THE EFFICIENCY STUDY OF BELT CONVEYOR FOR SOLVING BATTS ACCUMULATION PROBLEM

by

HUSNI BT MOHAMAD FADZIL
(1532121582)

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Author

Husni Bt Mohamad Fadzil

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AGV	Automated guided vehicles
CAD	Computer aided design
CAE	Computer aided engineering
EMS	Electrical monorail system
FEM	Finite element method
FF	Formaldehyde free
PIW	Pound per Inch of Width
UNLD	Unload

LIST OF SYMBOLS

V_C	Constant velocity
L_d	Length of conveyor
β_0	Intercept
B_j	Coefficient (j = 1, 2, …, k)
ε	Accidental component of the regression model
T_d	Delivery time
v_c	Conveyor velocity
R_f	Material flow rate
R_L	Loading rate
T_L	Loading time
T_U	Unloading time
s_c	Center-to-center spacing
n_p	Number of parts per carrier

Kajian Kecekapan Tali Sawat Untuk Menyelesaikan Masalah Pengumpulan Batts

ABSTRAK

Sistem pengangkutan bahan digunakan dalam bidang pembuatan dan perkilangan untuk memindahkan barang dari satu lokasi ke lokasi yang lain. sistem tali sawat merupakan salah satu jenis pengendalian mekanikal yang biasa digunakan untuk memindahkan barang dari satu lokasi ke lokasi yang lain. Sistem tali sawat yang merupakan sebuah sistem yang cepat dan cekap untuk mengangkut pelbagai jenis barang membuatkan sistem ini digunapakai secara meluas di dalam industri pengendalian dan pembungkusan barang. Sekiranya berlaku permasalahan semasa proses pengeluaran sedang berlangsung, ia akan menyebabkan proses penghantaran barang terganggu. Oleh itu, kajian ini menjalankan analisa mengenai masalah pengumpulan produk *Batts* yang berlaku di syarikat PGF Insulation Sdn. Bhd.akibat daripada perbezaan masa untuk memuatkan barang di antara dua tali sawat yang berbeza. Sebuah analisa matematik yang menggunakan analisa tali sawat satu arah digunakan untuk mengkaji kecekapan tali sawat dan sebuah rekabentuk tali sawat yang baharu dicadangkan untuk mengatasi masalah ini. Hasil daripada kajian menunjukan rekabentuk tali sawat yang baharu adalah lebih baik disebabkan oleh masa untuk memuatkan barang adalah lebih lama atau sama berbanding dengan masa untuk memunggahkan barang. Rekabentuk tali sawat yang baharu ini memenuhi garis panduan dalam mengatasi permasalahan pengumpulan *Batts* secara teorinya.

THE EFFICIENCY STUDY OF BELT CONVEYOR FOR SOLVING BATTS ACCUMULATION PROBLEM

ABSTRACT

Material transport systems are used in manufacturing and production environments to take materials from one location to another. A conveyor system is a common piece of mechanical handling equipment that moves materials from one location to another. Conveyor systems allow quick and efficient transportation for a wide variety of materials, which make them very popular in the material handling and packaging industries. If problems occur on conveyor system during running production, it can disturb the flow of materials transportation. Thus, this study presents Batts accumulation problems that occur in PGF Insulation Sdn. Bhd. due to the tolerance between loading time and unloading time from two conveyors. A mathematical analysis is done using single direction conveyor analysis to find the conveyors efficiency and a new design for conveyor is proposed in order to overcome the problem. Result shows that the new conveyor design is better since the loading time is equal or more than unloading time. The new conveyor design is meet the theoretical rules to overcome the Batts accumulation problem.

CHAPTER 1 : INTRODUCTION

1.1 Overview

According to the Material Handling Industry of America (2017), material handling is a movement, storage, protection and control of materials throughout the manufacturing and distribution process, including their consumption and disposal. The material transportation should be designed with safety, can perform efficiently, at low cost, in timely manner, and operate accurately in order to deliver the right materials in the right quantities to the right location and can deliver materials without damage. Material handling is often overlooked in the general scheme of production. As stated by Frost & Sullivan (2008), material handling can account for 30-75% of production costs and can reduce operational costs by 15-30%. Hence it does become an obvious area of focus for any productivity enhancement and cost reduction movement.

Material handling equipment includes material transport equipment, material storage systems, material unitizing equipment, and identification and tracking systems. Material transport equipment can be fall into five categories as follows:

i) Industrial trucks
ii) Automated guided vehicles (AGV)
iii) Monorails and other rail guided vehicles
iv) Conveyors
v) Cranes and hoists.

Material transport systems are used in manufacturing and production environments to take materials from one location to another. This study is going to focus on belt conveyors as transport system. A conveyor system is a common piece of mechanical handling equipment that moves materials from one location to another. Conveyors are especially useful in applications involving the transportation of heavy or bulky materials. Conveyor systems allow quick and efficient transportation for a wide variety of materials, which make them very popular in the material handling and packaging industries. Many kinds of conveying systems are available and are used according to the various needs of different industries. Some of the common conveyors that being used in manufacturing industries are belt conveyors, chain conveyors, and gravity conveyors.

According to Kumar & Mandloi (2013), a belt conveyor system consists of two or more pulleys (sometimes referred to as drums), with an endless loop of carrying medium that rotates around them. One or both of the pulleys are powered, moving the belt and the material on the belt forward. The powered pulley is called the drive pulley while the unpowered pulley is called the idler pulley.

There are two main industrial classes of belt conveyors in manufacturing which are belt conveyor that handling general material such as moving boxes along inside production floor and the other class of belt conveyor is that the one which handling bulk materials and transport large volumes of resources and agricultural materials, such as grain, salt, coal, ore, sand, overburden and more.

Belt conveyors can now be manufactured with curved sections which use tapered rollers and curved belting to convey products around a corner. These conveyor systems are commonly used in postal sorting offices and airport baggage handling systems.

Usually belt conveyors are using powered conveyors since they are the most versatile and least expensive. Product is conveyed directly on the belt so both regular and irregular shaped objects, large or small, light and heavy, can be transported successfully.

1.2 Problem Background

PGF Insulation Sdn. Bhd. (Figure 1.1) has more than 33 years of experience in insulation industry which includes designing, manufacturing and distributing glass mineral wool insulation for energy efficiency and climate control. Since 1984, PGF Insulation has consistently demonstrated its ability to produce new products that improve quality of life in term of thermal insulation for building, acoustic resistance, fire protection and also improve indoor air quality.

Figure 1.1: PGF Insulation Sdn. Bhd.

The most trending products been manufactured are glass wool in blanket types and cube types which called Batts. The processes for both products are similar except for the packaging process. The glass is melted in foreheart at minimum 1000°C and been fiberized using fiberizer at minimum 900 rpm. The raw glass wool is then carried out from the letdown conveyor to oven for curing process. The curing process will ensure all the moisture is been eliminated from the product so that the quality of the products can be prevent. Then the product will go through the cold end area before packaging process (Figure 1.2). At cold section area, it's divided into two section which is section A for Blanket type processing and section B for Batts type processing. For section B area, accumulation always occur during changing conveyor from main conveyor to inclined up conveyor due to different speeds. From main line conveyor, it will go through to inclined-up conveyor. Inclined-up conveyor is a conveyor that carries the Batts from main line to the packaging machine. It is perpendicularly connected to the main line conveyor as shown in Figure 1.2.

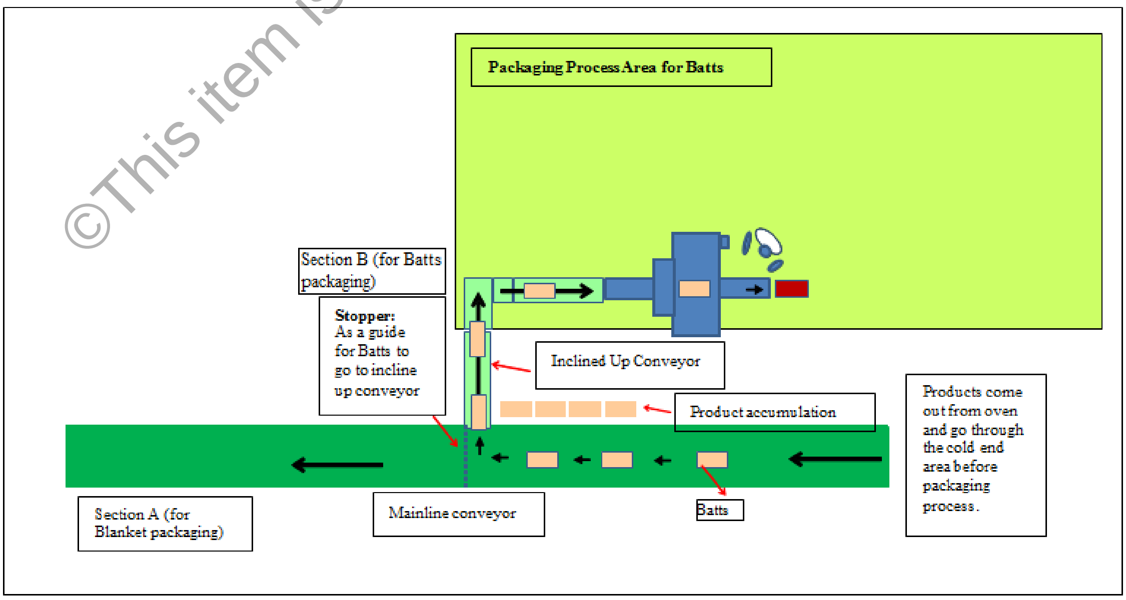

Figure 1.2: Cold-end area process layout

Main line conveyor speed is controlled by the density of the product and the glass pull rate from the main processes. Meanwhile, for inclined up conveyor, the speed is controlled at 30% higher than mainline conveyor speed. The engineers had been set up this parameter to create spacing centre-to-centre between the Batts and to avoid accumulation. Table 1.1 shows the parameter for mainline conveyor and inclined up conveyor.

Table 1.1: Conveyors Parameter

	Mainline Conveyor	Inclined Up Conveyor
Brand	Custom made by ICS Automation	Custom made by ICS Automation
Driver (Motor/Gravity)	TECO motor	TECO motor
Speed limit (m/min)	5 to 45	20 to 60
Length (m)	15	5

Generally Batts come in two size of width; 480 mm and 530 mm. They are been defined by their R-value which is a measure of thermal resistance. Thermal resistance is the ability of heat to transfer from low temperature to high temperature trough a medium such as insulation and wall. The thicker the Batts, the higher the R-value. This company is providing Batts with R-value from R2.0 to R4.1. By taking R4.1 Batts product as product to be study, main line conveyor is operated at speed of 27.5 m/min due to running low density product while inclined up conveyor will operate at 33 m/min. Unfortunately, as shown in Figure 1.3 below, the accumulation is still occurred during running production.

Figure 1.3: Accumulation area on production floor.

Theoretically, to avoid product accumulation, the speed for inclined up conveyor should be same or slower from main conveyor. Unfortunately, due to current machine capability and parameter setting, the product accumulations will occur when the production is running for low density products.

1.3 Problem Statement

During running low density products, the belt conveyors; main line conveyor and inclined-up conveyor, is having two different speed due to the current conveyors position is perpendicular to one another. Due to these, products will accumulate during running the production.

The focus of this study is to overcome the accumulations product by reducing the accumulation problem. Therefore, to overcome the accumulation, a mathematical analysis for conveyor is been done.

1.4 Objective

The objectives of this study are:

i. To identify the root cause of Batts' accumulation problem.

ii. To determine the efficiency of current conveyor design for Batts processing.

iii. To propose new conveyor design in order to reduce the accumulation problem.

1.5 Scope of Study

This study will focus on the different of conveyor speeds; 27.5m/min at main line conveyor and 33m/min at inclined-up conveyor, during running a low density product, R4.1 Batts. With this condition, the Batts will tend to accumulate at the entrance of the incline up conveyor.

CHAPTER 2 : LITERATURE REVIEW

2.1 Belt Conveyor System

As stated in Groover (2001), conveyors constituted in a large family of material transport equipment that are designed to move materials over fixed paths, which generally in large quantities or volumes. There are many types of conveyors in industries and some of the most common are roller conveyors, belt conveyors and tow line conveyors. It can be either powered or non-powered. Powered conveyors are distinguished from other types of powered material transport equipment in that the mechanical drive system is built into the fixed path. While for non-powered conveyors are activated either by human or by gravity.

Belt conveyors can now be manufactured with curved sections which use tapered rollers and curved belting to convey products around a corner. These conveyor systems are commonly used in postal sorting offices and airport baggage handling systems. A sandwich belt conveyor uses two conveyor belts, face-to-face, to firmly contain the item being carried, making steep incline and even vertical-lift runs achievable.

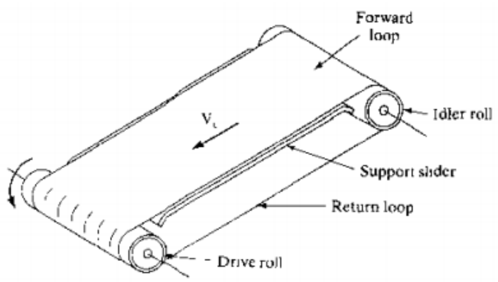

Figure 2.1: Belt (flat) conveyor (Groover, 2001)

Belt conveyors consist of a continuous loop which is half of its length is used for delivering materials while the other half is the return run. The belt is made of reinforced elastomer (rubber), so that it possesses high flexibility but low extensibility. At one end of the conveyor is a drive roll that powers the belt. The flexible belt is supported by a frame that has roller or support sliders along its forward loop. Belt conveyors are available in two common forms which are:

i) Flat belts (as shown in Figure 2.1): pallets, individual parts or certain types of bulk materials
ii) Troughed belts: bulk materials

Materials placed on the belt surface travel along the moving pathway. In the case of troughed belt conveyors, the rollers and supports give the flexible belt a V-shape on the forward (delivery) loop to contain bulk materials such as coal, gravel, grain, or small particulate materials.

Groover (2001) also stated that conveyor systems are divided into two basic types in terms of characteristic motion of the materials moved by the system which are continuous and asynchronous. Continuous motion conveyors move at a constant velocity, V_c, along the path. They include belt, roller, skate-wheel, overhead trolley and slat conveyors.

Asynchronous conveyors operate with a stop-and-go motion in which loads, usually contained in carriers, move between stations and then stop and remain at station until released. Asynchronous handling allows independent movement of each carrier in the system. Examples of this type include overhead power-and-free trolley, in-floor towline, and cart-on-track conveyors. Some roller and skate-wheel conveyors can also be operated asynchronously. The reasons for using this type of conveyors are to accumulate loads, for temporary storage, to allow for differences of production rates between adjacent processing areas, to smooth production when cycle times vary at stations along the conveyor, and to accommodate different conveyor speeds along the pathway.

Groover (2001) also stated that conveyor system can be classified into three categories. There are single direction conveyors, continuous loop conveyors and recirculating conveyors. Single direction conveyors are used to transport load one way from origination point to destination point as shown in Figure 2.2. Length of conveyor between load station, LOAD, and unload station, UNLD, is stated as L_d and the conveyor velocity is stated as V_c. These systems are appropriate when there is no need to move loads in both directions or to return containers or carriers form unloading stations back to the loading stations. Single direction powered conveyors include roller, skate wheel, belt, and chain-in-floor types. In addition, all gravity conveyors operate in one direction.

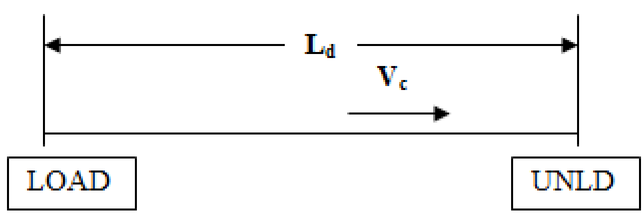

Figure 2.2: Single Direction Conveyor (Groover, 2001)

Continuous loop conveyors form a complete circuit as shown in Figure 2.3. An overhead trolley conveyor is an example of this conveyor type. However, any conveyor type can be configured as a loop, even those previously defined as single direction conveyors, simply by connecting several single direction conveyor sections into a closed loop. Continuous loop conveyors are used when loads are move in carriers between loads, LOAD, and unload, UNLD, stations and the carriers are affixed to the conveyor loop. The loads are move in constant velocity, V_c. In this design, the empty carriers are automatically returned from the unload station back to the load station.

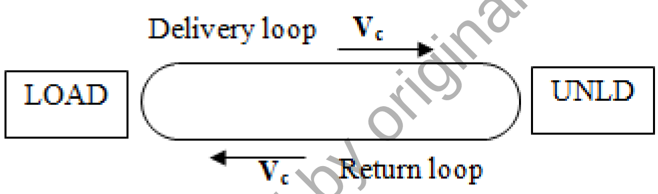

Figure 2.3: Continuous loop conveyor (Groover, 2001)

The preceding description of a continuous loop conveyor assumes that items loaded at the station and unloaded at the unload station. There are no loads in the return loop. The purpose of the return loop is simply to send the empty carriers back for reloading. This method of operation overlooks an important opportunity offered by a closed loop conveyors which is to store as well as deliver parts. Conveyor systems that allow parts to remain on the return loop for one or more revolutions are called recirculating conveyors. In providing a storage function, the conveyor system can be used to accumulate parts to smooth out effects of loading and unloading variations at stations in the conveyor. There are two problems that can plague the operation of a recirculating conveyor system. One is that there may be times during the operation of the conveyor that no empty carriers are immediately available at the loading station when needed. The other problem is that no loaded carriers are immediately available at the unloading station when needed.

It is possible to construct branching and merging points into a conveyor track to permit different routings for different loads moving in the system. In nearly all conveyor systems, it is possible to build switches, shuttles, or other mechanisms to achieve these alternate routings. In some systems, a push-pull mechanism or lift-and-carry device is required to actively move the load from the current pathway onto the new pathway.

Chen (2010) had done a study for a company called Chaohu Machinery Manufacturing Co. Ltd.. The study was to get a better method to optimizing and fully optimized the belt conveyor for manufacturing process. Understanding a few basic principles of belt/structure compatibility is essential to achieve an optimum system performance. Without it even a new material handling system can be doomed to inefficiency and lost production. The rated strength of the belt is expressed as PIW, an abbreviation for Pounds per Inch of Width. This rating is based on the type of ply material, number of plies, and if it is steel cable belt, the size of the cables. The higher the rated tension of the belt, the more critical the compatibility of the belt and structure becomes. For instance, a 3-ply belt may have each ply rated at 110 PIW, which translates to a 330 PIW belt. This is the maximum rated tension at which the belt can be operated without damage. Exceeding the rated tension of the belt will likely cause breakage, excessive stretch, splice failure, and belt cupping. Factors that affect the rated tension are belt length, width, material, angle of incline, and parasitic drags, such as the size and quantity of rolling components, belt cleaners, and length of transition sealing systems.

2.2 Conveyor Belt as Material Transportation

Conveyor belts are being used widely in any industrial areas as material transportation systems due to the flexibility and less maintenance needed. Joppe (2011) has made a study on transportation systems to be applied in mine-mouth power plants to bring coal from the mining area to the storage or usage area. Conveyor belts is one of the material transportation system that can be used for coal transport in hilly terrain where roads are relatively inaccessible, typically being used to move coal over 10km to 30km distances. The only adverse environmental impacts of conveyor belts for coal transport are coal dust losses during loading, unloading, or transport.

Joppe (2011) had emphasis on hydraulic coal transport a feasible alternative in comparison to more conventional barge or conveyor belt transport. The study was done at South Kalimantan mining area. According to Joppe (2011), in 2009, a company called BSS had done an investigation on the possibility of constructing a conveyor belt between Lok Buntar and Sungai Puting to transport the coal (refer to Figure 2.4). A detailed design of the whole conveyor belt is made by the constructing company called Laing O'Rourke. This design is used to compare the conveyor belt with the other transport modes. All information about the construction of a conveyor belt from Tatakan to Sungai Puting is based on the design of Laing O'Rourke.

The conveyer belt from Tatakan to Sungai Puting consists of four different parts. The different parts are connected with each other by a so called transfer chute. At these transfer chutes one conveyor is goes up several meters and the coal falls down at the next conveyor. The block schematization for conveyer belt transport is made according to the American design guidelines. The block schematization is different from the block schematizations for barge transport and hydraulic transport, not used to make a detailed design of a conveyor belt. However, the block schematizations give an overview on the parameters which are important in designing a conveyor belt. It is interesting to recognize the similarities between conveyor belt transport and hydraulic transport where in hydraulic transport, friction head is important to determine the required energy. With designing a conveyor belt, the belt tension is the measurement for the calculation of the required energy.

From the study, Joppe (2011) conclude that transportation by conveyor belt between Tatakan and Sungai Puting is a relative cheap alternative. In particular the power costs are relative low. This is of big advantage, since the costs for fuel are probably going to increase the next couple of years.

Figure 2.4: Example of Coal Conveyor in Indonesia (Joppe, 2011)