Mohamed Khider University, Biskra
Science and Technology
Mechanical Engineering

MASTER'S THESIS

Field: Science and Technology
Branch: Mechanical Engineering
Specialty: Mechanical Construction

Ref: Enter the document reference

Presented and supported by:
Mohamed Amine MAAZ

On : mardi 25 juin 2024

Design and production of a belt conveyor

Jury :

Dr.	ABDELHAKIM BAGAR	MCA	University of Biskra	Superviser
Pr.	CHEBBAH MOHAMED-SAID	Pr	University of Biskra	Président
Dr.	TAREK DJOUDI	MCA	University of Biskra	Examinateur

Academic year : 2023 – 2024

Acknowledgment

Praise be to Allah, by whose grace good deeds are completed. I offer my prayers and peace upon the last of the prophets and messengers, our prophet Muhammed, and upon his family and companions.

I extend my deepest gratitude and appreciation to my supervisors who greatly guided and supported me throughout my research journey:

Dr. ABDELHAKIM BAGAR

I also extend my sincere thanks to all the members of the evaluation and discussion committee:

Pr. Mohamed Said Chebbah

Dr.Tarek Djoudi

My special thanks to Mr. Ammar BOUCETTA, my mentor during my internship at ENASELL Whom I owe my deep gratitude for his invaluable guidance and support in shaping my understanding and enriching my professional growth and inspiration to do this work.

I cannot forget to express my gratitude to everyone who contributed their advice, guidance, and support, from professor and colleagues in the department of architecture who have been a great help and support throughout this journey.

Dedication

To the ones who have been my pillars of strength and unlimited support and encouraged me throughout my life my beloved parents.

I am forever grateful to my dear siblings and niephlings who have always stood by my side, offering their love, support, and kindness.

To my friends who have provided invaluable advice and guidance during my academic journey (Yassin, Ayoub, Abderrahmane)

And special thanks to my Soulmate for all the effort and support

I dedicate this work to everyone who has been there for me and helped me in my educational career.

Mohamed Amine Maaz

Table of Contents

Table of Contents

List of Figures

List of Tables

List of Symbols and their units

Symbols	Meaning	Unit
a_i	Pitch of impact sets	m
a_u	Pitch of return sets	m
a_0	Pitch of carrying sets	m
C_p	Resultant of tensions	daN
D_{Dint}	Internal diameter of drive pulley	mm
D_{Dout}	Outer diameter of drive pulley	mm
D_{Rint}	Internal diameter of return pulley	mm
D_{Rout}	Outer diameter of return pulley	mm
L_{10}	Bearing Life	/
M_f	Bending moment	$daN.m$
M_t	Torsion moment	daN
N_D	Rotation speed of the drive pulley	RPM
N_D	Rotation speed of the drive pulley	RPM
V_t	Drive Pulley volume	m^3
m_t	Drive Pulley mass	kg
m_t	Drive Pulley mass	kg
q_G	Weight of conveyed material per linear meter	Kg/m
C_{a_1}	Dynamic load	daN
C_{r_1}	The dynamic load on the return set	daN
C_a	Static load	daN
C_q	Coefficient of fixed resistance	/
C_r	The static load on the return set	daN
C_t	Coefficient of passive resistance given by temperature	/
C_w	Wrap factor	/
F_d	Shock factor	/
F_m	Environmental factors	/
F_p	Participation factor	/
F_s	Service factors	/

F_v	**Speed factors**	/
I_M	**Loaded volume**	m^3 / h
I_V	**Load capacity of the belt**	t / h
I_{VT}	**Theoretical Load Volume**	m^3 / h
L_t	**Transition Distance**	m
M_{if}	**Ideal bending moment**	daN
N_M	**Motor speed**	RPM
N_r	**Number of rollers**	/
T_{max}	**Maximum Tension**	daN
T_{umax}	**Working load and belt breaking strain**	N/mm
T_0	**The minimal tension**	daN
T_1	**The maximum tension upstream of the drive pulley**	daN
T_2	**The tension downstream from the drive pulley**	daN
T_3	**The tension downstream of the return pulley**	daN
a_g	**Distance between supports and pulley flanges**	**m**
c_a	**The load on the most stressed roller**	daN
c_r	**The load on a single or pair of return rollers**	daN
p_{pRI}	**Weight of lower rotating parts**	Kg
p_{pRS}	**Weight of upper rotating parts**	Kg
q_{RO}	**Weight of the upper rotating parts**	Kg / m
q_{Ru}	**Weight of the lower rotating parts**	Kg / m
q_S	**Specific weight of the material**	t / m^3
q_b	**weight of the belt per linear meter**	K_g/m
q_t	**Pulley weight**	daN
σ_{amm}	**Allowable Stress**	daN / mm^2
C	**Roller length**	**mm**
d	**Axis diameter**	**mm**
I	**Belt width**	**mm**
S	**The distance between the end of the pulley belt and the hub center**	**mm**
C	**Dynamic load rating of the bearing**	daN
D	**Roller Diameter**	mm
Fa	**Active Force**	daN
Fr	**Rotating Parts Force**	daN
Fu	**Tangential force**	daN

H	**Height changes of belt**	**m**
L	**Centers of conveyor**	**m**
L	**Length of the pulley**	**mm**
N	**Belt width**	mm
P	**Driving power**	kw
SF	**Safety Factor**	/
T	**Required Torque**	Nm
w	**Risistance module**	mm^3
A	**Belt width**	mm
L	**Load centers**	/
P	**Mass Density**	kg / m^3
V	**Belt speed**	m / s
d	**Drive / Return pulley Shaft Diameter**	mm
f	**Coefficient of internal friction**	/
n	**Number of roller rotations**	t/min
η	**Efficiency of the reduction gear**	/
α	**Angle of wrap**	**Degree**
β	**Angle of surcharge**	**Degree**
λ	**Troughing set angle**	**Degree**
ϕ	**Angle of repose**	**Degree**

Abstract

In every complex, factory, or mine, various means of transport replace human effort, leading to time savings and increased production efficiency. For this project, we selected a belt conveyor as the ideal transport solution for bulk products.

The design of the conveyor required precise dimensioning of its components. After thorough calculations, we determined the appropriate type of belt, drums and their shafts, as well as the upper and lower carrying rollers. For the motor mechanism, speed reducer, and transmission system, we carefully selected the main characteristics of each component.

This thesis details the entire process of designing and implementing the conveyor, highlighting the technical choices and solutions adopted to develop an efficient and reliable system.

ملخص

في كل مجمع أو مصنع أو منجم، تُستخدم وسائل النقل المختلفة لتحل محل الجهد البشري، مما يؤدي إلى توفير الوقت وزيادة كفاءة الإنتاج. في هذا المشروع، اخترنا الناقل بحزام كحل نقل مثالي للمنتجات السائبة.

تطلب تصميم الناقل تحديد أبعاد مكوناته بدقة. بعد حسابات دقيقة، حددنا نوع الحزام المناسب، والأسطوانات ومحاورها، وكذلك البكرات الحاملة العلوية والسفلية. بالنسبة لآلية المحرك، ومخفض السرعة، ونظام النقل، قمنا بعناية باختيار الخصائص الرئيسية لكل عنصر.

توضح هذه الرسالة العملية الكاملة لتصميم وتنفيذ الناقل، مسلطة الضوء على الاختيارات التقنية والحلول المعتمدة لتطوير نظام فعال وموثوق.

General Introduction

Bulk material transportation is a vital aspect across various industries, particularly in salt production where operational efficiency is paramount to sustaining productivity. Within the Enasel salt factory, establishing an effective conveyor system is a top priority to ensure a continuous and secure flow of salt throughout the production process.

This thesis presents the outcomes of an internship conducted at the Enasel salt factory, focusing on the design and implementation of an optimized salt conveyor system. The primary objective was to address the specific requirements of the factory by designing a system that is efficient, reliable, and cost-effective. This process involved a detailed analysis of the factory's operational needs and precise calculations to determine the parameters of the conveyor elements.

A significant portion of this work was dedicated to utilizing computer-aided design (CAD) software, particularly SolidWorks, to model and simulate the conveyor system. SolidWorks facilitated visualization and optimization of the conveyor design, taking into account factors such as material strength, durability, and energy efficiency.

Simultaneously, a prototype of the conveyor was fabricated to validate the proposed designs and evaluate their performance under real-world conditions. This experimental phase highlighted the strengths and weaknesses of the proposed system, leading to adjustments and enhancements to optimize its performance.

In this thesis, we will delve into the design process of the salt conveyor system using SolidWorks, as well as the fabrication and testing of the prototype. By emphasizing the obtained results and lessons learned throughout this project, we aim to provide valuable insights for future developments of conveyor systems in the salt industry and beyond.

Chapter I
General Information on Conveyors

I Introduction:

Conveyors represent a fundamental element in the field of industrial handling and logistics. They are used for the transportation of materials, goods, and finished products through production lines, warehouses, and distribution centers. This continuous transport system helps optimize workflow, increase efficiency, and reduce operational costs. Conveyors come in various types and configurations, each tailored to specific needs and environments. From belt conveyors to roller conveyors, chain conveyors, and modular systems, they form the backbone of many modern industrial operations. Their design and implementation require a thorough understanding of logistics processes, the characteristics of materials to be transported, and production requirements. This introduction explores the fundamental aspects of conveyors, their significance, and the different technologies available to meet the diverse challenges of contemporary industries.

II Conveyor Types:

II.1 Magnetic Conveyor [1-6]:

Magnetic conveyors are specialized handling devices primarily used for transporting ferromagnetic materials. These conveyors utilize magnetic force to move objects in a controlled and secure manner. They find wide applications in various industries such as automotive, metallurgy, recycling, and metal parts manufacturing, owing to their efficiency and reliability.

Operating Principle

A magnetic conveyor operates through a series of magnets arranged beneath the conveyor surface. These magnets generate a magnetic field that attracts and holds ferromagnetic objects on the transport surface. Here are the main components and detailed functioning:

Permanent Magnets or Electromagnets: The magnets used can be either permanent or electromagnetic. Permanent magnets provide a constant magnetic field, while electromagnets can be activated and deactivated as needed.

Conveyor Belt: The conveyor belt can be made of stainless steel or coated with non-ferromagnetic materials. It is designed to allow magnetic fields to pass through and attract metallic objects.

Movement Mechanism: The conveyor is equipped with a movement mechanism, usually an electric motor, which continuously drives the conveyor belt, ensuring the movement of magnetically attached objects.

Applications

Magnetic conveyors are employed in various applications where precise and secure handling of metallic objects is essential. Here are some examples:

Automotive Industry: Transporting metal parts such as casings, gears, and transmission components on production lines.

Recycling: Separating and transporting ferrous metals in recycling facilities, enabling efficient material recovery.

Metallurgy: Handling sheets, bars, and metal profiles in steel mills and metal processing plants.

Manufacturing: Transporting machined parts and finished metal products in component and metal assembly manufacturing plants.

Advantages

Magnetic conveyors offer several advantages over other types of conveyors:

Increased Safety: Metallic objects are firmly held in place, reducing the risks of falls and damage during transportation.

Efficiency: Capable of transporting objects at high speeds and over complex paths, including inclines and curves.

Reduced Maintenance: Fewer moving parts and minimal component wear, resulting in lower maintenance requirements.

Adaptability: Easy integration into existing production lines and can be configured to meet specific needs in terms of size, weight, and shape of transported objects.

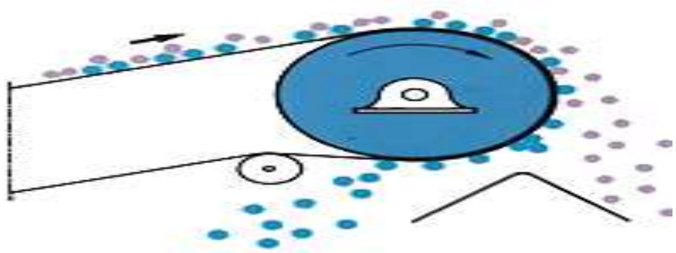


Figure 1: Magnetic Conveyor

II.2 Roller conveyor [7-9]

A roller conveyor is a transportation system used in various industrial environments to move materials or products from one point to another. It consists of a series of rollers aligned along a frame, typically made of steel or aluminum. The objects to be transported rest on the rollers and are pushed or driven by them when set in motion.

This type of conveyor is often used for transporting light to medium loads in warehouses, production plants, distribution centers, etc. The rollers can be motorized to facilitate the movement of loads over long distances or for greater precision in product positioning.

Roller conveyors can be designed to be straight or curved according to specific application needs. They provide an efficient solution for automating handling and logistics processes, thereby improving the efficiency and productivity of industrial operations.

Structure and Components: Roller conveyors are typically built on a sturdy steel or aluminum frame. The rollers are mounted on this frame at regular intervals and can be made of various materials such as steel, PVC, or plastic. Some conveyors may have motorized rollers to facilitate load movement.

Flexibility: These conveyors offer great flexibility in terms of configuration. They can be designed to be straight, curved, or even inclined to facilitate vertical transportation of products. Straight sections can be connected to curved sections to create customized routes based on the layout of the factory or warehouse.

Applications: Roller conveyors are widely used in many industries for transporting goods such as boxes, pallets, crates, bags, etc. They are commonly used in warehouses for loading and unloading trucks, in production lines to transport products from one stage to another, and in distribution centers for sorting and shipping goods.

Control Options: Roller conveyors can be equipped with various control devices to regulate the speed and movement of loads. This may include sensors to detect the presence of products, weighing systems to measure loads, and programmable controls to automate operations.

Maintenance: Like any industrial equipment, roller conveyors require regular maintenance to ensure proper operation and extend their lifespan. This may include replacing worn rollers, lubricating moving components, and inspecting motors and control systems.

Figure 2: Roller conveyor

II.3 Screw conveyor [10,11]

A screw conveyor is a mechanical transportation system used to move bulk materials such as grains, pellets, powders, etc. It consists of a tube or a hopper containing the material to be transported and a helical screw inside this tube. When the screw rotates, it grips the material and transports it along the tube to its destination.

This type of conveyor is widely used in various industries such as agriculture, food processing, mining, etc. It is valued for its ability to efficiently transport bulk materials over long distances with minimal loss and degradation of the material. Additionally, it is relatively simple to install and maintain.

Basic structure: A screw conveyor generally consists of the following elements:

A hopper or tube: This is the container where bulk materials are loaded.

A helical screw: This screw is the main component of the conveyor. It is usually mounted inside the tube and can have different diameters and pitches according to the specific needs of the application.

A motor: The motor is responsible for rotating the screw to move the materials along the tube.

Bearings and seals: These components ensure the proper operation of the screw and reduce friction and efficiency losses.

Operation: When the motor of the screw conveyor is activated, the helical screw starts to rotate. As it rotates, the screw blades grab the materials in the hopper and move them along the tube. As the screw continuously turns, the materials are pushed towards the outlet of the conveyor where they can be discharged into another container or another transportation system.

Adaptability: Screw conveyors can be adapted to meet various transportation needs. They can be inclined to facilitate the transport of materials on slopes or equipped with dosing devices to precisely control the amount of material discharged. Additionally, different screw configurations can be used depending on the nature and properties of the materials to be transported.

Applications: Screw conveyors are widely used in many industries, including:

Agricultural industry: Transport of grains, seeds, animal feed, etc.

Food industry: Handling of powders, flours, sugar, etc.

Mining industry: Transport of ore, coal, sand, etc.

Chemical industry: Movement of bulk products such as granules, powders, chemicals, etc.

Advantages:

Cost-effective: Screw conveyors are generally less expensive to install and maintain than other transportation systems.

Versatility: They can transport a wide variety of bulk materials.

Efficiency: They can operate continuously, thus facilitating transport over long distances.

Compactness: They can be designed to fit into restricted spaces.

Figure 3: Screw conveyor

II.4 Bucket conveyor [12,13]

A bucket conveyor is a continuous conveying system used to move bulk materials such as grains, pellets, minerals, etc. It consists of a series of buckets attached to a chain or belt. The buckets are designed to collect material from a source, such as a silo or hopper, and transport it along a defined path to a specific destination, such as another processing or storage point.

This type of conveyor is widely used in various industries such as agriculture, mining, construction, food industry, etc. It is valued for its ability to efficiently transport large quantities of materials over long distances and varying heights. Additionally, it allows for continuous loading and unloading, improving the efficiency of industrial processes.

A bucket conveyor typically consists of the following elements:

Chain or belt: This is the basic structure of the conveyor. The chain or belt travels in a closed loop with pulleys at the ends to create continuous rotational movement.

Buckets: These are containers attached at regular intervals along the chain or belt. Buckets can come in different shapes and sizes depending on the specific material transport needs. They can be made of plastic, steel, rubber, or other materials, depending on the properties of the material being transported and the environment in which the conveyor is used.

Bucket supports: These are attached to the chain or belt and serve as attachment points for the buckets. The supports must be sturdy to withstand the weight of the transported material.

Drive: A drive mechanism, usually an electric motor, is used to provide the power needed to move the chain or belt and thus move the buckets along the circuit.

Tensioning devices: Tensioning devices are used to keep the chain or belt taut, ensuring smooth and regular operation of the conveyor.

Casing: This is a protective structure that covers the conveyor to prevent material spills and protect workers from potential hazards.

Loading and unloading system: This can include hoppers, feed chutes, spouts, or other devices designed to efficiently load materials into the buckets at the conveyor inlet and to unload materials at the outlet.

Bucket conveyors are suitable for transporting a wide variety of bulk materials such as grains, powdered chemicals, minerals, pellets, etc. Their modular design allows for easy adaptation to different environments and transport requirements, making them a versatile solution for many industrial applications.

Figure 4: Bucket conveyor

II.5 hovercraft conveyor [14]

A hovercraft conveyor is a transportation system that utilizes hovercraft to move materials or goods. Hovercraft are vehicles that use an air cushion to float above a surface, significantly reducing friction and allowing for swift and efficient movement. In the context of conveyors, hovercraft can be employed to transport goods over short or long distances, across diverse terrains, including water or rough terrain where other means of transportation might encounter difficulties. This system can be particularly useful in industries where fast and flexible transport is essential, such as logistics, construction, or mining. A hovercraft conveyor is a sophisticated transport system using hovercraft as a means of conveyance. Here is a detailed description of its operation:

Hovercraft: The hovercraft is a vehicle that uses an air cushion to float above the surface, significantly reducing friction. It is propelled by engines and can move in various directions.

Track structure: The track of the hovercraft conveyor is specially designed to allow for the movement of hovercraft. It can be constructed on various terrains, including water, land, or other surfaces, and can also be equipped with lifting devices to overcome obstacles or changes in elevation.

Guidance system: To ensure precise and safe movement, the conveyor can be equipped with a guidance system that controls the trajectory of the hovercraft along the track. This may include sensors, rails, or other automatic guidance devices.

Loading and unloading: The hovercraft conveyor can be equipped with loading and unloading points located along the track. These points allow goods to be loaded onto the hovercraft from shipping platforms and unloaded at specific destinations.

Maintenance: Like any mechanical system, the hovercraft conveyor requires regular maintenance to ensure proper operation. This may include inspection of the hovercraft, repair of the track, and replacement of faulty components.

Advantages: The advantages of a hovercraft conveyor include high travel speed, ability to overcome obstacles and diverse terrains, as well as flexibility for transporting goods over short or long distances.

Figure 5: Hovercraft conveyor

II.6 Belt Conveyors:

Definition: Belt conveyors are transport systems used to efficiently and continuously move bulk materials or objects from one place to another.

History: The earliest belt conveyors date back to the early 20th century, with initial applications in mines and material processing facilities.

Importance: Belt conveyors have become essential components in various industrial sectors, contributing to the automation of production processes and improving logistical efficiency.

Design and Components:

Structure: Belt conveyors consist of a conveyor belt supported by rollers or slides. The structure can be made of steel, aluminum, or plastic, depending on load requirements and environmental conditions.

Belts: Conveyor belts can be made from various materials such as rubber, PVC, polyurethane, or composite materials depending on load requirements, abrasion resistance, and temperature.

Auxiliary Systems: Belt conveyors may include belt tensioning systems, guiding devices, drive and return drums, as well as cleaning devices to maintain the belt in good working condition.

The main components of a conveyor belt and their operation are essential to understanding the overall functioning of this transportation system. Here is a detailed explanation of the key components of a conveyor belt:

The conveyor belt:

Function: The conveyor belt is the essential element of the conveyor belt, responsible for transporting materials from one point to another.

Materials: Belts can be made from various materials depending on load requirements, abrasion resistance, and temperature. Common materials include rubber, PVC, polyurethane, or composite materials.

Coatings: Belts can be coated with specific materials to resist abrasion, chemicals, or heat, according to application needs.

Support rollers:

Function: Support rollers are mounted on the conveyor frame and support the conveyor belt throughout its journey.

Types: There are different types of rollers, including support rollers, return rollers, and tension rollers, each with a specific role in maintaining belt stability.

Conveyor structure:

Function: The conveyor structure supports the entire system, including the conveyor belt, rollers, and any other auxiliary equipment.

Materials: Conveyor structures can be made of steel, aluminum, or plastic, depending on load requirements and operating environment.

Drive and return drums:

Function: Drive drums are responsible for driving the conveyor belt using a motor, while return drums maintain belt tension and guide its movement.

Power transmission: Drive drums are usually equipped with pulleys and power transmission belts, while return drums can be smooth or grooved for better contact with the belt.

Tensioning and guiding systems:

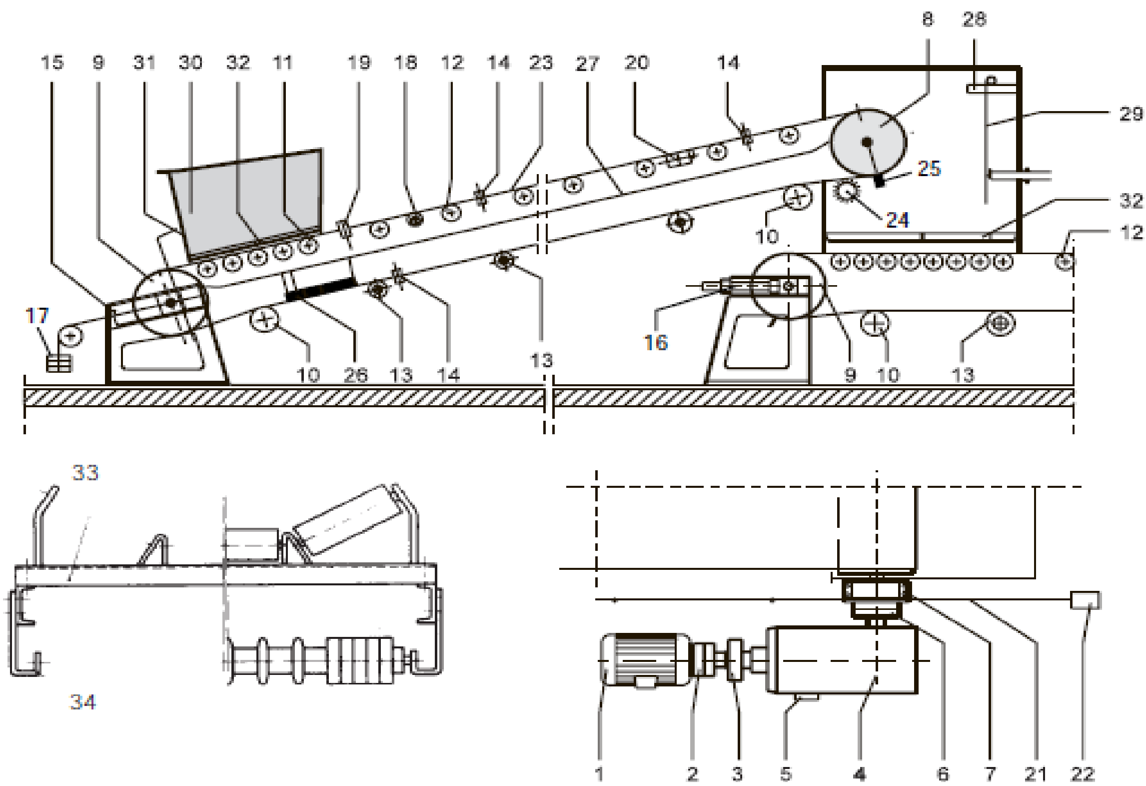
Function: Tensioning systems maintain the conveyor belt at the appropriate tension to prevent excessive fluttering or loosening, while guiding systems help maintain the belt in a stable trajectory.

Types: Tensioning systems can be tension screws, springs, or hydraulic devices, while guiding systems can be guiding rollers or automatic centering devices.

Cleaning devices:

Function: Cleaning devices, such as belt scrapers and cleaning brushes, are used to remove debris and residues that may accumulate on the conveyor belt, thereby avoiding obstructions and damage.

These components work together to ensure the efficient and reliable operation of a conveyor belt, allowing for the continuous and safe transportation of various materials in a range of industrial applications.



1 Motor
2 Motor Coupling
3 Brake
4 Drive Transmission
5 Anti Runback
6 Drive Coupling
7 Pulley Bearings
8 Drive Pulley
9 Tail Pulley
10 Deflection or Snub Pulley
11 Impact Idler Garland
12 Carrying Side Idler
13 Return Side Idler
14 Guide Roller
15 Counter Weight Take-up
16 Screw Take-up
17 Take-up Weight
18 Belt Run Counter
19 Off Track Control
20 Belt Steering Idler
21 Pull Wire
22 Emergency Switch
23 Conveyor Belt
24 Brush Roller
25 Scraper
26 Plough
27 Decking Plate
28 Cowl (Head Guard)
29 Baffle Bar
30 Delivery Chute
31 Chute Lining
32 Skirt Board
33 Upper Belt Location
34 Lower Belt Location

Figure 6: Belt conveyors

Operation and Mechanisms:

Operating Principle: Belt conveyors use the rotational motion of a drive drum to drive the conveyor belt, thus moving materials from one point to another.

Power Transmission: Conveyors can be powered by electric motors, speed reducers, belts and pulleys, or hydraulic systems depending on load and speed requirements.

Loading and Unloading: Materials can be loaded onto the belt manually, by automatic loading equipment, or using application-specific loading systems.

Waste Management: Belt conveyors can be equipped with waste detection and collection systems to prevent environmental pollution and maintain cleanliness in the work area.

Industrial Applications:

Mining and Quarries: Belt conveyors are widely used for transporting bulk materials such as coal, iron ore, and aggregates.

Agriculture: In agriculture, belt conveyors are used for transporting grains, hay, agricultural products, and animal feed.

Logistics and Warehousing: Belt conveyors facilitate the movement of goods in warehouses, distribution centers, and ports.

Manufacturing: In manufacturing plants, belt conveyors are used for transporting parts and components between workstations.

Advantages and Disadvantages:

Advantages: Belt conveyors offer continuous transport, high load capacity, process automation, low maintenance, and high reliability.

Disadvantages: Disadvantages include high initial cost, space requirements, risks of blockages and overloading, as well as the need for regular maintenance.

Effects on Efficiency and Productivity:

Belt conveyors improve operational efficiency by reducing downtime, speeding up processing times, and reducing labor costs.

Automation of transport processes contributes to increased overall productivity in industrial facilities.

Safety:

Belt conveyors pose potential risks such as pinch points, falling objects, and belt blockages.

Safety measures such as protective barriers, emergency stops, and adequate operator training are necessary to prevent accidents.

Evolution and Future Trends:

Technological advancements such as sensor integration, automation, and the use of lighter and more durable materials are expected to continue improving the performance and efficiency of belt conveyors.

Increasing demand for energy efficiency and carbon emission reduction could drive the development of belt conveyors powered by renewable energy sources and equipped with energy recovery systems.

III Conclusion:

Conveyors play a crucial role in the efficient operation of many industries, providing a reliable solution for transporting materials and products. Their use not only streamlines production processes, but also improves worker safety and lowers operating costs. Recent advances in conveyor design, such as the integration of sustainable materials and intelligent technologies, open up new prospects for increased efficiency and better adaptation to the specific needs of each industry. It is therefore essential for companies to keep abreast of these innovations in order to maintain their competitiveness in the global marketplace. By investing in modern conveyor systems and exploiting their full potential, companies can not only optimize their operations but also boost their long-term growth and success.

Chapter II
Belt Conveyor Study

I Introduction:

In this project's scope for designing a belt conveyor system for salt transportation, we meticulously analyzed key component parameters, including drums, rollers, and the motor mechanism. This study aims to ensure efficient, safe, and durable operation of the conveyor, taking into account the physical properties of salt, operational conditions, and performance requirements. By relying on precise calculations and an integrated approach, we aim to design a conveyor system that not only meets immediate needs but also guarantees long-term functionality and minimal maintenance.

The aim of this study is to construct a belt conveyor that meets specific performance criteria while efficiently handling the physical characteristics of the salt being transported. The design process includes precise calculations and detailed specifications to ensure the conveyor's reliability and effectiveness.

We aim to build a belt conveyor with the following specifications:

Material Transported: Salt

Conveyor Length: 40 meters

load capacity of the belt: $I_V = 450\ (t\ /\ h)$

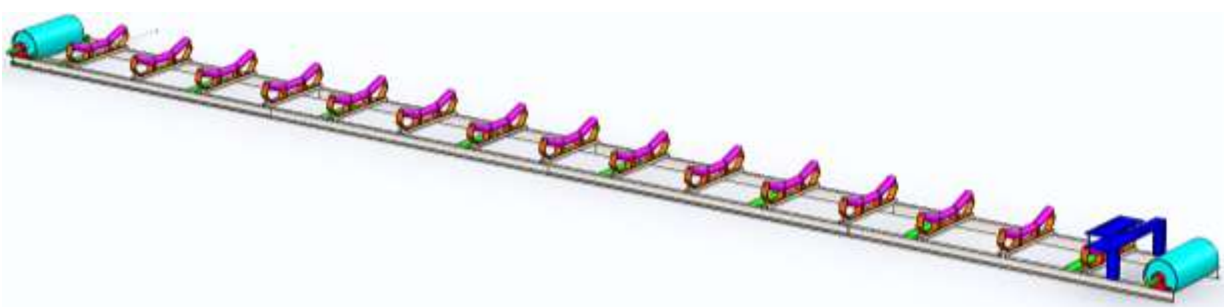


Figure (A): 3D model design for belt conveyor

II Material Characteristics:

II.1 Transported product:

To properly measure our belt conveyor, we must first evaluate the physical properties of the product to be handled, specifically the angle of bending and rolling.

II.2 Physical properties of salt:

Salt is the item that has to be transported, and the accompanying table lists its physical characteristics [15]:

Data: (See Table 01)

II.2.1 Volume mass:

The volume mass of (salt common dry fine) is between 1,12 and 1,28 $(t\ /\ m^3)$.

II.2.2 Granulometry of salt:

The salt lump size is variable, ranging from 70 to 80 mm.

II.2.3 The transported product's abrasiveness and corrosiveness:

The salt is mildly abrasive or corrosive.

II.3 Angle of repose:

The angle that a material will settle to when piled freely is called its angle of repose, also referred to as its "angle of natural friction".

extends to the horizontal plane when projected onto a horizontal surface.

$\boldsymbol{\phi = 25^{\circ}}$

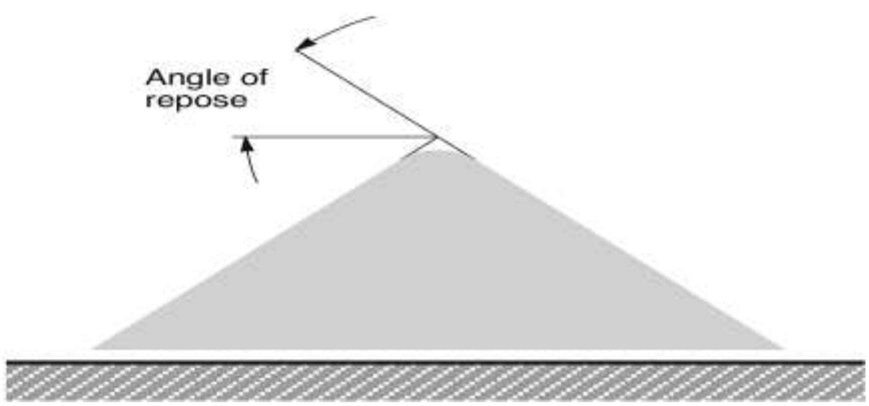


Figure 01a: Angle of Repose [15]

II.4 Angle of surcharge:

The surcharge angle refers to the angle of the material's surface being transported by a moving belt, measured in relation to the horizontal plane.

$\boldsymbol{\beta = 10^{\circ}}$

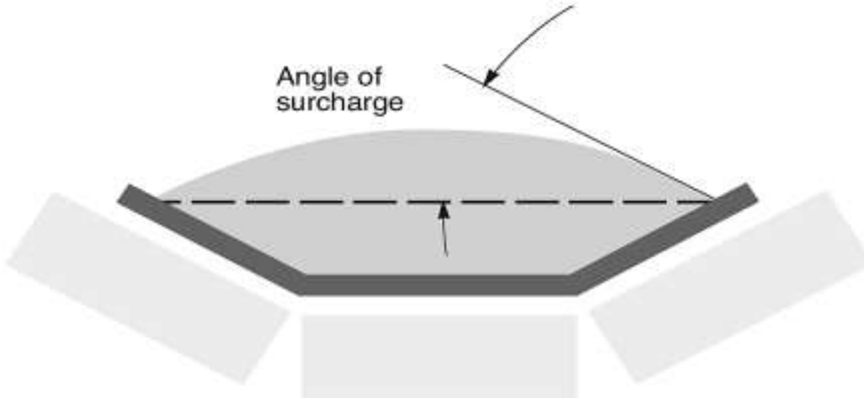


Figure 01b: Angle of Surcharge [15]

III Engineering Calculations:

III.1 Belt Speed:

The belt speed depends on material properties and experimental data.

For 70/80 mm lumps, the maximum suggested speed is 2.3 m/s (See Table 02).

III.2 Loaded volume (I_M):

The belt's volumetric load is calculated using the following formula:

$$I_M = \frac{I_V}{q_S} \quad (m^3 / h)$$

where:

I_V = load capacity of the belt (t / h)

q_S = specific weight of the material (t / m^3)

$$I_M = \frac{450}{1{,}12} = 401{,}78 \;\; (m^3 / h)$$

III.3 Theoretical Load Volume (I_{VT}) :

$$I_{VT} = \frac{I_M}{V}$$

Where: I_M: load volume (m^3 / h)

V: belt speed (m / s)

$$I_{VT} = \frac{401{,}78}{2{,}3} = 174{,}68 \ \ (m^3 \ / \ h)$$

III.4 Determination of Belt Width:

We may conclude that the angle of surcharge is in the order of $\mathbf{10^{\circ}}$ given the product's troughing set angle, which is around $\mathbf{30^{\circ}}$ (See Table 03).

With a troughing set angle ($\boldsymbol{\lambda} = \mathbf{30^{\circ}}$) selected for the carrier station, $\boldsymbol{A} = \mathbf{800}\boldsymbol{mm}$ is the belt width that equates to the Load volume theoretic $\boldsymbol{I_{VT}} = \mathbf{174, 68} \ (\boldsymbol{m^3} \ / \ \boldsymbol{h})$.

III.5 Preliminary belt selection:

A type (EP 400/3 3:1,5) belt is picked from a variety of suggested varieties whose coating pair is 3+1,5 mm (3 mm for the top coating, 1,5 mm for the bottom coating) (See Table 04) [16], while 400 specifies the permitted nominal operating tension (400 N/mm). The belt must next be checked for nominal working tension (this selection is preliminary).

For the final belt choice, we still need to compute the nominal service tension, which may lead us to switch to a higher type.

IV Roller and Troughing Set Design:

IV.1 Roller Design Parameters:

It is made out of a steel tube with the appropriate thickness and diameter for its intended function, machined at both ends for optimum mounting precision.

The bearing cages are either welded or wrapped around the ends.

Figure 02: Rollers [15]

IV.1.1 Determination of Roller Diameter and Speed:

The choice of diameter must take into account the belt width. (Table 05) displays roller diameters as a function of belt width.

In our example, the belt width is 800 mm, so at a speed of 2.3 $(m\ /\ S)$, we can use rollers with a diameter of 89 (mm) ,($\emptyset = 89(mm)$).

IV.1.2 Calculation of Number of Rotations:

We can determine the number of roller rotations based on the belt's speed and the roller's diameter:

$n = \frac{V \times 1000 \times 60}{D \times \pi} \quad (t/min)$ where: D = roller diameter(mm) ; V = belt speed $(m\ /\ S)$

$$n = \frac{2{,}3 \times 1000 \times 60}{89 \times 3{,}14} = 493{,}8 \quad (t/min)$$

IV.2 Troughing Set Configuration:

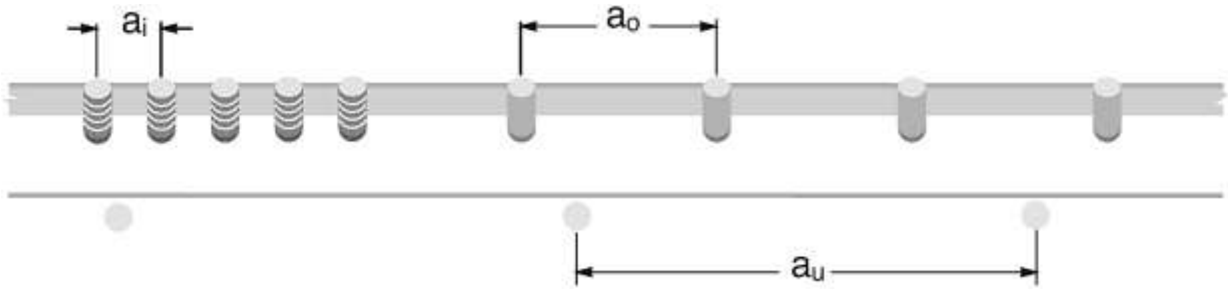


Figure 03: The distance between two Troughing set pitch (a_0, a_u, a_i) [15]

The distance between two Troughing set pitch on a belt conveyor is:

a_0: pitch of carrying sets (for the upper strand) m

a_u: pitch of return sets (for the lower strand) m

a_i: pitch of impact sets m

From (Table 06) of the spacing between troughing set pitches, we have:

Upper station spacing: $a_0 = 1{,}35m$

Lower station spacing: $a_u = 3m$

To avoid this, the minimum spacing between suspended stations $\mathbf{a}_i$ is calculated.

Any contact between adjacent chains during the station band's normal wobbling operation:

$a_i = \frac{a_0}{a_u} = \frac{1{,}35}{3} = 0{,}45m$

IV.2.1 Spacing of Upper and Lower Stations:

For the upper pitch of sets (UPS), the recommended spacing is 1 meter.

As a result, there are 40 UPS stations.

For lower pitch of sets (LPS), the recommended spacing is 3 meters.

The LPS number is 13, defined as follows: $N_L = \frac{L}{a_u} = \frac{40}{3} = 13$

L: load centers

a_u: pitch of return sets (for the lower strand) m

IV.2.2 Determining the number of rollers:

A) FOR 3 roll troughing sets

$N_r = Nu \times 3 = 40 \times 3 = 120$ rollers.

B) for flat roller sets:

$N_r = \frac{L}{3} = \frac{40}{3} = 13$ rollers.

In order for the belt to take on the curved shape in the slope loading zones and for the deflection not to exceed the permissible limits in the loading zone, we need to add two (02) stations, so the number UPS equals 42 and the number of rollers Nr equals:

$N_r = 42 \times 3 = 126$ The number of UPS rollers is equal to 126.

IV.3 Calculation of Transition Distance (L_t):

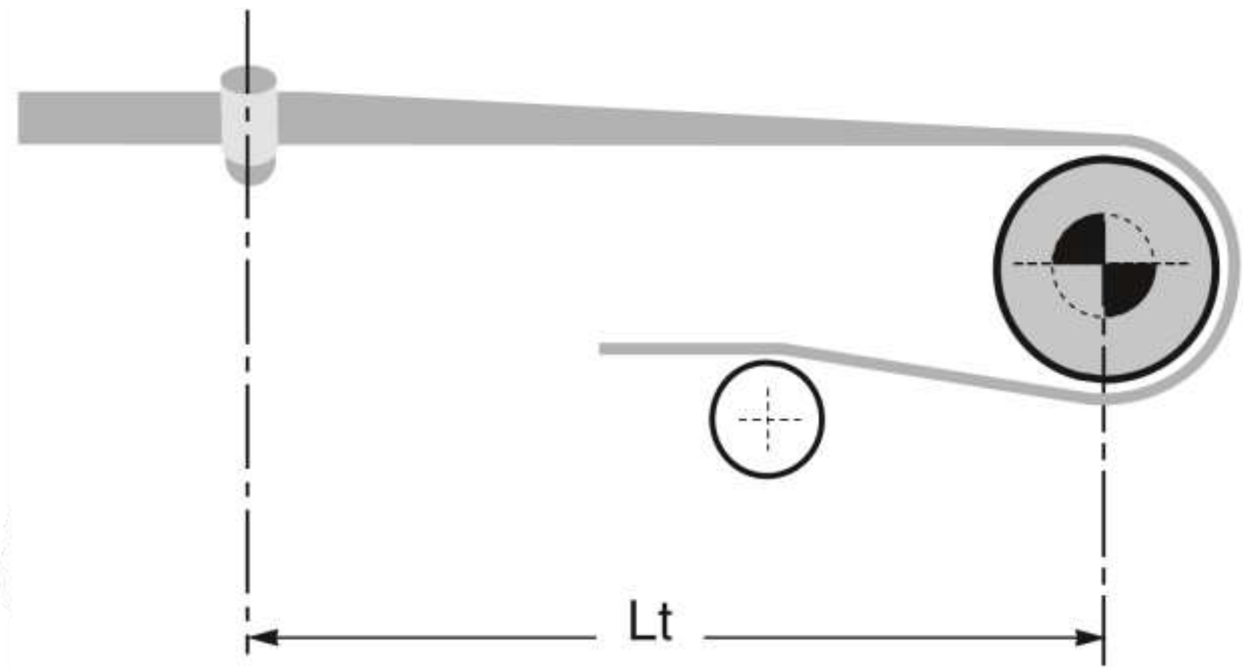


Figure 04: Transition distance (L_t) [15]

The distance between the last troughing set close to the head or tail pulley of a conveyor and the pulleys themselves is known as the transition distance. [15]

Along this length, the belt changes from a trough shape as specified by the inclination of the rollers of the carrying sets to a flat belt to match the flat pulley, and vice versa.

The edges of the belt are placed in this area under an extra force that reacts to the side rollers.

Generally, the transition distance must not be smaller than the belt width to avoid excess pressure.

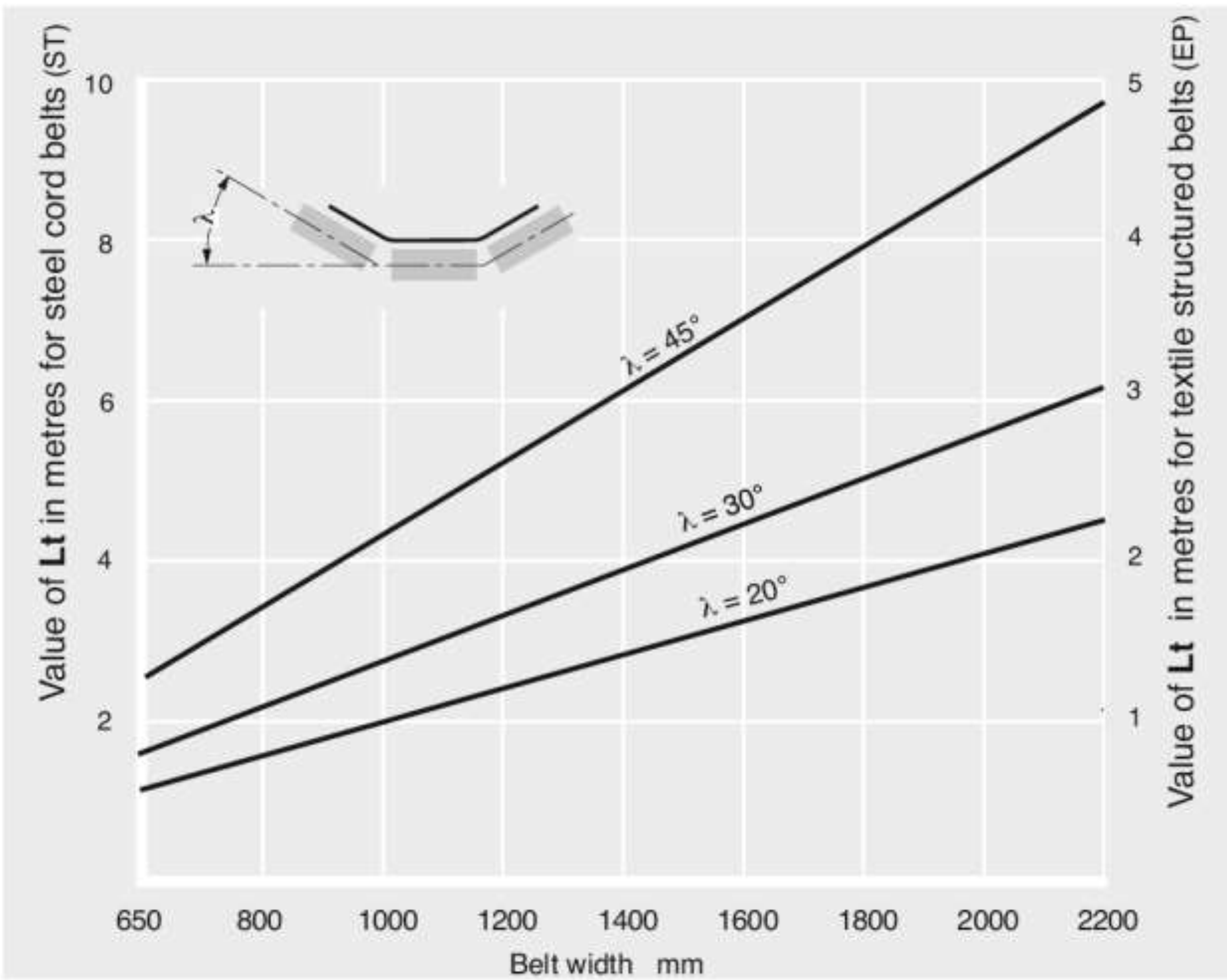


Figure 05: (L_t) Value [15]

It is possible to conclude from the graph that the transition distance for a belt (EP) with a width of 800 mm and troughing set at 30° is approximately 1,1 meters.

V Load Calculations:

V.1 weight of the belt (q_b):

The weight of the belt per linear meter (q_b) in kilograms per meter (K_g/m) [15], can be determined by adding the weight of the belt core to that of the upper and lower covers. The covers contribute approximately $1{,}15\ K_g\ /\ m^2$ for each millimeter of their thickness.

The formula for calculating (q_b) is as follows:

q_b =Weight of the belt core +1,15 (thickness of the upper cover +thickness of the lower cover)

where:

(EP) belts typically have a weight of around 1,5 $K_g\ /\ m^2$ per ply.

The weight of the belt core =$1.5 \times 3 = 4{,}5\ K_g\ /\ m^2$

Each millimeter of cover thickness contributes approximately $1.15 Kg\ /\ m^2$

Calculate the weight of each cover:

Upper cover weight =$3 \times 1{,}15 = 3.45\ \ K_g\ /\ m^2$

Lower cover weight =$1{,}5 \times 1.15 = 1{,}725\ \ K_g\ /\ m^2$

q_b = Weight of belt core + Weight of upper cover + Weight of lower cover

$q_b = 4{,}5 + 3{,}45 + 1{,}725 = 9{,}675\ k_g\ /\ m$

Assuming a belt width of 1 meter:

$q_b = 9{,}675\ k_g\ /\ m$

V.2 Factors:

V.2.1 Participation factor (F_p) :

According to (Table 07):

We have $\boldsymbol{\lambda = 30^\circ}$

For the (UPS) $\boldsymbol{F_p = 0,65}$

For the (LPS) $\boldsymbol{F_p = 1}$

V.2.2 Shock factor $(\boldsymbol{F_d})$:

For 70/80 mm lumps, and 2.3 m/s speed, Shock factor $F_d = 1$ (See Table 08)

V.2.3 Service factors $(\boldsymbol{F_s})$:

Daily use lasts between 6 and 9 hours; therefore, $\boldsymbol{F_s = 1}$. (See Table 09)

V.2.4 Environmental factors $(\boldsymbol{F_m})$

Our product is mildly abrasive and mildly corrosive. $F_m = 1$. (See Table 10)

V.2.5 Speed factors $(\boldsymbol{F_v})$:

Speed factors $F_v = 1.01$. (See Table 11)

V.3 Static load $(\boldsymbol{C_a})$:

After determining the diameter of the roller based on speed and revolutions, calculate the static load C_a on the carrying troughing set using the formula below:

$$C_a = a_0 \times \left(q_b + \frac{I_V}{3.6 \times V}\right) 0{,}981 = 1{,}35 \times \left(9{,}675 + \frac{450}{3{,}6 \times 2{,}3}\right) O, 981 = \mathbf{84{,}78\ daN}$$

By multiplying the operational factors, we can calculate the dynamic load C_{a_1} on the transom.

$$C_{a_1} = C_a \times F_d \times F_S \times F_m = 84{,}78 \times 1 \times 1 \times 1 = \mathbf{84{,}78\ daN}$$

Multiplying by participation factors yields the load (c_a) on the most stressed roller (the central roller in a troughing set with equal roller lengths).

$$c_a = C_{a_1} \times Fp = 84{,}78 \times 0{,}65 = \mathbf{55{,}1\ daN}$$

The static load on the return set, C_r (without considering material weight), is calculated using the formula below:

$$C_r = a_u \times q_b \times 0{,}981 = 3 \times 9{,}675 \times 0{,}981 = \mathbf{28{,}47\ daN}$$

The dynamic load on the return set is as follows:

$$C_{r_1} = C_r \times F_S \times F_m \times Fv = 28{,}47 \times 1 \times 1 \times 1{,}01 = \mathbf{28{,}75\ daN}$$

The load on a single or pair of return rollers is calculated as

$$c_r = C_r \times F_P = 28{,}75 \times 0.65 = \mathbf{18,68\ daN}$$

VI Roller selection:

For an 800 mm belt, we can select rollers for both the upper and lower pitches of sets. Sets with a lower pitch are picked using regular rollers. All roller dimensions are represented in the following figure.

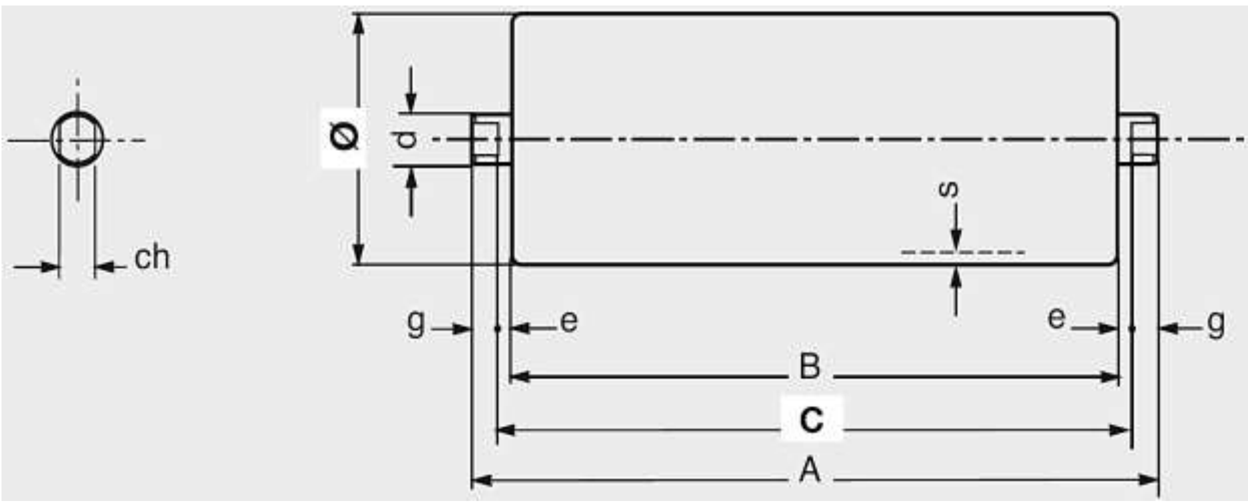


Figure 06: Roller [15]

VI.1 Roller selection for the upper transom for three rollers:

The roller dimensions are given in Table 12.

Rollers for upper transom for three rollers type PSV/1-FHD, $\emptyset 89mm$ (See Table 12):

bearing reference 6204 (20 × 47 × 14)

Roller length (C) = 323 mm

Axis diameter (d) = 20mm

load capacity is $132daN$.

VI.1.1 Roller selection for lower return brackets:

The roller dimensions are given in Table 12.

Rollers for lower return brackets type PSV/1-FHD, $\emptyset 89mm$:

bearing reference 6204 (20× 47×14)

Roller length C =958 mm

Axis diameter (d) = 20 mm

Load capacity equals $126 daN$.

VI.2 Choice of troughing sets:

Referencing Table 13, the relationship between belt width and roller diameter allows us to select the upper pitch of sets "A3M -30°". The dimensions of this particular roller type can be found in the (Figure 07) below [15].

In Table 14, we consider the model "A3M 1/3K" in the diagram.

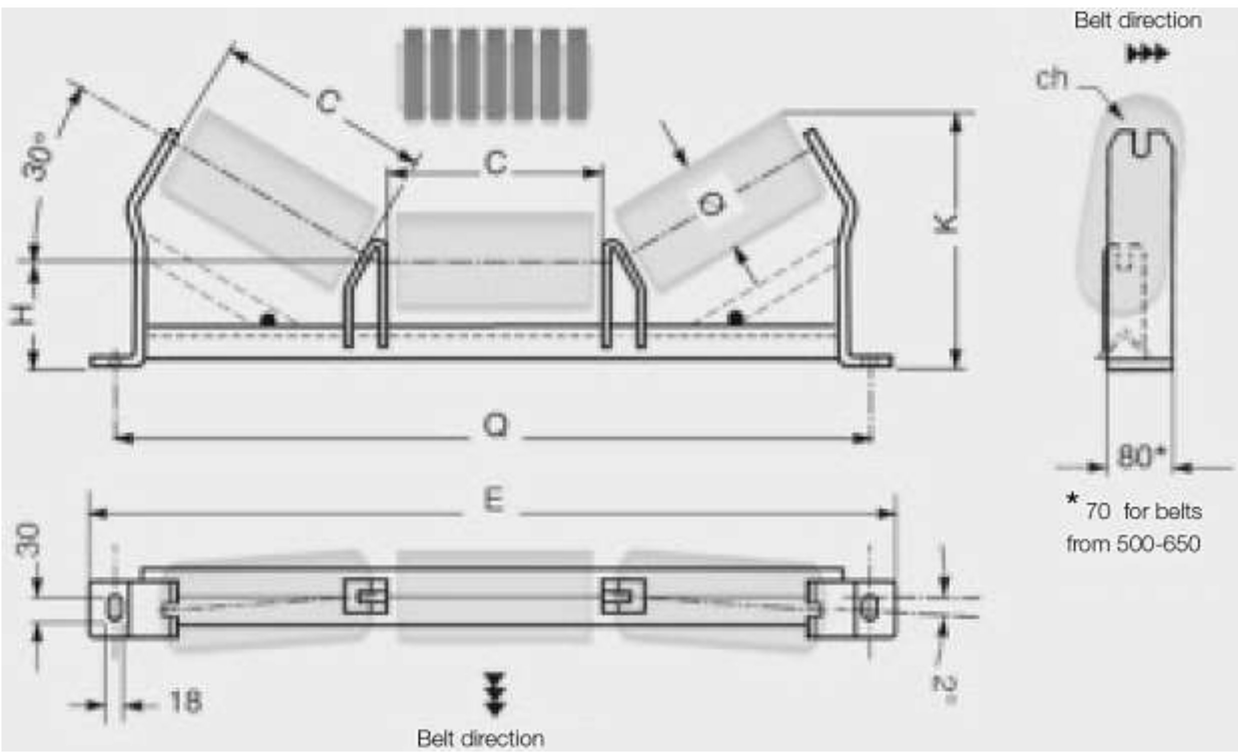


Figure 07: the schema of upper pitch of sets "A3M -30°" [15]

According to Table 15, we may determine the series number based on the shape of the arrangements.

The graphic below (Figure 08) shows the schema of lower return brackets, while Table 16 describes their characteristics.

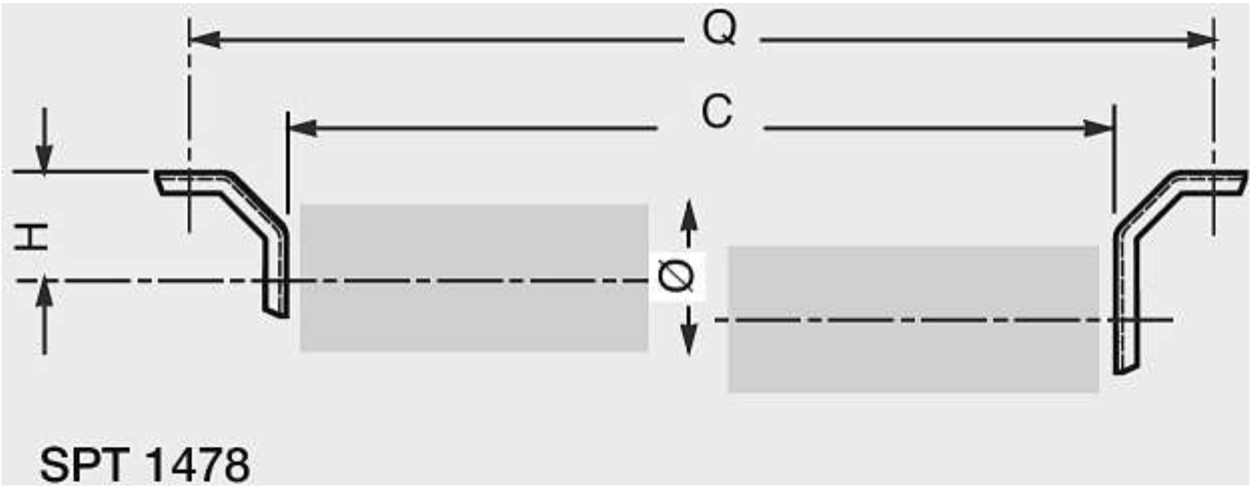


Figure 08: the schema of lower return brackets [15]

VIILoad Calculations:

To begin, it is necessary to compute the total tangential force F_u at the outer edge of the driving pulley. The cumulative tangential force must surpass all the opposing forces resulting from movement, which includes the combination of the following forces [15]:

*The force required to move the laden belt must exceed the frictional forces exerted by the carrying troughing sets (both upper and lower), the pulleys, the return mechanism, the snub, etc.

*The amount of force required to overcome any secondary resistances created by any accessories, such as rubber skirts, reversing units, cleaners, scrapers, mobile unloaders, and "trippers."

VII.1 passive resistance:

VII.1.1 Coefficient of fixed resistance (C_q):

From Table 17, we find out that the coefficient of fixed resistance $C_q = 2{,}2$

VII.1.2 Coefficient of passive resistance given by temperature (C_t):

From Table 18, we find out that the coefficient of passive resistance given by temperature $C_t = 1$

VII.1.3 Coefficient of internal friction (f) of materials and of the rotating parts:

From Table 19, we find out that the coefficient of internal friction (f) of materials and of the rotating parts $f = 0{,}017$

VII.2 Weight of rotating parts of the rollers (upper/lower):

In Tabel 20, the approximate weights of rotating parts of an upper transom troughing set and a lower flat return set are indicated.

The weight of the upper rotating parts q_{RO} and lower q_{Ru} is given by:

$$q_{RO} = \frac{p_{pRS}}{\mathrm{a}_0} = \frac{10{,}4}{1{,}35} = 7{,}70\ \ Kg\ /\ m$$

where:

p_{pRS}: weight of upper rotating parts. $p_{pRS} = 10{,}4\ Kg$

a_0: upper troughing set pitch. $\mathrm{a}_0 = 1{,}35\ m$

$$q_{Ru} = \frac{p_{pRI}}{\mathrm{a}_u} = \frac{7{,}8}{3} = 2{,}6\ \ Kg\ /\ m$$

where:

p_{pRI}: weight of lower rotating parts. $p_{pRI} = 7{,}8\ Kg$

a_u: return set roller pitch. $\mathrm{a}_u = 3\ m$

VII.3 Tangential force:

The total tangential force Fu at the driving pulley periphery is given by:

$$Fu = \left[\left(L \times C_q \times C_t \times f \times (2q_b + q_G + q_{RU} + q_{R0}\right) \pm (q_G \times H))\right] \times 0{,}981$$

For decline belts, a negative sign (-) is used in the formula.

where:

L : centers of conveyor (m)

C_q : fixed coefficient of resistance (belt accessories)

C_t : passive coefficient of resistance

f : coefficient of friction of internal rotating parts (troughing sets).

q_b : belt weight per linear meter, in (Kg/m).

q_G : weight of conveyed material per linear meter (Kg/m).

q_{RU} : weight of lower rotating parts in (Kg/m).

q_{RO}: weight of upper rotating parts in (Kg/m).

H : height changes of belt. (In our case, $H = 0$).

$Fu = [(40 \times 2{,}2 \times 1 \times 0{,}017 \times (2(9{,}675) + 54{,}34 + 2{,}6 + 7{,}7))] \times 0{,}981 = \mathbf{123{,}26\ daN}$

$Fu = \mathbf{123{,}26\ daN}$

Dividing into Active and Rotating Parts Forces, to calculate fu as the sum of (F_a) and (F_r):

$F_u = F_a + F_r$

VII.3.1 Active Force (F_a):

$Fa = \left[\left(L \times C_q \times C_t \times f \times (q_b + q_G + q_{R0})\right)\right] \times 0{,}981$

$Fa = [(40 \times 2{,}2 \times 1 \times 0{,}017 \times (9{,}675 + 54{,}34 + 7{,}7))] \times 0{,}981 = \mathbf{105{,}24\ daN}$

$Fa = \mathbf{105{,}24\ daN}$

VII.3.2 Rotating Parts Force (F_r):

$Fr = \left[\left(L \times C_q \times C_t \times f \times (q_b + q_{RU})\right)\right] \times 0{,}981$

$Fr = [(40 \times 2{,}2 \times 1 \times 0{,}017 \times (9{,}675 + 2{,}6))] \times 0{,}981 = \mathbf{17{,}42\ daN}$

$Fr = \mathbf{17{,}42\ daN}$

$F_u = F_a + F_r = 105{,}24 + 17{,}42 = \mathbf{122{,}66\ daN}$

Which to use:

For maintenance, troubleshooting, or if precision in component forces is needed, we use $\boldsymbol{F_u = 122{,}66\ daN}$

VII.4 Driving power:

Taking into account the belt speed, the efficiency ($\eta = 0{,}86$) of the reduction gear, and the total tangential force at the drive pulley's periphery, the minimum driving power required is:

$$P = \frac{F_u \times V}{100 \times \eta}$$

Where:

Fu: The total tangential force

V: Belt speed ($m\ /\ S$)

η: Efficiency of the reduction gear

$$P = \frac{122{,}66 \times 2{,}3}{100 \times 0.86} = \mathbf{3,28\ kw}$$

$$P = \mathbf{3,28\ kw}$$

VII.5 Belt tension:

The various tensions that need to be checked in a conveyor with a motorized belt system must be taken into account.

At the pulley circumference, the total tangential force (Fu) is equal to the difference in tensions T_1 (tight side) and T_2 (output side). The torque required to start moving the belt and transmit power is calculated from these:

$$\boldsymbol{F_u = T_1 - T_2}$$

Getting from Point **A** to Point **B** The belt tension increases exponentially from value T_1 to value T_2 in (Figure 09) below.

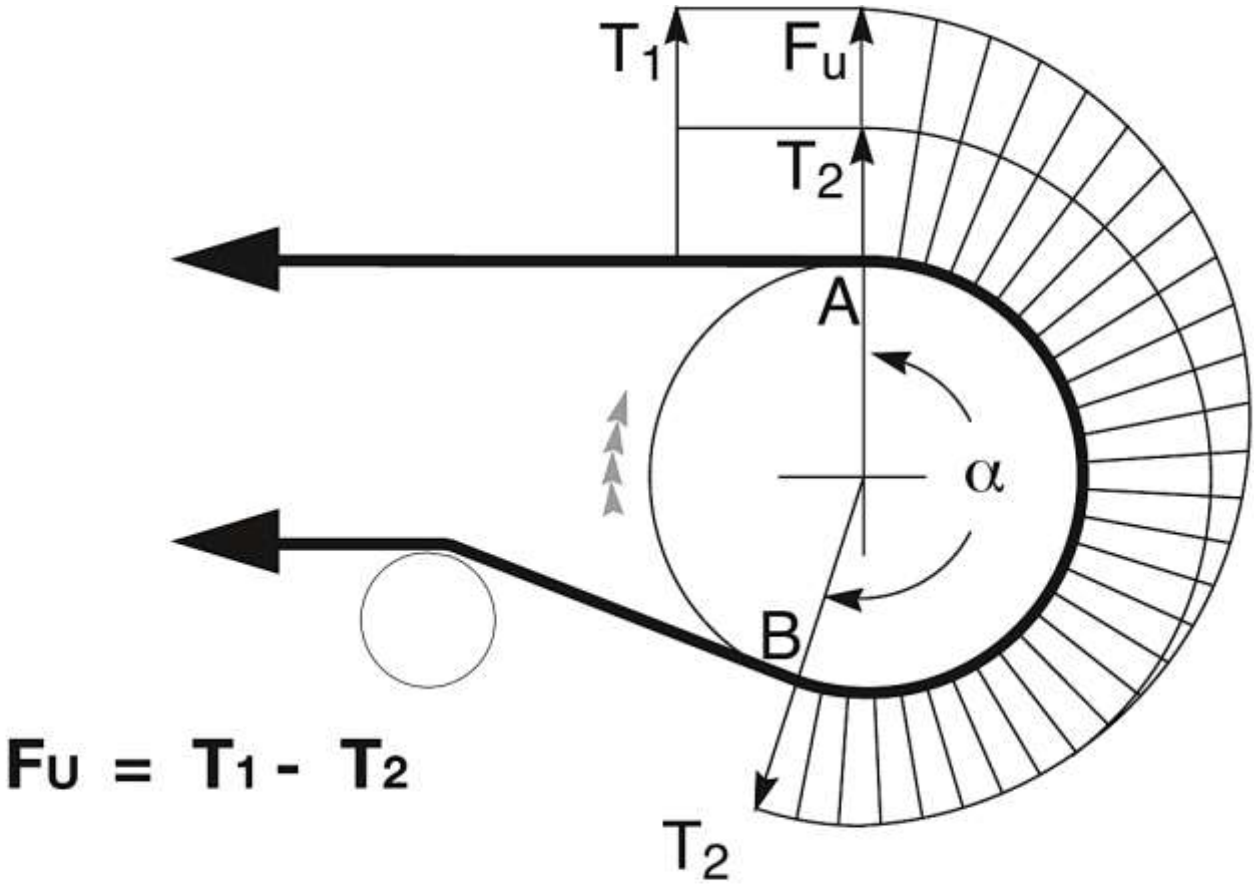


Figure 09: The belt tensions [15]

VII.5.1 Wrap factor (C_w):

Table 22 displays the wrap factor C_w values based on wrap angle, tensioning mechanism, and pulley condition (lagged or unlagged) [15].

Wrap factor $\boldsymbol{C_w = 0,75}$

Angle of wrap $\boldsymbol{\alpha = 200^{\circ}}$

VIII Calculation of Tensions (T_0, T_1, T_2, T_3):

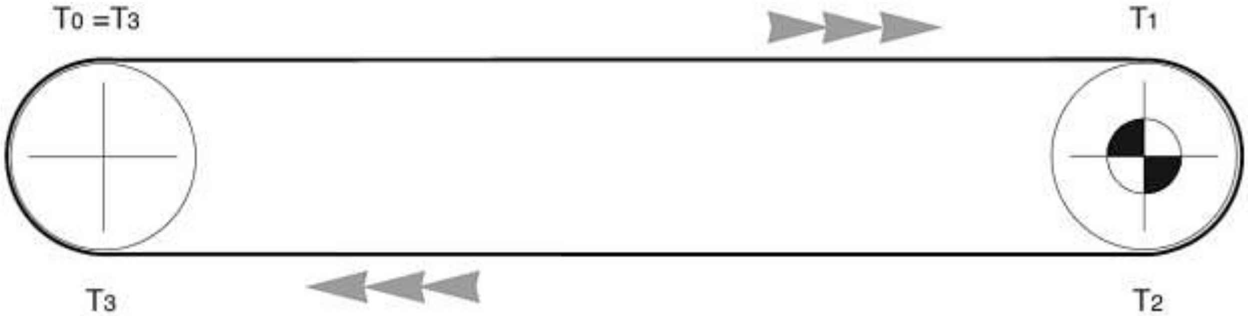


Figure 10: Tensions (T0, T1, T2, T3) [15]

VIII.1 Tensions T_2 :

The tension downstream from the drive pulley is given by:

$T_2 = F_u \times C_w$

$T_2 = 122{,}66 \times 0{,}75 = \mathbf{91{,}99\ daN}$

$\mathbf{T_2 = 91{,}99\ daN}$

VIII.2 Tensions T_1 :

The maximum tension upstream of the drive pulley will be:

$T_1 = F_u + T_2$

$T_1 = 122{,}66 + 91{,}99$

$\mathbf{T_1 = 214{,}65\ daN}$

VIII.3 Tensions T_3 :

The tension downstream of the return pulley is:

The tension T3 at the tail pulley's slack side (Fig. 10) is calculated by adding the tensions T2 and tangential forces Fr to a single return section of the belt.

$T_3 = T_2 + F_r$

$T_3 = 91{,}99 + 17{,}42 = \mathbf{109{,}41\ daN}$

$\mathbf{T_3 = 109{,}41\ daN}$

VIII.4 Tensions T_0 :

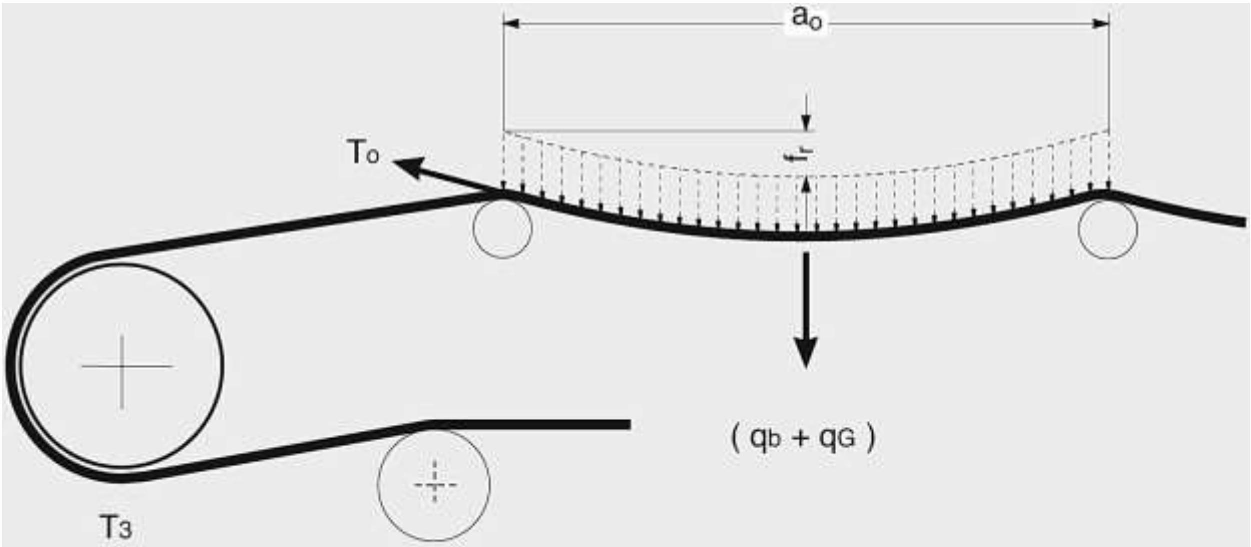


Figure 11: Tensions T_0 [15]

The minimum necessary tension T_3 at the slack side of the return pulley, besides guaranteeing belt adhesion to the driving pulley so as to transmit the movement, must also ensure a deflection not exceeding 1.5% of the length of pitch between consecutive troughing sets.

Furthermore, the tensions must reduce material spillage from the belt and excessive passive resistance created by the material dynamics when the belt passes over the troughing sets (Figure 11).

The following formula provides the minimal tension T_0 necessary to maintain a 1.5% deflection:

for 1.5% deflection = 8,4

$T_0 = 8{,}4(q_b + q_G)\mathrm{a}_0 \times 0{,}981$

where:

q_b: total belt weight per linear meter (Kg/m).

q_G: weight of conveyed material per linear meter (Kg/m).

a_0: pitch of troughing sets on upper strand in meter (m).

$T_0 = 8{,}4(9{,}675 + 54{,}34)1{,}35 \times 0{,}981 = \mathbf{529{,}86\ daN}$

$\boldsymbol{T_0 = 529{,}86\ daN}$

VIII.5 Typical tension device:

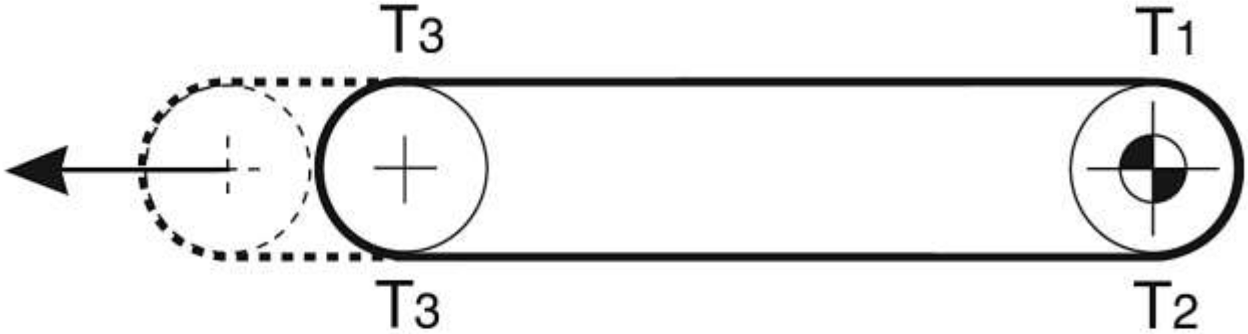


Figure 12: the screw tensioning [15]

In this configuration, the tension is often adjusted by periodically examining the tensioning screw.

VIII.6 Maximum Tension T_{max} :

From all the tensions above, we can see that:

$$\boldsymbol{T_{max} = T_0 = 529,86\ daN}$$

$$\boldsymbol{T_{max} = 529,86\ daN}$$

VIII.7 Working load and belt breaking strain T_{umax} :

T_{max} is used to compute the maximum tension of the belt, known as T_{umax}, in a unitary manner, based on the following formula:

$$T_{umax} = \frac{T_{max} \times 10}{N}$$

where:

N: belt width in $(\boldsymbol{mm})$.

T_{max}: tension at the highest stress point of the belt in $(\boldsymbol{daN})$.

$$T_{umax} = \frac{529{,}86 \times 10}{800} = \boldsymbol{6,62\ N/mm}$$

$$\boldsymbol{T_{umax} = 6,62\ N/mm}$$

For security purposes, it is important to take into account the maximum working load of the belt with a textile core. This load should be approximately 1/10 of the belt's breaking load.

The breaking load of the belt equals the working load multiplied by a safety factor of 10 for textile-reinforced belts.

$$6,62 \times 10 = 66,2\ N/mm < 400\ N/mm$$

IX Pulley (Drum):

IX.1 Drive Pulley:

IX.1.1 Pulley diameters:

The dimensions of a head pulley's diameter are closely related to the properties of the belt type that is being used.

Table 22 provides the minimum diameters that are suggested based on the kind of belt employed. These recommendations aim to prevent any harm to the belt layers or the reinforcing fabric, such as de-layering or laceration.

IX.1.2 Sizing of the drive pulley:

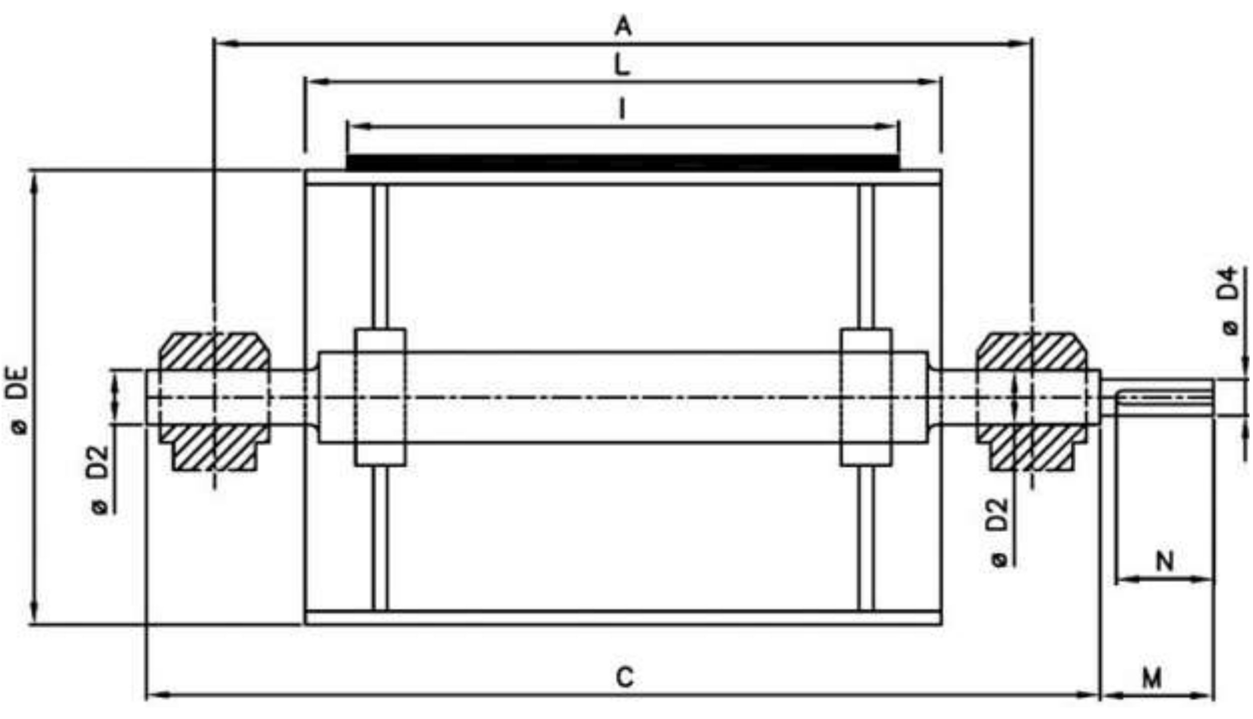


Figure 13: schema of Pulley [17]

The driving pulley's shaft experiences cyclic bending and twisting, leading to fatigue-induced failure.

In order to accurately calculate the shaft diameter, it is essential to estimate both the bending moment $\left(M_f\right)$ and the torsion moment (M_t).

For economic reasons, the pulley will be considered hollow, with the inner diameter representing 95% of the outer diameter. This means that the internal diameter (D_{Dint}) is 95% of the outer diameter (D_{Dout}).

From (Table 23) we have:

$D_{Dout} = 400\ mm$; $D_{Dint} = 380\ mm$

IX.1.3 Drive Pulley mass calculation:

$m_t = P \times V_t$

We chose XC38 steel with the following characteristics:

Mass Density: $\boldsymbol{P = 7850\ kg / m^3}$

Yield Strength: $\boldsymbol{580 \times 10^6 N / m^2}$

$$V_t = \frac{\pi}{4}(D_{Dint}^2 - D_{Dout}^2) \times L$$

$$V_t = \frac{3{,}14}{4}(0{,}400^2 - 0{,}380^2) \times 0{,}950 = \boldsymbol{11{,}63 \times 10^{-3}\ m^3}$$

$$\boldsymbol{V_t = 11{,}63 \times 10^{-3}\ m^3}$$

Where:

L: length of the pulley

D_{Dout}: the outer diameter $= 400\ mm$

D_{Dint}: the internal diameter $= 380\ mm$

$m_t = P \times V_t$

$m_t = 7850 \times 11{,}63 \times 10^{-3} = \boldsymbol{91{,}29\ kg}$

$\boldsymbol{m_t = 91{,}29\ kg}$

IX.1.4 Pulley weight calculation (q_t):

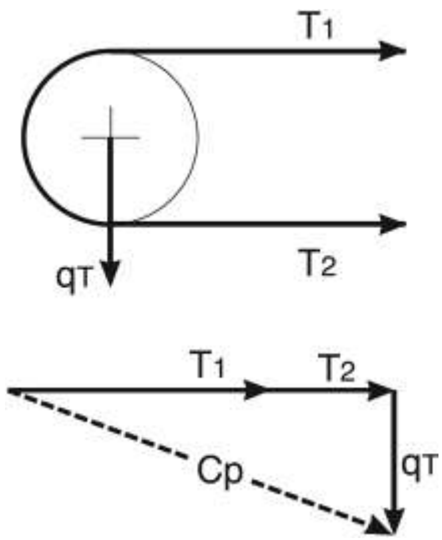


Figure 14: q_t & C_p [15]

$q_t = m_t \times G$

$q_t = 91{,}29 \times 9{,}81 = \mathbf{89{,}5\ daN}$

$\boldsymbol{q_t = 89{,}5\ daN}$

IX.1.5 Resultant of tensions (C_p):

$C_p = \sqrt{(T_1 + T_2)^2 + q_{tM}^2}$

$C_p = \sqrt{(214{,}65 + 91{,}99)^2 + (89{,}5)^2} = \mathbf{319{,}43\ daN}$

$\boldsymbol{C_p = 319{,}43\ daN}$

IX.1.6 Bending moment (M_f):

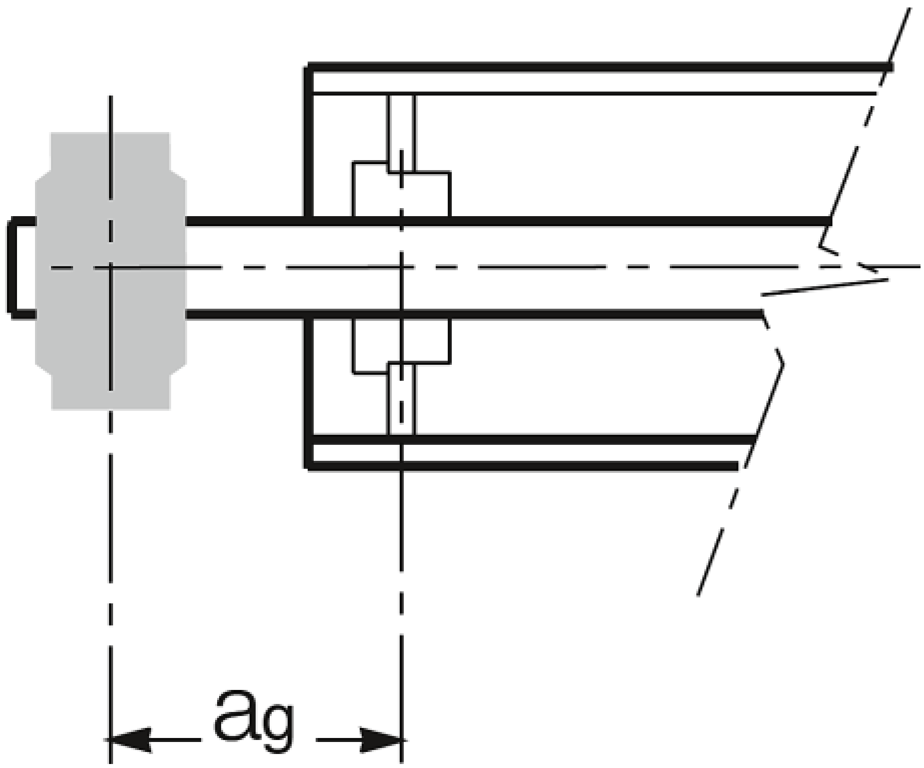


Figure 15: a_g [15]

A: The shaft length between supports depends on belt width and pulley diameter (refer to table 23).

For the drive pulley, return pulley: A = 1275 mm

I: belt width: I = 800 mm

L: length of pulleys; L = 950 mm

The distance S between the end of the pulley belt and the hub center is assumed to be S = 80 mm.

ag: distance between supports and pulley flanges. (See Figure 15)

For the drive and return pulleys, we have:

$$a_g = \frac{A - L}{2} + \frac{L - I}{2} + S$$

$$a_g = \frac{1275 - 950}{2} + \frac{950 - 800}{2} + 80 = \mathbf{317,5mm}$$

$$\boldsymbol{a_g = 317,5mm = 0,3175\ m}$$

IX.1.7 Bending moment (M_f)

$$M_f = \frac{c_P}{2} \times a_g$$

$$M_f = \frac{319,43}{2} \times 0,3175 = \mathbf{50,62\ daN.m}$$

$$\boldsymbol{M_f = 50,62\ daN.m}$$

IX.1.8 Rotation speed of the drive pulley calculation:

$$N_D = \frac{V \times 1000 \times 60}{D_{Dout} \times \pi}$$

Where:

N_D: rotation speed of the drive pulley (RPM)

V: belt speed (m / s)

D_{Dout}: Diameter of Pulley (mm)

$$N_D = \frac{2,3 \times 1000 \times 60}{400 \times 3,14} = \mathbf{109,87\ RPM}$$

$$\boldsymbol{N_D = 109,87\ RPM}$$

IX.1.9 Torsional moment (M_t):

$$M_t = \frac{P}{N} \times 954,9$$

Where:

P: absorbed power in kW

N_D: rotation speed of the drive pulley (RPM)

$$M_t = \frac{3,28}{109,87} \times 954,9 = \mathbf{28,5\ daN}$$

$\boldsymbol{M_t = 28{,}5\ daN}$

IX.1.10 Ideal bending moment (M_{if}):

We can now determine the ideal bending moment:

$$M_{if} = \sqrt{\left(M_f\right)^2 + 0{,}75 + (M_t)^2}$$

$$M_{if} = \sqrt{(50{,}62)^2 + 0{,}75 + (28{,}5)^2} = \mathbf{56{,}31\ daN}$$

$\boldsymbol{M_{if} = 56{,}31\ daN}$

IX.1.11 Allowable Stress for XC38 Steel:

Yield strength for XC38 steel: $580 \times 10^6 N\ /\ m^2$

Safety Factor (SF): Typically, for mechanical applications, a safety factor of 2 to 3 is used. For this example, we will use a safety factor of 2,5.

$$\sigma_{amm} = \frac{580 \times 10^6}{2{,}5} = \mathbf{2{,}32\ daN\ /\ mm^2}$$

$\boldsymbol{\sigma_{amm} = 2{,}32\ daN\ /\ mm^2}$

IX.1.12 Calculation of the Drive pulley Shaft Diameter:

$$w = \frac{M_{if} \times 1000}{\sigma_{amm}}$$

$$w = \frac{56{,}31 \times 1000}{2{,}32} = \mathbf{24271{,}55\ mm^3}$$

$\boldsymbol{w = 24271{,}55\ mm^3}$

$$d = \sqrt[3]{\frac{w \times 32}{\pi}}$$

$$d = \sqrt[3]{\frac{24271{,}55 \times 32}{3{,}14}} = \mathbf{62{,}77\ mm}$$

$\boldsymbol{d = 62{,}77\ mm}$

the Drive pulley Shaft Diameter is: $\boldsymbol{d = 62,77\ mm}$

IX.1.13 Bearings

IX.1.13.1 Selecting Appropriate Bearings for drive pulley:

Based on the (Table 24), the bearing selection method is as follows:

IX.1.13.2 Bearing Selection Criteria:

Radial Load Calculation: Total load acting on the bearing: $\boldsymbol{C_p = 319,43\ daN}$

Rotational Speed: $\boldsymbol{N_D = 109,87\ RPM}$

Shaft Diameter: Shaft diameter: $\boldsymbol{d = 62,77\ mm}$

IX.1.13.3 Bearing Type:

Considering the high radial load and potential for misalignment, spherical roller bearings are typically suitable for this application.

Bearing Load Capacity

Using the bearing load rating formula:

$$L_{10} = \left(\frac{C}{C_p}\right)^{10/3} \times 10^6$$

C: Dynamic load rating of the bearing

C_p: Equivalent dynamic bearing load $\boldsymbol{C_p = 319,43\ daN}$

IX.1.13.4 Bearing Selecting:

Figure 16: spherical roller bearings SKF 22215 EK [18]

By using the (Table 24), we got (22215 EK) with the following characteristics:

Dynamic Load Rating $C = 217\ KN\ (2170\ daN)$.

Bore Diameter: 75 mm.

Speed Rating: Suitable for 109.87 *RPM*

IX.1.13.5 Calculations for Bearing Life:

$L_{10} = \left(\frac{C}{C_p}\right)^{10/3} \times 10^6$

$L_{10} = \left(\frac{2170}{319{,}43}\right)^{10/3} \times 10^6 = 593 \times 10^6$

$\boldsymbol{L_{10} = 593 \times 10^6}$

$$L_{10h} = \left(\frac{C}{C_p}\right)^{10/3} \times \frac{10^6}{60 \times N_D}$$

$$L_{10h} = \left(\frac{2170}{319{,}43}\right)^{10/3} \times \frac{10^6}{60 \times 109{,}87} = \mathbf{90070\ hour}$$

$$\boldsymbol{L_{10h} = 90070\ hour}$$

IX.1.13.6 Plummer block housings:

Plummer block housings are designed to work with specific bearing types and sizes.

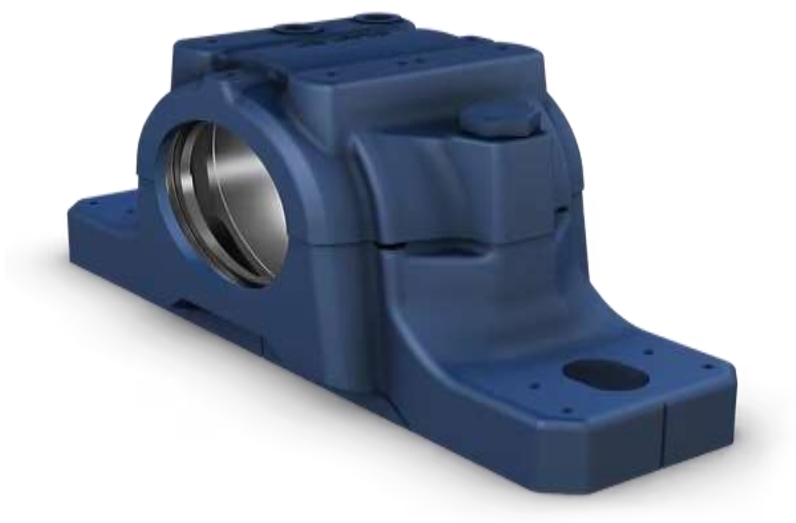


Figure 17: Plummer block housings SKF SNL 515-612 [18]

IX.1.13.7 Specifications for the SNL 515-612 Housing:

Suitable for Shaft Diameter: Typically for 75 mm, with adapter sleeve to fit 62,77 mm

Bearing Compatibility: Designed to accommodate bearings like the 22215 EK series [18]

IX.1.13.8 Adapter Sleeve SKF HA 315 (for fitting the bearing on the shaft):

Figure 18: adapter sleeve SKF HA 315

To fit the 75 mm bore bearing onto the 62,77 mm shaft, an adapter sleeve is necessary. We chose the (HA 315) adapter sleeve, which can accommodate minor differences in shaft size.

The (**SKF SNL 515-612)** Plummer block housing with the (**SKF 22215 EK**) spherical roller bearing and (**SKF HA 315**) adapter sleeve is suited for our application. This configuration assures that the bearing can take the needed load, speed, and any misalignment, while the housing offers sturdy support for the assembly [18].

IX.2 Return pulley:

IX.2.1 Sizing of the Return pulley:

From (Table 23) we have:

$D_{Rout} = 315\ mm$

$D_{Rint} = 299{,}25\ mm$

IX.2.2 Return Pulley mass calculation:

$m_t = P \times V_t$

We chose XC38 steel with the following characteristics:

Mass Density: $\boldsymbol{P = 7850\ kg\ /\ m^3}$

Yield Strength: $\boldsymbol{580 \times 10^6 N\ /\ m^2}$

$$V_t = \frac{\pi}{4}(D_{Rint}^2 - D_{Rout}^2) \times L$$

$$V_t = \frac{3{,}14}{4}(0{,}315^2 - 0{,}29925^2) \times 0{,}950 = \boldsymbol{7{,}21 \times 10^{-3}\ m^3}$$

$\boldsymbol{V_t = 7{,}21 \times 10^{-3}\ m^3}$

Where:

L: length of the pulley

D_{Rout}: the outer diameter $= 315\ mm$

D_{Rint}: the internal diameter $= 299{,}25\ mm$

$m_t = P \times V_t$

$m_t = 7850 \times 7{,}21 \times 10^{-3} = \boldsymbol{56{,}59\ kg}$

$\boldsymbol{m_t = 56{,}59\ kg}$

IX.2.3 Pulley weight calculation (q_t):

(See Figure 14)

$q_t = m_t \times G$

$q_t = 56{,}59 \times 9{,}81 = \boldsymbol{555{,}14\ daN}$

$\boldsymbol{q_t = 555{,}14\ daN}$

IX.2.4 Resultant of tensions (C_p):

$$C_p = \sqrt{(T_3 + T_0)^2 + (q_t)^2}$$

$C_p = \sqrt{(109{,}41 + 529{,}86)^2 + (555{,}14)^2} = \mathbf{846{,}66\ daN}$

$\boldsymbol{C_p = 846{,}66\ daN}$

IX.2.5 The bending moment ($\boldsymbol{M_f}$):

ag: distance between supports and pulley flanges.

$\boldsymbol{a_g = 317{,}5mm = 0{,}3175\ m}$

$$M_f = \frac{c_P}{2} \times a_g$$

$$M_f = \frac{846{,}66}{2} \times 0{,}3175 = \mathbf{134{,}4\ daN.m}$$

$\boldsymbol{M_f = 134{,}4\ \ daN.m}$

IX.2.6 Rotation speed of the return pulley calculation:

$$N_R = \frac{V \times 1000 \times 60}{D_{Rout} \times \pi}$$

Where:

N_R: rotation speed of the drive pulley (RPM)

V: belt speed ($m\ /\ s$)

D_{Rout}: Diameter of Pulley (mm)

$$N_R = \frac{2{,}3 \times 1000 \times 60}{315 \times 3{,}14} = \mathbf{139{,}52 RPM}$$

$\boldsymbol{N_R = 139{,}52\ RPM}$

IX.2.7 Torsional moment ($\boldsymbol{M_t}$):

$$M_t = \frac{P}{N} \times 954{,}9$$

Where:

P: absorbed power in kW

N_R: rotation speed of the return pulley (RPM)

$$M_t = \frac{3{,}28}{139{,}52} \times 954{,}9 = \mathbf{22{,}44\ daN.m}$$

$$\boldsymbol{M_t = 22{,}44\ daN.m}$$

IX.2.8 Ideal bending moment (M_{if}):

We can now determine the ideal bending moment:

$$M_{if} = \sqrt{(M_f)^2 + 0{,}75 + (M_t)^2}$$

$$M_{if} = \sqrt{(134{,}4)^2 + 0{,}75 + (22{,}44)^2} = \mathbf{135{,}83\ daN.m}$$

$$\boldsymbol{M_{if} = 135{,}83\ daN.m}$$

IX.2.9 Allowable Stress for XC38 Steel:

Yield strength for XC38 steel: $580 \times 10^6 N / m^2$

Safety Factor (FS): Typically, for mechanical applications, a safety factor of 2 to 3 is used. For this example, we will use a safety factor of 2,5.

$$\sigma_{amm} = \frac{580 \times 10^6}{2{,}5} = \mathbf{2{,}32\ daN / mm^2}$$

$$\boldsymbol{\sigma_{amm} = 2{,}32\ daN / mm^2}$$

IX.2.10 Calculation of the pulley Shaft Diameter:

$$w = \frac{M_{if} \times 1000}{\sigma_{amm}}$$

$$w = \frac{135{,}83 \times 1000}{2{,}32} = \mathbf{58547{,}41\ mm^3}$$

$$\boldsymbol{w = 58547{,}41\ mm^3}$$

$$d = \sqrt[3]{\frac{w \times 32}{\pi}}$$

$$d = \sqrt[3]{\frac{58547{,}41 \times 32}{3{,}14}} = \mathbf{84{,}18\ mm}$$

$$\boldsymbol{d = 84{,}18\ mm}$$

the Return pulley Shaft Diameter is: $\boldsymbol{d = 84{,}18\ mm}$

IX.2.11 Bearings:

IX.2.11.1 1Selecting Appropriate Bearings for Return Pulley:

Based on the (Table 25), the bearing selection method is as follows:

IX.2.11.2 Bearing Selection Criteria

Radial Load Calculation: Total load acting on the bearing: $\boldsymbol{C_p = 846{,}66\ daN}$

Rotational Speed: $\boldsymbol{N_R = 139{,}52\ RPM}$

Shaft Diameter: Shaft diameter: $\boldsymbol{d = 84{,}18\ mm}$

IX.2.11.3 Bearing Type:

Considering the high radial load and potential for misalignment, spherical roller bearings are typically suitable for this application.

Bearing Load Capacity

Using the bearing load rating formula:

$$L_{10} = \left(\frac{C}{C_p}\right)^{10/3} \times 10^6$$

C: Dynamic load rating of the bearing

C_p: Equivalent dynamic bearing load $C_p = 846{,}66\ daN$

IX.2.11.4 Bearing Selecting:

Figure 19: spherical roller bearings SKF 22219 EK [18]

By using (Table 25), we got (22219 EK) with the following characteristics [18]:

Dynamic Load Rating $C = 393\ KN$ ($3930\ daN$).

Bore Diameter: 95 mm.

Speed Rating: Suitable for 139.52 *RPM.*

IX.2.11.5 Calculations for Bearing Life:

$$L_{10} = \left(\frac{C}{C_p}\right)^{10/3} \times 10^6$$

$$L_{10} = \left(\frac{3930}{846{,}66}\right)^{10/3} \times 10^6 = 166 \times 10^6$$

$$\boldsymbol{L_{10} = 166 \times 10^6}$$

$$L_{10h} = \left(\frac{C}{C_p}\right)^{10/3} \times \frac{10^6}{60 \times N_R}$$

$$L_{10h} = \left(\frac{3930}{846{,}66}\right)^{10/3} \times \frac{10^6}{60 \times 139{,}52} = \boldsymbol{19929\ hour}$$

$L_{10h} = 19929\ hour$

IX.2.11.6 Plummer block housings:

Plummer block housings are designed to work with specific bearing types and sizes.

IX.2.11.6.1 Specifications for the FSNL 519-616 Housing:

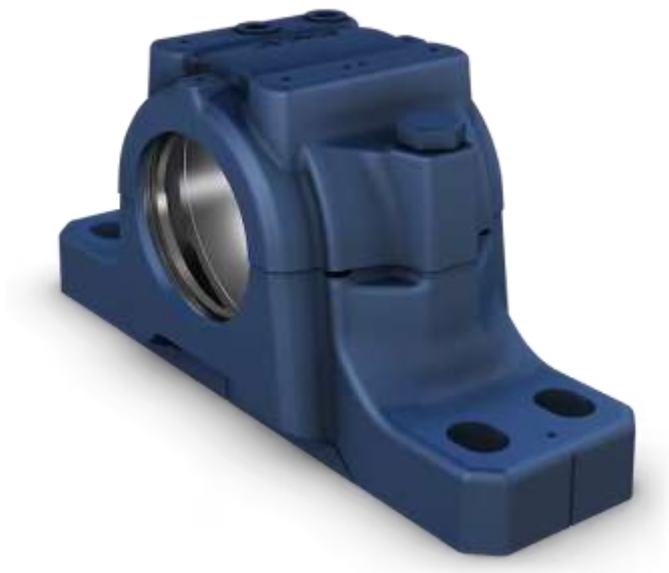


Figure 20: Plummer block housings FSNL 519-616 [18]

Suitable for Shaft Diameter: Typically for 95 mm, with adapter sleeve to fit 84.18 mm

Bearing Compatibility: Designed to accommodate bearings like the 22219 EK series

IX.2.11.7 Adapter Sleeve H 319 (for fitting the bearing on the shaft):

Figure 21: adapter sleeve H 319 [18]

To fit the 95 mm bore bearing onto the 84.18 mm shaft, an adapter sleeve is necessary. We chose the (H 319) adapter sleeve, which can accommodate minor differences in shaft size.

The **(SKF FSNL 519-616)** Plummer block housing with the (**SKF 22219 EK**) spherical roller bearing and (**SKF H 319**) adapter sleeve is suited for our application [18]. This configuration assures that the bearing can take the needed load, speed, and any misalignment, while the housing offers sturdy support for the assembly [18].

X Motor and gearbox and coupling:

X.1 Selecting the Motor:

In order to select the suitable motor, it is essential to have information regarding the power requirement, conveyor speed, and torque.

X.2 Calculate the Required Torque

$$T = \frac{P \times 9550}{N}\ Nm$$

T: the torque in Newton-meters (Nm)

P: the power in kilowatts (kw) $\boldsymbol{P = 3,28\ kw}$

N: the rotational speed in revolutions per minute (RPM) $\boldsymbol{N = 109,87\ RPM}$

9550: is a constant that comes from converting the units to get torque in (Nm) when power is in (kw) and speed is in (RPM).

$$T = \frac{3,28 \times 9550}{109,87} = \boldsymbol{285,1\ Nm}$$

$\boldsymbol{T = 285,1\ Nm}$

We recommend using a motor with a slightly greater power rating to ensure security and manage any unexpected increases in load. A motor with a power output of $\boldsymbol{4}$ ($\boldsymbol{kw}$) would be suitable.

According to (table 26), we find that (**DRN 112M 4**) meets our requirements with the following characteristics [19]:

P: the power in kilowatts (kw) $\boldsymbol{P = 4\ kw}$

N: the rotational speed in revolutions per minute (RPM) $\boldsymbol{N = 1464\ RPM}$

X.3 Select the Gearbox (Reducer):

Gear Ratio: The gearbox should lower the motor speed to the desired conveyor speed.

the motor speed is $\boldsymbol{N_M = 1464\ RPM}$

N_D: rotation speed of the drive pulley $\boldsymbol{N_D = 109,87\ (RPM)}$

$$\boldsymbol{Gear\ Ratio = \frac{N_M}{N_D}}$$

$$Gear\ Ratio = \frac{1464}{109{,}87} = \mathbf{13,32}$$

Table 27 reveals that (R57) [20], meets our needs with the following properties:

When used with the motor selected (DRN 112M 4) we got:

T: the torque in Newton-meters $\boldsymbol{T = 430\ Nm}$

exceeds our requirement of $\boldsymbol{285,1\ Nm.}$

X.4 Coupling:

A coupling is a mechanical device used to connect two shafts for power transmission, accommodating various degrees of alignment accuracy and torque requirements by being either rigid or flexible [21]. In this context, the motor acts as the driving side, while the gearbox and pulley constitute the driven side. Notably, couplings do not transfer the motor's heat to the driven side, thus preventing thermal damage.

Moreover, couplings absorb shock and vibration, thereby protecting surrounding components from potential damage. They are essential for connecting separately manufactured units, such as a motor and a generator, addressing shaft misalignment [22], providing mechanical flexibility, and mitigating the transmission of shock loads between shafts. Additionally, they offer protection against overloads, ensuring the longevity and reliability of the system [23].

Figure 22: RINGFEDER GWB AK [24]

Bellows couplings are flexible coupling with twin coupling ends called hubs. These couplings have excellent torsional rigidity to accurately transmit velocity, angular position, and torque. They are usually made up of stainless steel.

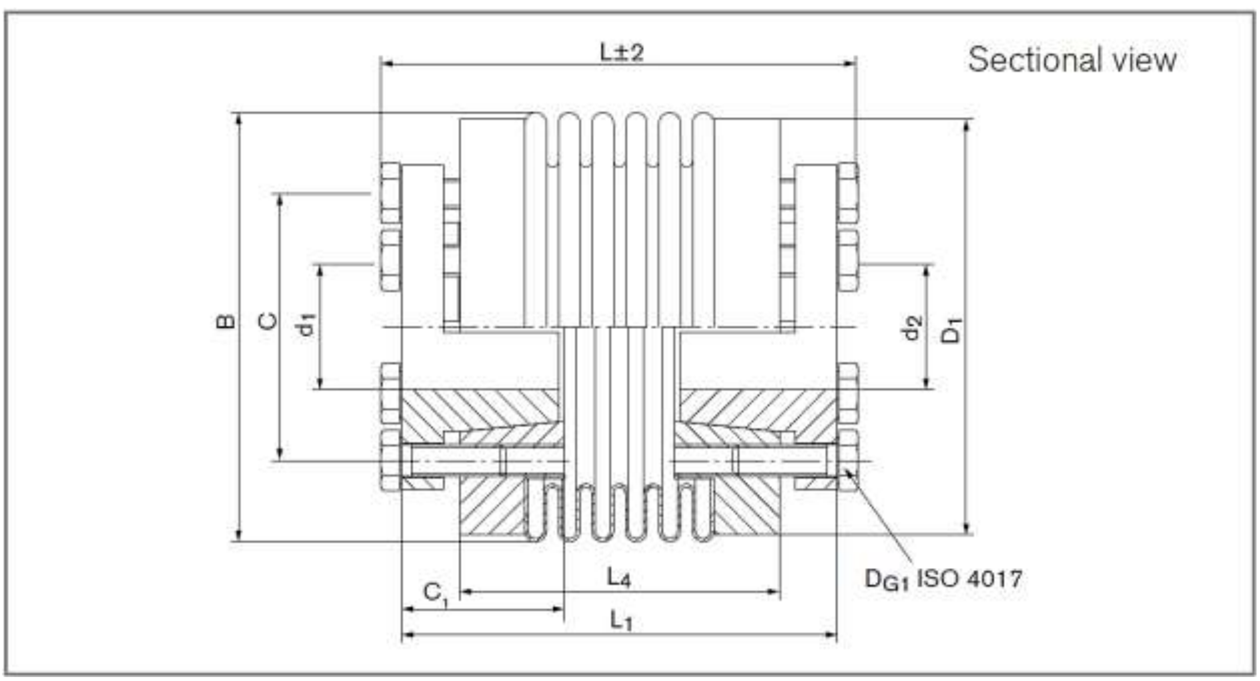


Figure 23: RINGFEDER GWB AK Sectional view [24]

Bellows coupling consists of thin walls and has minor flexibility angular, axial, or parallel misalignment.

According to (table 28a) we confirmed that the RINGFEDER GWB AK Size **800** can accommodate diameters in the range of **30-70 mm**, which covers both the gearbox shaft diameter ($\boldsymbol{d = 35\ mm}$) [20], and the pulley shaft diameter ($\boldsymbol{d = 62{,}77\ mm}$).

Gearbox torque : $\boldsymbol{T = 430\ Nm}$.

Safety Margin: At least 1.5 times gearbox torque.

Required Torque: 430 $Nm \times 1{,}5 = \boldsymbol{645\ Nm}$.

According to (table 28b) the selected size 800 give us $\boldsymbol{T = 800\ Nm}$

$$\boldsymbol{645\ Nm < 800\ Nm}$$

The torque capacity of 800 Nm for size 800 is greater than the required 645 Nm, ensuring safety.

XI Conclusion:

The foundation of our concept is a thorough examination of the specifications of the drum, roller, and motor mechanisms to create a belt conveyor system specifically for transporting salt. We have created an efficient, dependable, and secure conveyor system by incorporating accurate calculations, evaluating operating needs, and carefully choosing components. This system is specifically developed to satisfy the needs of salt transportation and is also engineered to provide long-term endurance and effective load control. By implementing this comprehensive strategy, we have complete confidence in the capability of our conveyor system to efficiently and cost-effectively fulfill the requirements of salt transportation.

Chapter III
SolidWorks Simulation

I Introduction:

Industrial drafting is crucial to transforming an idea into a finished product, whether by manual or computer-aided design (CAD and CAC). This universal language, subject to rigorous standards defined by the International Organization for Standardization (ISO), is widely used by technicians and engineers.

II CAD (Computer-Aided Design):

CAD digitizes traditional drawing tools such as rulers, compasses, erasers, and squares, modernizing them. It enables users to modify drawings, analyze geometric features (such as coordinates, centers of gravity, and distances), and take precise measurements at any time.

III CAC (Computer-Aided Conception):

CAC offers advanced design tools, enabling not only kinematic simulations but also the archiving of company knowledge in CAC libraries. It also enables strength-of-materials calculations, allowing designs to be validated prior to the manufacturing phase.

IV SolidWorks:

SolidWorks is an automated mechanical design software widely used by students, designers, engineers, and other professionals. It enables the creation and experimentation of 3D models of parts, assemblies, and drawings, providing precise visualization of models in all three dimensions as they would appear after manufacture.

IV.1 SolidWorks components:

Parts: The basic elements of any design.

Assemblies: Compositions of several parts to form more complex mechanisms or structures.

Drawings: Detailed representations of parts and assemblies for manufacturing.

IV.2 SolidWorks Simulation:

SolidWorks Simulation is a set of structural analysis tools using the Finite Element Analysis (FEA) method to predict the actual physical behavior of a product by virtually testing CAD models.

Features include dynamic and static, linear and non-linear analyses, covering various studies such as:

Static: The study of forces and moments in a stationary structure.

Frequential: Analysis of natural frequencies and vibration modes.

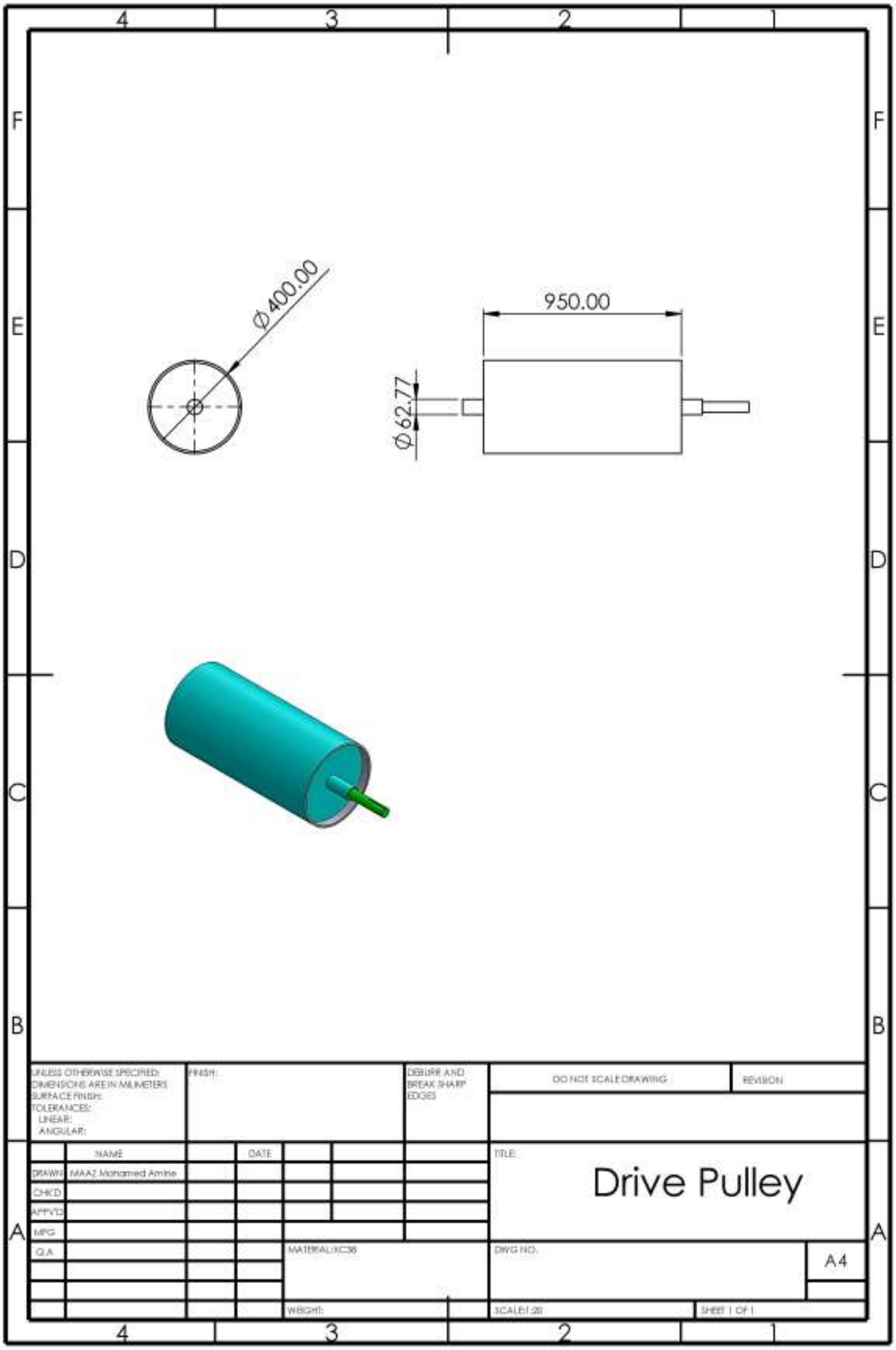
Buckling: Testing structural stability under load.

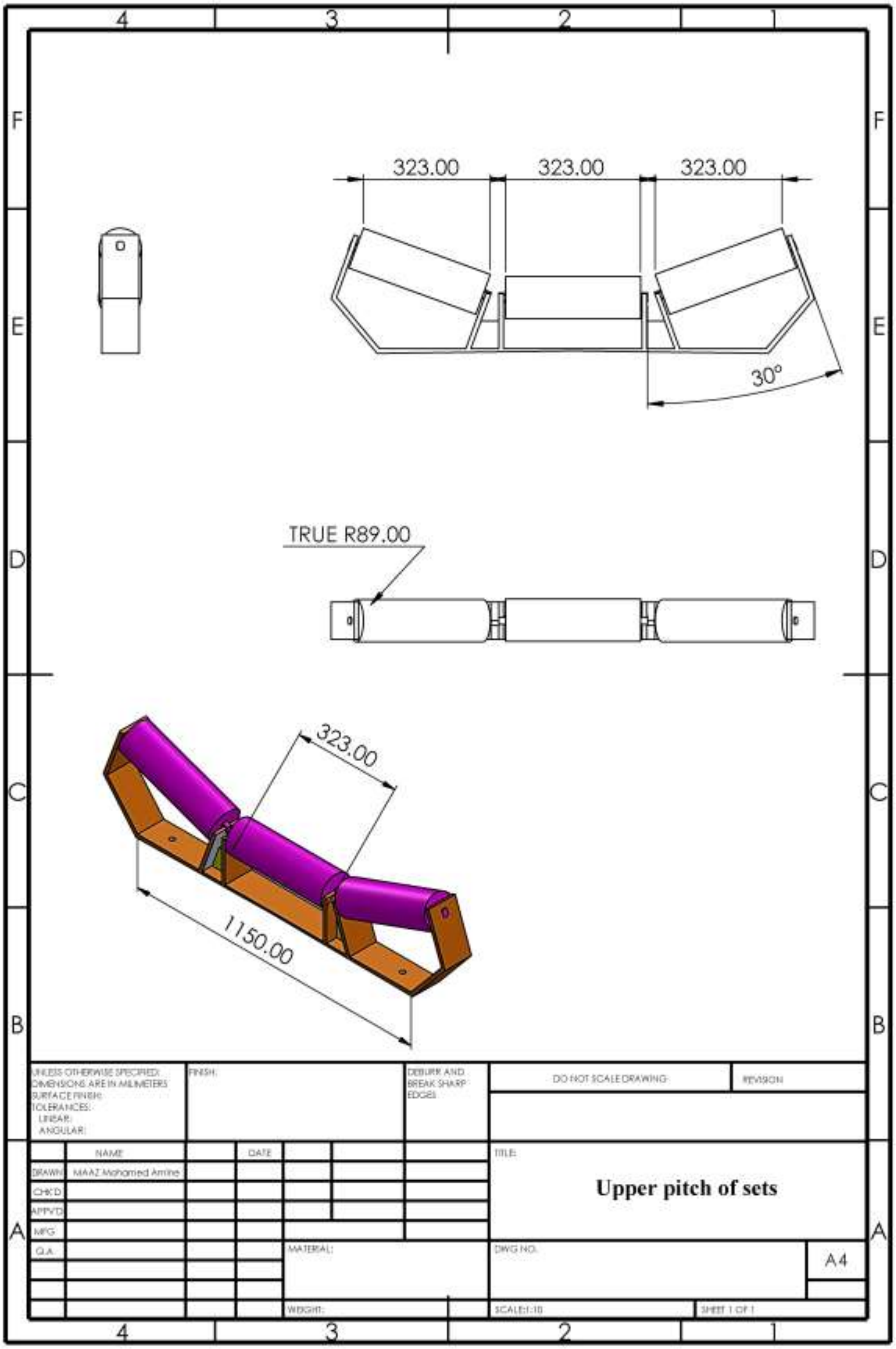
Thermal: Study of the effects of temperature on materials.

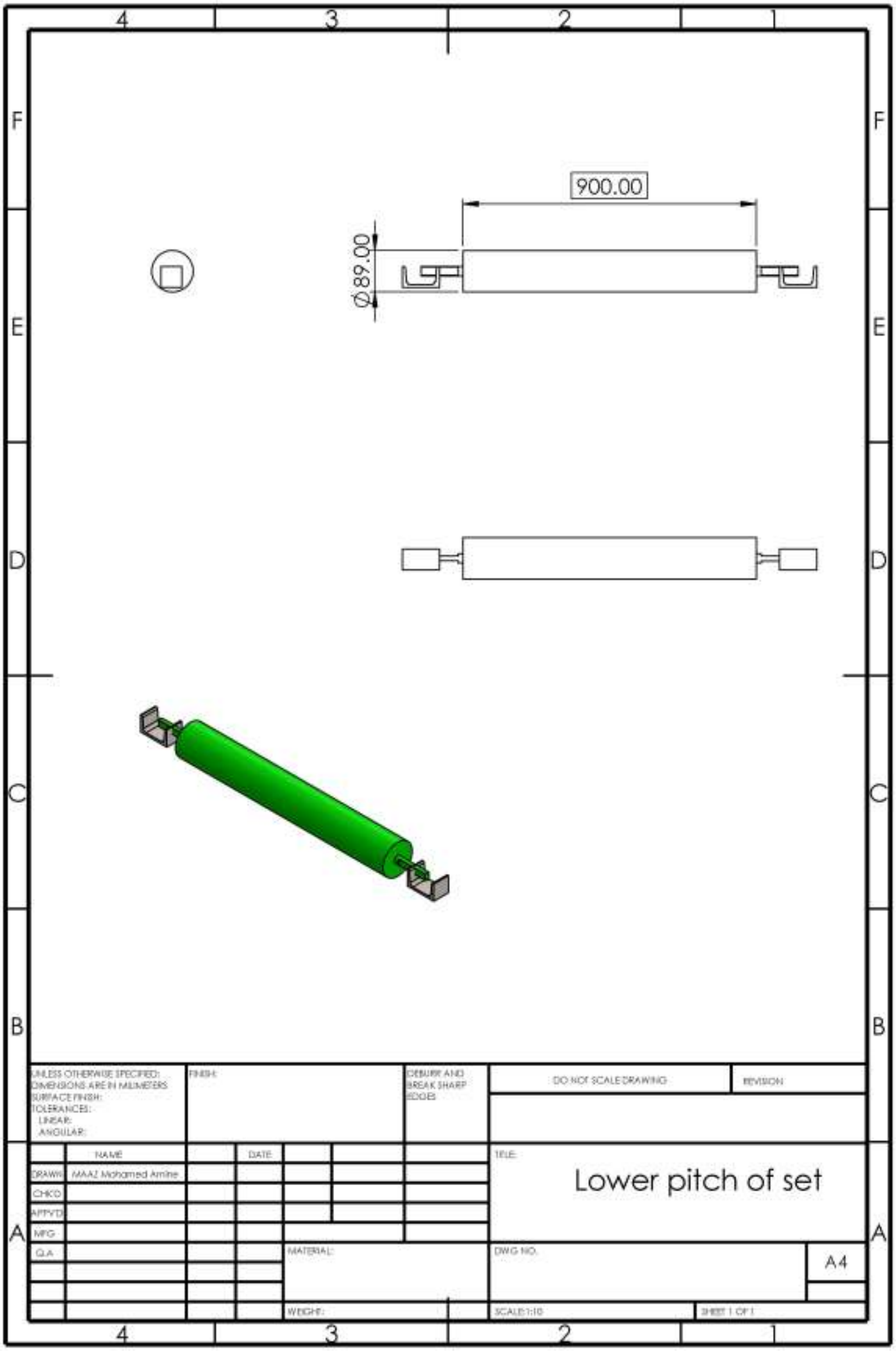
Drop test: Simulation of impacts in the event of a drop.

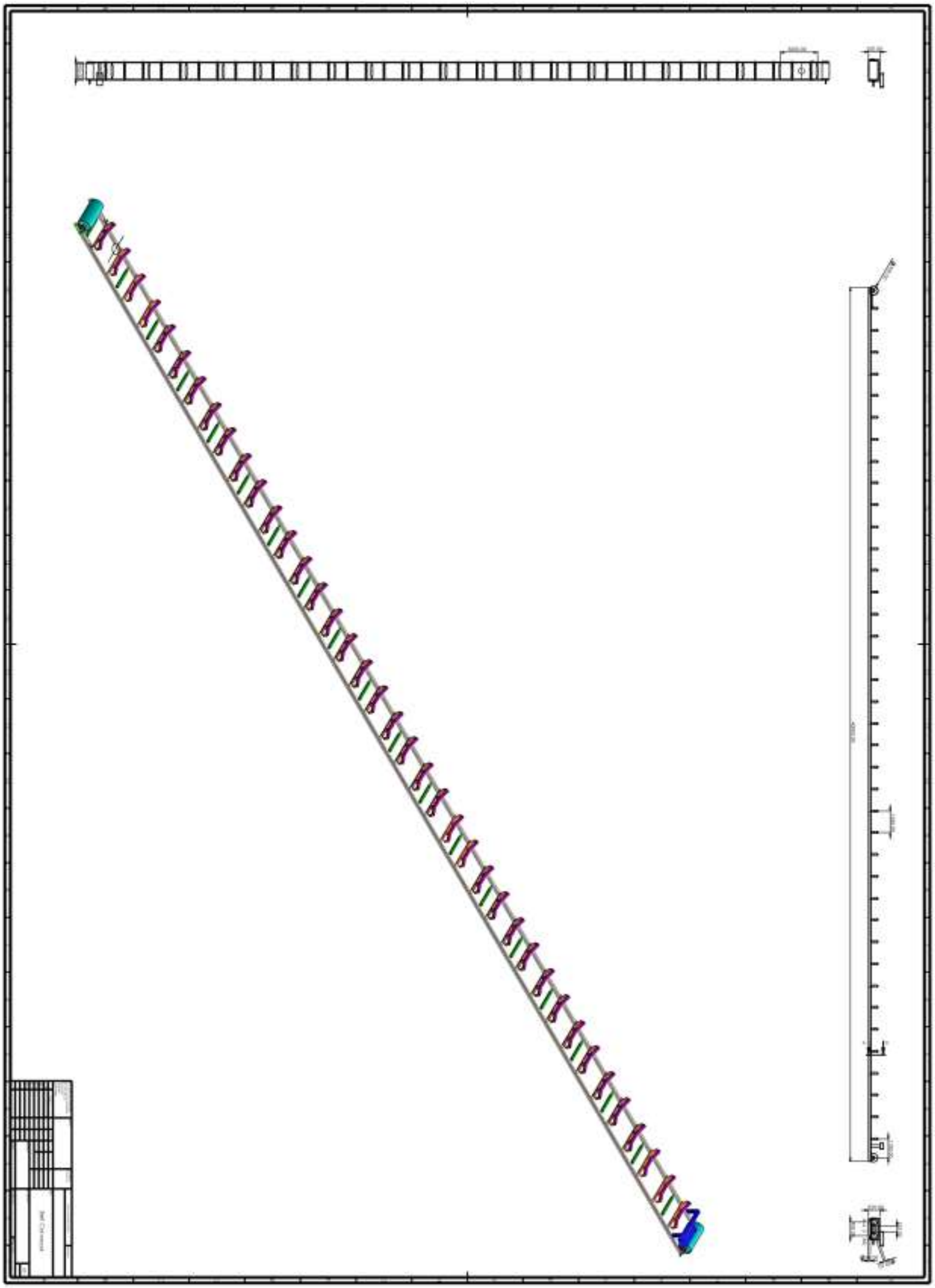
Fatigue: Predict the material's service life after repeated loading.

Dynamics: Analysis of behavior under dynamic loads (modal, harmonic, spectral, random).


Ø400.00
950.00
Ø62.77
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:
FINISH:
DEBURR AND BREAK SHARP EDGES
DO NOT SCALE DRAWING
REVISION
NAME
DATE
DRAWN
MAAZ Mohamed Amine
CHK'D
APPV'D
MFG
Q.A
TITLE:
Drive Pulley
MATERIAL:XC38
DWG NO.
A4
WEIGHT:
SCALE:1:20
SHEET 1 OF 1


323.00
323.00
323.00
30°
TRUE R89.00
323.00
1150.00
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:
FINISH:
DEBURR AND
BREAK SHARP
EDGES
DO NOT SCALE DRAWING
REVISION
NAME
DATE
DRAWN
MAAZ Mohamed Amine
CHK'D
APPV'D
MFG
Q.A
TITLE:
Upper pitch of sets
MATERIAL:
DWG NO.
A4
WEIGHT:
SCALE:1:10
SHEET 1 OF 1


900.00
Ø89.00
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:
FINISH:
DEBURR AND BREAK SHARP EDGES
DO NOT SCALE DRAWING
REVISION
NAME
DATE
DRAWN MAAZ Mohamed Amine
CHK'D
APPV'D
MFG
Q.A
MATERIAL:
WEIGHT:
TITLE:
Lower pitch of set
DWG NO.
A4
SCALE:1:10
SHEET 1 OF 1



Chapter IV
Realization of Prototype

I Introduction

In this chapter dedicated to the implementation of the belt conveyor, we will detail the practical and operational steps necessary to transform theoretical plans into a functional and efficient system. This crucial part of the project involves various activities, from the fabrication of components to final testing and commissioning. Below is a description of the main practical and operational steps:

II 1- Component Fabrication

Material Selection:

Choosing appropriate materials for each component based on design specifications.

II.1.1 Part Manufacturing:

Cutting, forming, and welding metal parts.

Producing drums, rollers, and supports for the conveyor belt.

II.1.2 Manufacturing the conveyor belt from rubber or PVC as needed.

III 2- Assembly

III.1 Pre-assembly:

Pre-assembling sub-assemblies (frame, drums, rollers, etc.) in the workshop to check fits and tolerances.

III.2 Final Assembly:

Assembling sub-assemblies to form the complete conveyor.

Installing the conveyor belt on drums and rollers.

Attaching motors, speed reducers, and other mechanical components.

Figure 01: The Prototype

Figure 02: The power source (power supply, speed controller, motor)

Figure 03: Top View

Figure 04: Bottom View

IV 3- On-Site Installation

IV.1 Site Preparation:

Preparing the ground and support structures to accommodate the conveyor.

Checking the alignment and levelness of supports.

IV.2 Conveyor Installation:

Transporting assembled components to the installation site.

Positioning and securing the conveyor on the support structures.

Connecting electrical and control systems.

V 4- Testing and Adjustments

V.1 Operational Testing:

Initial startup to check mechanical and electrical operations.

Observing belt movement and material transport to detect any potential issues.

V.2 Fine Adjustments:

Adjusting belt tension, alignment, and speeds.

Correcting malfunctions and optimizing performance.

General Conclusion

Throughout the duration of our internship at the salt factory, our main objective has been to study in detail all the main components of the conveyor belt. With this aim in mind, we favored the use of standardized or prefabricated elements to minimize the installation costs. Our in-depth analysis has revealed that the conveyor belt is a complex system, subject to multiple factors influencing its optimal functioning and durability. Consequently, it requires continuous monitoring and rigorous maintenance to minimize breakdowns and unforeseen costs.

Furthermore, we have identified the calculation of the metal structure as an area that could be the subject of a complementary project. Solid knowledge of metal construction and soil science is necessary to successfully carry out this task. Further study could allow us to explore the possibility of increasing the conveyor's throughput by considering modifications such as installing a multiple-roller chute or increasing speed. These adjustments could have a significant impact on the various parameters associated with the conveyor's operation.

In addition to these technical considerations, it is important to emphasize the importance of careful planning and effective coordination among the various departments involved in the design, implementation, and maintenance of the conveyor belt. An integrated approach, involving experts in mechanical, electrical, and hydraulic engineering, as well as maintenance management specialists, is essential to ensure the continuous proper functioning of the installation.

Proactive risk management, including a thorough analysis of potential failures and the implementation of appropriate preventive measures, is also essential to minimize production interruptions and unforeseen costs associated with breakdowns.

Furthermore, the adoption of advanced monitoring and diagnostic technologies, such as smart sensors and telemetry systems, can enable early detection of anomalies and optimization of the conveyor's operational performance.

Finally, it is worth noting the evolving nature of this field, where technological advances and constant innovations continually offer new improvement opportunities. Active technological surveillance and a culture of innovation within the company are therefore essential to remain competitive in an ever-changing market.

Bibliographical Reference

Bibliographical Reference

[1]. Hobson, B. (2008). Magnetic Conveying and Elevating. Material Handling & Logistics. Disponible sur: Material Handling & Logistics.

[2]. Mulcahy, D. E. (2007). Materials Handling Handbook. McGraw-Hill Professional. ISBN: 978-0070440025.

[3]. Groover, M. P. (2015). Automation, Production Systems, and Computer-Integrated Manufacturing. Pearson. ISBN: 978-0133499612.

[4]. Myers, R. (2007). The Basics of Conveyors: Applications, Types, and Industries. Industrial Press. ISBN: 978-0831133350.

[5]. Ostojic, G., Bojic, S., & Tadic, D. (2014). Conveyor Systems: Considerations and Design. Springer. ISBN: 978-3319052561.

[6]. Thompson, R. (2012). Industrial Magnetics: Principles, Applications and Devices. CRC Press. ISBN: 978-1466503830.

[7]. Patrick M McGuire, "Conveyors: Application, Selection, and Integration", CRC Press, 2009.

[8]. M. A. Alspaugh, "Bulk Material Handling by Conveyor Belt 7", Society for Mining Metallurgy & Exploration, 2008.

[9]. Thomas S. Skocir, "Conveyor Equipment Manufacturers Association Handbook", Conveyor Equipment Manufacturers Association, 2004.

[10]. Roberts, J. M. (2018). Bulk Material Handling by Conveyor Belt 7. Society for Mining, Metallurgy, and Exploration.

[11]. Masutani, S., Takahashi, T., & Oikawa, H. (2015). Numerical simulation of particle motion in screw conveyors: effect of particle shape on conveying efficiency. Powder Technology, 271, 341-348.

[12]. Harrison, A. (1997). "Bucket Elevators and Conveyor Systems." Australian Bulk Handling Review, 9(2), 20-23.

[13]. oberts, A. W., & Bower, A. B. (1987). "The handling of bulk solids by belt conveyors." Transactions of the Institution of Engineers, Australia, 4(1), 23-28.

[14]. DeLaurier, James D,(2000) Air Cushion Vehicles – Systems Integration and Technology Management, Springer

[15]. BULK HANDLING Rulmeca Holding S.p.A Via A. Toscanini,1 I- 24011 Almè Bergamo Italy

[16]. Apex Belting Ltd data sheet

[17]. Promati Catalogue Tambours pour bandes transporteuses-Belgique

[18]. SKF. https://www.skf.com/fr.

[19]. SEW-EURODRIVE DRN Motors

[20]. SEW-EURODRIVE Servo Gear Units Edition 02/2024

[21]. Smith, J. (2020). Mechanical Power Transmission and Couplings. Engineering Press.

[22]. Johnson, R. (2018). Industrial Shaft Couplings: Design and Applications. Industrial Machinery Journal.

[23]. Thompson, L. (2019). Vibration Control and Coupling Mechanics. Vibration Analysis Review.

[24]. Metal Bellows Couplings RINGFEDER 08/2019

Appendix

Appendix

Table 01: Physical properties of materials [15]

Type	Average specific weight qs t/m³	lbs. / Cu.Ft	Angle of repose	Abrasive - ness	Corrosive - ness
Quartz 40 mm to 80 mm lumps	1,36-1,52	85-95	-	C	A
Quartz, dust	1,12-1,28	70-80	-	C	A
Quartz, 13 mm screening	1,28-1,44	80-90	-	C	A
Rubber, pelletized	0,80-0,88	50-55	35°	A	A
Rubber, reclaim	0,40-0,48	25-30	32°	A	A
Salt, common dry, coarse	0,64-0,88	40-55	-	B	B
Salt, common dry, fine	1,12-1,28	70-80	25°	B	B
Sand, damp	1,76-2,08	110-130	45°	C	A
Sand, dry	1,44-1,76	90-110	35°	C	A

A: non-abrasive/non-corrosive

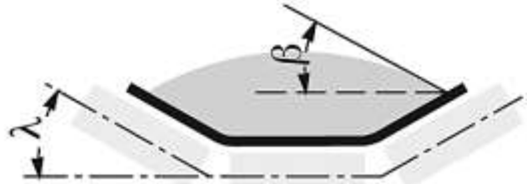
B: mildly abrasive/mildly corrosive

C: very abrasive/very corrosive

Table 02: Maximum speeds advised [15]

Lump size max. dimensions uniform up to mm	mixed up to mm	Belt min. width mm	max. speed A	B	C	D
50	100	400	2.5	2.3	2	1.65
75	150	500				
125	200	650	3	2.75	2.38	2
170	300	800	3.5	3.2	2.75	2.35
250	400	1000	4	3.65	3.15	2.65
350	500	1200				
400	600	1400	4.5	4	3.5	3
450	650	1600				
500	700	1800	5	4.5	3.5	3
550	750	2000				
600	800	2200	6	5	4.5	4

Table 03: Loaded volume with 3 roll troughing sets $V = 1\ (m / s)$ [15]



Belt width mm	Angle of surcharge β	I_{VT} m³/h λ = 20°	λ = 25°	λ = 30°	λ = 35°	λ = 45°
650	5°	80.3	94.4	107.2	118.6	136.3
	10°	94.4	108	125	131	147.1
	20°	123	136	147	156.3	169.3
	25°	138	150	160	169	180
	30°	153	165	175	182	192.7
800	5°	125.9	148.1	168.2	186	213.8
	10°	148.1	169.5	188.7	205.4	230.8
	20°	193.5	213.3	230	245.1	265.6
	25°	217	235.9	252.2	265.7	283.6
	30°	241.2	259.3	274.6	286.9	302.2
1000	5°	207.5	244.1	277.1	306.1	351
	10°	243.2	278.4	309.8	337.1	377.9
	20°	316	348.5	376.7	400.4	433
	25°	353.7	384.8	411.4	433.1	461.4
	30°	392.5	422.2	447	466.9	490.8

Table 04: Rubber Belt data sheet (EP 400/3 3:1,5) [16]

Belt Construction

Number of fabrics	3	
Fabric material	Polyester/ Polyamide	
Top cover material	SBR Rubber	
Top cover thickness	3.0 mm	0.118 in
Top cover profile	Smooth	
Top cover colour	Black	
Top cover hardness	60 Shore A	
Bottom cover material	SBR Rubber	
Bottom cover thickness	1.5 mm	0.059 in
Bottom cover profile	Smooth	

Technical Data

Thickness	8 mm	0.315 in
Weight	8.40 kg/m2	1.721 lbs/ft2
Nominal Tensile Strength	400 n/mm	2235.89 lbs/in
Minimum pulley diameter	315 mm	0.236 in
Minimum pulley back flex diameter	250 mm	9.843 in
Minimum temperature	-20 °C	-4 °F
Maximum temperature	80 °C	176 °F
Maximum width	2600 mm	102.362 in

Table 05: Recommended roller diameter [15]

Belt width mm	For speed ≤ 2 m/s Ø roller mm			2 ÷ 4 m/s Ø roller mm			≥ 4 m/s Ø roller mm		
500	89			89					
650	89			89	108				
800	89	108		89	108	133	133		
1000	108	133		108	133		133	159	
1200	108	133		108	133	159	133	159	
1400	133	159		133	159		133	159	
1600	133	159		133	159	194	133	159	194
1800	159	159	194	159	194				
2000	159	194		159	194		159	194	
2200 and more	194			194			194		

Table 06: Maximum advised pitch of troughing sets [15]

Belt width	Pitch of sets upper specific weight of conveyed material t/m^3			lower
	< 1.2	1.2 ÷ 2.0	> 2.0	
mm	m	m	m	m
300	1.65	1.50	1.40	3.0
400				
500				
650				
800	1.50	1.35	1.25	3.0
1000	1.35	1.20	1.10	3.0
1200	1.20	1.00	0.80	3.0
1400				
1600				
1800				
2000	1.00	0.80	0.70	3.0
2200				

Table 07: Participation factor (F_p) [15]

0°	20°	20°	30°	35°	45°	30°-45°	60°
1.00	0.50	0.60	0.65	0.67	0.72	~0.52 - 0.60	0.47
						Shorter central roller	5 rollers garland

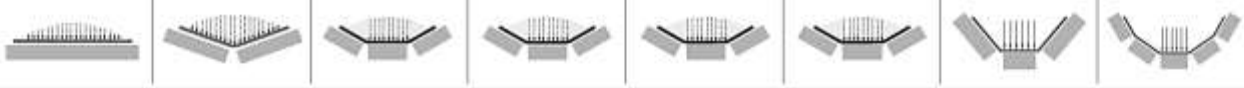


Table 08: Shock factor (F_d) [15]

Lump size	Belt speed m/s						
	2	2.5	3	3.5	4	5	6
0 ÷ 100 mm	1	1	1	1	1	1	1
100 ÷ 150 mm	1.02	1.03	1.05	1.07	1.09	1.13	1.18
150 ÷ 300 mm with layers of fine material	1.04	1.06	1.09	1.12	1.16	1.24	1.33
150 ÷ 300 mm without layers of fine material	1.06	1.09	1.12	1.16	1.21	1.35	1.50
300 ÷ 450 mm	1.20	1.32	1.50	1.70	1.90	2.30	2.80

Table 09: Service factors (F_s) [15]

Working life	Fs
Less than 6 hours per day	0.8
From 6 to 9 hours per day	1.0
From 10 to 16 hours per day	1.1
Over 16 hours per day	1.2

Table 10: Environmental factors (F_m) [15]

Conditions	Fm
Clean and with regular maintenance	0.9
Presence of abrasive or corrosive materials	1.0
Presence of very abrasive or very corrosive materials	1.1

Table 11: Speed factors (F_v) [15]

Belt speed	Roller diameter mm						
m/s	60	76	89-90	102	108-110	133-140	159
0.5	0.81	0.80	0.80	0.80	0.80	0.80	0.80
1.0	0.92	0.87	0.85	0.83	0.82	0.80	0.80
1.5	0.99	0.99	0.92	0.89	0.88	0.85	0.82
2.0	1.05	1.00	0.96	0.95	0.94	0.90	0.86
2.5			1.01	0.98	0.97	0.93	0.91
3.0			1.05	1.03	1.01	0.96	0.92
3.5					1.04	1.00	0.96
4.0					1.07	1.03	0.99
4.5					1.14	1.05	1.02
5.0					1.17	1.08	1.00

Table 12: Rollers series PSV/1-FHD [15]

Ø 89 N

Bearing 6204
(20 X 47 X 14)

d = 20
ch = 14
s = 3
e = 4
g = 9

belt width mm (arrangements: flat)	(2-roll)	(3-roll)	roller dimensions mm B	C	A	weight Kg rotating parts	total	load capacity daN, belt speed m/s 0.5	1	1.5	2	2.5	3
		400	160	168	186	1.7	2.2	226	179	157	142	132	124
	300	500	200	208	226	2.0	2.5	226	179	157	142	132	124
	400	650	250	258	276	2.3	3.0	226	179	157	142	132	124
	500	800	315	323	341	2.7	3.6	226	179	157	142	132	124
300	650	1000	380	388	406	3.1	4.1	226	179	157	142	132	124
	800	1200	465	473	491	3.7	4.9	226	179	157	142	132	124
400			500	508	526	3.9	5.2	226	179	157	142	132	124
		1400	530	538	556	4.1	5.5	226	179	157	142	132	124
500	1000		600	608	626	4.6	6.1	204	179	157	142	132	124
	1200		700	708	726	5.2	7.0	173	173	157	142	132	124
650			750	758	776	5.5	7.4	161	161	157	142	132	124
	1400		800	808	826	5.8	7.9	150	150	150	142	132	124
800			950	958	976	6.8	9.2	126	126	126	126	126	124
1000			1150	1158	1176	8.1	11.0	104	104	104	104	104	104
1200			1400	1408	1426	9.7	13.2	85	85	85	85	85	85
1400			1600	1608	1626	11.0	15.0	75	75	75	75	75	75

The indicated load capacity relates to a project working life of 30,000 hours.

Table 13: Capacity of standard transom [15]

belt width mm	type of transom and diameter of suitable rollers: A2 S-20° Ø 60÷110 Kg	A3 L-30° Ø 76÷110	A3 M-30° Ø 89÷110	Ø 133÷140
300	338			
400	286	286		
500	205	247	247	247
650	167	205	205	205
			354	354
800	167	167	289	289
			460	460
1000			244	244
			388	388

Table 14: Transom A3 M-30° [15]

order codes	belt	roller			transom						weight without rollers
	width mm	Ø mm	C	ch	capacity Kg	H mm	K max	Q	E		Kg
A3 M 1/3A	500	89 - 90 - 108 -110	208	14 - 30	247	135	292	740	800		6.0
A3 M 1/3E	650		258		205	135	317	890	950		6.7
A3 M /22					354	135	317	890	950		8.1
A3 M 1/3K	800		323		289	140	354	1090	1150		10.7
A3 M /24					460	140	354	1090	1150		13.3
A3 M 1/3P	1000		388		244	140	387	1290	1350		12.2
A3 M /28					388	140	387	1290	1350		15.1
A3 M 1/3J	1200		473		204	140	429	1540	1600		14.0
A3 M /32					325	140	429	1540	1600		17.4

Table 15: Programme of transoms and brackets [15]

Series	Arrangements	Descriptions
A2 S 20°		upper transom for two rollers
A3 L 30° A3 M 30° A3 P 30° A3 S 35°		upper transom for three rollers
SPT 1657 - 1660 SPT 070 SPT 1795		upper brackets for one roller
SPT 1478 - 1490 SPT 243 SPT 1495		lower return brackets for plain roller

Table 16: Support brackets SPT 1478 [15]

belt width mm	roller Ø mm	C	ch	H SPT 1478 mm	SPT 1490	Q	weight of two brackets without rollers SPT 1478 Kg	SPT 1490
300	SPT 1478 : 60 ÷ 133 SPT 1490: 60 ÷ 180	388	SPT 1478: 14 -17 SPT 1490; 14 - 18 - 22	70	100	520	0.7	1.5
400		508		70	100	640	0.7	1.5
500		608		70	100	740	0.7	1.5
650		758		70	100	890	0.7	1.5
800		958		70	100	1090	0.7	1.5
1000		1158		70	100	1290	0.7	1.5
1200		1408		70	100	1540	0.7	1.5
1400		1608		70	100	1740	0.7	1.5

Table 17: Coefficient of fixed resistance (C_q) [15]

Centres m	Cq
10	4.5
20	3.2
30	2.6
40	2.2
50	2.1
60	2.0
80	1.8
100	1.7
150	1.5
200	1.4
250	1.3
300	1.2
400	1.1
500	1.05
1000	1.03

Table 18: Coefficient of passive resistance given by temperature (C_t) [15]

Temperature °C	+ 20°	+ 10°	0	- 10°	- 20°	- 30°
Fattore Ct	1	1,01	1,04	1,10	1,16	1,27

Table 19: Coefficient of internal friction (f) of materials and of the rotating parts [15]

Horizontal belt conveyor rising and gently falling	speed m/s					
	1	2	3	4	5	6
Rotating parts and material with standard internal friction	0,0160	0,0165	0,0170	0,0180	0,0200	0,0220
Rotating parts and material with high internal friction in difficult working conditions	from 0,023 to 0,027					
Rotating parts of a conveyor in descent with a brake motor	from 0,012 to 0,016					

Table 20: Weight of rotating parts of the rollers (upper/lower) [15]

Belt width	Roller diameter mm									
	89		108		133		159		194	
	Pprs	Ppri	Pprs	Ppri	Pprs	Ppri	Pprs	Ppri	Pprs	Ppri
mm	Kg									
400	–	–	–							
500	5.1	3.7	–							
650	9.1	6.5	–							
800	10.4	7.8	16.0	11.4	–					
1000	11.7	9.1	17.8	13.3	23.5	17.5				
1200			20.3	15.7	26.7	20.7	–			
1400					29.2	23.2	–			
1600					31.8	25.8	–			
1800							47.2	38.7	70.5	55.5
2000							50.8	42.2	75.3	60.1
2200							–	–	–	–

Table 21: Wrap factor (C_w) [15]

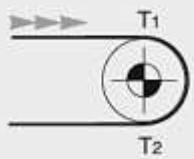
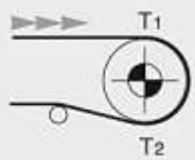
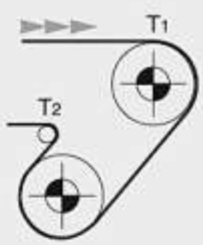
Drive arrangement	Angle of wrap	tension unit or counterweight		screw tension unit	
		pulley		pulley	
		unlagged	lagged	unlagged	lagged
	180°	0.84	0.50	1.20	0.80
	200° 210° 220° 240°	0.72 0.66 0.62 0.54	0.42 0.38 0.35 0.30	1.00 0.95 0.90 0.80	0.75 0.70 0.65 0.60
	380° 420°	0.23 0.18	0.11 0.08	- -	- -

Table 22: Minimum pulley diameters recommended [15]

Belt breaking load	Belt with textile core EP DIN 22102			Belt with steel core ST DIN 22131		
	Ø motorised pulley	return pulley	direction change	Ø motorised pulley	return pulley	direction change
N/mm	mm		drum	mm		pulley
200	200	160	125	-	-	-
250	250	200	160	-	-	-
315	315	250	200	-	-	-
400	400	315	250	-	-	-
500	500	400	315	-	-	-
630	630	500	400	-	-	-
800	800	630	500	630	500	315
1000	1000	800	630	630	500	315
1250	1250	1000	800	800	630	400
1600	1400	1250	1000	1000	800	500
2000	-	-	-	1000	800	500
2500	-	-	-	1250	1000	630
3150	-	-	-	1250	1000	630

Table 23: Standard drum dimensions[17]

Belt width l	Ferrule length L	Pulley diameter Ø DE	Bearing diameter Ø D2	A	C	Reducer diameter Ø D4	M	N
<u>800</u>	<u>950</u>	200	40	1214	1344	38	(according to gearbox supplier prescription)	(according to gearbox supplier prescription)
		250	40	1214	1344	38		
			50	1225	1365	48		
			65	1245	1415	60		
		<u>315</u>	50	1225	1365	48		
			65	1245	1415	60		
			80	<u>1275</u>	1465	75		
		<u>400</u>	50	1225	1365	48		
			65	1245	1415	60		
			80	<u>1275</u>	1465	75		
		500	65	1245	1415	60		
			80	1275	1465	75		
			100	1301	1521	95		
		630	80	1275	1465	75		
			100	1301	1521	95		
			125	1337	1587	120		
		800	100	1301	1521	95		
			125	1337	1587	120		
			160	1376	1746	150		

Table 24: SNL series for bearings on an adapter sleeve, with standard seals [18]

Désignation des composants appropriés	Diamètre d'arbre	Dimensions principales du palier			
		Largeur	Hauteur	Hauteur du centre	Longueur
	d_a [mm]	A [mm]	H [mm]	H_1 [mm]	L [mm]
FSNL 515-612 + C 2215 K + HA 315 E	61.913	115	155	80	280
FSNL 518-615 + 1315 K + HA 315	61.913	140	192	100	345
FSNL 518-615 + 21315 EK + HA 315	61.913	140	192	100	345
FSNL 518-615 + 22315 EK + HA 2315	61.913	140	192	100	345
FSNL 518-615 + 2315 K + HA 2315	61.913	140	192	100	345
FSNL 518-615 + C 2315 K + HA 2315	61.913	140	192	100	345
SNL 515-612 + 1215 K + HA 215	61.913	115	155	80	280
SNL 515-612 + 2215 EKTN9 + HA 315	61.913	115	155	80	280
<u>SNL 515-612 + 22215 EK + HA 315</u>	61.913	115	155	80	280
SNL 515-612 + C 2215 K + HA 315 E	61.913	115	155	80	280
SNL 518-615 + 1315 K + HA 315	61.913	140	192	100	345

Table 25: SNL series for bearings on an adapter sleeve, with standard seals [18]

Désignation des composants appropriés	Diamètre d'arbre	Dimensions principales du palier			
		Largeur	Hauteur	Hauteur du centre	Longueur
	d_a [mm]	A [mm]	H [mm]	H_1 [mm]	L [mm]
FSNL 519-616 + 1219 K + H 219	85	145	210	112	345
FSNL 519-616 + 2219 KM + H 319	85	145	210	112	345
<u>FSNL 519-616 + 22219 EK + H 319</u>	85	145	210	112	345
FSNL 522-619 + 1319 K + H 319	85	175	242	125	410
FSNL 522-619 + 21319 EK + H 319	85	175	242	125	410
FSNL 522-619 + 22319 EK + H 2319	85	175	242	125	410
FSNL 522-619 + 2319 K + H 2319	85	175	242	125	410
FSNL 522-619 + C 2319 K + H 2319	85	175	242	125	410
SNL 519-616 + 1219 K + H 219	85	145	210	112	345
SNL 519-616 + 2219 KM + H 319	85	145	210	112	345
SNL 519-616 + 22219 EK + H 319	85	145	210	112	345

Table 26: SEW-EURODRIVE DRN Motors [19]

4-pole DRN.. motors/brakemotors for 400 V, 50 Hz, IE3

DRN.. motor type	P_N kW	M_N Nm	n_N rpm	m kg	J_{Mot} 10^{-4} kgm²	BE..	Z_0 BG BGE 1/h	M_B Nm	m_B kg	J_{Mot_BE} 10^{-4} kgm²
DRN 80M 4	0.75	4.95	1440	14	24.7	BE1	3200 8200	10	18	26.2
DRN 90S 4	1.1	7.2	1455	20	54	BE2	2300 6000	14	24	58.7
DRN 90L 4	1.5	9.8	1461	23	67.2	BE2	2200 5800	20	27	71.9
DRN 100LS 4	2.2	14.5	1450	27	81.4	BE5	- 6100	28	33	87.4
DRN 100L 4	3	19.7	1456	34	112	BE5	- 3700	40	40	118
DRN 112M 4	4	26	1464	45	178	BE5	- 2900	55	52	183
DRN 132S 4	5.5	36	1461	56	241	BE11	- 2100	80	71	251
DRN 132M 4	7.5	49	1468	73	381	BE11	- 1100	110	91	403
DRN 132L 4	9.2	60	1470	81	439	BE20	- 980	150	110	490
DRN 160M 4	11	71	1473	115	817	BE20	- 900	150	145	877
DRN 160L 4	15	97	1474	130	1040	BE20	- 800	200	165	1100

Table 27: SEW-EURODRIVE R57 Gearbox [20]

R57, n_e = 1400 min⁻¹, $M_{a\,max}$/Nm — 450 Nm

i	n_a min⁻¹	$M_{a\,max\,G}$ Nm	F_{Ra} 1) N	$\varphi_{(/R)}$ °	AMS 63	71	80	90	100	112	132S/M
							2				
4.39	319	280	1900	10			81	106	205	260	280
5.05	277	305	1730	10	33	33	93	122	230	300	305
5.82	241	320	1820	10	38	38	107	141	260	320	320
6.41	218	335	1770	9	42	42	118	155	280	335	335
7.53	186	350	1950	9	49	49	139	173	315	350	350
7.97	176	355	2020	9	52	52	148	176	330	355	355
9.06	155	375	2010	9	60	60	168	181	355	375	
9.35	150	370	3180	7	61	61	173	225	370	370	370
10.79	130	390	3330	7	70	70	200	260	390	390	390
11.88	118	405	3430	7	78	78	220	285	405	405	405
13.95	100	430	3610	7	92	92	255	320	430	430	430
14.77	95	435	3690	7	97	97	270	325	435	435	435
16.79	83	450	3860	7	111	111	310	335	450	450	
18.60	75	450	4050	7	123	123	335	345	450	450	
21.93	64	450	4370	7	146	146	350	360	450		
24.99	56	450	4640	6	166	166	370	375			
26.31	53	450	4750	6	175	175	370	380			

Table 28a: RINGFEDER GWB AK [24]

Size	L	C	$d_1;d_2$ min-max	B	D_1	C_1	L_1	L_4
	mm	mm	mm	mm	mm	mm	mm	mm
30	52/60	31	9 - 20	56	55	20	45/53	30/38
60	63/73	37	12 - 25	66	64	25	55/65	35/46
80	79/91	51	15 - 35	82	80	30	72/83	49/61
150	79/91	51	15 - 35	82	80	30	72/84	49/61
200	80/93	51/56	15 - 42	90	90	30	72/85	50/63
300	93/104	62/75	15 - 50	110	110	33	80/93	56/67
500	102/113	75/80	24 - 55	122	119	38	94/105	61/72
800	170	92/100	30 - 70	157	140	60	150	110
1400	170	92/100	35 - 70	157	140	60	150	110
3000	191	100/125	50 - 80	199	190	60	171	131
5000	199	100/125	60 - 90	250	230	65	179	139

Table 28b: RINGFEDER GWB AK [24]

Size	T	n_{max}	C_{Tdyn}	C_r	C_a	ΔK_a	ΔK_w	ΔK_r	J	D_{G1}	T_{A1}	Gw
	Nm	1/min	10^3 Nm/rad	N/mm	N/mm	mm	degree	mm	10^{-3}kgm²	mm	Nm	kg
30	36	11000	35/25	720/220	50/30	0,4/0,5	1,0/1,5	0,1/0,2	0,15	6 x M4	3	0,281
60	72	9100	75/50	1100/330	90/55	0,4/0,5	1,0/1,5	0,1/0,2	0,24	6 x M6	8,5	0,482
80	96	7000	130/75	1200/400	80/55	0,4/0,5	1,0/1,5	0,2	0,65	6 x M6	10	0,846
150	180	7000	150/100	2000/600	150/85	0,4/0,5	1,0/1,5	0,2	0,65	6 x M6	14	0,846
200	240	6700	170/120	2500/450	150/85	0,4/0,5	1,0/1,5	0,2	0,87	6 x M6	14	1,005
300	360	5200	318/500/280	6300/1500	235/280/150	0,4/0,5	1,0/1,5	0,2	2,33	6 x M8	18	1,915
500	600	4600	680/310	8800/1000	100/85	0,5/1,0	1,0/1,5	0,2	5,73	6 x M8	26	2,448
800	800	3700	760	510	190	1,0	1,5	0,2	26,10	6 x M16	50	9,978
1400	1400	3700	1300	710	280	1,0	1,5	0,2	26,10	6 x M16	80	9,202
3000	3000	2800	2800	8060	880	1,0	1,5	0,2	86,83	6 x M16	130	14,57
5000	5000	2800	4800	9190	737	1,0	1,5	0,2	170,30	6 x M16	210	24,3