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SMART ENERGY EFFICIENT CONVEYOR SYSTEM

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SMART ENERGY EFFICIENT CONVEYOR SYSTEM

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ABSTRACT

Conveyor Systems (CS) begin with a conveyor belt in the beginning before the design has been upgraded from time to time. Since CS was invented two centuries ago, the main issue in the latest update is energy management. One of the main concerns in the CS issue is related to energy efficiency and power consumption, which lead to the issue of energy costs becoming too high, so there has been a lot of research done to address the energy management problem in CS. This project proposes and implements an approach for an energy-efficient CS, focusing on the improvement of energy management is CS by intelligently adjusting the speed and power of the conveyor belts by recognizing the weight of the object being transported. A smart energy management strategy controller is developing a working via rule-based Energy Management System (EMS) that aims to revolutionise the application of CS in an effort to bring it to a rural industry to boost productivity while maintaining low-cost energy usage from a simulator scenario. From the simulated scenario, the evaluation of integrated CS with smart EMS demonstrated remarkable results, showcasing an impressive power-saving capability of up to 80 percent compared to conventional conveyors. Overall, this final-year project has demonstrated the potential for integrating smart technology into Small-Scale Industries (SSI) conveyors technology.

ABSTRAK

Sistem Penghantar (SP) bermula dengan tali sawat penghantar pada permulaannya sebelum reka bentuk telah dinaik taraf dari semasa ke semasa. Sejak SP dicipta dua abad yang lalu, isu utama dalam kemas kini yang terbaru ialah pengurusan tenaga. Salah satu kebimbangan utama dalam isu SP adalah berkaitan kecekapan tenaga dan penggunaan kuasa, yang membawa kepada isu kos tenaga menjadi terlalu tinggi, jadi terdapat banyak penyelidikan yang dilakukan untuk menangani masalah pengurusan tenaga dalam SP. Projek ini mencadangkan dan melaksanakan pendekatan untuk SP yang cekap tenaga, memfokuskan kepada peningkatan pengurusan tenaga iaitu SP dengan melaraskan kelajuan dan kuasa tali sawat penghantar secara bijak dengan mengenali berat objek yang diangkut. Pengawal strategi pengurusan tenaga pintar sedang dibangunkan melalui kerja Sistem Pengurusan Tenaga (SPT) berasaskan peraturan yang bertujuan untuk merevolusikan aplikasi SP dalam usaha untuk membawanya ke industri luar bandar bagi meningkatkan produktiviti sambil mengekalkan penggunaan tenaga kos yang rendah daripada senario simulator. Menurut senario simulasi, penilaian SP bersepadu dengan SPT pintar menunjukkan hasil yang luar biasa, mempamerkan keupayaan penjimatan kuasa yang mengagumkan sehingga 80 peratus berbanding penghantar konvensional. Secara keseluruhannya, projek tahun akhir ini telah menunjukkan potensi untuk menyepadukan teknologi pintar ke dalam teknologi penghantar Industri Berskala Kecil (IBK).

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LIST OF ABBREVIATIONS

CS	-	Conveyor Systems
DC	-	Direct Current
EMS	-	Energy Management System
IEA	-	International Energy Agency
PWM	-	Pulse Width Modulation
RPM	-	Revolutions Per Minute
SSI	-	Small-Scale Industries
SEECS	-	Smart Energy Efficient Conveyor System

LIST OF SYMBOLS

F	-	Force
P	-	Power
τ	-	Torque
v	-	Velocity

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CHAPTER 1

INTRODUCTION

1.1 Background

The first Conveyor System (CS) was created by Thomas Robin for the coal industry in 1892. The primary objective of this innovation was to facilitate the transfer of materials with little or no human intervention [1]. Steel CS were created in 1901 by the Swedish company Sandvik. The steel CS made it possible for companies to employ conveyors in demanding and complex processes, which Thomas Robins' original design lacked [1]. depicts the first long belt conveyor used in industry centuries ago. Besides, Henry Ford, the well-known vehicle maker, is another important figure in the history of the conveyor belt which being credited with bringing the concept of a conveyor belt assembly line to his Michigan factory, where he worked, and with continually improving the technology behind the system. By doing so, Ford brought CS into the mainstream, which only served to increase their appeal [2].

In term of its development, CS are started with belt conveyor in the beginning before the design have been upgraded from time to time. Since the CS have been invented in two centuries ago, the main concern in latest update is about the energy management of the CS. Due to the fact that CS uses more energy in industries expense throughout the years, which means the cost of buying electricity is high and expensive. In addition, certain material handling and manufacturing processes such as CS can be automated to increase productivity and efficiency while also saving some expense. In relation to this issue, Figure 1.1 shows a result research of electric power consumption versus belt speed [3]. The line graph is increasing with the higher belt speed, the higher electric power used by meaning that belt speed influence toward the electric power.

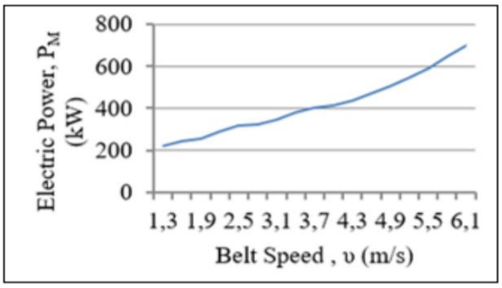

Figure 1.1 The relationship between electric power use and belt speed at a steady feed rate of T = 65.4 t/h.

Theoretical and practical study in [4] has shown that the high energy costs associated with the conveyance of cargo by a belt conveyor are attributable to the significant non-uniformity of an input cargo flow that creates a load on a conveyor that is not the maximum attainable. In fact, the requirements of energy management in CS are a big problem that has to be solved given the increasing demand that exists in businesses. Since the CS is such a crucial component in each and every business, there is an urgent need for improvements to be made in terms of its energy efficiency.

Furthermore, research discovered that lower consumer costs, less fuel imports, and fewer emissions are currently observed in nations that have made significant efforts to increase energy efficiency during the past few decades [5]. From both a financial and an environmental point of view, industries are put under a lot of pressure to improve the patterns of their energy usage. The reason to this is mining sector has been compelled to upgrade Energy Management System (EMS) and the technologies of operations that use a lot of energy in order to comply with sustainable development guidelines and energy legislation [6]. The legislation that pertains to energy efficiency from International Energy Agency (IEA) [7], which was most recently modified on November 15th, 2021, states:

> *Law 47-09, or the "Law on Energy Efficiency" aims to increase energy efficiency in the use of energy sources, to avoid waste, to reduce the energy costs on the national economy, and to enhance sustainable development. The law includes a range of measures such as mandatory energy audits, minimum energy performances standards for appliances and preferential tariffs (known as super-peak tariffs) for industries that voluntarily shift their energy consumption away from peak periods.*
>
> (IEA, Law 47-09)

According to the data from [8] as displayed in Figure 1.2, there has been a significant increase in the amount of research into the pattern of energy efficiency in recent years. According to the structure of the graph, it demonstrates that there has been an increase in research into energy-efficient practices from one year to the next. The published line in red indicates that there has been an exceptionally rapid increase in recent years. This demonstrates that energy efficiency is a fascinating topic for researchers to study at the present time in the context of trending research. The main explanation for this is that humans are becoming more conscious of the importance of energy efficiency in this day and age. In point of fact, the primary concern is how to implement energy efficiency measures inside the CS that will be utilised by the small-scale manufacturing business. Thus, the application of a smart EMS method to the conveyor will ensure that it complies with the energy efficiency standards.

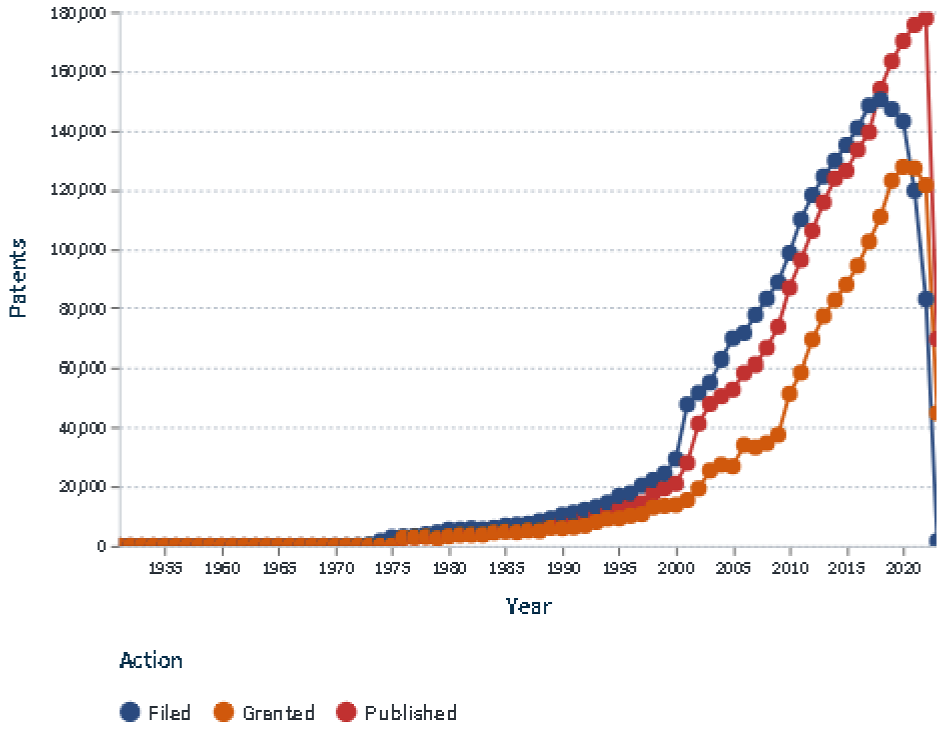

Figure 1.2	Energy efficiency research pattern from lens.org.

In fact, the rising demand for energy does have a negative impact on the surrounding ecosystem as well. Internationally, energy consumption is by far the major contributor to greenhouse gas emissions resulting from human activity [9]. Approximately two-thirds of worldwide emissions of greenhouse gases are attributable to the fossil fuel combustion for energy used in heating, power generation, transportation, and industry [9]. According to the data presented, the production of electricity and heat are the two factors that are responsible for the biggest number of emissions of greenhouse gases [10].

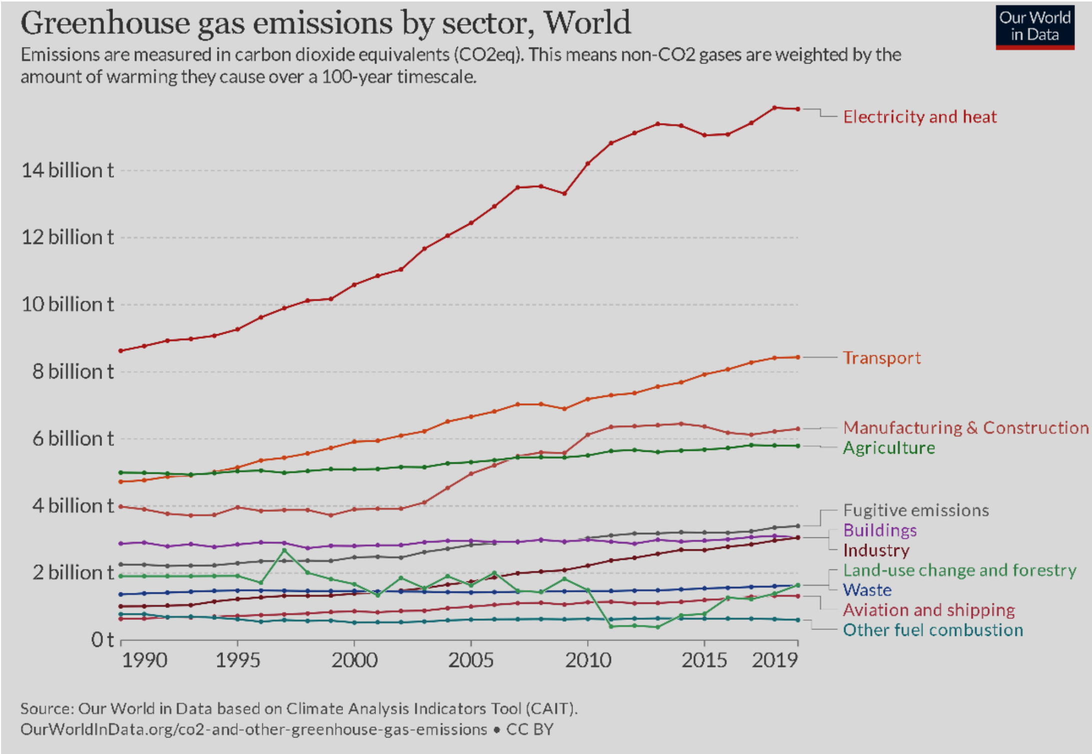

Figure 1.3 Greenhouse gas emissions by sector.

1.2 Problem Statements

CS implementation is expensive, and small businesses are concerned about the price that electricity would cost them**.** The cost associated with implementing CS can be a significant concern for small businesses. The initial investment required for purchasing and installing CS, along with the ongoing operational costs, such as electricity consumption, can pose financial challenges. Small businesses, with limited resources, may hesitate to adopt CS due to the potential impact on their overall expenses.

Next, the weight of the items being carried is not considered by a conventional CS, which does not practice energy efficiency**.** Conventional CS typically operate at a fixed speed, irrespective of the weight of the items being transported. This lack of consideration for item weight often leads to energy inefficiencies. When the conveyor belt runs at a constant speed, regardless of the load, energy is wasted as the motor exerts unnecessary effort. This inefficient energy usage contributes to increased electricity consumption and higher costs for businesses.

In addition, the practicality of the use of CS in small industries is unproven and needs further investigation**.** While CS have long been utilized in large-scale industries, their practicality and effectiveness in small industries are yet to be established. Small businesses operate under different constraints, such as limited space, budget, and operational requirements. It is essential to investigate whether CS can effectively address the specific needs and challenges faced by small industries. This investigation involves evaluating factors such as adaptability, scalability, cost-effectiveness, and overall feasibility in the context of small-scale industries (SSI) operations.

By addressing these points in the problem statement, it highlights the financial concerns of small businesses regarding CS implementation, the energy inefficiencies of conventional systems, and the need to investigate the practicality of using conveyors in small industries. This sets the stage for proposing an energy-efficient CS that considers item weight and demonstrates its potential benefits for SSI operations.

1.3 Research Objective

The objectives of the research are:

(a) To design a CS suitable for SSI.

(b) To develop a smart EMS for CS, focusing on the optimization of power consumption.

(c) To evaluate the performance of the integrated CS with smart EMS.

1.4 Scope of Project

The scope of this project is centered around the optimization of energy efficiency within the prototype CS designed for SSI. The focus is to develop a solution that effectively manages and reduces energy consumption during operation, thereby addressing the concerns of small businesses regarding escalating electricity costs.

Flexibility in the specifications of the CS prototype is a key consideration, allowing for potential modifications to suit different application requirements. The design will emphasize modularity, enabling customization and adaptability to accommodate diverse industry needs.

Automation will be integral to the system plan, ensuring streamlined and efficient conveyor operations. However, to account for unforeseen circumstances or specific operational adjustments, an override feature will be implemented. This manual control capability empowers operators to intervene when necessary, ensuring optimal system performance and adaptability to varying operational conditions.

While the project does not incorporate battery-powered functionality for portability, the real-world applications of the CS will necessitate the use of power sockets. The system will be engineered to seamlessly interface with standard power sources commonly found in industrial environments. This approach ensures practicality and compatibility with existing infrastructure, facilitating seamless integration and widespread implementation.

The optimization of energy efficiency, offering flexibility in specifications, incorporating automation with manual override functionality, and accounting for power socket reliance in real-world applications, this project strives to deliver an advanced CS tailored to the specific needs of SSI. The ultimate aim is to foster sustainable energy management practices and alleviate the financial burden associated with electricity consumption for small businesses.

1.5 Report Outline

This report is divided up into five chapters, and each of those chapters will provide more specific information on this project.

In chapter 1, we will introduce the background research, which is related to the current problem of energy management of CS. A concise overview of this project was presented, which included the problem statement that generated the inspiration with this project, the objectives, the scope of project for as a guideline to properly deliver the project, and a chapter summary.

Chapter 2 is a literature review, which will provide an explanation and an analysis of the past work that has been performed by other researchers. It is regarded as a study of current findings about the strategies that are employed to maximize energy efficiency in the CS.

In chapter 3, the strategy and method that were used for this project are discussed. It included project flow charts, an energy efficiency strategy for the CS, and a computation for power consumption, among other aspects. They were then followed by the technique or method that will be used to maximize the Smart Energy Efficient Conveyor System (SEECS), the fundamental model or components that are necessary for this project, as well as the software and hardware development that will be utilized to simulate and deliver the outcome.

In chapter 4, the data analysis of the outcomes, including graphs derived from the observations that have been made, is the topic of discussion. The findings will be interpreted in the table, and then the table's rationale will be discussed. While this is going around, there are different categories of weight condition that are included: no load, light load, medium load, heavy load, and overweight load. In this chapter, the comparison of all the data has been presented in detail.

In the last chapter 5, conclusions are deduced from the finding according to the experimental work that address the objective. The future recommendation also included that may be required for this project.

1.6 Summary

This chapter's summary can be evaluated in terms of the history of CS, demand of energy efficiency, law of energy efficiency, problem statements, research objective, project scopes, and outline of the report. The smart technology which is smart EMS will enable a more effective utilisation of energy. Thus, conclusion is that the efficiency of the system will increase proportionately to the decrease in the total cost.

The smart EMS of CS development's contribution to the SSI sector is that it can produce high productivity. In addition to this, there is the potential to make considerable cost reductions with regard to the consumption of energy across the facilities used. Last but not least, there is the possibility of lowering down on both the demand for energy and the emissions of greenhouse gases.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This chapter's primary focus is on providing a description of and background material pertaining to the idea of a SEECS. When compared to the conventional CS, the information that has been gained about technology can be applied to improve the way that energy is managed in order to make it more efficient.

2.2 CS in Industries

CS refers to a mechanical system that is employed in transferring items from one workstation to another and is used in the majority of processing and manufacturing sectors [11]. This system is employed in a lot of different industries. In order to move the belt, the CS utilizes a motor, which requires energy. The speed of the motor that is being utilized determines the source of the energy that is being applied. According to research, approximately 60 percentof the conveyors, whether loaded or emptied, are thought to be operating continually in the actual world [12]. The most frequent kind of CS employs standard configurations to ensure continuous operation of the conveyor while consuming a significant amount of power.

A CS that needed a lot of energy to carry the load onto the conveyor would render the system inefficient because of the high cost of the energy that it used. For instance, a big part of lowering the cost of extracting materials for mining businesses is lowering the cost of the electricity used to move the materials. At the typical loading of the CS, 20 percent of the cost of extracting the material is spent on transportation from the location of extraction to the location of distribution and processing [13]. Since