous different kinds of conveyor belts were created to service specialised industries.

## 1.2 Market researchers:

Portable Belt Conveyor had become a well-known device which present and produced in various nations. On the market it is not difficult to find a wide variety of Portable Belt Conveyors that are available in a range of sizes and configurations. The circumstances in which it is used and the function it serves are both distinct for each kind.

The first type of Portable Belt Conveyor that should be mentioned is the one that has an enormous structure, normally used in mining, port, cement, steel, metallurgy, electric power, coal, machinery, etc. The conveyor in image 4 is also called a Portable Radial Stacking conveyor. With this kind of conveyor, loading material can be up to several tons.

Image 4. 80 Foot (24.4m) Radial Stacking Conveyor (Screen Machine, 2018)

The common perception of Portable Belt Conveyors is that they typically consist of conveyors of moderate size, akin to the one illustrated in image 5. This is another popular style of this product that comes in a variety of forms and patterns. Because this conveyor is designed to transfer products of medium size and weight, its size is likewise modest. The conveyor may be moved by attaching it to the back of the vehicle due to its reasonable construction and moveable wheels. The price of this product can be easily looked up on the market.

Image 5. Portable Belt Conveyor (Portable Belt Conveyor, 2014)

### 1.2.1 Domestic market:

There are a few companies in Finland that provide products related to conveyor belt.

In Finland, Laitex Oy is one of the most often encountered companies when exploring the market for Conveyor Belt. Cooling Chain Conveyors, Pneumatic Conveyors, Screw Conveyors, and many more types of conveyors are among their various offerings. Belt Conveyor is also one of their products. Belt conveyors for handling bulk materials in industrial settings are what Laitex specialises in designing and manufacturing. There's a wide range of belt conveyor sizes available, from little machines to industrial-scale systems. Complete conveyor solutions for every need are possible with the right understanding of process technology. Image 6 showcases a product that is commonly produced by Laitex Oy. (Innovatiivista Materiaalinkäsittelyä | Laitex, 2022)

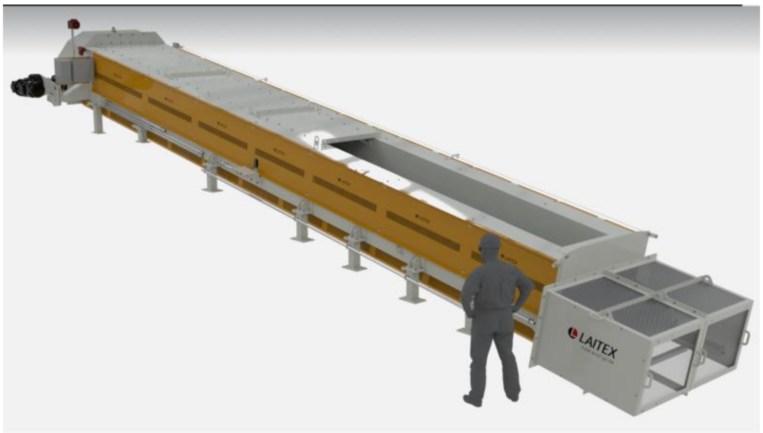


Image 6. Heavy-Duty Belt Conveyors (Heavy Duty Belt Conveyors | Laitex Oy, 2022)

The second organisation is called MA-TECH, and it is possible that they are the ones that deserve the "special" label. They did not have a defined catalogue of goods, unlike other competing businesses. Their business model is around tailoring conveyor systems to individual client requirements. (MA-Tech Conveyor Manufacturer, 2023)

Their design had been used and recommended in many different companies, for example: KASKEA, VALUKUMPU, AQUA CLEAN and so on. The product depicted in image 7 represents one of the designs created by the company for its partner organization. (MA-Tech Conveyor Manufacturer, 2023)

Image 7. Design of MA-TECH for VALUKUMPU (MA-Tech Conveyor Manufacturer, 2023)

Roxon, a subsidiary of Australia's NEPEAN Conveyors, is a major firm here. This firm has been in operation since 1962. Despite being in Australia, it has a location in Finland, which is in Hollola. As a business introduction, ROXON offers customers complete system solutions to increase efficiency. Their services include entire conveyor products such as the HC100 Belt Conveyor, which is utilised in mines, power plants, and stockyard sectors, chain conveyors, and the HC 200 Link Conveyor and so on. The physical appearance illustrated in image 8 has been replicated from the corresponding platform on the internet. (“ROXON,” 2022)

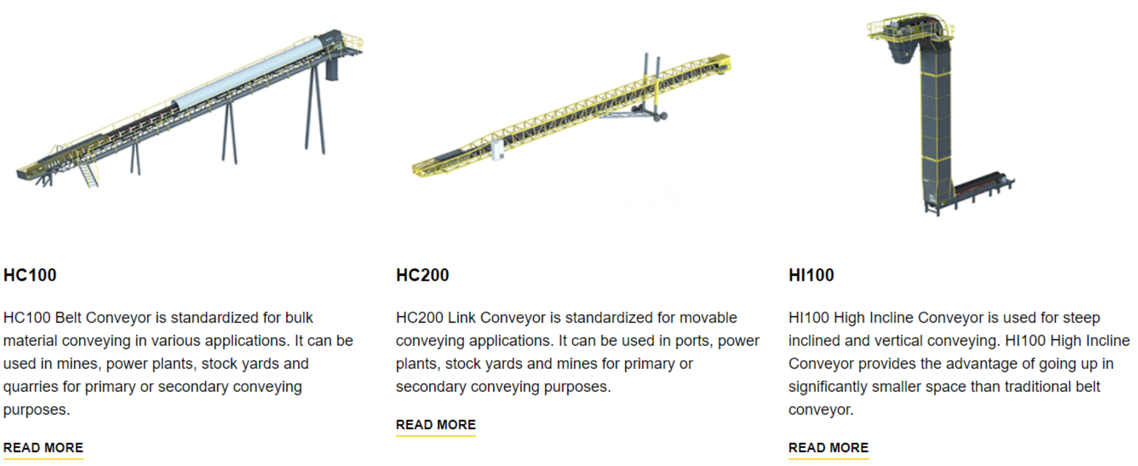


Image 8. A few Conveyors products produced by ROXON (Equipment Archive» ROXON, 2017)

The reason that ROXON should be acknowledged is that it not only provides Completed Conveyor goods but also Conveyor components such as rollers, pulleys, roller frames, and Belt Cleaners. Several of their products were displayed in Image 9. This plays a crucial role in the essay since it makes it easier to inspect the model and access the product catalogue, which offers the essential dimensions that might aid in the 3D model development for the final product. (ROXON, 2022)


Image 9. ROXON Conveyor Components (Components Archive» ROXON, 2021)

### 1.2.2 International market:

In 2021, the worldwide market for conveyor belts was worth $5.9 billion. Forecasts indicate the market would expand at a CAGR of 3.8% between 2023 and 2028, eventually reaching USD 7.5 billion. (“Global Conveyor Belt Market Report and Forecast 2023-2028,” 2023)

As indicated in image 10, medium-weight conveyor belts delight the largest market share among product categories, owing to their superior load-bearing capabilities. Based on end-use, the mining industry led the market on account of the rising utilisation of the product for the transportation of diverse commodities over short distances. (Conveyor Belt Market Size, Share, Trends, Analysis, Report 2023-2028, 2023)

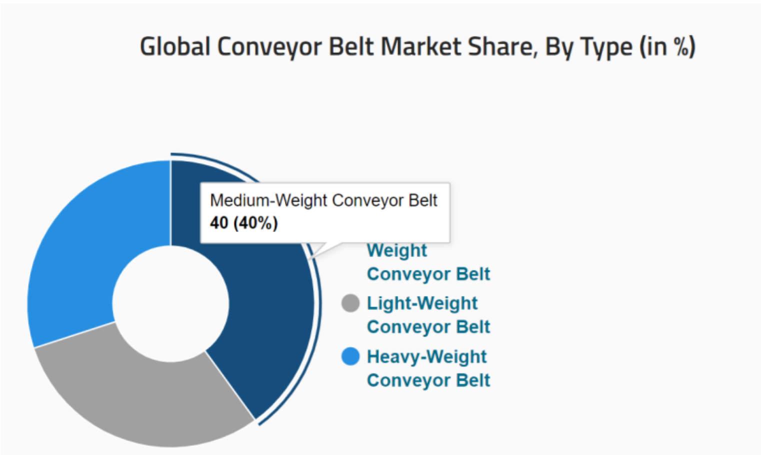


Image 10. Global Conveyor Belt Market Share (Conveyor Belt Market Size, Share, Trends, Analysis, Report 2023-2028, 2023)

Conveyor belts are widely used in many different sectors because to their adaptability, portability, and low cost. Moreover, it is commonly utilized in various environments such as airports and the culinary sector, particularly in Mining and Metallurgy, as depicted in the statistical chart illustrated in image 11. (Global Conveyor Belt Market Report and Forecast 2023-2028, 2023)

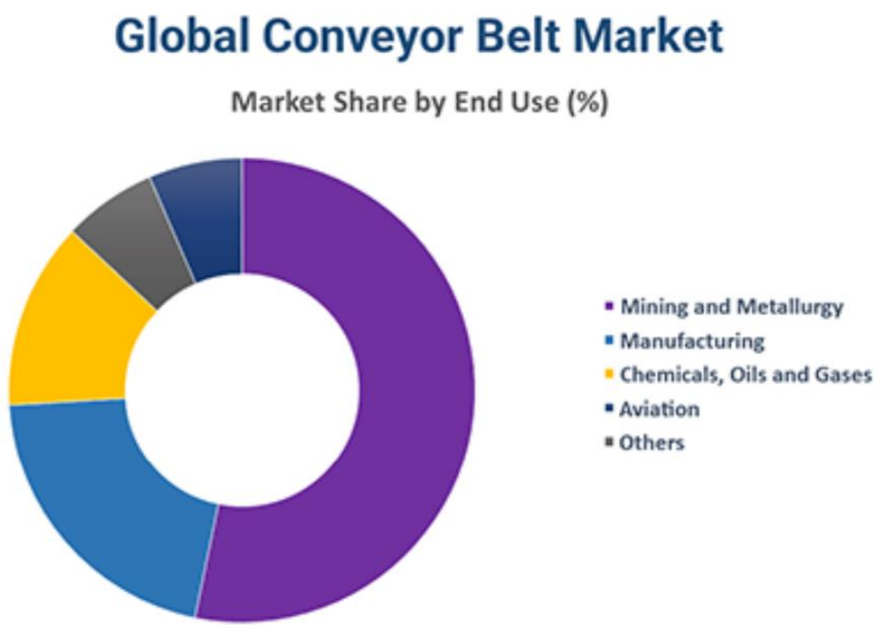


Image 11. Global Conveyor Belt Market Pie Chart (Global Conveyor Belt Market Report and Forecast 2023-2028, 2023)

The research includes a thorough analysis of the competitive landscape of the industry as well as profiles of the top players of the market. Some of the prominent corporation names are Bando Chemical industries Ltd., Fenner Conveyor Belting Pvt Ltd., Intralox LLC, Volta Belting Technology Ltd., Fives Group, etc. (Global Conveyor Belt Market Report and Forecast 2023-2028, 2023)

Volta Belting Technology Ltd focuses on manufacturing procedures and belt goods for industries ranging from ceramic tile production, recycling, and automotive to the ever-important food processing industry. Image 12 displays one of the frequently occurring products of Volta. (About Us -, 2022).


Image 12. Volta Belting Technology (Homepage -, 2022)

# 2 Definition:

## 2.1 Basic structure:

The most basic structure that is commonly seen when mentioning “Portable Belt Conveyor Structure” has been shown in figure 1.

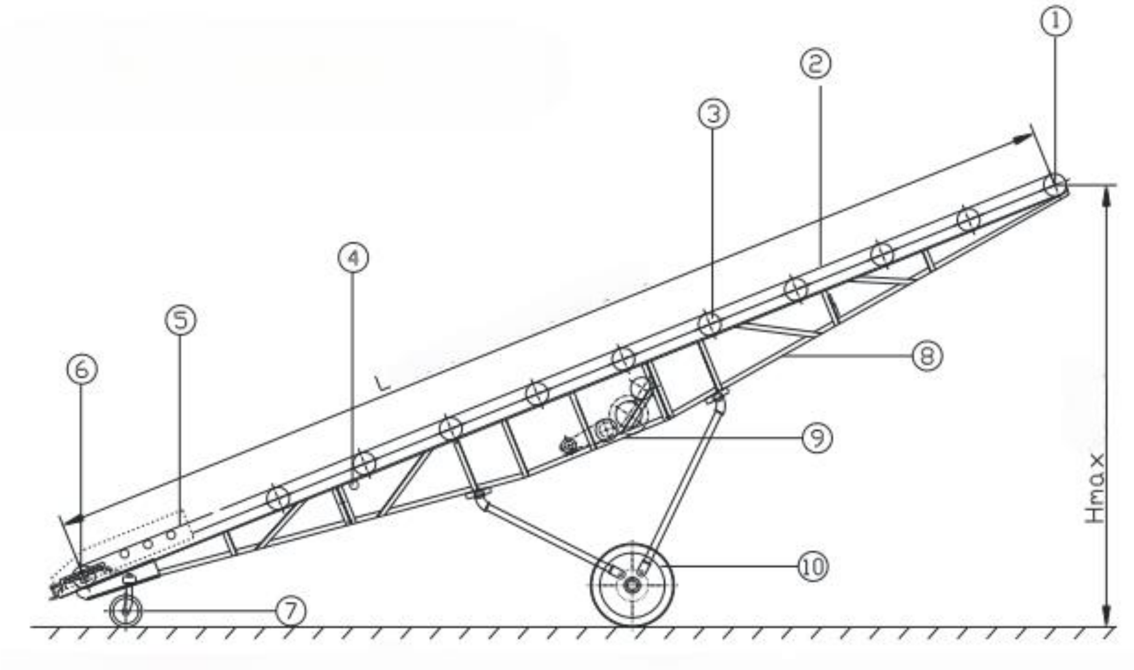


Figure 1. Mobile Belt Conveyor Basic structure (Dy Mobile Belt Conveyor, 2020)

1. Electric drum.
2. Belt.
3. The upper idler group.
4. The below idler group.
5. Feed chute.
6. Bend pulley.
7. The steering equipment.
8. Rach.
9. Lifting device.
10. Walking device.

For different types of Portable Belt Conveyors, there might include some different parts, for example, Radial Stacking Conveyor had been shown in figure 2.

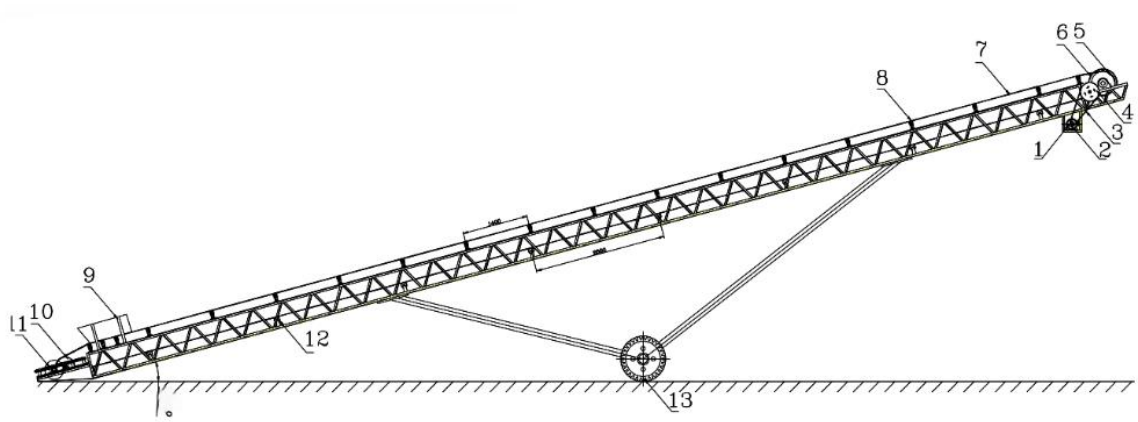


Figure 2. Basic structure of Portable Belt Conveyor (Radial Stacking Conveyor)

1. Power.
2. Small pulley.
3. Frame.
4. Big pulley.
5. Head pulley.
6. Transmission chain.
7. Belt.
8. Impact idler.
9. Feed chute
10. Tail pulley.
11. Screw takeup.
12. Return idler.
13. Walking device.

The constructions seen in the two illustrations are the most typical ones found on the market. There are various more designs that could be utilized for different firms and for separate purposes.

## 2.2 Working principle:

Belt conveyors work in a single vertical plane, horizontally, or with an inclination (up or down) based on the frictional characteristic of the load transported. The conveyor is driven by the motor. There is a gearbox mounted at the output of the motor to reduce the speed of the motor to match the required speed of the conveyor. The positioning of the motor around the conveyor body can vary, with a common orientation being towards the drive pulley. As depicted in image 13, the motor has been affixed to the end of the conveyor and directly connected to the drive pulley.

Image 13. Portable Mobile Conveyor Belt (Mobile Conveyor - Vivian Conveyors, 2022)

Figure 3 illustrates the fundamental structure and placement of the crucial components necessary for comprehending the operational mechanism of the belt conveyor.

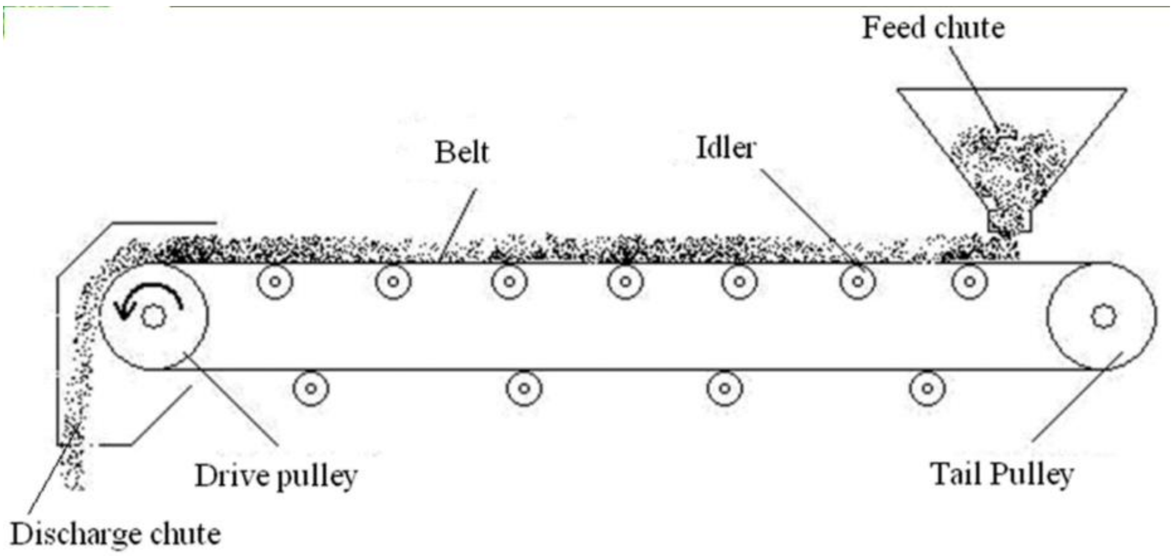


Figure 3. Working principle of Belt Conveyor (TNHH, 2021)

With the engine running, the head pulley rotates, and the belt follows suit due to the frictional force between them. When the conveyor belt is slack, friction is created between the active roller and the belt by adjusting the tail pulley and allowing the conveyor belt to extend. The friction force between the conveyor belt and the roller will make the conveyor move reciprocally. Material put on the conveyor belts surface will be moved by the conveyor belt movement. Rollers are employed under the conveyor surface to prevent the conveyor belt from sagging, which also lowers frictional force along the track of the conveyor. (Wat Electrical, 2021).

The rubber conveyor belt is covered by high quality rubber material, of which the inside is made of Polyester, a synthetic fibber and polyamide fibre, which has the characteristics of being very durable, water- and weather-resistant. The Belt of conveyor is required to be durable, strong, wear-resistant and high-friction. A very important factor is that the belt extension coefficient must be very low, carry a lot, can transfer materials at medium and long distances with high speed. (QUALITY in the MAKING – HOW RUBBER CONVEYOR BELTS ARE MADE, 2021).

## 2.3 Customer need:

Customer demands are critical from both a customer and a brand aspect. Customer demands are the characteristics that businesses must address in order to entice current or new customers to make a purchase. Price and usefulness of goods and services are two customer demands that might inspire purchases. To understand client demands, brands might perform market research or collect customer input. When a company solves a client's issue, it is more probable that it will be able to cater to the consumer, meet their wants, and develop customer loyalty, allowing the firm to thrive.

The product is focus on the functionality and basic construction of the movable conveyor, the aims of the progress focus on development process in create a basic model of Portable conveyor. Moreover, it should include some outstanding advantages of this type of Belt Conveyor.

Based on the market research, Medium-Weight Conveyor Belt is the one that had more consumption than the rest, so the movable belt conveyor size is chosen is estimated to have an average measurement.

It is common to see this kind of conveyor can be used to transport some powdery or granular materials, such as grain, mineral powder particles and so on. Moreover, portable belt conveyors may also be used to move bagged finished items. Loading, for example, uses bagged grain in bags, which enhances loading efficiency and saves human resources. In addition, its lightweight and adaptable wheels, the portable belt conveyor may be transported anywhere for better working conditions.

Furthermore, the ability of this kind of conveyor to adjust the elevator angle enables it to function in a variety of scenarios, like the 2D drawing in figure 4 below, used for carrying products from a truck to a warehouse, traveling uphill, and so on.

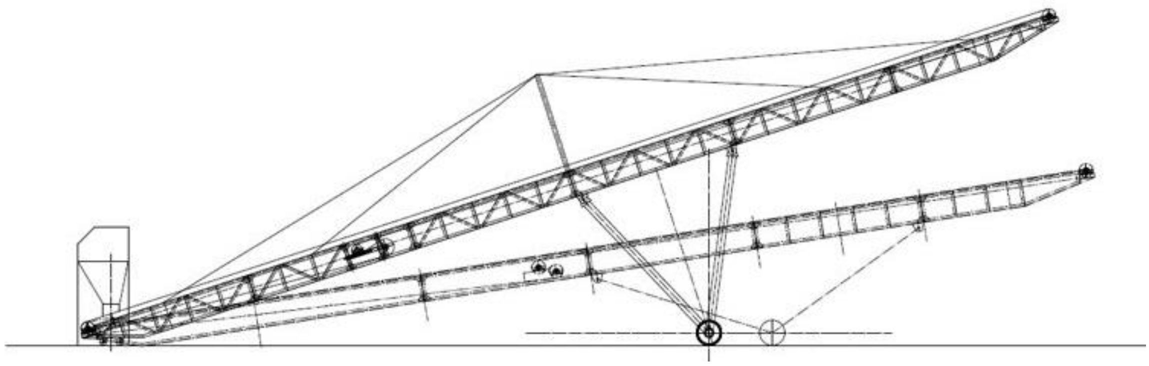

Figure 4. Lifting height may be changed to meet individual requirements. ("Portable Belt Conveyor, Moveable Belt Conveyor, Mobile Conveyor —Henan Excellent Machinery Co., Ltd.," 2018)

As a person from a developing nation, it is clear to notice that in the countryside, human labor for transportation is still used, for example in image 14, either due to the tiny size of the plant or the high cost of goods.

Image 14. Workers are carrying rice (Thanh Tâm - Vietnam, 2017)

For this reason, the final requirement that should be considered is the price of the product. Because of its benefits, conveyors have been applied in many different industries. They can also be used consecutively, especially in small space that does not have enough area for fixed conveyor line. Image 15 depicts an instance of employing multiple conveyors in a transport line.

Image 15. Mobile Belt Conveyor-100kg Bag Handling (Mobile Conveyors | Mobile Conveyor - Vivian Conveyors, 2022)

Finally, the design is intended for those who want a Movable Belt Conveyor capable of loading products onto transport vehicles or operating in confined spaces. It is critical to maintain conveyor sizes on average, which is Medium-Weight Conveyor might be used for a variety of functions. The pricing of the design is as low as feasible while yet ensuring the quality of the conveyor. Bags or cartons weighing up to 50kg can be transported by the conveyor. The addition of wheels beneath the mechanism allows the Conveyor to move more freely. To meet a range of operational requirements, lifting and lowering are achieved utilising a pulley and a motor.

## 2.4 Specification:

To be able to accomplish the requirement of the customer as best result as possible, it is vital to determine relevant product parameters such as delivery volume, conveyor angle, belt speed, conveyor length, and conveyor width. It is an essential aspect of the design process since it gives an overview of the idea selection stage as well as the initial data for the following calculating portions. To be able achieve this requirement, the table in the in identify section has been made.

Note: The data in the table below are not specifications; they primarily serve for analysis and explanation only. The major purpose is to evaluate a few criteria and their appropriateness considering customer requirements. Those values would change during the calculating procedure due to the multiple separate additional pieces of the specific design.

### 2.4.1 Identification:

According to the need of customers, the movable inclined conveyor would be used in an average area, which could be able to transport goods into different spaces.

The Portable Belt Conveyor that should be regularly used in the bag handling sectors typically had a length that could be modified from 3000 to 12000 millimetres. Similarly, for the fundamental design, there are various common sizes that can be easily obtained in the market, such as 3 metres, 4 metres, 5 metres, 6 metres, 8 metres, 10 metres, and 12 metres. Conveyor angles in this application can be modified from 5 to 30 degrees.

There is one unchanging A in the figure 5 below, a standard number to compare when the conveyor changes its angle. A has a value of 1500 millimetres, which is represented by the maximum distance from the ground to the floor of the biggest transport vehicles, a container. Other vehicles, such as trucks weighing 15 tonnes, 10 tonnes, or less, have distances that are less than the A numbers.

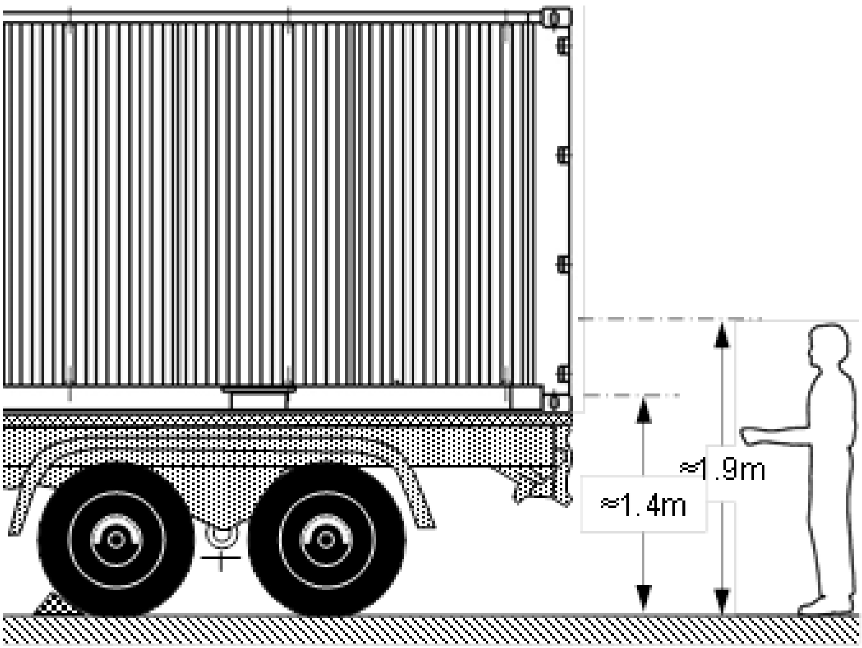


Figure 5. Distances between the ground and the container's floor (3 Removing Seals - Transport - CTU Code - UNECE Wiki, 2014).

Furthermore, the angle of the conveyor is determined at an average distance to minimise slippage and keep the angle inclination from being too harsh. The figure 6 below illustrates that angle alpha 1 has a value of 10 degrees, which is the lowest parameter of the angle.

Alpha 2 has a value of 25 degrees, which is the maximum angle parameter. Likewise, symbol C r denoted the height of the conveyor when it reaches alpha 1, symbol B represented the height of the conveyor when it reaches alpha 2. Moreover, the angle of the conveyor when it remains at A is beta.

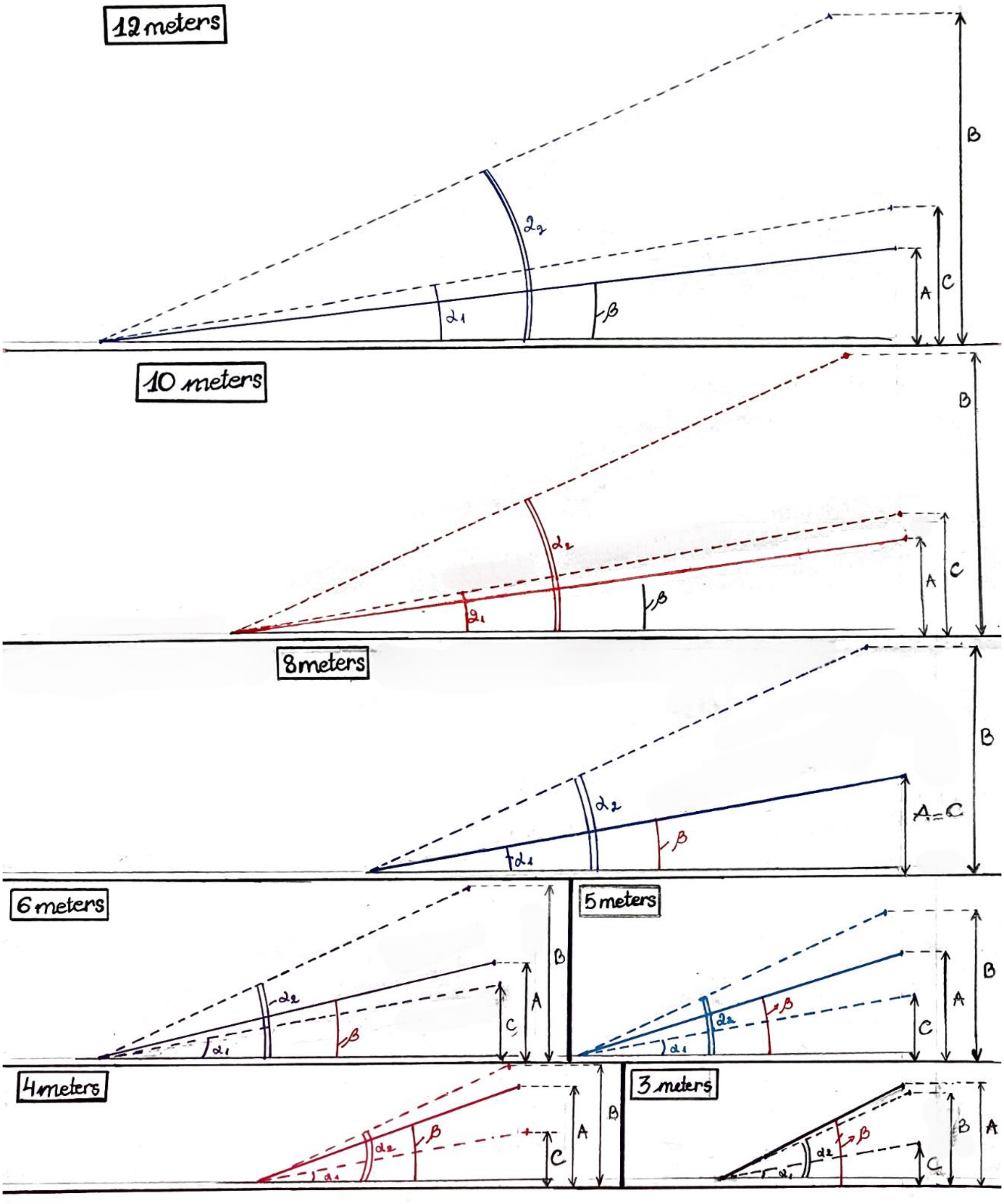


Figure 6. Analysis of the length and angle of conveyors.

Table 1. Analysis of the length and angle of conveyors based on the figure 6.

| **X** (mm) | **Alpha 1 (**10°C) | **C** (mm) | **Alpha 2 (**22°C) | **B** (mm) | **Beta** (°C) | **A** (1500 mm) |
|---|---|---|---|---|---|---|
| **3000** | 10°C | 621 mm | 25°C | 1367 mm | 27.8°C | 1500 mm |
| **4000** | 10°C | 795 mm | 25°C | 1790 mm | 20.5°C | 1500 mm |
| **5000** | 10°C | 968 mm | 25°C | 2213 mm | 16.3°C | 1500 mm |
| **6000** | 10°C | 1142 mm | 25°C | 2636 mm | 13.5°C | 1500 mm |
| **8000** | 10°C | 1489 mm | 25°C | 3481 mm | 10°C | 1500 mm |
| **10000** | 10°C | 1837 mm | 25°C | 4326 mm | 8°C | 1500 mm |
| **12000** | 10°C | 2184 mm | 25°C | 5171 mm | 7°C | 1500 mm |

C had been calculated based on formula: X * sin (10°C) + 100 = C

D had been calculated based on formula: X * sin (25°C) + 100 = C

Beta had been calculated based on formula: $\sin^{-1}$ ((1500-100) / X) = Beta

Note: 100 mm represented the distance of the conveyor to the ground.

Based on table 1 and figure 6, it appears that conveyors of 5 and 6 meters in length may be able to adjust to the need for angles. However, for storage in a warehouse, the conveyor with a length of 8 meters may be preferable to others. To employ the 8-meter-long conveyor, the minimum angle should be modified to make it easier and more realistic for conveying items into vehicles.

For the first adjust beta angle equal 7.5 degree, the lowest point the conveyor can reach is 1144 millimetres. Even if the vehicle is a container or a truck with a high bottom, this height is still higher than that of other vehicles. The lowest angle of beta 2 changes to 5 degrees for the second adjustment, and the lowest point that it may reach is 797 millimetres. The conveyor can thus reach even tiny vehicles such as a 1 tonne or 2 tonne truck.

There is typically one size that is less than 50 cm for bags or boxes used to convey things weighing up to 50kg. There are a few instances when unusual sizes may be required, however in this case, when utilized in small places with simple structures, normal sizes may be counted. Because of this, the width of the conveyor could be designed bigger than 500 mm.

Portable Belt conveyors with correlation characteristics such as load capacity, length, and weight determined the speed of the movable inclined conveyor and delivery volume. These parameters are also within the acceptable range of typical usage.

### 2.4.2 Specification list:

Table 2. Specification list

| | |
|---|---|
| Application Industrial: | Manufacturing, Post, Farms, Home Use, Construction, etc. |
| Condition: | New |
| Structure: | Portable Conveyor Belt |
| Core component: | Motor, Gearbox, Bearings |
| Loading capacity: | Up to 50kg |
| Delivery volume: | 130 ton/hour |
| Angle of conveyor: | 5 degrees to 25 degrees |
| Belt speed: | 1.6 m/s |
| Conveyor length: | 8000mm |
| Belt width: | >500 mm |
| Standard: | SFS-ISO 5048: 1989 |

# 3 Concept generation:

## 3.1 Concept selection:

The needs of the client should be taken into consideration throughout the idea selection step. The concept had been chosen based on Medium-Weight Conveyor Belt type, and this product need to use the basic belt – rubber band. In addition to the fact that this kind of belt is appropriate for the circumstance at hand, the decision to purchase it was based on the reasonable cost of it.

Table 2. Conveyor Belt Price comparison

| Type of belt: | Picture: | Description: | Price: |
|---|---|---|---|
| PVC Conveyor Belt (PVC Conveyor Belt, 2017) |  | Material: PVC.<br>Belt Width: 1500mm.<br>Belt Thickness: 10mm.<br>Features: Heat resistant. | 28,38 Euro/ meter. |
| Food Grade PVC Conveyor Hygienic & Odourless Belt (PVC Conveyor Hygienic & Odorless Belts, 2023) |  | Material: PVC.<br>Belt Width: 100 - 1500mm.<br>Belt Thickness: 3-5 mm.<br>Features: Hygienic and odourless for food. | 113,53 Euro/ meter. |
| Mazcon PVC, Rubber Saw Tooth Conveyor Belt (Saw Tooth Conveyor Belt, 2022) |  | Material: PVC, rubber<br>Belt Width: 500 - 1000mm.<br>Belt Thickness: 2-5 mm. | 28,38 Euro/ meter. |

| | | | |
|---|---|---|---|
| Speed age Nylon Sandwich Belts (Nylon Sandwich Belts, 2023) |  | Material: Nylon<br>Belt Width: 50 - 70 mm<br>Belt Thickness: 5 – 6 mm<br>Feature: High impact, Abrasion resistance. | 68,12 Euro/ meter. |
| Rubber Conveyor Belt (Rubber Conveyor Belt, 2022) |  | Material: Rubber<br>Belt Width: 500 - 2400 mm<br>Belt Thickness: 7 – 20 mm<br>Feature: Heat resistance, Chemical resistance. | 10,10 Euro/ meter. |

According to the information shown in table 2, the rubber conveyor belt demonstrated that it is a product with an affordable price (according to India market) that satisfied all of the essential specifications for the moveable inclined conveyor that is being designed. Because transported goods are already packaged in bags or boxes, there is no need to use goods associated with food, such as a PVC Hygiene Belt for the conveyor system.

Moreover, the concept had been comprehensively considered in many aspects.

There are two basic forms for idlers: a straight design and a V shape. In addition, the price of the conveyor is affected not only by its form but also by the number of idlers it contains.

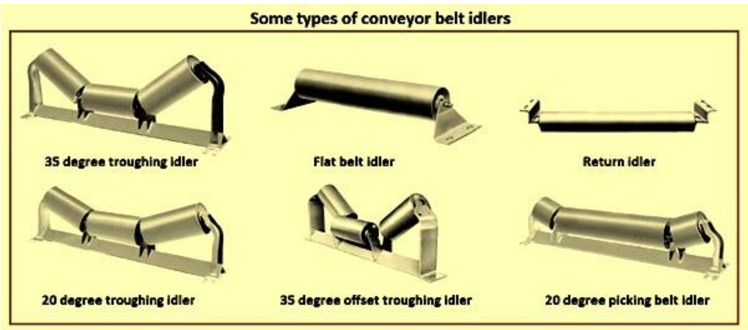


Image 16. Some types of conveyor belt (Belt Conveyor Idlers – IspatGuru, 2021)

Furthermore, the thing that has to be taken into consideration is the frame of the conveyor. In order to reduce the complexity of the final product, the decision was made to make the frame out of a solid bar rather than a frame structure.

Table 4. A comparison of the price and function of a solid bar conveyor with a frame construction conveyor.

| **Solid bar structure** (price: 283,83 Euro) | **Frame structure** (price: 317,89 Euro) |
|---|---|
| <br>Portable Belt Conveyor with Solid bar structure (Portable Belt Conveyor, 2023) | <br>Portable Belt Conveyor with Frame structure (Portable Conveyors, 2014) |
| • This conveyor has a capacity of between 200 and 300 kilogrammes per linear foot.<br>• This conveyor also has the capability of adjusting its own length. The use of an automated control system.<br>• Made in India | • This conveyor has a capacity of 200 kilogrammes per foot of length.<br>• The length of the conveyor is 5 meters. It is not possible to alter the length.<br>• Made in India |

Not only complexity structure but also the price of the frame product (in the market with accessible price like India) seem to have a higher price than a solid bar conveyor. Additionally, when building a portable Belt Conveyor from fresh, a solid bar is recommended over a frame. It might be adjusted depending on the necessity due to the production method as well as the materials, for example, wood.

Those concepts displayed below had gone through all the prerequisites when carefully chosen to meet the end aim based on the analysis that had been given.

- The V-shape idlers of the conveyor included two rollers, and the flat idlers was chosen.
- The rubber band is applied.
- To achieve the previously specified goal of simplifying the design and lowering the price of the conveyor, the frame for concepts that should be employed is a Solid Bar.
- The structure is kept as straightforward as possible.
- Perform competently in accordance with the necessity of transferring bags or boxes.

### 3.1.1 Concept 1:

The concept that had been shown in figure 7 was inspired by the most basic portable conveyor, which used V-idlers (two idlers) and is also known as a Trough Conveyor.

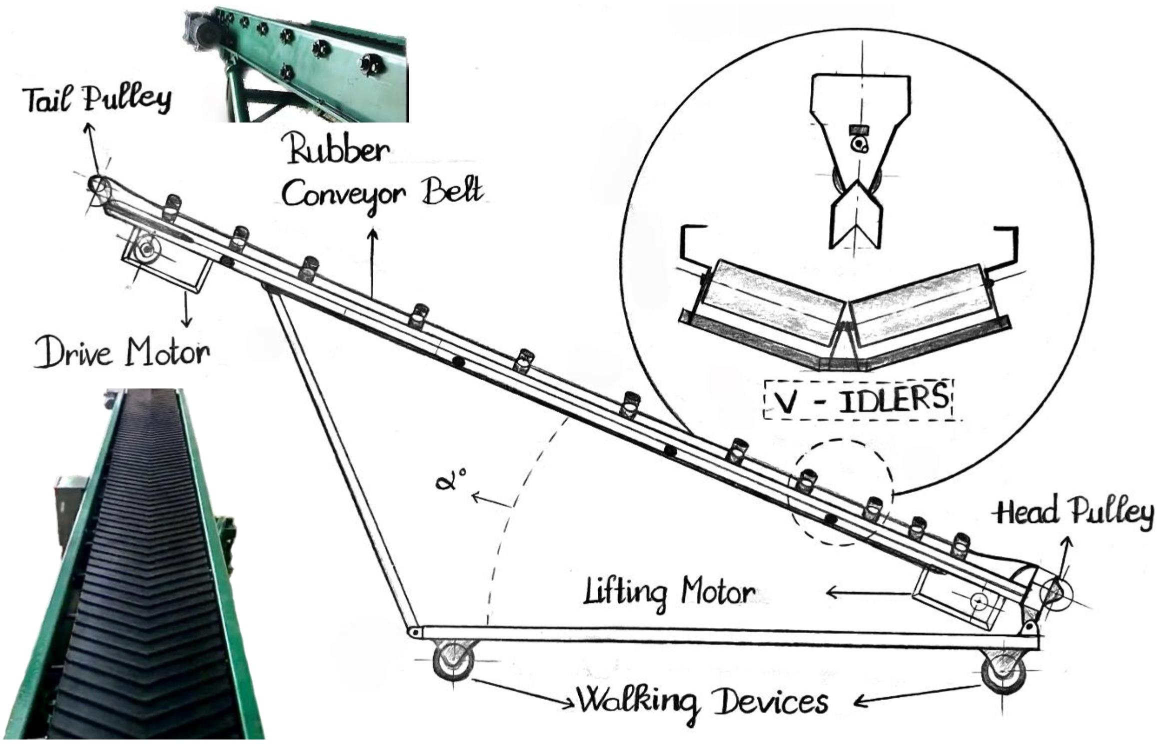


Figure 7. Concept 1 with a V- idler and a conveyor reference model.

The idlers from CEMA standards are shown in the picture as examples of how the idler looks. V-Idlers, or conveyor belt support rollers, are built of materials such as galvanised iron or stainless steel.

Return idlers are Flat Idlers that are often made of galvanised iron, 201 stainless steel, or 304 stainless steels.

The driving and lifting motors had been separated and positioned in opposing positions. The driving motor is at the tail pulley, while the lifting motor is near the head pulley.

The electrical control system works with a single-phase or three-phase power source.

The speed of the conveyor is intended to adjust depending on the purpose of usage and is controlled automatically by the traction of the motor.

### 3.1.2 Concept 2:

The second concept is another frequent sort of basic portable conveyor that may be found un-der the Medium-Weight Conveyor Belt section, using a flat idler like the one that is shown in figure 8.

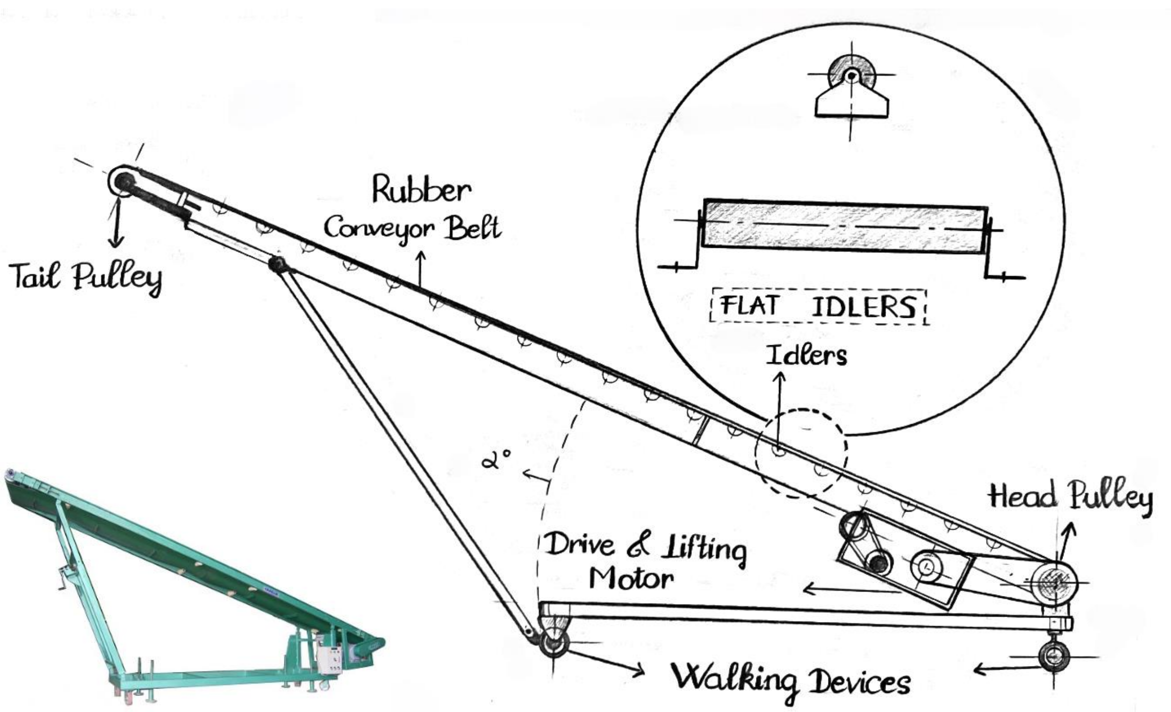


Figure 8. Concept 2 with Flat idler with reference model of conveyor.

Another frequent sort of basic portable conveyor may be found under the Medium-Weight Conveyor Belt section, using flat idler.

The driving and lifting motors are both located on the frame near the Head pulley in this conveyor type. Delivered and return idlers of this conveyor are both flat, so the material of it could be galvanised iron, 201 stainless steel, or 304 stainless steels. CEMA standard idlers are provided as samples of how the idler should appear.

The speed of the conveyor is intended to adapt based on the application and is regulated automatically by the traction of the motor.

## 3.2 Final concept:

### 3.2.1 Potential benefits and drawbacks:

Table 3. Advantages and disadvantages of concepts.

| | Concept 1: | Concept 2: |
|---|---|---|
| Advantages: | The capability of adjusting the incline of the conveyor.<br><br>Flexible mobility.<br><br>V-idlers are considered to have a great transportability. | The capability of adjusting the incline of the conveyor.<br><br>Flexible mobility.<br><br>Simple structure and could be manufactured without difficulty.<br><br>Saving material for making engine frame.<br><br>The engine is simple to repair and replace. |
| Disadvantages: | Rollers are susceptible to wear due to friction.<br><br>Repair and maintain the engine of the conveyor might complicated.<br><br>V-idlers increase the number of the roller, which might increase the price. | Rollers are susceptible to wear due to friction. |

### 3.2.2 Final selection:

According to table 4, concept 2 may offer greater advantages than concept 1 in this specific instances. Furthermore, the V-idler conveyor frame required greater manufacturing complexity than the flat one. As a result, the production process may take more time and material resources than concept 2.

The number of idlers is also an essential aspect to consider, even if the prices of items in the national market may change, but it may also grow more than flat idlers. Additionally, because of the flat surface, concept 2 appears to be more popular in the conveying bag or box industries.

In conclusion, concept number 2 is a final solution and a feasible choice for the movable inclined belt conveyor that acquired specifications based on the information that was investigated and assessed.

# 4 Calculation:

## 4.1 Calculation of working parts – conveyor:

### 4.1.1 Finalizing Belt:

- Belt Width:

The width of the belt symbol that can be utilized is represented by the variable "b" and can be determined using the formula illustrated in figure 9.

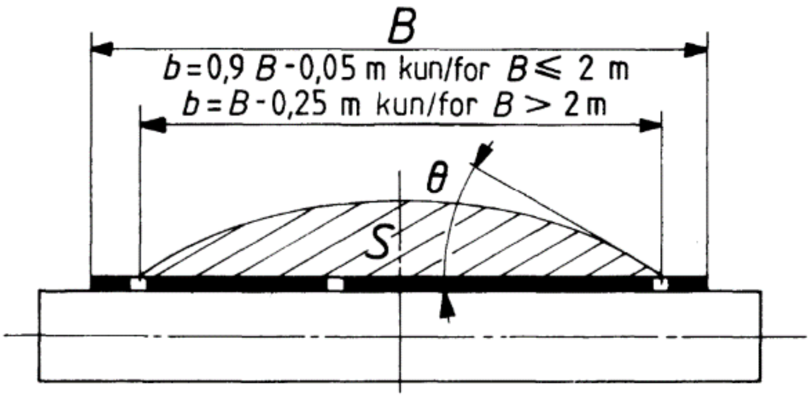


Figure 9. The usable width of the belt (SFS-ISO 5048).

According to specification list, combine with standard ISO 5048: 2000mm > B > 500 mm (SFS-ISO 5048).

$$b = 0.9*B - 0.05 \text{ m.} \quad (1)$$

Because of the rubber belt width guidelines and to make the B have a realistic number, b should be 535 mm. The formula 2 had been made based on formula 1.

$$B = \frac{b + 50\ mm}{0.9} = 650 \text{ mm} = 0.65 \text{ m.} \quad (2)$$

Load per unit length due to cargo weight is given by the formula 3 (DESIGN DATA BOOK - PSG TECH, 2020).

$$q_G = \frac{Q}{3.6 * v} = 22.569 \text{ (kg/m).} \quad (3)$$

With the width of the belt is 650mm then the value of $q_B$ is equal to 9kg/m (Based on psg design data book).

### 4.1.2 Choosing idlers:

The troughing conveyor necessitates reduced spacing between idlers due to its typical application in the transportation of large quantities of materials. It is possible to increase the spacing between idlers in order to transport goods over longer distances. Furthermore, the spacing idler located between the carrying side and the reverse side exhibits dissimilarities. Typically, the spacing idler located on the reverse side exhibits larger dimensions in comparison to the carrying side. With regard to Figure 10, the idler spacing on the carrying side measures 250 millimetres, while on the reverse side of the conveyor, it measures 800 millimetres.

**Idler Spacing**

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Factors to consider when selecting idler spacing are **belt weight**, **material weight**, **idler load rating**, **belt sag**, **idler life**, **belt rating**, **belt tension**, and **radius in vertical curves**

Table 5-2. Suggested normal spacing of belt idlers ($S_i$).*

| Belt Width (inches) | Troughing Idler Spacing | | | | | | Return Idlers |
|---|---|---|---|---|---|---|---|
| | Weight of Material Handled, lbs/cu ft | | | | | | |
| | 30 | 50 | 75 | 100 | 150 | 200 | |
| 18 | 5.5 | 5.0 | 5.0 | 5.0 | 4.5 | 4.5 | 10.0 |
| 24 | 5.0 | 4.5 | 4.5 | 4.0 | 4.0 | 4.0 | 10.0 |
| 30 | 5.0 | 4.5 | 4.5 | 4.0 | 4.0 | 4.0 | 10.0 |
| 36 | 5.0 | 4.5 | 4.0 | 4.0 | 3.5 | 3.5 | 10.0 |
| 42 | 4.5 | 4.5 | 4.0 | 3.5 | 3.0 | 3.0 | 10.0 |
| 48 | 4.5 | 4.0 | 4.0 | 3.5 | 3.0 | 3.0 | 10.0 |
| 54 | 4.5 | 4.0 | 3.5 | 3.5 | 3.0 | 3.0 | 10.0 |
| 60 | 4.0 | 4.0 | 3.5 | 3.0 | 3.0 | 3.0 | 10.0 |
| 72 | 4.0 | 3.5 | 3.5 | 3.0 | 2.5 | 2.5 | 8.0 |
| 84 | 3.5 | 3.5 | 3.0 | 2.5 | 2.5 | 2.0 | 8.0 |
| 96 | 3.5 | 3.5 | 3.0 | 2.5 | 2.0 | 2.0 | 8.0 |

* Spacing indicated in feet. Spacing may be limited by load rating of idler. See idler load ratings in Tables 5-7— 5-11.

Figure 10. Idler spacing DEMA Standard (IDLER SELECTION GUIDE, n.d.).

As pointed out earlier, the idlers selected for the design are sourced from the manufacturer ROXON. ROXON has presented a practical formula and an intuitive method for customers to select an appropriate product. The formula depicted in figure 11 of the catalogue is presented herein.

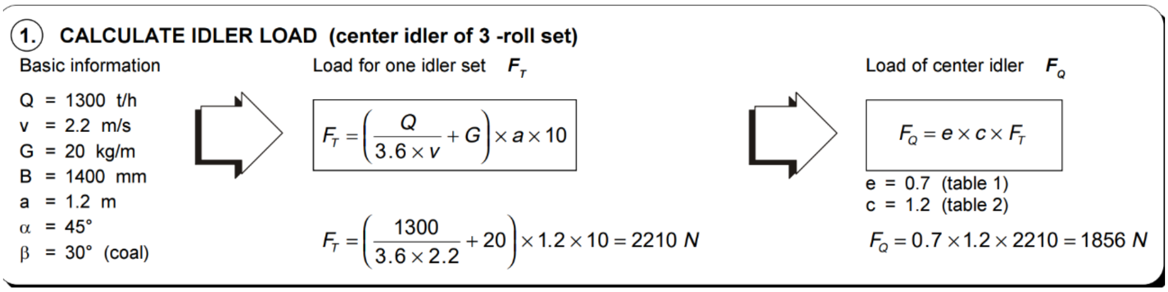



Figure 11. Selection and load rating of the idlers for belt conveyors step 1 (Roxon Conveyor Component Product Catalogue, 2001).

With idler spacing on the carrying side following by the formula 5 (Roxon Conveyor Component Product, 2001)

$$F_{To} = \left(\frac{Q}{3.6*v} + G\right) * a_o * 10 = 78.936\ \text{N} \quad (5)$$

With idler spacing on the reverse side identified by the formula 6 (Roxon Conveyor Component Product, 2001)

$$F_{Tu} = \left(\frac{Q}{3.6*v} + G\right) * a_u * 10 = 252.56\ \text{N} \quad (6)$$

The diameter of the idler (D) is identified based on figure 12.

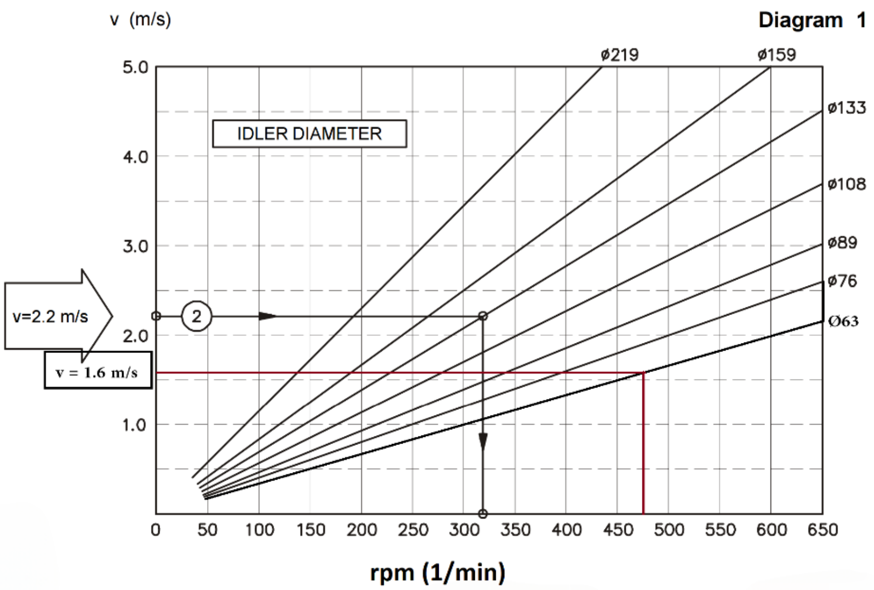



Figure 12. Determined the idler diameter and idler speed (“Roxon Conveyor Component Product Catalogue, 2001”).

Based on diagram one, the idler diameter is 63 mm, and the idler speed (n) averages 475 rpm.

To be able to identify the idler shaft diameter, diagram number 2 in figure 13 is applied.

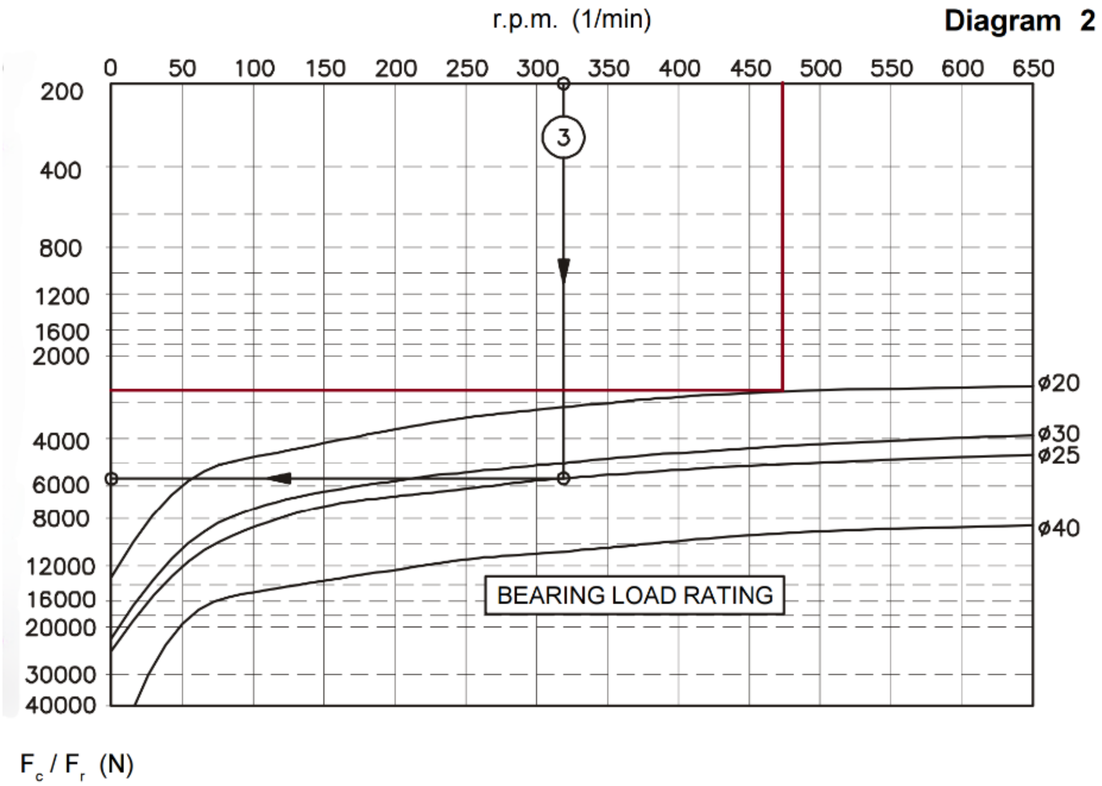



Figure 13. Select the shaft size (Roxon Conveyor Component Product, 2001).

Based on the idler speed that had been chosen in diagram 1 then select the appropriate diameter for it. In cases the shaft diameter is 20 mm then the bearing load rating could be seen in the diagram is an average of 2700 N. The work life of the bearing with the lifetime is 50 000 hours. (Roxon Conveyor Component Product, 2001)

$$F_r * k = 2700 * 0.79 = 2133 \text{ (N)} \quad (7)$$

The coefficient k depends on the lifetime that had been chosen and could be defined in the Roxon Conveyor Component Product catalogue.

Before going to the final step of the choosing process, it is necessary to check through the standard lengths of the idlers recommended by Roxon which is represented in figure 14.

**STANDARD LENGTHS OF THE IDLERS**

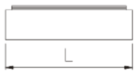
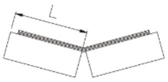
| | | Belt width B | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 400 | 500 | 650 | 800 | 1000 | 1200 | 1400 | 1600 | 1800 | 2000 | 2200 | 2400 |
|  | L | 500 | 600 | 750 | 950 | 1150 | 1400 | 1600 | 1800 | 2000 | 2200 | | |
|  | L | 250 | 315 | 380 | 465 | 600 | 670 | 750 | 900 | 1000 | 1150 | 1400 | 1400 |

Figure 14. Standard lengths of the idlers (Roxon Conveyor Component Product, 2001).

According to the Roxon standard for idlers, the standard length of flat idlers suited for a belt width of 650 mm is 750 mm.

The final stage in the selection process is illustrated in figure 15 as diagram 3.

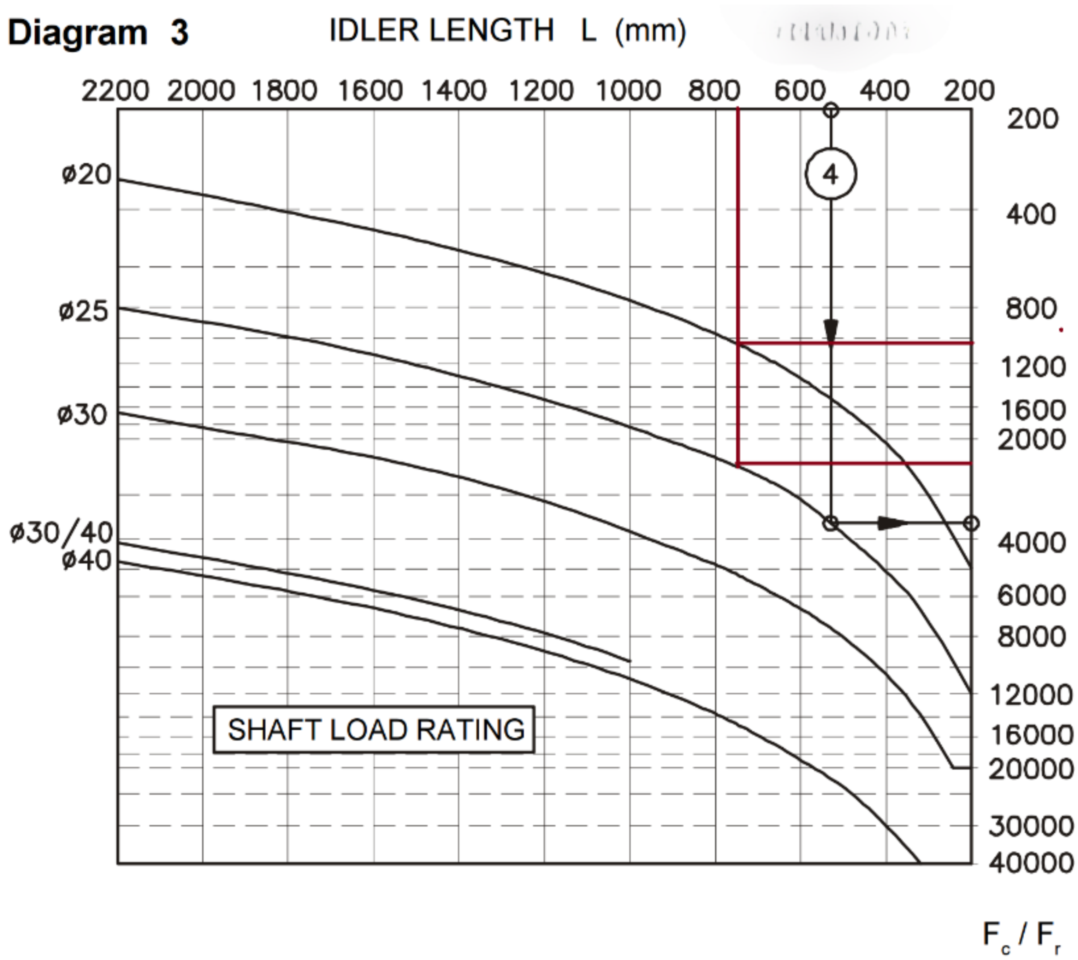



Figure 15. The load rating of the idler shaft and steel construction (Roxon Conveyor Component Product, 2001).

In cases that the idler diameter is 20 millimetres, the shaft load rating is average 900 newton.

In conclusion, the idler chosen, with a diameter of 63 millimetres and a shaft diameter of 20 millimetres, meets the design requirement.

The TS-E idler, a competitive standard idler for belt conveyors, was chosen from the Roxon idlers product line for conveyor. The steel sealing casing and weather seal make a durable protection against splashing water, which is why it was chosen. (ROXON CONVEYOR COMPONENT PRODUCT CATALOGUE, 2001).

Product code for the idler: TS63E – 20 B -750 K.

Product code for the snub idler: TS89E – 25 B -750 K.

Idler total weight: $w = 4.5$ kg

Weight of rotating part: $w_r = 2.6$ kg

Mass per meter of the revolving idler parts along the carrying side of the conveyor is identified by formula 8 (DESIGN DATA BOOK - PSG TECH, 2020):

$$q_{RO} = \frac{w_r}{a_0} = 10.4 \text{ (kg/m)}. \quad (8)$$

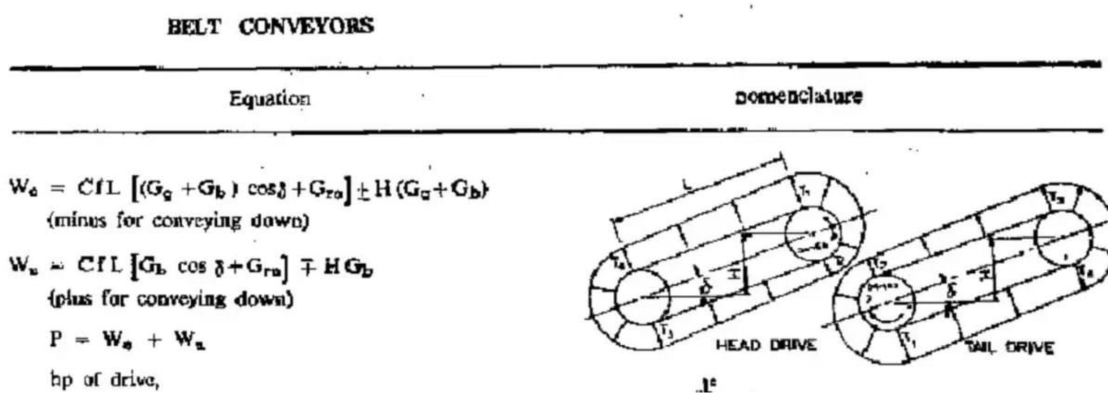
Mass per meter of the revolving idler parts along the return side of the conveyor calculated by formula 9 (DESIGN DATA BOOK - PSG TECH, 2020)

$$q_{Ru} = \frac{w_r}{a_u} = 3.25 \text{ (kg/m)}. \quad (9)$$

The idler bracket should be selected from the Roxon catalogue’s "Self-Aligning idler bracket for the return belt," since the idler utilized throughout the conveyor is flat.

### 4.1.3 Effective force on belt:

The determination of the effective forces acting upon the belt is a crucial aspect of the design process. This facilitates the identification not only of the motor power but also of the head and tail pulley of the conveyor. Additionally, it is utilized to establish the thickness of the conveyor belt. The equations depicted in Figure 16 would be employed for the purpose of calculating the forces of belt tension.



BELT CONVEYORS

| Equation | nomenclature |
| --- | --- |
| $W_a = CfL\left[(G_g + G_b)\cos\delta + G_{ro}\right] \pm H(G_g + G_b)$ (minus for conveying down) | |
| $W_u = CfL\left[G_b \cos\delta + G_{ru}\right] \mp HG_b$ (plus for conveying down) | |
| $P = W_a + W_u$ | |
| hp of drive, | |



Figure 16. Belt tension forces formulas (DESIGN DATA BOOK - PSG TECH, 2020).

To simplify the calculation process, the computation would take into consideration the utmost inclination angle attainable by the conveyor, which is 25 degrees. The graphical representation in Figure 17 depicts the precise location of the head and tail pulley of the conveyor, along with the direction of the forces. These factors have a significant impact on the applicable formulas that must be applied.

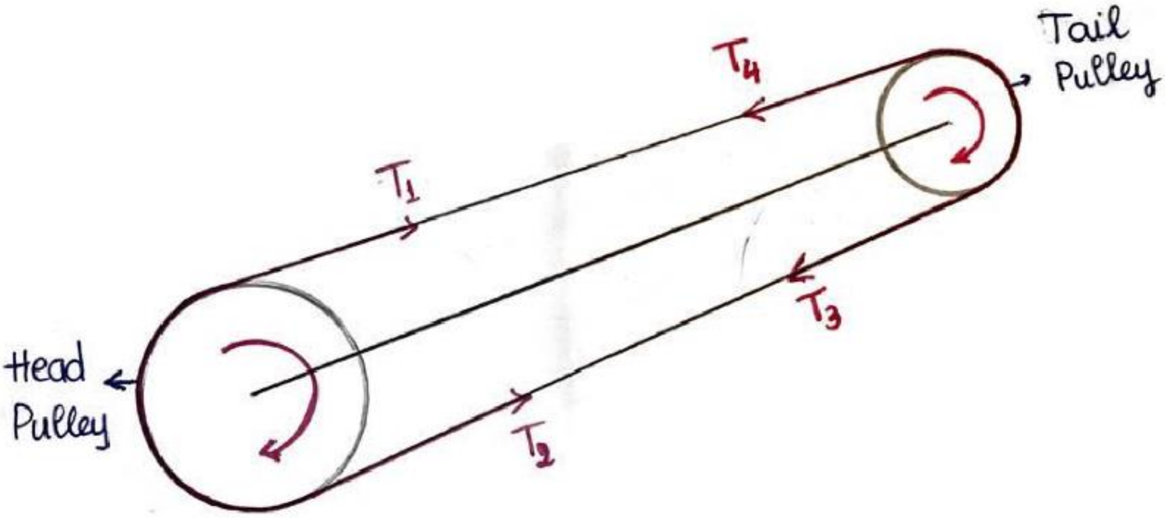




Figure 17. Conveyor forces.

Based on the previous formulas, applied to the maximum lifting angle.

H = sin (25°) * 8000 = 3381 mm = 3.381 m

The second resistance force, denoted as C, was observed to have a value of 5.1 for a conveyor with a length of 8 meters.

Resistances of belt on the top run is identified by the formula 10 (DESIGN DATA BOOK - PSG TECH, 2020)

$$F_0 = (C * f * L * ((q_G + q_B) * \cos(\alpha) + q_{RO}) + H * (q_G + q_B)) * g = 1.395 * 10^3 \text{ N.} \quad (10)$$

Resistances of belt on the bottom run is identified by the formula 11 (DESIGN DATA BOOK - PSG TECH, 2020)

$$F_u = (C * f * L * ((q_B * \cos(a) + q_{RU})) - H * q_B) * g = -207.122 \text{ N} \quad (11)$$

$$P_A = F_0 + F_u = 1.152 * 10^3 \text{ N} \quad (12)$$

Max tension in the belt can be calculated with formula 13 (DESIGN DATA BOOK - PSG TECH, 2020)

$$T_1 = P * \frac{e^{\delta * \mu}}{e^{\delta * \mu - 1}} = 1.978 * 10^3 \text{ N} \quad (13)$$

With $\delta$ is wrap angle equal to 200 degrees and must be transfer to radians. The value of $\mu$ equal to 0.25.

Tension on slack side of the belt can be calculated with formula 14 (DESIGN DATA BOOK - PSG TECH, 2020).

$$T_2 = T_1 - P = 826.646 \text{ N} \quad (14)$$

### 4.1.4 Belt thickness:

The formula 15 is used to determine the belt thickness (DESIGN DATA BOOK - PSG TECH, 2020).

$$i\ l_{cal} = \frac{T_1}{B * F} = 0.647 \quad (15)$$

The value of F may be obtained from Tables 4 and 5 located on pages 9.21. Given a conveyor width of 650mm and a belt fabric designation of 28 oz, the value of F is determined to be 0.48 (Ali, 2020).

It is recommended that a minimum of four plies and a maximum of seven plies be utilized. In this instance, the optimal number of plies to select would be four.

The selected belt type from the MESTO catalogue is EP 500/4. This particular belt type has an average weight of 12.8 kg/m2 and a thickness of 10.8mm, with the top layer measuring 5mm and the bottom layer measuring 2mm.

### 4.1.5 Choosing Pulleys:

Because the Roxon standard is likewise based on SFS-ISO 5048, it is permissible to choose the proper pulleys using the "Selection on conveyor pulley" documents of the Roxon Catalogue. To begin, verify the specified minimum diameter of the pulley with the rubber belt type selected, which is EP 500/4.

| Frame type of the EP -fabric belt | Recommended minimum diameter of the pulley | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Percentage (%) of belt tension during conveyor run from maximum allowed tension | | | | | | | | |
| | ( 60 ) - 100 % | | | ( 30 ) - 60 % | | | 30 % | | |
| | Location of the pulley | | | Location of the pulley | | | Location of the pulley | | |
| | A | B | C | A | B | C | A | B | C |
| 160/2 | 250 | 200 | 160 | 200 | 160 | 125 | 160 | 160 | 125 |
| 200/2 | 250 | 200 | 160 | 200 | 160 | 125 | 160 | 160 | 125 |
| 250/2 315/3 | 320 | 250 | 200 | 250 | 200 | 160 | 200 | 200 | 160 |
| 315/2 400/3 500/3 | 400 | 320 | 250 | 320 | 250 | 200 | 250 | 250 | 200 |
| 400/2 630/4 500/4 630/3 | 500 | 400 | 320 | 400 | 320 | 250 | 320 | 320 | 250 |
| 630/5 800/4 1000/3 | 630 | 500 | 400 | 500 | 400 | 320 | 400 | 400 | 320 |
| 800/5 1250/4 1000/4 | 800 | 630 | 500 | 630 | 500 | 400 | 500 | 500 | 400 |
| 1000/5 1600/4 1600/5 | 1000 | 800 | 630 | 800 | 630 | 500 | 630 | 630 | 500 |

Figure 18. The minimum diameter of the pulley according to the belt type (Roxon Conveyor Component Product, 2001)

The meanings of A, B, and C in the following table are respectively: drive pulleys or other pulleys with heavy belt tensions, freely rotating tail pulleys, freely rotating tail pulleys with wrap angle less than 30 degrees.

The pulley standards (head and tail pulley) are DL/BL and DK/BK, according to the ROXON catalogue. Despite the fact that they are both standard pulleys, the DK/BK have a larger load capacity than the DL/BL-type pulleys. Furthermore, it is more ideal for rubber belts than other sorts. Furthermore, the pulleys' sealing technique is a 2-lips polyurethane seal, and the condition to which it is applied is normal, unclean, and damp.

From the table of recommended minimum diameter of the pulley, choose the size for the head pulley equal to 320 millimetres and the shaft diameter is 40 millimetres, which has the load capacity of the pulley is 11 kN. The tail pulley has a diameter of 270 millimetres, the shaft diameter is 40 millimetres, and has the load capacity same as the head pulley.

The ordering code for pulleys that had been chosen is DL 50 – 320 K – 750 as a head pulley and BL 40 – 270 K – 750 as a tail pulley.

The next step to do is consider the bearing life and need for balancing.

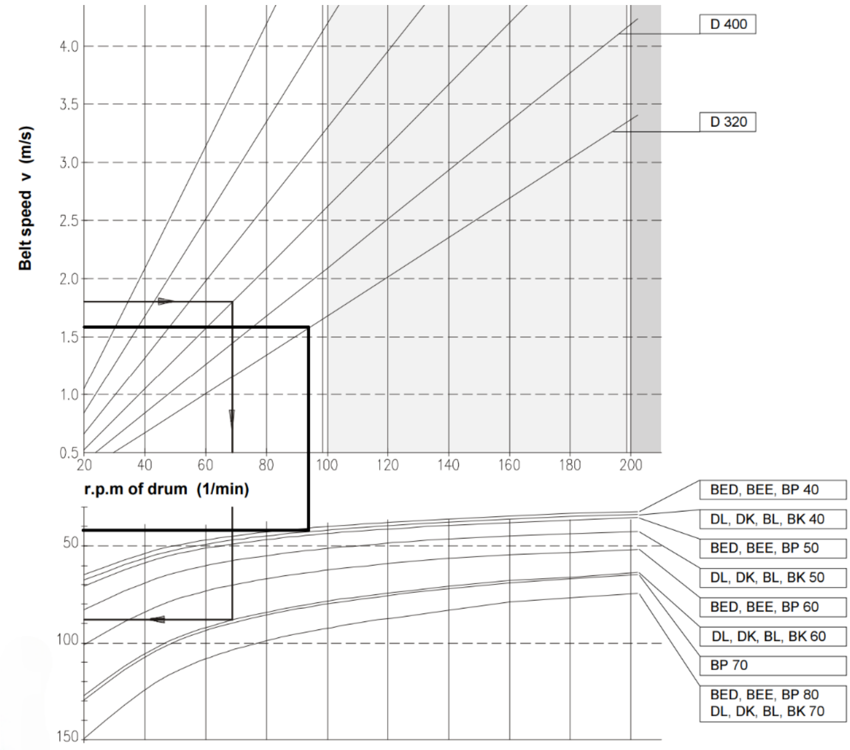



Figure 20. Bearing life and need for balancing (Roxon Conveyor Component Product, 2001)

From the diagram, the bearing life ($R_L$) equals 44 kN. The expected life as requested by 50000 hours, then k has a value of 0.81. $R_L$' = 0.81 * 44 = 35.64 kN. (Roxon Conveyor Component Product, 2001)

$$R_1 = T_1 + T_2 \quad (16)$$

The measured values for $R_1$ at an angle of 25 degrees are 1174.46 Newton.

So, when the results are compared, it is clear that RL' is larger than both R1 and R2, indicating that the pulley bearing will endure the needed amount of time.

### 4.1.6 Screw take-up:

It is calculated when the conveyor stays at 25 degrees. Resultant load of the tail pulley defined in formula 17. (Roxon Conveyor Component Product, 2001)

$$R = T_3 + T_4 = 1250.58 \text{ N} \quad (17)$$

When the conveyor has a screw take-up, the resulting load R of the tail pulley must be doubled by the safety factor 1.5. (Roxon Conveyor Component Product, 2001)

$$R = 1.5 * R = 1875.87 \text{ N} \quad (18)$$

Traction force in one screw calculated by formula 19 (Roxon Conveyor Component Product, 2001)

$$F_{cr} = \frac{R}{2} * 1.5 = 1406.9 \text{ N} \quad (19)$$

The screw take-up device type that had been choose in this situation is UR6 – 1. With the pulley diameter is 40 millimetres, the threaded screw in metric system is M16.

Tensile stress at screw cross-section followed by the formula 20 (Roxon Conveyor Component Product, 2001)

$$\sigma = \frac{F_{cr}}{\frac{\pi * d_1^2}{4}} = 7.56 \text{ N/mm}^2 \quad (20)$$

The tensile stress that had been calculated was more diminutive than the allowed tensile stress.

## 4.2 Calculation of transmission:

### 4.2.1 Drive motor power:

Assuming $n_{mech}$ = 0.95. The power of the conveyor is calculated by the formula 21 (SFS-ISO 5048)

$$P = \frac{P_A * v}{n_{mech}} = 1.94 \text{ kW} \quad (21)$$

The formula 22 is used to identify revolutions per minute (DESIGN DATA BOOK - PSG TECH, 2020)

$$n = \frac{60 * v}{k * \pi * D} = 97.44 \text{ r.p.m} \quad (22)$$

The motor that is used for this conveyor is a creation of SEW EURORIVE. At first, using the finding product system that SEW offered to get the recommendation for the suitable motor. At first, it is necessary to identify the applied circumstances, in this case is belt conveyor. The application data for the finding process comprised the following information: mass of the product was 50 kilograms, driving pulley diameter was 320-millimetre, velocity was 1.6 m/s, and the working duration was 8 hours each day. Moreover, is around 95%. The gear unit properties then contained a right-angle gear unit with a foot-mounted design that used a solid shaft.

According to the information provided, three types of motors have been recommended:

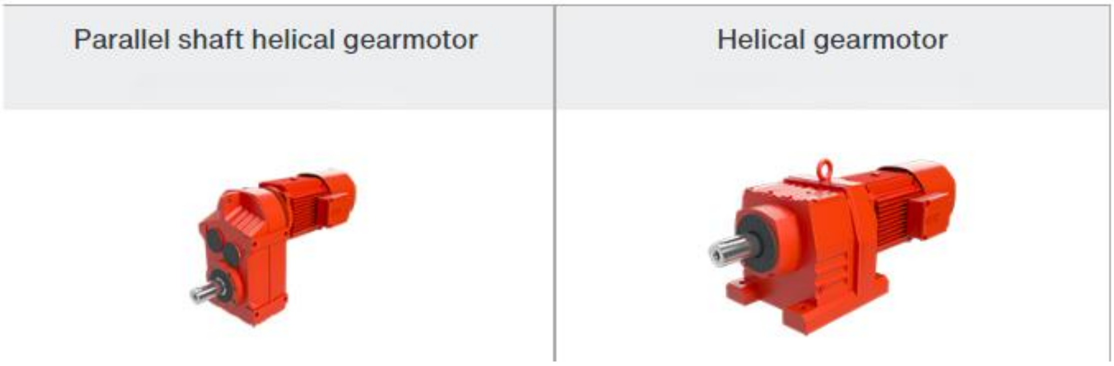



Figure 21. Drive recommendations. (SEW Eurodrive Antriebsauslegung | Drive Selection, 2023)

The recommended motors have the motor speed from 1200 to 1500 revolutions per minute.

So, the gear ratio is around: $i = \frac{1200}{97.44}$ = 12.31 and $i = \frac{1500}{97.44}$ = 15.39.

In summary, the selection of a 2.2 kW motor is deemed necessary to facilitate optimal performance during peak hours and to effectively counteract the effects of gravity. The final product that had been chosen is R47DRU100L4.

### 4.2.2 Chain Drive:

The chain drive would be employed in the moveable inclined conveyor with a 2.2 kW motor with a rated motor speed of 101 r.p.m. This conveyor can operate for 8 hours every day with smooth transmission.

If there are frequent or severe load variations, the chain transmission capacity is diminished. Depending on the kind of machine or motor, you must use the relevant factor (4.1.2 Coefficients Used in Selection, 2023).

Based on the condition of the chain, choosing the service factor in the table that showed in figure 22.

| Load | Prime mover / Driven machine | Motor turbine | Combustion engine | |
|---|---|---|---|---|
| | | | W/hyd. equipment | W/o hyd. equipment |
| Smooth loading | Belt conveyor, subjected to small loading variation, chain conveyor, centrifugal pump, centrifugal blower, textile machine and other machinery subjected to small loading variation. | 1.0 | 1.0 | 1.2 |
| With some shocks | Centrifugal compressor, marine propulsion system, conveyer subjected to some loading variations, automatic furnace, drier, crusher, machine tool , compressor, construction and civil engineering machinery, and papermaking machine | 1.3 | 1.2 | 1.4 |
| With heavy shocks | Press, crusher, mining machinery, vibratory machine, oil-well machinery, rubber mixer, roll, roll gang, and other machinery subjected to reversing load or heavy shock. | 1.5 | 1.4 | 1.7 |

Figure 22. Chain service factor Ks (SELECTING and HANDLING of ROLLER CHAINS Chain Power Transmission Tables, n.d.)

The motor that had been chosen is electric and it is used for belt conveyor, so the appropriate service factors this time is Ks = 1.2.

The next step that is necessary in calculating the chain drive is identify the corrected transmission power.

The Adjusted transmission power is equal to the transmission power multiplied by the service factor when the number of Roller Chain Strands is one. (K.C.M Selecting and Handling of roller chains)

$$\text{The Adjusted transmission power} = P * K_s = 2.2 * 1.2 = 2.64 \text{ kW} \quad (34)$$

Then based on the figure 23, selecting the roller chain pitch.

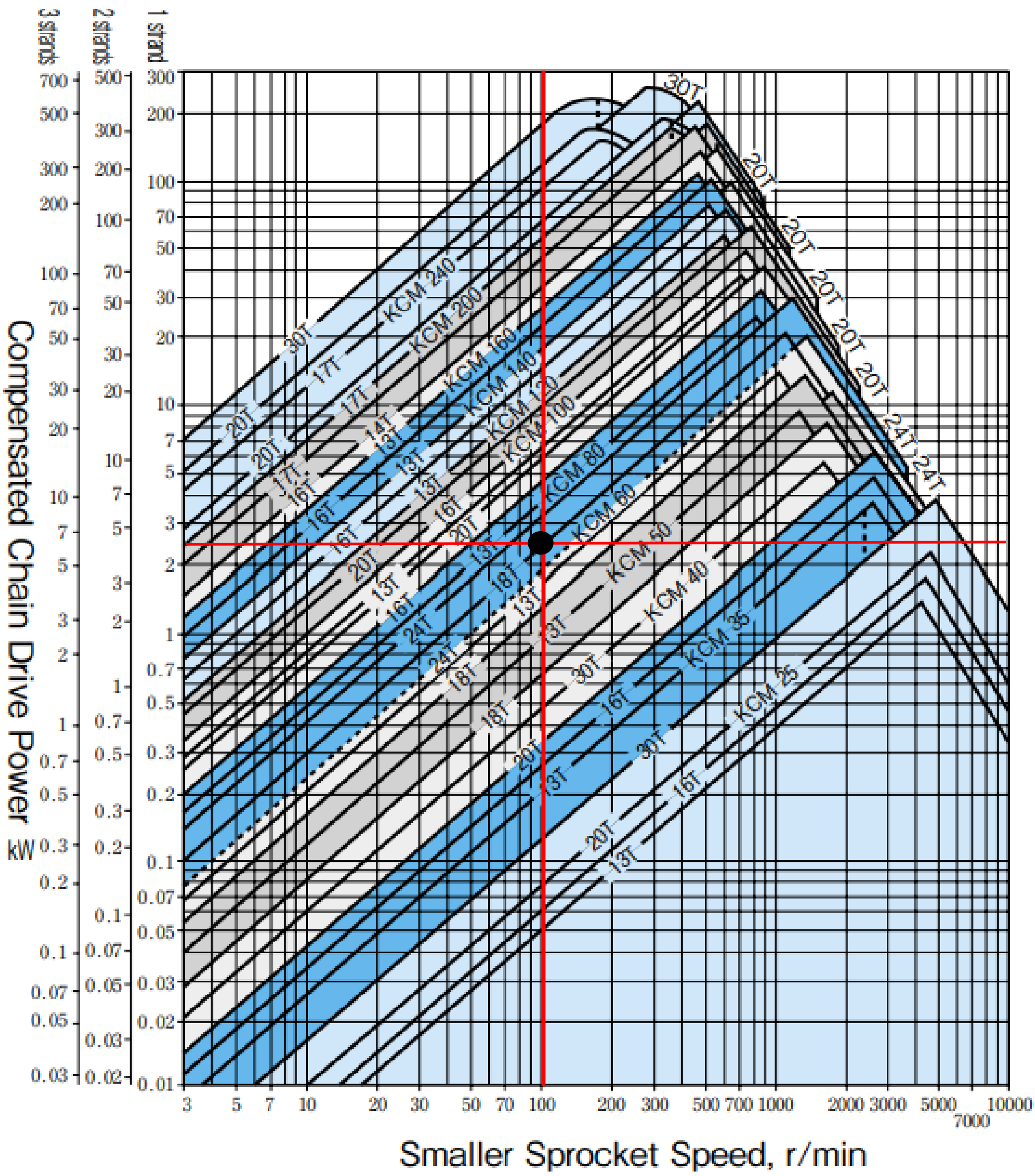



Figure 23. Roller chain pitch selection (SELECTING and HANDLING of ROLLER CHAINS Chain Power Transmission Tables, n.d.)

According to figure 23, for the predicted chain drive power of 2.64 kW, the product is between 18T and 24T of K.C.M 60 and K.C.M 80. Compare the results from the technical data for 18T and 24T of K.C.M 60 and K.C.M 80 to see whether it can adjust to needs.

It is clearly from the catalogue the outcome of 18T prevented K.C.M 60 from adapting to the need. On the other hand, the load of the K.C.M 80 with 18T is bigger than expected at 4.27 kW, which is acceptable number. In conclusion, the smaller sprocket that had been chosen is K.C.M 80 with 18T.

The velocity of a chain can be expressed in terms of its pitch (p), which has a value of 25.40 millimeters for K.C.M 80. Additionally, the velocity is dependent on the number of teeth on the smaller sprocket (N), which is equal to 18, and the rotational speed of the sprocket (n).

The formula 23 is used in order to evaluate chain speed (K.C.M Selecting and Handling of roller chains, 2023)

$$V = \frac{p * N * n}{1000} = \frac{25.40*18*100}{1000} = 45.72 \text{ m/min} \quad (23)$$

Load acting on roller chain is determined by formula 24 (K.C.M Selecting and Handling of roller chains, 2023)

$$F_{rc} = \frac{6120*P}{V} = \frac{6120*2.2}{45.72} = 294.49 \text{ kgf} \quad (24)$$

After determining the number of teeth for the small sprocket, the number of teeth for the large sprocket must be determined.

Take notice that the number of teeth on a smaller sprocket must be 17 or more, while the number of teeth on a bigger sprocket must be 114 or fewer. Calculate the number of teeth on the bigger sprocket by multiplying the number of teeth on the smaller sprocket by the smaller sprocket's RPM ratio (speed ratio) to the larger sprocket. (SELECTING and HANDLING of ROLLER CHAINS Chain Power Transmission Tables, n.d.).

With a smaller sprocket has 18 teeth and the speed ratio is 2:1, the number of teeth on the larger sprocket is 36.

The next step is to calculate the centre-to-centre Distance between the Drive and Driven shafts, which is Cp.

Cp could be identified by the formula (K.C.M Selecting and Handling of roller chains, 2023)

$$Cp = 1/4 * \left\{ Lp - \frac{N1 + N2}{2} + +\sqrt{\left(Lp - \frac{N1 + N2}{2}\right)^2 - \frac{2}{\pi^2} * (N2 - N1)^2} \right\} \quad (25)$$

Is this cases, Cp = 303.32 millimetres (this number could be identified by the 3D modelling process). The value of $\frac{2}{\pi^2} * (N2 - N1)^2$ could be collected based on the catalogue standards table for the value. With the difference between two sprockets is 18 then the value of the equation $\frac{2}{\pi^2} * (N2 - N1)^2$ is 65.72. Moreover, Lp is the overall chain length (no. of pitches).

Lp could be calculated by using the following formula (K.C.M Selecting and Handling of roller chains, 2023):

$$Lp = \frac{N1 + N2}{2} + 2 * Cp + \frac{\{(N2 - N1)/\,2 * \pi\}^2}{Cp} \quad (26)$$

With the difference in the number of teeth between small and big sprockets being 18 the value of the equation $\{(N2\ - N1)/\ 2\ *\ \pi\}^2$ is 8.22. The value of Lp must be an even number. Applying the accepted calculations, we get an average Lp value of 1272 millimetres.

### 4.2.3 Lifting device:

Lifting device using in for this machine is an electric rope motor that is easily operated by a remote. Image 17 depicts its functioning principles.

Image 17. A Movable Inclined Conveyor using rope for lifting (HKD VIET NAM, 2019)

The concept would replace the manual control with an electric rope motor for the hoisting portion. The rope is attached to a shaft that is horizontally placed between two front legs. When the rope is released, the conveyor lowers. To make it rise up, however, the rope should be reeled back and then the conveyor should lift up. Moreover, wheels were added from the tops of the two front legs, allowing the legs to move as the conveyor lifts.

The device that would be used is a winch with a capacity of up to 2 tons, attached from the bottom of the conveyor. The device overview would be shown in the Image 18 below.

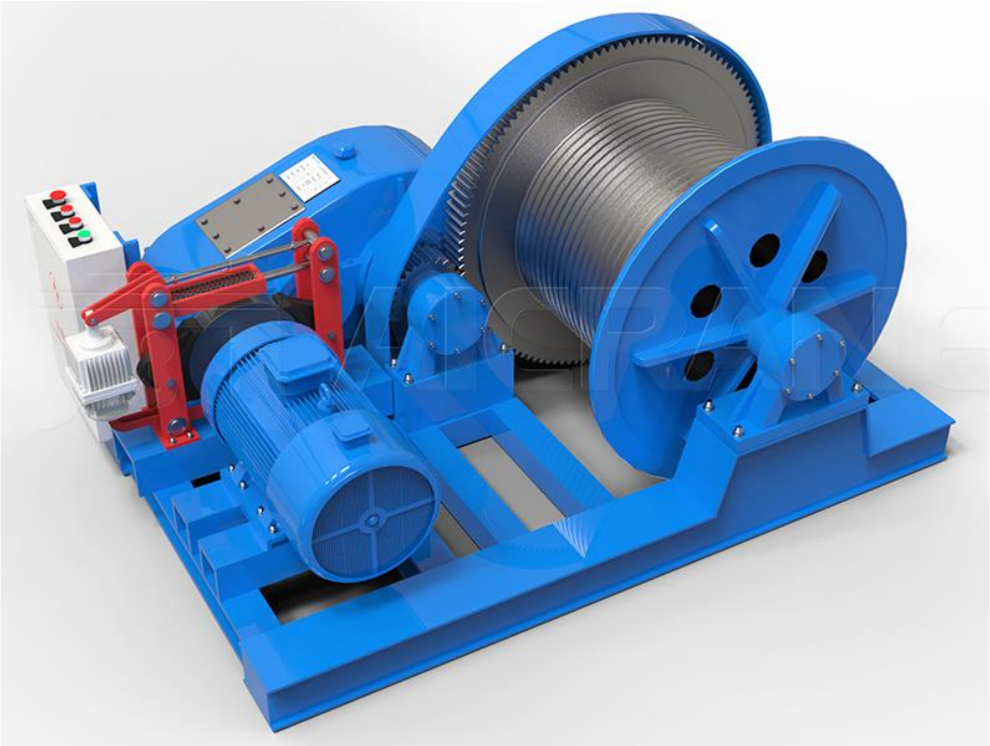


Image 18. 5-ton winch (5 Ton Winch - Winches for Sale from Aicrane, 2022)

# 5 Concept design:

## 5.1 3D modelling:

It is critical to review the component list before delving into the model specifics. Figure 24 depicts the fundamental components of the conveyor.

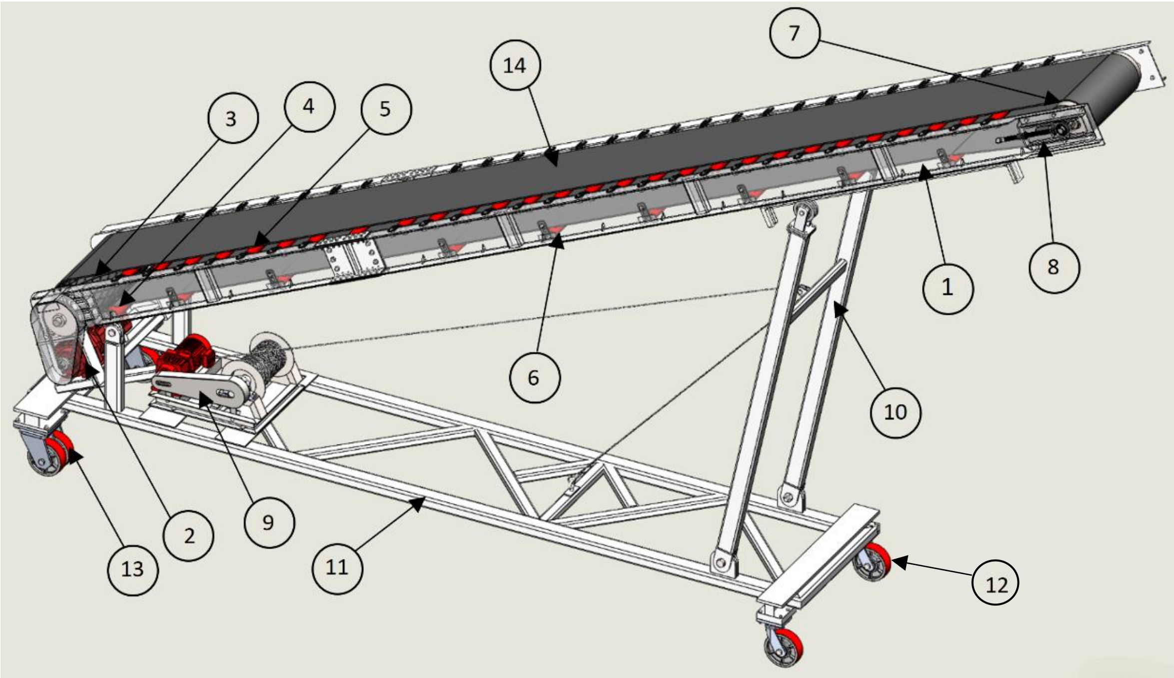



Figure 24. Model for identifying parts.

| No. | Part Name | No. | Part Name |
|---|---|---|---|
| 1. | Main Frame | 8. | Take-up device |
| 2. | Drive Motor | 9. | Lifting Motor |
| 3. | Head Pulley | 10. | Lifting Leg |
| 4. | Snub Idler | 11. | Motor Base |
| 5. | Drive Idler | 12. | Front Wheels |
| 6. | Return Idler | 13. | Back Wheels |
| 7. | Tail Pulley | 14. | Belt |

The 3D model would be shown from two separate perspectives. The beginning angle is 5 degrees, while the maximal angle is 25 degrees. The 3D model of components would be separated into two parts. The first component is the conveyor moving belt, and the second is the conveyor base.

### 5.1.1 Concept overview:

The image 19 below shows the conveyor at 5 degrees.

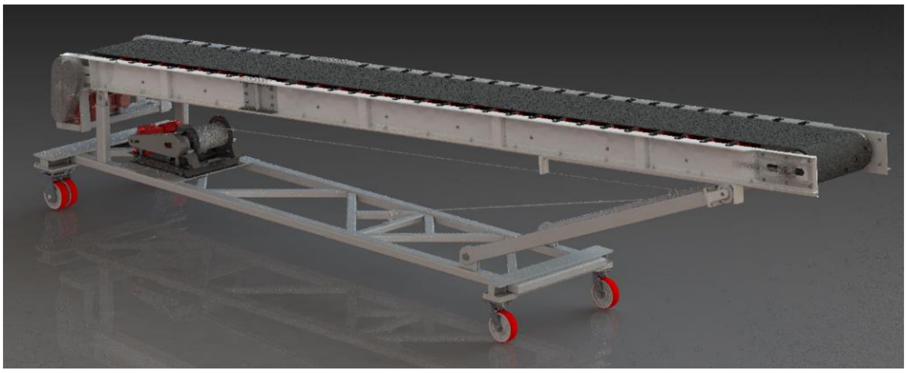


Image 19. The conveyor at 5 degrees

Following by the image 19, image 20 portrays the model at an elevation of 25 degrees, representing the optimal maximum lifting angle.

Image 20. The conveyor at 25 degrees

### 5.1.2 The conveyor belt and the attached components.

The conveyor belt overview will be displayed as a full assembly in image 21 below, followed by the connected components.

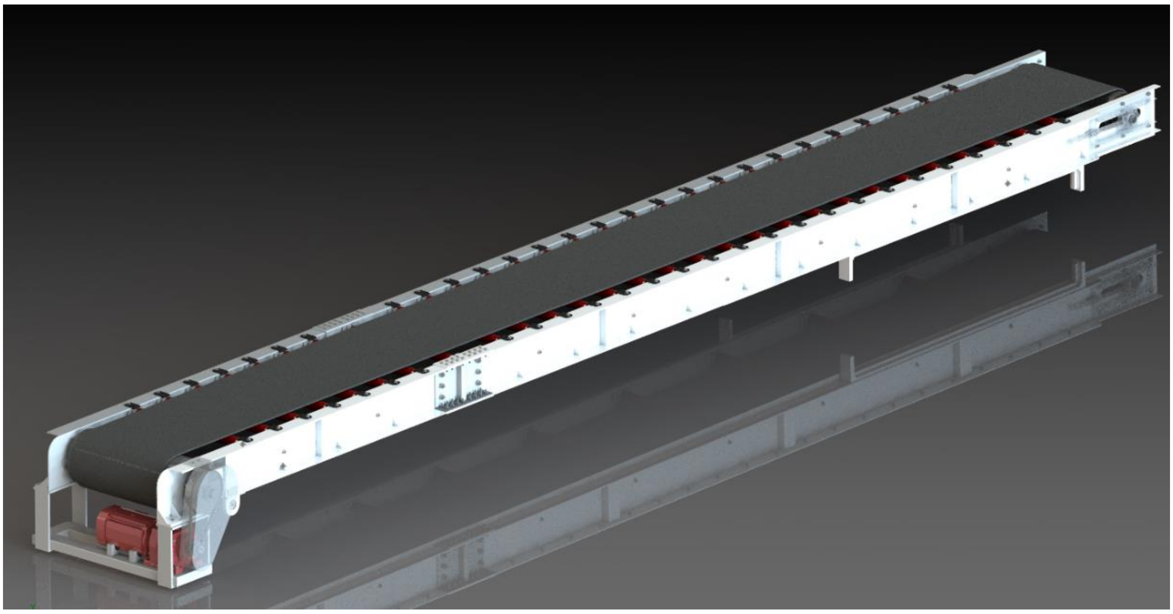
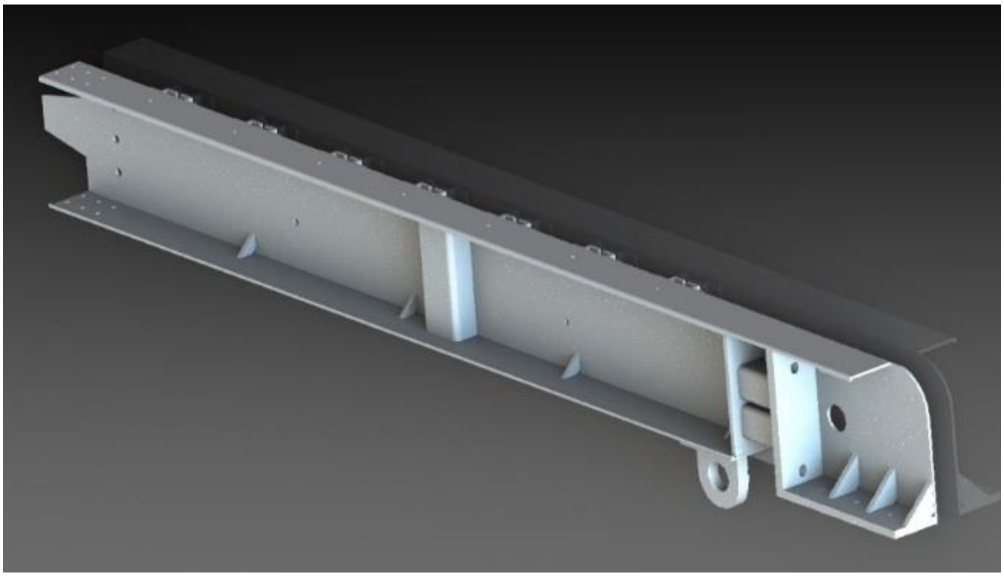


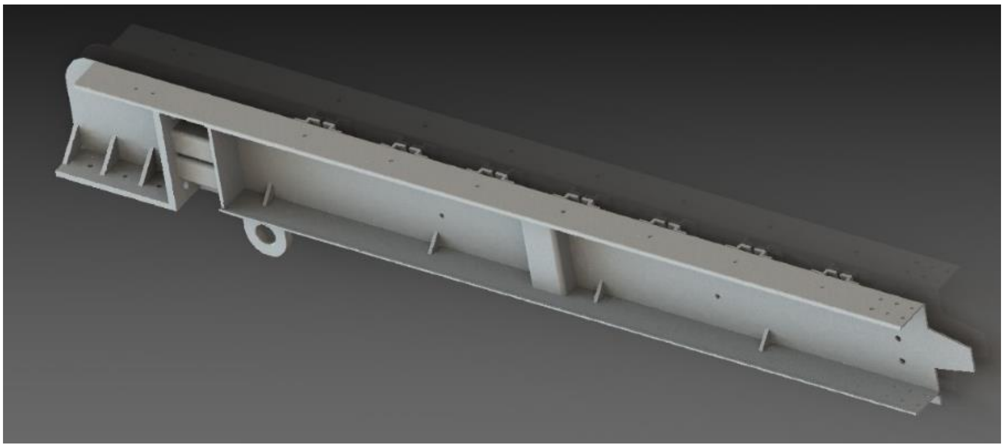
Image 21. The conveyor belt overview

The Belt, Main Frame 2000 as viewed from both the right and left sides, as well as the Main Frame 6000, the linked component connecting two frames is a crucial element in the system. The components under consideration are the motor, chain and sprockets, and drive pulley. The components provided in the package were a Bearing for Drive Pulley, a standard idler with a diameter of 63mm, a snub idler with a diameter of 89mm, a tail pulley, a take-up device, and various other parts. In addition, the measurements of the drive pulley, tail pulley, and idlers are sourced from the ROXON catalogue. The bearing is a suggested item listed in the catalogue, and SFK provides 3D models for the bearing. The categorization of figure order is also based on the order in which individuals are listed.

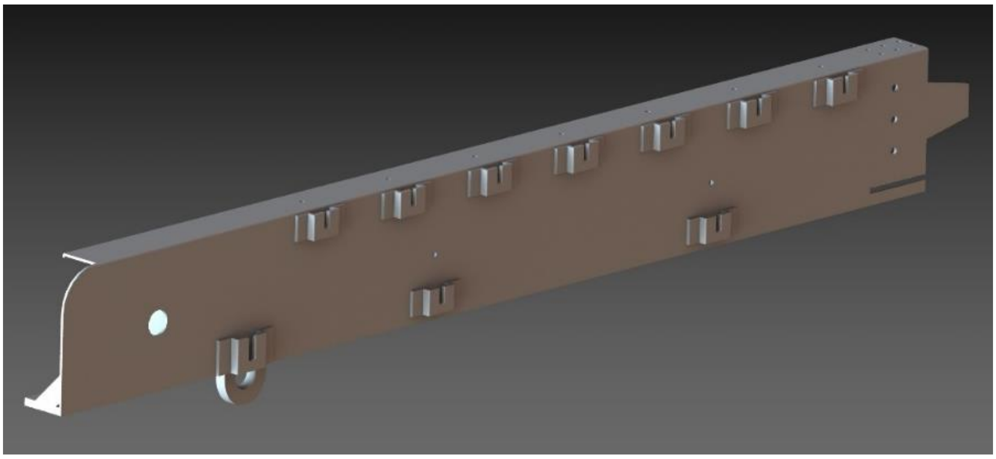
The right side of the main frame 2000 exhibits a dissimilarity from its left counterpart in that it features the inclusion of two mini perforations intended for the purpose of linking the chain cover. Hence, the visual representation depicted in image 22 encompasses the anterior perspective of both the left and right sides.



(a) Left side from the front view



(b) Right side from the front view



(c) Back view

Image 22. Main Frame 2000

In contrast to the Main Frame 2000, the Main Frame 6000 possesses identical dimensions on both sides and does not incorporate any additional features. For this reason, image 23 for the Mainframe 6000 only shows the front and back of the component.

Image 23. Front and back view of the Main Frame 6000

Connecting flats were developed to facilitate the connection between Main Frame 2000 and Main Frame 6000. Image 24 depicted various configurations of the flat structures in independent positions.

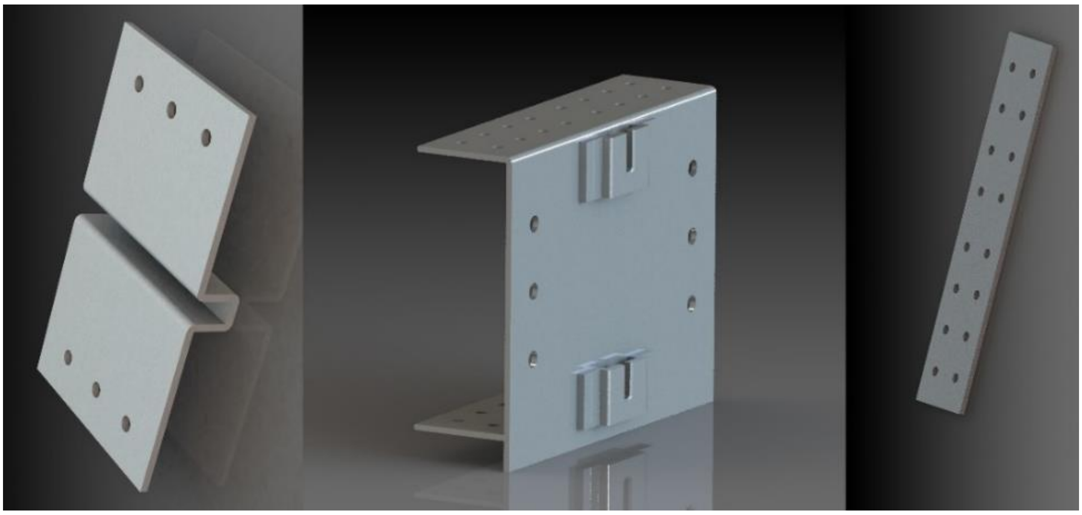


Image 24. The plates used to join two frames.

The motor model was chosen and developed by SEW. The motor base depicted in image 25 is designed to facilitate the connection of the motor to the primary framework, near the head pulley. The utilization of a chain drive in the conveyor obviates the necessity of linking the head pulley in a direct manner to the motor.

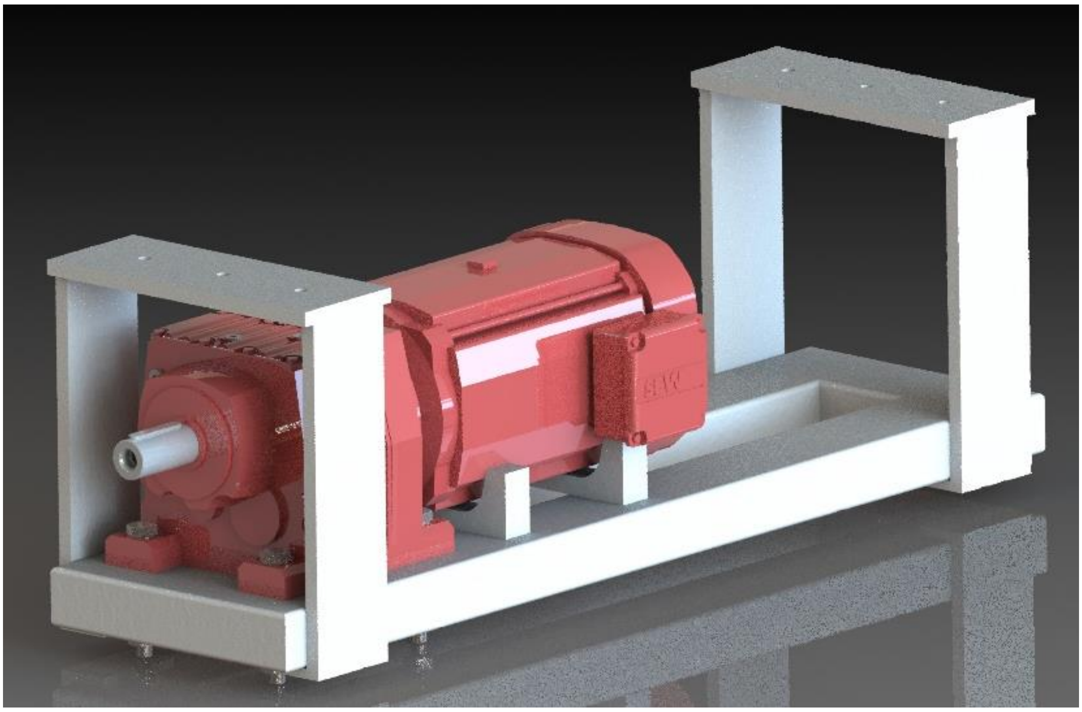


Image 25. The motor and its base

As previously stated, the selection of the pulley was made from the ROXON catalogue. However, it should be noted that no 3D models of the product were made available. The construction of the drive pulley depicted in image 26 was informed by its visual appearance and the prescribed measurements.

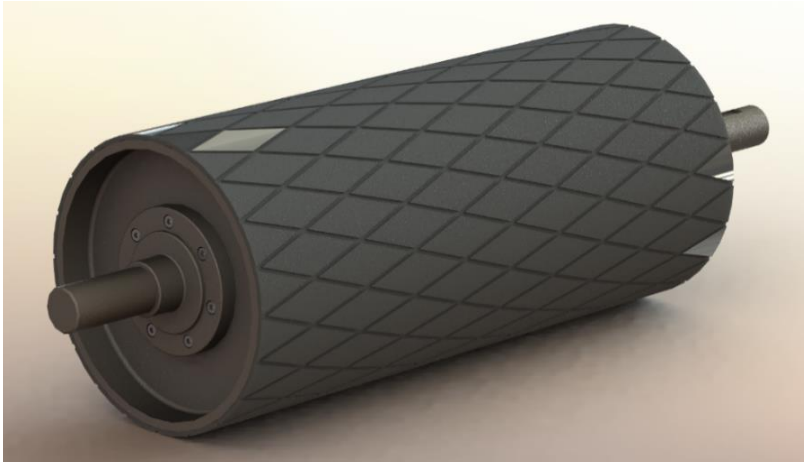


Image 26. Drive Pulley

The illustrated bearing in image 27 is supplied by SFK; however, ROX-ON suggests its use for the suitable pulley.


Image 27. SFK_SNL511-609 +22211K

Same as the head pulley, the drive pulley in image 28 was also built based on the dimensions provided by ROXON.

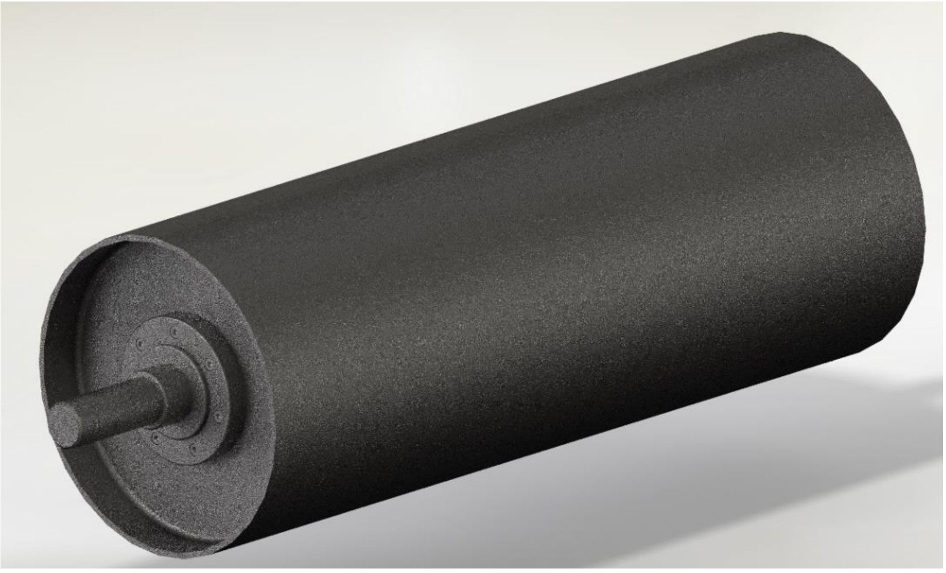


Image 28. Tail Pulley.

The take-up device depicted in image 29 utilizes an SFK bearing, while the frame and screw components are sourced from alternative catalogues. However, these components are designed to conform to the same standards and dimensions suitable for the bearing.

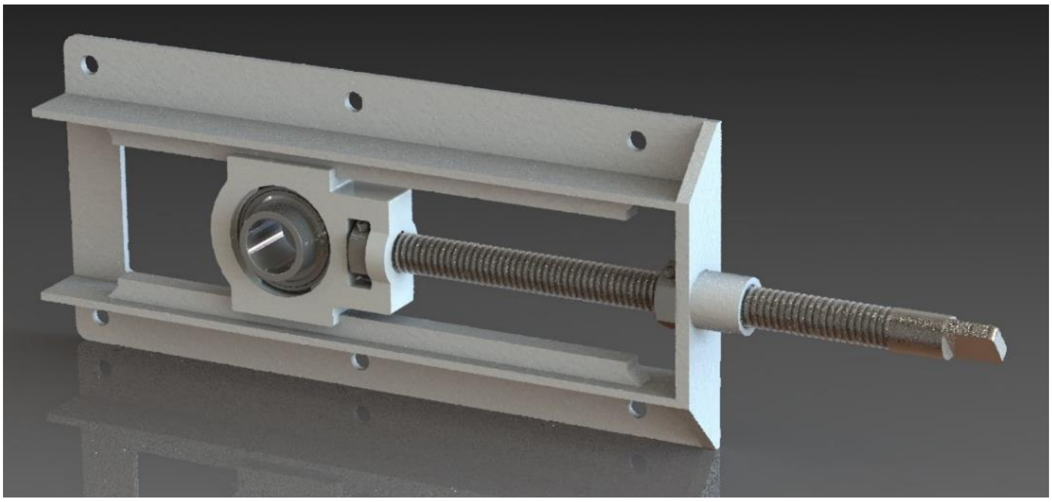


Image 29. Take-up device.

Similar to the pulleys, the idler utilised for the conveyor depicted in image 30 was constructed in accordance with the dimensions furnished by ROXON.

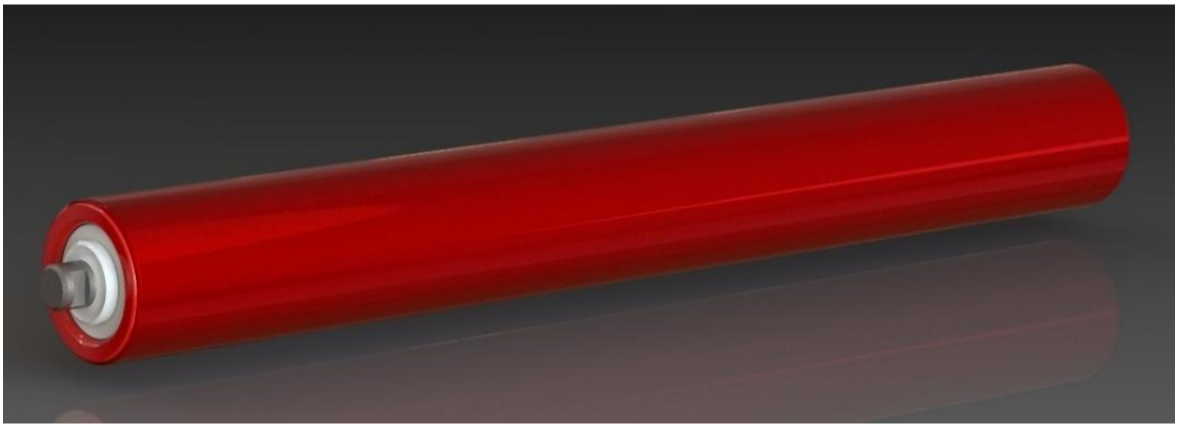


Image 30. Idler.

The multiple-sealing labyrinth effectively prevents dirt from entering the idler and it would be showed the manufacturing drawing. In this case, the multiple-sealing labyrinth lacks precise measurements and thus was constructed solely for the purpose of visually demonstrating its placement among the idlers. The fundamental surface treatments include shot blasting and application of RAL3000 red epoxy powder coating. Special surface treatment can also provide benefits to adhesive materials (“ROXON CONVEYOR COMPONENT PRODUCT CATALOGUE, 2001”).

### 5.1.3 Conveyor base:

The components that were incorporated in the design were the Main Base, Lifting Leg, and other related parts. The categorization of image order is also determined by the order in which they are listed.

Images 31 and 32 depict the base and lifting leg of the conveyor, respectively. These components are deemed flexible as they do not have a prescribed shape. The design of said components may be altered in terms of shape and size, provided that functionality is not compromised and is contingent upon the specific requirements and desired outcome.

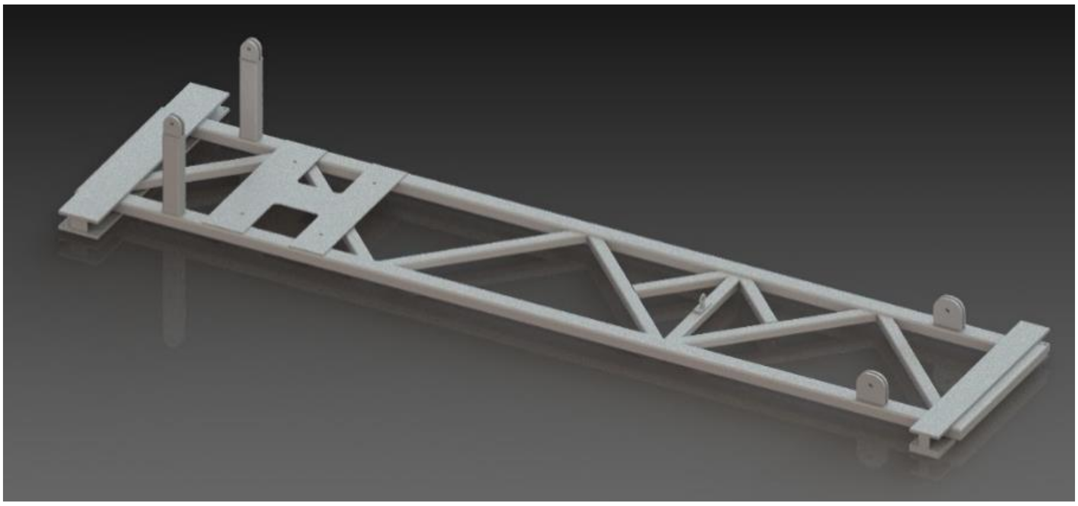


Image 31. Main Base of the conveyor.

Image 32. Lifting Leg with full components.

The component illustrated in image 33 comprises wheels that have been constructed in accordance with the reference dimensions for capacities of 1500 kg and 3000 kg. The diameter of the wheel is 250 millimeters. The visual aspects were altered to closely resemble a realistic model.

(a) Single wheel for 1500 kg

(b) Double wheel for 3000kg.

Image 33. EDL Extra-Heavy 250mm

## 6 Final result and conclusion:

The final 3D product is quite similar to the initial design idea. According to the 2D designs of the conveyor at 5 degrees and 25 degrees, the conveyor could carry with the smallest horizontal distance average of 7232 millimetres and the maximum vertical lifting distance average of 4478 millimetres. In contrast to 25 degrees, at 5 degrees, the conveyor could achieve the highest transport distance at an average of 7951 millimetres and the minimum vertical lifting distance at an average of 1919 millimetres. Considering it is still a 3D idea, further testing is required before establishing the machine in operation. The final product cost is impossible to determine due to the price of materials from several manufacturers varying or the lack of such information. The assembled machine weighs roughly one tonne.

In many different industries, the conveyor belt is a widely used device. Because of this, manufacturers have made it easier for customers to purchase and install necessary components for their own conveyor. It is fascinating for individuals with an interest in machinery as it can be built with a variety of materials and designs, allowing for customization and creativity. Although selecting components and designs is now simple and convenient, it still calls for certain mechanical processes like cutting, welding, and grinding. Homemade construction is appropriate for small, low-capacity devices. Large, powerful equipment nevertheless need technology, i.e., specialised factories for manufacturing and testing.

Overall, the conveyor belt is an example of human ingenuity and has indirectly been a part of our everyday lives. Such devices are not only practical for transporting goods but also a vital component in manufacturing.

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## Appendices

Appendix 1. Detail calculation.

- Belt Width:

According to specification list, combine with standard ISO 5048: 2000mm > B > 500 mm.

The usable width of the belt is b, could be calculated by this formula: b = 0.9*B – 0.05 m.

Because of the rubber belt width guidelines and to make the B have a realistic number, b should be 535 mm.

If b = 535 mm = 0.535 m. then $B = \frac{b + 50\ mm}{0.9}$ = 650 mm = 0.65 m.

Load per unit length due to cargo weight: $q_G = \frac{Q}{3.6 * v}$ = 22.569 (kg/m).

With the width of the belt is 650mm then the value of $q_B$ is equal to 9kgf/m ( Based on psg design data book)

WEIGHT OF CONVEYOR BELTS, kgf/m

Table 1:

| Belt width, mm | 400 | 500 | 650 | 800 | 1000 |
|---|---|---|---|---|---|
| Average weight per metre run, kgf. | 5 | 6.5 | 9 | 12 | 16 |

- Choosing idlers:

Idler spacing on the carrying side of the conveyor: $a_0$ = 250 mm = 0.25 m

Idler spacing on the reverse side of the conveyor: $a_u$ = 800 mm = 0.8 m

As mentioned before, the idlers that would be used for the design is from ROXON.

**1. CALCULATE IDLER LOAD (center idler of 3 -roll set)**

Basic information

Q = 1300 t/h
v = 2.2 m/s
G = 20 kg/m
B = 1400 mm
a = 1.2 m
α = 45°
β = 30° (coal)

Load for one idler set $F_T$

$$F_T = \left(\frac{Q}{3.6 \times v} + G\right) \times a \times 10$$

$$F_T = \left(\frac{1300}{3.6 \times 2.2} + 20\right) \times 1.2 \times 10 = 2210\ N$$

Load of center idler $F_Q$

$$F_Q = e \times c \times F_T$$

e = 0.7 (table 1)
c = 1.2 (table 2)

$$F_Q = 0.7 \times 1.2 \times 2210 = 1856\ N$$

With idler spacing on the carrying side:

$$F_{To} = \left(\frac{Q}{3.6*v} + G\right) * a_o * 10 = \left(\frac{130}{3.6*1.6} + 9\right) * 0.25 * 10 = 78.936 \text{ (N)}$$

With idler spacing on the reverse side:

$$F_{Tu} = \left(\frac{Q}{3.6*v} + G\right) * a_u * 10 = \left(\frac{130}{3.6*1.6} + 9\right) * 0.8 * 10 = 252.56 \text{ (N)}$$

**2. DETERMINE THE IDLER DIAMETER**

Select the idler diameter D so that the idler speed n is between 300...650 1/min. For speeds over 650 1/min contact our technical service department.

**Selection**: D = 133 → n = 320 1/min (Diagram 1).

**3. SELECT THE SHAFT SIZE**

Select the shaft diameter according to bearing life time with the help of previously calculated idler load $F_Q$ and idler speed n.

**Selection**: d = 25 → $F_r$ = 5750 N (Diagram 2).

The working life of the bearing is calculated by multiplying the bearing load rating $F_r$ in table 3 by the coefficient k.

h = 50 000 h

$F_r$ x k = 5750 N x 0.79 = 4542 N

**4. CHECK THE LOAD RATING**

Check the load rating of the idler shaft and steel construction from diagram 3.

For the belt width B = 1400 is idler lenght L = 530 mm. When d = 25, diagram 3 gives:

$F_c$ = 3900 N

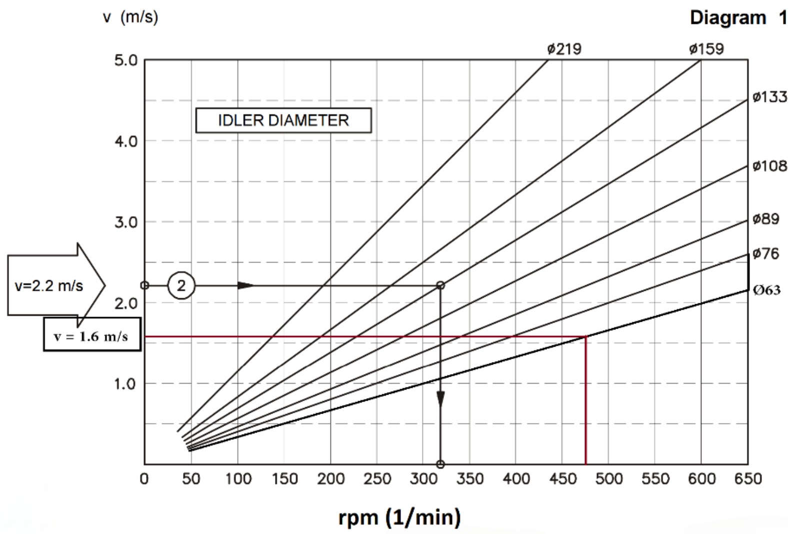
The idler load $F_Q$ must always be less than the bearing load rating $F_r$ x k and shaft load rating $F_c$.

$$F_c \geq F_Q \leq (F_r \times k)$$

3900 N ≥ 1856 ≤ 4542

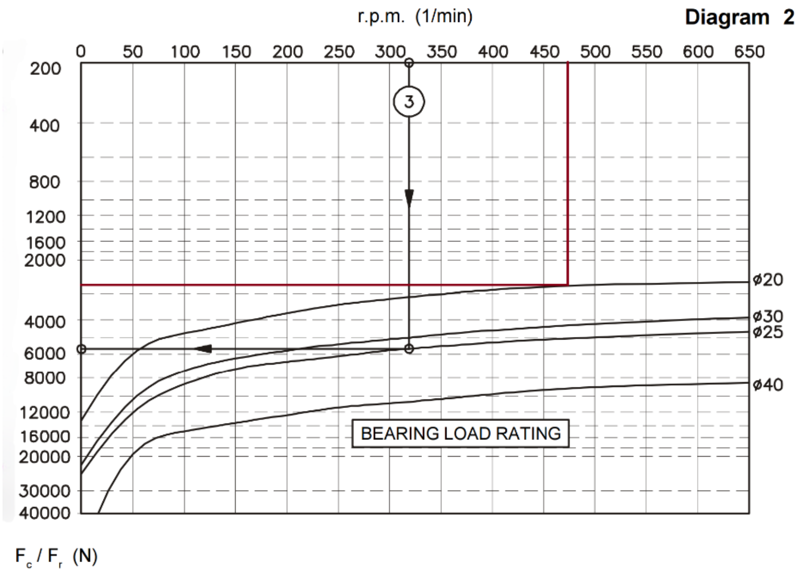
$F_Q$ = idler load (N)
$F_c$ = shaft load rating (N)
$F_r$ = bearing load rating (N)
h = expected life (h)

The diameter of the idler (D) is identified.




Based on diagram one, the idler diameter is 63 mm, and the idler speed (n) averages 475 rpm.

To be able to identify the idler shaft diameter, diagram number 2 is applied.



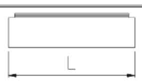
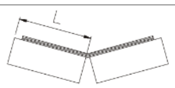

Based on the idler speed that had been chosen in diagram 1 then select the appropriate diameter for it. In cases the shaft diameter is 20 mm then the bearing load rating could be seen in the diagram is an average of 2700 N. The work life of the bearing with the lifetime is 50 000 hours:

$F_r * k = 2700 * 0.79 = 2133$ (N)

The coefficient k depends on the lifetime that had been chosen and could be defined in the Roxon Conveyor Component Product catalogue.

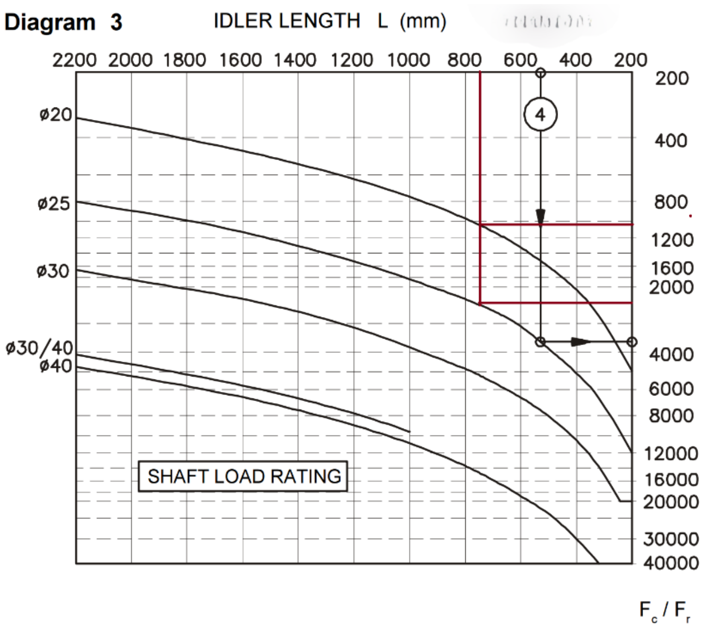
Before going to the final step of the choosing process, it is necessary to check through the standard lengths of the idlers recommended by Roxon.

**STANDARD LENGTHS OF THE IDLERS**

| | | Belt width B | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **400** | **500** | **650** | **800** | **1000** | **1200** | **1400** | **1600** | **1800** | **2000** | **2200** | **2400** |
|  | **L** | 500 | 600 | 750 | 950 | 1150 | 1400 | 1600 | 1800 | 2000 | 2200 | | |
|  | **L** | 250 | 315 | 380 | 465 | 600 | 670 | 750 | 900 | 1000 | 1150 | 1400 | 1400 |

According to the Roxon standard for idlers, the standard length of flat idlers suited for a belt width of 650 mm is 750 mm.

The final stage in the selection process is illustrated as diagram 3.




In cases that the idler diameter is 20 millimetres, the shaft load rating is average 900 newton.

In conclusion, the idler chosen, with a diameter of 63 millimetres and a shaft diameter of 20 millimetres, meets the design requirement.

Product code for the idler: TS63E – 20 B -750 K.

Product code for the snub idler: TS89E – 25 B -750 K.

Idler total weight: w = 4.5 kg

Weight of rotating part: $w_r$ = 2.6 kg

Mass per meter of the revolving idler parts along the carrying side of the conveyor:

$$q_{RO} = \frac{w_r}{a_0} = \frac{2.6}{0.25} = 10.4 \text{ (kg/m)}$$

Mass per meter of the revolving idler parts along the return side of the conveyor:

$$q_{Ru} = \frac{w_r}{a_u} = \frac{2.6}{0.8} = 3.25 \text{ (kg/m)}$$

The idler bracket should be selected from the Roxon catalogue’s "Self-Aligning idler bracket for the return belt," since the idler utilized throughout the conveyor is flat.

- Effective force on belt:

Calculate with α = 25°

Based on the previous calculation, applied to the maximum lifting angle.

H = sin (25°) * 8000 = 3381 mm = 3.381 m

The second resistance force, denoted as C, was observed to have a value of 5.1 for a conveyor with a length of 8 meters.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| L (m) | 3 | 4 | 5 | 6 | 8 | 10 | 13 | 16 | 20 |
| C | 9.0 | 7.6 | 6.6 | 5.9 | 5.1 | 4.5 | 4.0 | 3.6 | 3.0 |
| L (m) | 25 | 32 | 40 | 50 | 63 | 80 | 90 | 100 | 120 |
| C | 2.9 | 2.6 | 2.4 | 2.2 | 2.0 | 1.92 | 1.86 | 1.78 | 1.70 |
| L (m) | 140 | 160 | 180 | 200 | 250 | 300 | 350 | 400 | 450 |
| C | 1.63 | 1.56 | 1.50 | 1.45 | 1.38 | 1.31 | 1.27 | 1.25 | 1.20 |
| L (m) | 500 | 550 | 600 | 700 | 800 | 900 | 1000 | 1500 | 2000 |
| C | 1.20 | 1.18 | 1.17 | 1.14 | 1.12 | 1.10 | 1.09 | 1.06 | 1.00 |

Resistances of belt on the top run is identified by the formula:

$F_0 = (C * f * L * ((q_G + q_B) * \cos(\alpha) + q_{RO}) + H * (q_G + q_B)) * g$

$= (5.1 * 0.02 * 8 * ((22.569 + 9) * \cos(25) + 10.4) + 3.381 * (22.569 + 9)) * 9.81$

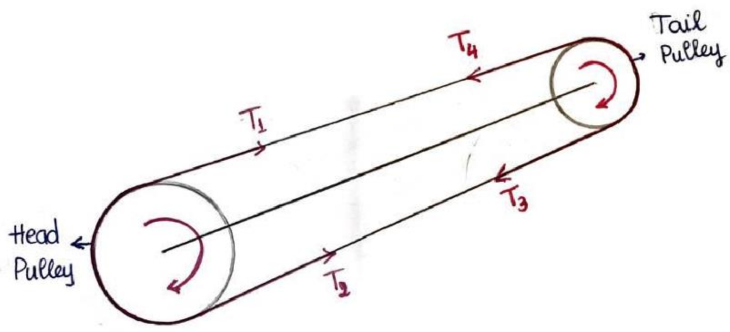
$= 1.359 * 10^3$ N

$F_u = (C * f * L * ((q_B * \cos(a) + q_{RU})) - H * q_B) * g$

$= (5.1 * 0.02 * 8 * ((9 * \cos(25) + 3.25) - 3.381 * 9) * 9.81 = -207.22$ N

$P_A = F_0 + F_u = 1.359 * 10^3 - 207.22 = 1.152 * 10^3$ N

Effective forces on Belt.




$T_1 = P_A * \frac{e^{\delta * \mu}}{e^{\delta * \mu - 1}} = 1.978 * 10^3$ N

With $\delta$ is wrap angle equal to 200 degrees and must be transfer to radians. The value of $\mu$ equal to 0.25.

$T_2 = T_1 - P_A = 826.646$ N

- Belt Thickness:

$i = \frac{T_1}{B*F} = 0.647.$

It is recommended that a minimum of four plies and a maximum of seven plies be utilized. In this instance, the optimal number of plies to select would be four.

The selected belt type from the MESTO catalogue is EP 500/4. This particular belt type has an average weight of 12.8 kg/m2 and a thickness of 10.8mm, with the top layer measuring 5mm and the bottom layer measuring 2mm.

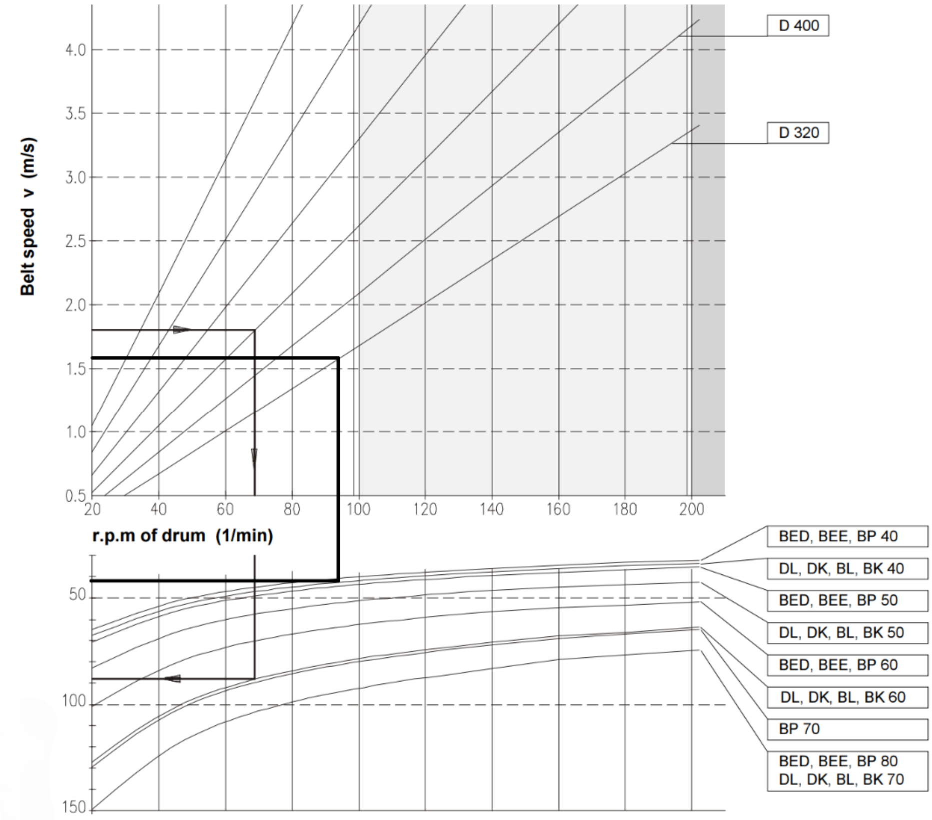
- Choosing Pulleys:

Because the Roxon standard is likewise based on SFS-ISO 5048, it is permissible to choose the proper pulleys using the "Selection on conveyor pulley" documents of the Roxon Catalogue. To begin, verify the specified minimum diameter of the pulley with the rubber belt type selected, which is EP 500/4.

| Frame type of the EP -fabric belt | Recommended minimum diameter of the pulley | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Percentage (%) of belt tension during conveyor run from maximum allowed tension | | | | | | | | |
| | ( 60 ) - 100 % | | | ( 30 ) - 60 % | | | 30 % | | |
| | Location of the pulley | | | Location of the pulley | | | Location of the pulley | | |
| | A | B | C | A | B | C | A | B | C |
| 160/2 | 250 | 200 | 160 | 200 | 160 | 125 | 160 | 160 | 125 |
| 200/2 | 250 | 200 | 160 | 200 | 160 | 125 | 160 | 160 | 125 |
| 250/2 315/3 | 320 | 250 | 200 | 250 | 200 | 160 | 200 | 200 | 160 |
| 315/2 400/3 500/3 | 400 | 320 | 250 | 320 | 250 | 200 | 250 | 250 | 200 |
| 400/2 630/4 500/4 630/3 | 500 | 400 | 320 | 400 | 320 | 250 | 320 | 320 | 250 |
| 630/5 800/4 1000/3 | 630 | 500 | 400 | 500 | 400 | 320 | 400 | 400 | 320 |
| 800/5 1250/4 1000/4 | 800 | 630 | 500 | 630 | 500 | 400 | 500 | 500 | 400 |
| 1000/5 1600/4 1600/5 | 1000 | 800 | 630 | 800 | 630 | 500 | 630 | 630 | 500 |

The ordering code for pulleys that had been chosen is DL 50 – 320 K – 750 as a head pulley and BL 40 – 270 K – 750 as a tail pulley.

The next step to do is consider the bearing life and need for balancing.




From the diagram, the bearing life ($R_L$) equals 44 kN. The expected life as requested by 50000 hours, then k has a value of 0.81. $R_L$' = 0.81 * 44 = 35.64 kN.

With an angle of 25 degrees: $R_1 = (T_1 + T_2)$ *g = 1174.46 N

So, when the results are compared, it is clear that RL' is larger than both R1 and R2, indicating that the pulley bearing will endure the needed amount of time.

- Screw take-up:

It is calculated when the conveyor stays at 25 degrees. Resultant load of the tail pulley is:

R = $T_3 + T_4$ = 63.174 * 2 * 9.81 = 1250.58 N

When the conveyor has a screw take-up, the resulting load R of the tail pulley must be doubled by the safety factor 1.5. ("ROXON CONVEYOR COMPONENT PRODUCT CATALOGUE, 2001").

R = 1.5 * R = 1.5 * 1250.58 = 1875.87 N.

Traction force in one screw: $F_{cr} = \frac{R}{2} * 1.5 = \frac{868.773}{2} * 1.5 = 1406.9$ N.

The screw take-up device type that had been choose in this situation is UR6 – 1. With the pulley diameter is 40 millimetres, the threaded screw in metric system is M16.

Tensile stress at screw cross-section: $\sigma = \frac{F_{cr}}{\frac{\pi * d_1^2}{4}} = \frac{651.58}{\frac{\pi * 15.39^2 .}{4}}$ = 7.56 N/mm2.

The tensile stress that had been calculated was more diminutive than the allowed tensile stress.

Calculation of transmission:

- Drive motor power:

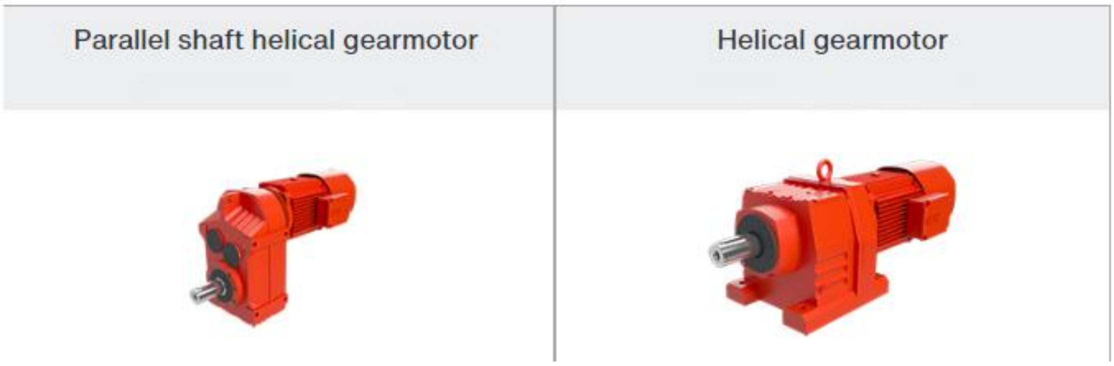
Power transmitted with the pulley:

$P = \frac{P_A * v}{n_{mech}}$ = 1.94 kW

Revolutions per minute:

n = $\frac{60 * v}{k * \pi * D}$ = 97.44 r.p.m.

According to the information provided, three types of motors have been recommended:




The recommended motors have the motor speed from 1200 to 1500 revolutions per minute.

So, the gear ratio is around: $i = \frac{1200}{97.44}$ = 12.31 and $i = \frac{1500}{97.44}$ = 15.39

The gear ratio should be maintained between 12.31 and 15.39. From the recommended products data sheets, all of them are satisfied the requirement. As it has the lowest suggested retail price, the Helical gear motor seems like the best option.

The power necessary for the inclined conveyor is determined by the product of the belt speed and the bell pulls. At first, it is necessary to identify the bell pull.

In summary, the selection of a 2.2 kW motor is deemed necessary to facilitate optimal performance during peak hours and to effectively counteract the effects of gravity. The final product that had been chosen is R47DRU100L4.

- Chain Drive:

The chain drive would be employed in the moveable inclined conveyor with a 2.2 kW motor with a rated motor speed of 101 r.p.m. This conveyor can operate for 8 hours every day with smooth transmission.

If there are frequent or severe load variations, the chain transmission capacity is diminished. Depending on the kind of machine or motor, you must use the relevant factor ("4.1.2 Coefficients Used in Selection," 2023).

| Load | Prime mover / Driven machine | Motor turbine | Combustion engine | |
|---|---|---|---|---|
| | | | W/hyd. equipment | W/o hyd. equipment |
| Smooth loading | Belt conveyor, subjected to small loading variation, chain conveyor, centrifugal pump, centrifugal blower, textile machine and other machinery subjected to small loading variation. | 1.0 | 1.0 | 1.2 |
| With some shocks | Centrifugal compressor, marine propulsion system, conveyer subjected to some loading variations, automatic furnace, drier, crusher, machine tool , compressor, construction and civil engineering machinery, and papermaking machine | 1.3 | 1.2 | 1.4 |
| With heavy shocks | Press, crusher, mining machinery, vibratory machine, oil-well machinery, rubber mixer, roll, roll gang, and other machinery subjected to reversing load or heavy shock. | 1.5 | 1.4 | 1.7 |

The motor that had been chosen is electric and it is used for belt conveyor, so the appropriate service factors this time is Ks = 1.2.

The next step that is necessary in calculating the chain drive is identify the corrected transmission power.

Then based on the figure below, selecting the roller chain pitch. With the output speed of the motor is 100 r/min, the type of chain that is being choose is single strands.

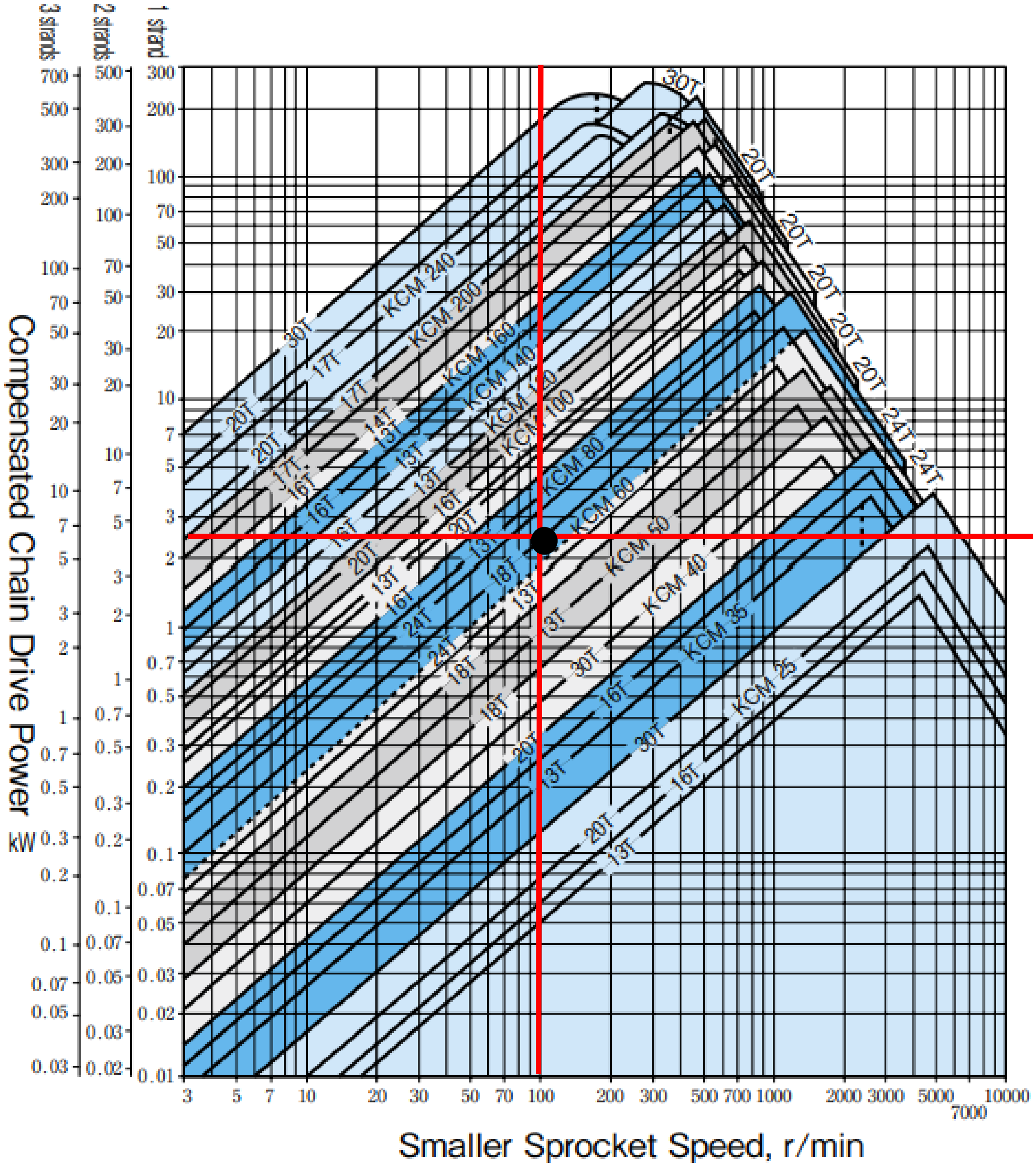
○ Single strand chain:

Compensated chain drive power = Power to be transmitted x Service factor

○ Multiple strand chain:

$$\text{Compensated chain drive power} = \frac{\text{Power to be transmitted} \times \text{Service factor}}{\text{Multiple strand factor}}$$

Compensated chain drive power = 2.2 * 1.2 = 2.64 kW



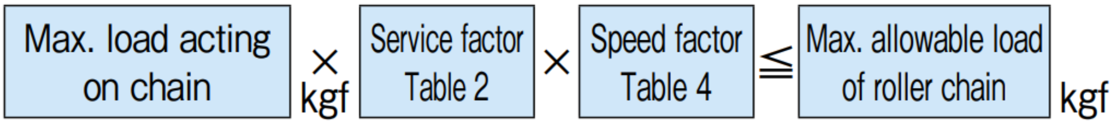

According to the above figure, for the predicted chain drive power of 2.64 kW, the product is between 18T and 24T of K.C.M 60 and K.C.M 80. Compare the results from the technical data for 18T and 24T of K.C.M 60 and K.C.M 80 to see whether it can adjust to needs.

It is clearly from the catalogue the outcome of 18T prevented K.C.M 60 from adapting to the need. On the other hand, the load of the K.C.M 80 with 18T is bigger than expected at 4.27 kW, which is acceptable number. In conclusion, the smaller sprocket that had been chosen is K.C.M 80 with 18T.

The velocity of a chain can be expressed in terms of its pitch (p), which has a value of 25.40 millimetres for K.C.M 80. Additionally, the velocity is dependent on the number of teeth on the smaller sprocket (N), which is equal to 18, and the rotational speed of the sprocket (n).

Chain speed: $V = \frac{p * N * n}{1000} = \frac{25.40 * 18 * 100}{1000}$ = 45.72 m/min.

Load acting on roller chain: $F_{rc} = \frac{6120 * P}{V} = \frac{6120 * 2.2}{45.72}$ = 294.49 kgf




| Chain Speed | Speed Factor |
|---|---|
| 15m/min or less | 1.0 |
| 15 to 30m/min | 1.2 |
| 30 to 50m/min | 1.4 |

After determining the number of teeth for the small sprocket, the number of teeth for the large sprocket must be determined.

Take notice that the number of teeth on a smaller sprocket must be 17 or more, while the number of teeth on a bigger sprocket must be 114 or fewer. Calculate the number of teeth on the bigger sprocket by multiplying the number of teeth on the smaller sprocket by the smaller sprocket's RPM ratio (speed ratio) to the larger sprocket. (*SELECTING and HANDLING of ROLLER CHAINS Chain Power Transmission Tables*, n.d.).

With a smaller sprocket has 18 teeth and the speed ratio is 2:1, the number of teeth on the larger sprocket is 36.

The next step is to calculate the centre-to-centre Distance between the Drive and Driven shafts, which is Cp.

Cp could be identified by the formula:

Cp = $1/4 * \left\{Lp - \frac{N1 + N2}{2} + +\sqrt{\left(Lp - \frac{N1 + N2}{2}\right)^2 - \frac{2}{\pi^2} * (N2 - N1)^2}\right\}$ (1)

Is this cases, Cp = 303.32 millimetres (this number could be identified by the 3D modelling process). The value of $\frac{2}{\pi^2} * (N2 - N1)^2$ could be collected based on the table that would be shown in the catalogue.

The difference between two sprockets is 17 then the value of the equation is 65.72.

Moreover, Lp is the overall chain length (no. of pitches). Lp could be calculated by using the following formula:

Lp = $\frac{N1 + N2}{2}$ + 2 * Cp + $\frac{\{(N2 - N1)/ 2 * \pi\}^2}{Cp}$

With the difference in the number of teeth between small and big sprockets being 17 the value of the equation $\{(N2 - N1)/ 2 * \pi\}^2$ is 8.22. The value of Lp must be an even number.

Applying the accepted calculations, we get an average Lp value of 1272 millimetres.

Appendix 2. Chain Power Transmission Table for K.C.M 60

## K.C.M.60(Single Strand Roller Chain)kW

| No. of Teeth / Small Spkt. | Revolutions Per Minute - Small Sprocket (r/min) | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 10 | 25 | 50 | 100 | 150 | 200 | 300 | 400 | 500 | 600 | 700 | 800 | 900 | 1000 | 1100 | 1200 | 1400 | 1600 | 1800 | 2000 | 2500 | 3000 | 3500 | 4000 | 4500 |
| **9** | 0.11 | 0.25 | 0.46 | 0.87 | 1.25 | 1.61 | 1.86 | 3.01 | 3.69 | 4.34 | 4.98 | 5.62 | 6.25 | 6.87 | 7.45 | 6.54 | 5.19 | 4.25 | 3.56 | 3.04 | 2.18 | 1.66 | 1.31 | 1.07 | 0.90 |
| **10** | 0.12 | 0.28 | 0.52 | 0.97 | 1.40 | 1.81 | 2.33 | 3.38 | 4.13 | 4.86 | 5.59 | 6.30 | 7.00 | 7.68 | 8.36 | 7.68 | 6.08 | 4.98 | 4.17 | 3.56 | 2.55 | 1.94 | 1.54 | 1.26 | 1.05 |
| **11** | 0.13 | 0.31 | 0.57 | 1.07 | 1.54 | 2.01 | 2.89 | 3.74 | 4.57 | 5.39 | 6.19 | 6.98 | 7.76 | 8.50 | 9.33 | 8.88 | 7.02 | 5.74 | 4.81 | 4.11 | 2.94 | 2.24 | 1.78 | 1.45 | 1.22 |
| **12** | 0.15 | 0.34 | 0.63 | 1.18 | 1.70 | 2.20 | 3.17 | 4.11 | 5.03 | 5.92 | 6.80 | 7.68 | 8.50 | 9.40 | 10.2 | 10.1 | 7.98 | 6.54 | 5.48 | 4.68 | 3.35 | 2.55 | 2.02 | 1.66 | 1.39 |
| **13** | 0.16 | 0.37 | 0.69 | 1.29 | 1.86 | 2.40 | 3.46 | 4.48 | 5.48 | 6.45 | 7.42 | 8.36 | 9.33 | 10.2 | 11.1 | 11.3 | 9.03 | 7.38 | 6.18 | 5.28 | 3.77 | 2.87 | 2.28 | 1.87 | 0 |
| **14** | 0.18 | 0.40 | 0.75 | 1.40 | 2.01 | 2.60 | 3.74 | 4.86 | 5.94 | 6.99 | 8.06 | 9.03 | 10.1 | 11.0 | 12.1 | 12.7 | 10.1 | 8.28 | 6.91 | 5.90 | 4.22 | 3.22 | 2.55 | 2.09 | 0 |
| **15** | 0.19 | 0.43 | 0.81 | 1.50 | 2.16 | 2.80 | 4.04 | 5.28 | 6.39 | 7.53 | 8.65 | 9.77 | 10.8 | 11.9 | 13.0 | 14.0 | 11.2 | 9.18 | 7.68 | 6.54 | 4.68 | 3.56 | 2.83 | 2.31 | 0 |
| **16** | 0.20 | 0.46 | 0.87 | 1.61 | 2.32 | 3.01 | 4.33 | 5.61 | 6.86 | 8.06 | 9.25 | 10.4 | 11.6 | 12.8 | 14.0 | 15.1 | 12.3 | 10.1 | 8.43 | 7.21 | 5.15 | 3.92 | 3.11 | 2.55 | 0 |
| **17** | 0.22 | 0.49 | 0.93 | 1.72 | 2.48 | 3.21 | 4.63 | 5.99 | 7.32 | 8.65 | 9.92 | 11.2 | 12.5 | 13.7 | 14.8 | 16.1 | 13.5 | 11.0 | 9.25 | 7.91 | 5.65 | 4.30 | 3.41 | 2.79 | 0 |
| **18** | 0.23 | 0.52 | 0.98 | 1.83 | 2.63 | 3.42 | 4.92 | 6.37 | 7.76 | 9.18 | 10.5 | 11.9 | 13.2 | 14.5 | 15.8 | 17.1 | 14.7 | 12.0 | 10.1 | 8.58 | 6.15 | 4.68 | 3.72 | 3.04 | 0 |
| **19** | 0.25 | 0.56 | 1.04 | 1.94 | 2.79 | 3.62 | 5.21 | 6.75 | 8.28 | 9.70 | 11.2 | 12.6 | 14.0 | 15.4 | 16.8 | 18.1 | 16.0 | 13.1 | 10.9 | 9.33 | 6.68 | 5.08 | 4.03 | 3.30 | 0 |
| **20** | 0.26 | 0.59 | 1.10 | 2.05 | 2.95 | 3.83 | 5.51 | 7.14 | 8.73 | 10.3 | 11.8 | 13.4 | 14.8 | 16.3 | 17.8 | 19.2 | 17.2 | 14.1 | 11.8 | 10.1 | 7.21 | 5.48 | 4.35 | 0 | |
| **21** | 0.27 | 0.62 | 1.16 | 2.16 | 3.11 | 4.03 | 5.80 | 7.53 | 9.18 | 10.8 | 12.5 | 14.0 | 15.6 | 17.2 | 18.7 | 20.2 | 18.5 | 15.1 | 12.7 | 10.8 | 7.76 | 5.90 | 4.68 | 0 | |
| **22** | 0.28 | 0.65 | 1.22 | 2.28 | 3.27 | 4.24 | 6.11 | 7.91 | 9.70 | 11.4 | 13.1 | 14.8 | 16.4 | 18.1 | 19.7 | 21.3 | 19.8 | 16.3 | 13.6 | 11.6 | 8.28 | 6.33 | 5.02 | 0 | |
| **23** | 0.30 | 0.69 | 1.28 | 2.38 | 3.43 | 4.45 | 6.41 | 8.28 | 10.1 | 11.9 | 13.7 | 15.5 | 17.2 | 18.9 | 20.7 | 22.3 | 21.2 | 17.4 | 14.5 | 12.5 | 8.88 | 6.77 | 5.36 | 0 | |
| **24** | 0.31 | 0.72 | 1.34 | 2.50 | 3.60 | 4.66 | 6.71 | 8.65 | 10.6 | 12.5 | 14.4 | 16.2 | 18.1 | 19.8 | 21.6 | 23.3 | 22.6 | 18.5 | 15.5 | 13.3 | 9.47 | 7.21 | 5.72 | 0 | |
| **25** | 0.33 | 0.75 | 1.40 | 2.61 | 3.76 | 4.86 | 7.01 | 9.10 | 11.1 | 13.1 | 15.0 | 16.9 | 18.9 | 20.7 | 22.6 | 24.4 | 24.0 | 19.7 | 16.5 | 14.1 | 10.1 | 7.68 | 6.08 | 0 | |
| **26** | 0.34 | 0.78 | 1.45 | 2.72 | 3.92 | 5.08 | 7.31 | 9.47 | 11.6 | 13.7 | 15.7 | 17.7 | 19.7 | 21.6 | 23.6 | 25.4 | 25.5 | 20.9 | 17.5 | 14.9 | 10.7 | 8.13 | 6.45 | 0 | |
| **28** | 0.37 | 0.84 | 1.58 | 2.95 | 4.24 | 5.50 | 7.91 | 10.3 | 12.5 | 14.8 | 17.0 | 19.2 | 21.3 | 23.4 | 25.5 | 27.6 | 28.5 | 23.3 | 19.5 | 16.7 | 11.9 | 9.10 | 0 | | |
| **30** | 0.40 | 0.91 | 1.70 | 3.18 | 4.57 | 5.92 | 8.50 | 11.0 | 13.5 | 16.0 | 18.3 | 20.7 | 23.0 | 25.2 | 27.5 | 29.7 | 31.6 | 25.9 | 21.7 | 18.5 | 13.3 | 10.1 | 0 | | |
| **32** | 0.43 | 0.98 | 1.83 | 3.40 | 4.90 | 6.36 | 9.18 | 11.9 | 14.5 | 17.1 | 19.6 | 22.2 | 24.6 | 27.1 | 29.5 | 31.9 | 34.8 | 28.5 | 23.9 | 20.4 | 14.6 | 11.1 | 0 | | |
| **35** | 0.47 | 1.07 | 2.01 | 3.75 | 5.40 | 7.00 | 10.1 | 13.1 | 16.0 | 18.8 | 21.6 | 24.4 | 27.1 | 29.8 | 32.5 | 35.1 | 39.8 | 32.6 | 27.3 | 23.3 | 16.7 | 12.7 | 0 | | |
| **40** | 0.54 | 1.25 | 2.32 | 4.33 | 6.24 | 8.06 | 11.6 | 15.1 | 18.4 | 21.7 | 25.0 | 28.1 | 31.3 | 34.4 | 37.5 | 40.6 | 46.6 | 39.8 | 33.3 | 28.5 | 20.4 | 0 | | | |
| **45** | 0.62 | 1.41 | 2.63 | 4.92 | 7.09 | 9.18 | 13.2 | 17.2 | 21.0 | 24.7 | 28.3 | 32.0 | 35.6 | 39.1 | 42.6 | 46.0 | 52.9 | 47.5 | 39.8 | 34.0 | 24.3 | 0 | | | |
| Lubrication Type | A | | | B | | | | | | | C | | | | | | | | | | | | | | |

Appendix 3. Chain Power Transmission Table for K.C.M 80

## K.C.M.80(Single Strand Roller Chain)kW

| No. of Teeth / Small Spkt. | Revolutions Per Minute - Small Sprocket (r/min) | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 10 | 25 | 50 | 100 | 150 | 200 | 300 | 400 | 500 | 600 | 700 | 800 | 900 | 1000 | 1100 | 1200 | 1400 | 1600 | 1800 | 2000 | 2200 | 2400 | 2700 | 3000 | 3400 |
| 9 | 0.25 | 0.58 | 1.08 | 2.02 | 2.91 | 3.77 | 5.43 | 7.03 | 8.58 | 10.1 | 11.6 | 13.1 | 12.7 | 10.8 | 9.40 | 8.21 | 6.53 | 5.35 | 4.48 | 3.83 | 3.32 | 2.91 | 2.44 | 2.08 | 1.73 |
| 10 | 0.28 | 0.65 | 1.22 | 2.26 | 3.26 | 4.22 | 6.09 | 7.91 | 9.62 | 11.3 | 13.1 | 14.7 | 14.8 | 12.7 | 11.0 | 9.62 | 7.68 | 6.27 | 5.25 | 4.48 | 3.89 | 3.41 | 2.86 | 2.44 | 2.02 |
| 11 | 0.31 | 0.72 | 1.34 | 2.51 | 3.61 | 4.68 | 6.74 | 8.73 | 10.7 | 12.6 | 14.5 | 16.3 | 17.2 | 14.6 | 12.7 | 11.1 | 8.80 | 7.23 | 6.06 | 5.17 | 4.48 | 3.93 | 3.30 | 2.81 | 1.27 |
| 12 | 0.35 | 0.79 | 1.48 | 2.75 | 3.97 | 5.14 | 7.41 | 9.62 | 11.7 | 13.8 | 15.9 | 17.9 | 19.5 | 16.6 | 14.5 | 12.7 | 10.1 | 8.21 | 6.90 | 5.89 | 5.11 | 4.48 | 3.76 | 3.21 | 0 |
| 13 | 0.38 | 0.87 | 1.61 | 3.01 | 4.33 | 5.61 | 8.06 | 10.4 | 12.8 | 15.1 | 17.3 | 19.5 | 21.7 | 18.8 | 16.3 | 14.3 | 11.3 | 9.33 | 7.76 | 6.65 | 5.76 | 5.06 | 4.24 | 3.62 | 0 |
| 14 | 0.41 | 0.93 | 1.75 | 3.25 | 4.69 | 6.07 | 8.73 | 11.3 | 13.9 | 16.3 | 18.7 | 21.2 | 23.5 | 21.0 | 18.2 | 16.0 | 12.7 | 10.4 | 8.73 | 7.43 | 6.44 | 5.65 | 4.74 | 4.04 | 0 |
| 15 | 0.44 | 1.01 | 1.88 | 3.51 | 5.05 | 6.54 | 9.40 | 12.2 | 14.9 | 17.6 | 20.2 | 22.8 | 25.4 | 23.3 | 20.2 | 17.8 | 14.1 | 11.5 | 9.62 | 8.21 | 7.14 | 6.27 | 5.25 | 4.48 | 0 |
| 16 | 0.47 | 1.08 | 2.01 | 3.76 | 5.42 | 7.02 | 10.1 | 13.1 | 16.0 | 18.9 | 21.6 | 24.5 | 27.2 | 25.7 | 22.2 | 19.5 | 15.5 | 12.7 | 10.6 | 9.10 | 7.83 | 6.90 | 5.79 | 4.94 | 0 |
| 17 | 0.51 | 1.16 | 2.15 | 4.01 | 5.78 | 7.46 | 10.8 | 14.0 | 17.1 | 20.1 | 23.1 | 26.1 | 29.0 | 28.1 | 24.4 | 21.4 | 16.9 | 13.9 | 11.6 | 9.92 | 8.58 | 7.53 | 6.33 | 5.41 | 0 |
| 18 | 0.54 | 1.22 | 2.29 | 4.27 | 6.15 | 7.98 | 11.5 | 14.8 | 18.2 | 21.4 | 24.6 | 27.8 | 30.9 | 30.7 | 26.6 | 23.3 | 18.5 | 15.1 | 12.7 | 10.8 | 9.40 | 8.21 | 6.90 | 5.89 | 0 |
| 19 | 0.57 | 1.30 | 2.42 | 4.53 | 6.52 | 8.43 | 12.2 | 15.7 | 19.2 | 22.7 | 26.1 | 29.4 | 32.7 | 33.2 | 28.8 | 25.3 | 20.1 | 16.4 | 13.7 | 11.7 | 10.1 | 8.95 | 7.46 | 6.39 | 0 |
| 20 | 0.60 | 1.37 | 2.57 | 4.78 | 6.89 | 8.95 | 12.8 | 16.6 | 20.4 | 24.0 | 27.6 | 31.1 | 34.5 | 35.9 | 31.1 | 27.3 | 21.6 | 17.8 | 14.8 | 12.7 | 11.0 | 9.62 | 8.06 | 0 | |
| 21 | 0.63 | 1.45 | 2.70 | 5.04 | 7.27 | 9.40 | 13.6 | 17.5 | 21.5 | 25.3 | 29.1 | 32.7 | 36.5 | 38.6 | 33.4 | 29.4 | 23.3 | 19.1 | 16.0 | 13.7 | 11.9 | 10.4 | 8.73 | 0 | |
| 22 | 0.67 | 1.52 | 2.84 | 5.30 | 7.61 | 9.92 | 14.2 | 18.5 | 22.6 | 26.6 | 30.6 | 34.5 | 38.3 | 41.4 | 35.9 | 31.5 | 25.0 | 20.4 | 17.2 | 14.6 | 12.7 | 11.1 | 9.33 | 0 | |
| 23 | 0.70 | 1.60 | 2.98 | 5.57 | 7.98 | 10.4 | 15.0 | 19.4 | 23.7 | 27.9 | 32.1 | 36.2 | 40.2 | 44.2 | 38.3 | 33.6 | 26.7 | 21.9 | 18.4 | 15.7 | 13.6 | 11.9 | 10.0 | 0 | |
| 24 | 0.73 | 1.67 | 3.13 | 5.83 | 8.43 | 10.9 | 15.7 | 20.3 | 24.8 | 29.2 | 33.6 | 37.9 | 42.1 | 46.3 | 40.9 | 35.9 | 28.5 | 23.3 | 19.5 | 16.6 | 14.5 | 12.7 | 10.6 | 0 | |
| 25 | 0.77 | 1.75 | 3.26 | 6.09 | 8.80 | 11.3 | 16.3 | 21.2 | 25.9 | 30.9 | 35.1 | 39.5 | 44.0 | 48.4 | 43.4 | 38.1 | 30.3 | 24.8 | 20.7 | 17.8 | 15.4 | 13.5 | 11.3 | 0 | |
| 26 | 0.80 | 1.83 | 3.40 | 6.36 | 9.18 | 11.9 | 17.1 | 22.2 | 27.0 | 31.9 | 36.6 | 41.3 | 45.9 | 50.4 | 46.1 | 40.4 | 32.1 | 26.3 | 22.0 | 18.8 | 16.3 | 14.3 | 12.0 | 0 | |
| 28 | 0.87 | 1.98 | 3.69 | 6.89 | 9.92 | 12.8 | 18.5 | 23.9 | 29.3 | 34.5 | 39.7 | 44.7 | 49.8 | 54.7 | 51.5 | 45.2 | 35.9 | 29.4 | 24.6 | 21.0 | 18.2 | 16.0 | 0 | | |
| 30 | 0.93 | 2.13 | 3.98 | 7.42 | 10.7 | 13.8 | 19.9 | 25.8 | 31.6 | 37.2 | 42.7 | 48.2 | 53.6 | 58.9 | 57.1 | 50.1 | 39.8 | 32.5 | 27.3 | 23.3 | 20.2 | 17.8 | 0 | | |
| 32 | 1.00 | 2.28 | 4.26 | 7.98 | 11.4 | 14.8 | 21.3 | 27.7 | 33.9 | 39.9 | 45.8 | 51.6 | 57.4 | 63.1 | 62.9 | 55.2 | 43.8 | 35.9 | 30.1 | 25.7 | 22.2 | 19.5 | 0 | | |
| 35 | 1.10 | 2.51 | 4.69 | 8.73 | 12.6 | 16.3 | 23.6 | 30.5 | 37.3 | 43.9 | 50.4 | 56.9 | 63.3 | 69.6 | 72.0 | 63.2 | 50.1 | 41.0 | 34.4 | 29.4 | 25.4 | 0 | | | |
| 40 | 1.28 | 2.90 | 5.42 | 10.1 | 14.5 | 18.9 | 27.2 | 35.2 | 43.0 | 50.7 | 58.3 | 65.7 | 73.9 | 80.6 | 87.3 | 76.8 | 61.3 | 50.1 | 42.0 | 35.9 | 14.9 | 0 | | | |
| 45 | 1.45 | 3.30 | 6.15 | 11.5 | 16.6 | 21.4 | 30.9 | 40.0 | 48.9 | 57.6 | 66.2 | 74.6 | 82.8 | 91.0 | 99.2 | 91.8 | 73.1 | 59.8 | 50.1 | 40.3 | 0 | | | | |
| Lubrication Type | A | | B | | | | | | C | | | | | | | | | | | | | | | | |

## Appendix 4. Standards roller chains

○ Dimensions

[Unit: mm]

| Chain No. | | Pitch | Width between Inner Plates | Roller Dia. | Pin | | | | | | Link Plate | | JIS Tensile strength | Ave. Tensile Strength | Max. Allowable Load | Approx. Weight | Links of 1 unit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| KCM | JIS & ANSI | P | W | D | Dia. d | A | B | (A+A) $L_1$ | (A+B) $L_2$ | Offset L | Thickness T | Height H | kN (kgf) | kN (kgf) | kN (kgf) | (kg/m) | |
| **25** | 25 | 6.35 | 3.18 | *3.30 | 2.31 | 3.80 | 4.80 | 7.60 | 8.60 | — | 0.75 | 5.8 | 3.5( 357) | 4.4( 450) | 0.64( 65) | 0.13 | 480 |
| **35** | 35 | 9.525 | 4.78 | *5.08 | 3.59 | 5.70 | 7.10 | 11.40 | 12.80 | 13.65 | 1.25 | 8.8 | 7.9( 806) | 10.8( 1,100) | 2.16( 220) | 0.33 | 320 |
| **41** | 41 | 12.70 | 6.38 | 7.77 | 3.59 | 6.52 | 7.93 | 13.05 | 14.45 | 14.95 | 1.25 | 9.5 | 6.7( 683) | 11.8( 1,200) | 2.26( 230) | 0.40 | 240 |
| **40** | 40 | 12.70 | 7.95 | 7.92 | 3.97 | 8.02 | 9.53 | 16.05 | 17.55 | 18.95 | 1.5 | 11.7 | 13.9( 1,417) | 18.1( 1,850) | 3.63( 370) | 0.61 | 240 |
| **50** | 50 | 15.875 | 9.53 | 10.16 | 5.09 | 10.15 | 11.60 | 20.30 | 21.75 | 23.00 | 2.0 | 14.6 | 21.8( 2,223) | 29.9( 3,050) | 6.37( 650) | 1.01 | 192 |
| **60** | 60 | 19.05 | 12.70 | 11.91 | 5.96 | 12.65 | 14.15 | 25.30 | 26.80 | 29.45 | 2.4 | 17.5 | 31.3( 3,192) | 41.2( 4,200) | 8.83( 900) | 1.49 | 160 |
| **80** | 80 | 25.40 | 15.88 | 15.88 | 7.94 | 16.10 | 19.20 | 32.15 | 35.25 | 36.90 | 3.2 | 23.0 | 55.6( 5,670) | 72.6( 7,400) | 14.71(1,500) | 2.50 | 120 |
| **100** | 100 | 31.75 | 19.05 | 19.05 | 9.54 | 20.10 | 23.05 | 40.20 | 43.15 | 45.05 | 4.0 | 28.9 | 87.0( 8,872) | 112.8(11,500) | 22.56(2,300) | 3.85 | 96 |
| **120** | 120 | 38.10 | 25.40 | 22.23 | 11.11 | 25.20 | 28.60 | 50.40 | 53.80 | 55.90 | 4.8 | 35.0 | 125.0(12,746) | 156.9(16,000) | 30.40(3,100) | 5.66 | 80 |
| **140** | 140 | 44.45 | 25.40 | 25.40 | 12.71 | 27.30 | 31.30 | 54.60 | 58.60 | 60.50 | 5.6 | 40.7 | 170.0(17,335) | 210.8(21,500) | 40.21(4,100) | 7.19 | 68 |
| **160** | 160 | 50.80 | 31.75 | 28.58 | 14.29 | 32.45 | 37.15 | 64.90 | 69.60 | 71.85 | 6.4 | 46.7 | 223.0(22,740) | 269.7(27,500) | 52.96(5,400) | 9.63 | 60 |
| **200** | 200 | 63.50 | 38.10 | 39.68 | 19.85 | 39.65 | 46.65 | 79.30 | 86.30 | 89.20 | 8.0 | 58.4 | 347.0(35,384) | 470.7(48,000) | 71.59(7,300) | 15.97 | 48 |

NOTES: - KCM25 offset link is 2-pitch type.
- Asterisk (*) implies bush diameter.
- Connecting links of KCM25 to KCM60 are clip type (Both open and closed types are available for 40, 50, and 60).
- Connecting links of KCM 80 or larger models are split pin type.

Appendix 5. Table for the value of $\frac{2}{\pi^2} * (N2 - N1)^2$

| $N_2-N_1$ | $\frac{2}{\pi^2}(N_2-N_1)^2$ | $N_2-N_1$ | $\frac{2}{\pi^2}(N_2-N_1)^2$ | $N_2-N_1$ | $\frac{2}{\pi^2}(N_2-N_1)^2$ |
|---|---|---|---|---|---|
| **1** | 0.20 | **35** | 248.49 | **69** | 965.76 |
| **2** | 0.81 | **36** | 262.89 | **70** | 993.96 |
| **3** | 1.83 | **37** | 277.70 | **71** | 1022.56 |
| **4** | 3.25 | **38** | 292.91 | **72** | 1051.56 |
| **5** | 5.07 | **39** | 308.53 | **73** | 1080.98 |
| **6** | 7.30 | **40** | 324.56 | **74** | 1110.80 |
| **7** | 9.94 | **41** | 340.99 | **75** | 1141.19 |
| **8** | 12.98 | **42** | 357.82 | **76** | 1171.65 |
| **9** | 16.43 | **43** | 375.07 | **77** | 1202.69 |
| **10** | 20.28 | **44** | 392.71 | **78** | 1234.13 |
| **11** | 24.54 | **45** | 410.77 | **79** | 1265.97 |
| **12** | 29.21 | **46** | 429.23 | **80** | 1298.23 |
| **13** | 34.28 | **47** | 448.09 | **81** | 1330.88 |
| **14** | 39.76 | **48** | 467.36 | **82** | 1363.95 |
| **15** | 45.64 | **49** | 487.04 | **83** | 1397.42 |
| **16** | 51.93 | **50** | 507.12 | **84** | 1431.29 |
| **17** | 58.62 | **51** | 527.61 | **85** | 1465.58 |
| **18** | 65.72 | **52** | 548.50 | **86** | 1500.26 |
| **19** | 73.23 | **53** | 569.80 | **87** | 1535.36 |
| **20** | 81.14 | **54** | 591.50 | **88** | 1570.85 |
| **21** | 89.46 | **55** | 613.61 | **89** | 1606.76 |
| **22** | 98.18 | **56** | 636.13 | **90** | 1643.07 |
| **23** | 107.31 | **57** | 659.05 | **91** | 1679.78 |
| **24** | 116.84 | **58** | 682.38 | **92** | 1716.90 |
| **25** | 126.78 | **59** | 706.11 | **93** | 1754.43 |
| **26** | 137.13 | **60** | 730.25 | **94** | 1792.36 |
| **27** | 147.88 | **61** | 754.80 | **95** | 1830.70 |
| **28** | 159.03 | **62** | 779.75 | **96** | 1869.45 |
| **29** | 170.60 | **63** | 805.10 | **97** | 1908.60 |
| **30** | 182.56 | **64** | 830.86 | **98** | 1948.15 |
| **31** | 194.94 | **65** | 857.03 | **99** | 1988.11 |
| **32** | 207.92 | **66** | 883.61 | **100** | 2028.48 |
| **33** | 220.90 | **67** | 910.58 | | |
| **34** | 234.49 | **68** | 937.97 | | |

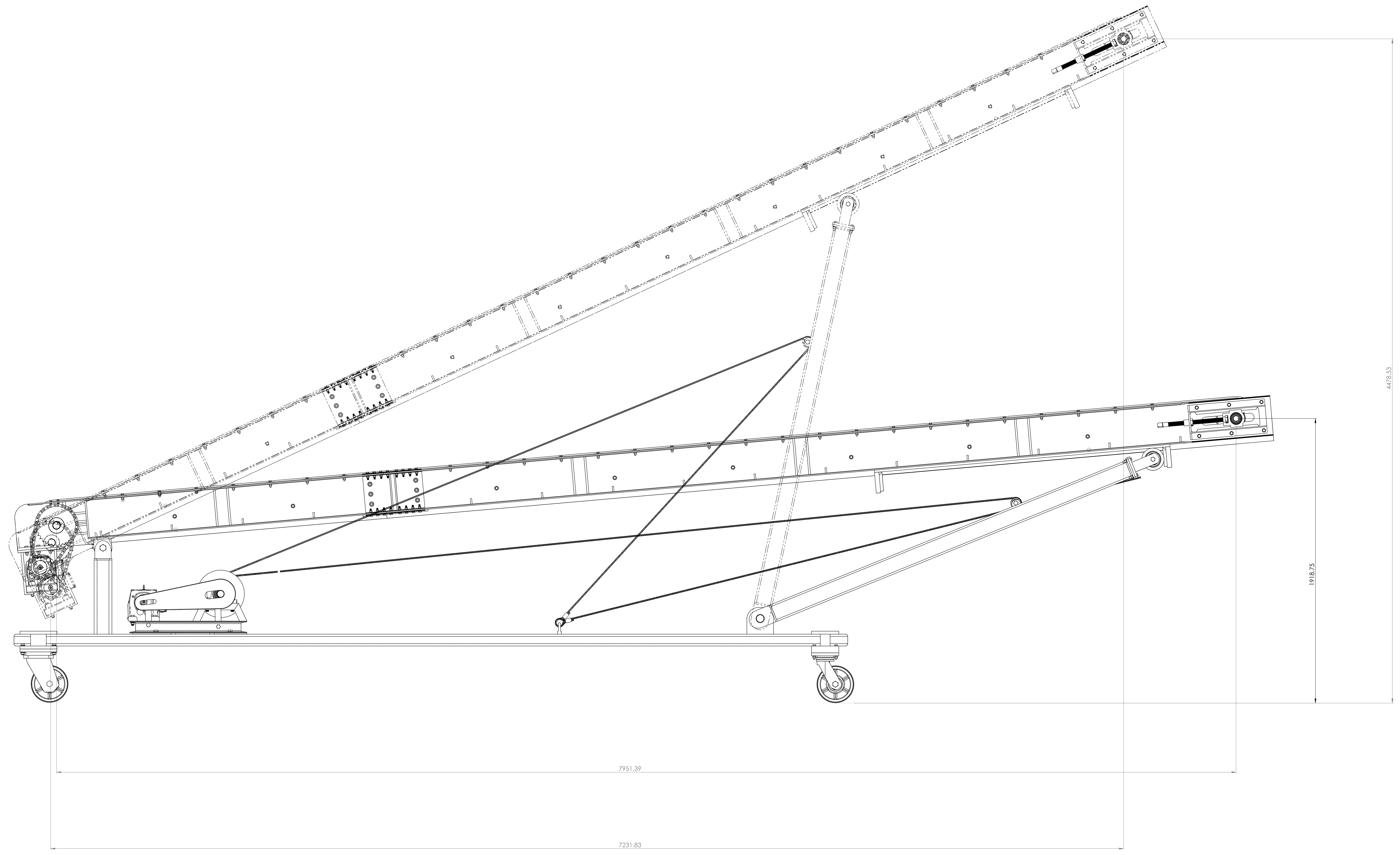
Appendix 6. Table for the value of $\{(N2 - N1)/ 2 * \pi\}^2$

| $N_2 - N_1$ | $\{(N_2 - N_1)/2\pi\}^2$ | $N_2 - N_1$ | $\{(N_2 - N_1)/2\pi\}^2$ | $N_2 - N_1$ | $\{(N_2 - N_1)/2\pi\}^2$ |
|---|---|---|---|---|---|
| **1** | 0.03 | **35** | 31.06 | **69** | 120.72 |
| **2** | 0.10 | **36** | 32.86 | **70** | 124.24 |
| **3** | 0.23 | **37** | 34.71 | **71** | 127.82 |
| **4** | 0.41 | **38** | 36.61 | **72** | 131.45 |
| **5** | 0.63 | **39** | 38.57 | **73** | 135.12 |
| **6** | 0.91 | **40** | 40.57 | **74** | 138.85 |
| **7** | 1.24 | **41** | 42.62 | **75** | 142.63 |
| **8** | 1.62 | **42** | 44.73 | **76** | 146.46 |
| **9** | 2.05 | **43** | 46.88 | **77** | 150.34 |
| **10** | 2.54 | **44** | 49.09 | **78** | 154.27 |
| **11** | 3.07 | **45** | 51.35 | **79** | 158.25 |
| **12** | 3.65 | **46** | 53.65 | **80** | 162.28 |
| **13** | 4.29 | **47** | 56.01 | **81** | 166.36 |
| **14** | 4.97 | **48** | 58.42 | **82** | 170.49 |
| **15** | 5.71 | **49** | 60.88 | **83** | 174.68 |
| **16** | 6.49 | **50** | 63.39 | **84** | 178.91 |
| **17** | 7.33 | **51** | 65.95 | **85** | 183.20 |
| **18** | 8.22 | **52** | 68.56 | **86** | 187.53 |
| **19** | 9.15 | **53** | 71.22 | **87** | 191.92 |
| **20** | 10.14 | **54** | 73.94 | **88** | 196.36 |
| **21** | 11.18 | **55** | 76.70 | **89** | 200.84 |
| **22** | 12.27 | **56** | 79.52 | **90** | 205.38 |
| **23** | 13.41 | **57** | 82.38 | **91** | 209.97 |
| **24** | 14.61 | **58** | 85.30 | **92** | 214.61 |
| **25** | 15.85 | **59** | 88.26 | **93** | 219.30 |
| **26** | 17.14 | **60** | 91.28 | **94** | 224.05 |
| **27** | 18.48 | **61** | 94.35 | **95** | 228.84 |
| **28** | 19.88 | **62** | 97.47 | **96** | 233.68 |
| **29** | 21.32 | **63** | 100.64 | **97** | 238.57 |
| **30** | 22.82 | **64** | 103.86 | **98** | 243.52 |
| **31** | 24.37 | **65** | 107.13 | **99** | 248.51 |
| **32** | 25.96 | **66** | 110.45 | **100** | 253.56 |
| **33** | 27.61 | **67** | 113.82 | | |
| **34** | 29.31 | **68** | 117.25 | | |

Appendix 7. Table for the value of the frictional coefficient for bearing.

| Bearing type | Friction coefficientμ |
|---|---|
| Deep groove ball bearing | 0.0010~0.0015 |
| Angular contact ball bearing | 0.0012~0.0020 |
| Self-aligning ball bearing | 0.0008~0.0012 |
| Cylindrical roller bearing | 0.0008~0.0012 |
| Full complement type needle roller bearing | 0.0025~0.0035 |
| Needle roller and cage assembly | 0.0020~0.0030 |
| Tapered roller bearing | 0.0017~0.0025 |
| Spherical roller bearing | 0.0020~0.0025 |
| Thrust ball bearing | 0.0010~0.0015 |
| Spherical thrust roller bearing | 0.0020~0.0025 |

Appendix 8. Manufacturing drawing.

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|---|---|---|---|
| Yleistoleranssit / General tolerances<br>Machining: ISO 2768-mK<br>Welded constructions: EN ISO 13920-BF<br>Welding quality level: C<br>Flame cutting: ISO 9013-331<br>Casting: ISO 8062-CT 11<br>Stamping: SFS 5803-m | Aihio / Preform | Suunnittelija / Designer: Hau Tran | Pvm / Date: 30.04.2023 |
| | Mitat / Dimensions | Hyväksyjä / Accepted by | Pvm / Date |
| Mittakaava / Scale: A0 1:10 | Materiaali / Material | Massa / Weight: kg | |
| LAB University of Applied Sciences<br>www.lab.fi | Nimitys / Description | Piirustusnumero / Item: Movable Inclined Conveyor | Revisio / Revision |

| Revision kuvaus / Revision Description | Muuttaja / Revision Modified By | Hyväksyjä / Revision Approved By |
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