COST EFFICIENT MILK PRE-COOLING SYSTEM

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronics Engineering Technology (Industrial Electronics) with Honours

Faculty of Electronics and Computer Technology and Engineering
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I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electronics Engineering Technology (Industrial Electronics) with Honours.

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DEDICATION

To my beloved mother, GHIDHA and father, CHANDRAKUMAR

and

To my beloved brothers, YOGESH and KUMANAN and

My sisters, GOKILADEVI and DEVIA DARSHINI

and

ALL MY FRIENDS

ABSTRACT

Milk spoils quickly if not cooled immediately after extraction, but conventional cooling systems are costly and energy-intensive, posing challenges for small to medium-sized dairy farms. An economical milk pre-cooling system has been developed to address these issues, improving milk quality, reducing operating costs, and minimizing environmental impact. This system uses renewable resources and modern heat exchange technology, combining air and ground-source cooling with an insulated tank, and reduces milk temperatures from 35°C to below 10°C using a plate heat exchanger cooled with room temperature water. This method cuts energy consumption by 30-50% compared to traditional methods. The initial installation costs are recovered within two years due to lower power usage and extended milk shelf life, making the milk more marketable. Additionally, the system is simple to maintain and can be adapted to different farm sizes, ensuring accessibility for a broader range of farmers. The quick cooling process also significantly reduces bacterial growth, enhancing milk safety. By leveraging local renewable resources, the system minimizes dependency on external energy sources. Its environmentally friendly design aligns with global efforts to combat climate change. Overall, this pre-cooling system provides an efficient, cost-effective, and sustainable solution for the dairy industry. As a result, it supports farmers in balancing economic constraints with the need to deliver high-quality milk. The implementation of this system could revolutionize milk handling practices, paving the way for more resilient and eco-friendly dairy farming. It holds promise for improving the livelihoods of dairy farmers while meeting consumer demands for fresh, safe milk.

ABSTRAK

Susu merosakkan dengan cepat jika tidak sejuk segera selepas pengekstrakan, tetapi sistem sejuk konvensional mahal dan bertenaga, mewujudkan cabaran bagi ladang susu kecil hingga menengah. Sistem pra-penyejuk susu yang ekonomis telah dibangunkan untuk menangani isu-isu ini, meningkatkan kualiti susu, mengurangkan kos operasi, dan meminimalkan kesan alam sekitar. Sistem ini menggunakan sumber boleh diperbaharui dan teknologi pertukaran haba moden, menggabungkan pendinginan udara dan sumber tanah dengan tangki terisolasi, dan mengurangkan suhu susu dari 35 ° C kepada di bawah 10 ° C menggunakan pertukar haba plat yang sejuk dengan air suhu bilik. Kaedah ini mengurangkan penggunaan tenaga sebanyak 30-50% berbanding kaedah tradisional. Kos pemasangan permulaan dikembalikan dalam tempoh dua tahun kerana penggunaan tenaga yang lebih rendah dan masa pakai susu yang lebih panjang, menjadikan susu lebih boleh diperdagangkan. Selain itu, sistem ini mudah untuk mengekalkan dan boleh disesuaikan untuk saiz ladang yang berbeza, memastikan aksesibiliti untuk pelbagai ladang. Proses sejuk yang cepat juga secara signifikan mengurangkan pertumbuhan bakteria, meningkatkan keselamatan susu. Dengan memanfaatkan sumber boleh diperbaharui tempatan, sistem ini mengurangkan ketergantungan kepada sumber tenaga luaran. Secara keseluruhan, sistem pra-penyejuk ini menyediakan penyelesaian yang cekap, kos dan berkelanjutan untuk industri susu. Hasilnya, ia menyokong petani dalam menyeimbangkan sekatan ekonomi dengan keperluan untuk membekalkan susu berkualiti tinggi. Implementasi sistem ini boleh merevolusi amalan pengendalian susu, membuka jalan untuk pertanian susu yang lebih tahan lama dan mesra alam. Ia menjanjikan untuk meningkatkan persekitaran hidup petani susu sambil memenuhi permintaan pengguna untuk susu segar dan selamat

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First and foremost, I would like to express my gratitude to my supervisor, MR. TS TG MOHD FAISAL BIN TENGKU WOOK for their precious guidance, words of wisdom and patient throughout this project.

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LIST OF SYMBOLS

≥	-	Greater-than or Equal To
≤	-	Lesser-than or Equal to

LIST OF ABBREVIATIONS

cfu/mL	-	colony-forming unit per millilitre.

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CHAPTER 1

INTRODUCTION

1.1 Background

When extracted milk is a very sensitive product which begins to spoil as it is if not cooled down as soon as possible. Although effective in preservation of milk, the conventional cooling systems are costly and demand excessive energy. For small to medium scale dairies, the costs of put in place equipment and maintaining these systems may be very expensive. These farms can face difficulties in achieving profitability owing to the high costs of energy in conventional cooling systems.

Milk cooling practices besides being expensive also pose environmental problems due to their impact on the environment. Gas production and usage in large quantities make it difficult for the dairy sector to embrace sustainability. These systems are highly inefficient especially because they require constant repairs and replacement of their components, which means that they generate waste and are expensive. This is why it is critical that a new approach be developed that is less expensive, in addition protective of the environment.

This was the case and more affording and environmental friendly cooling options are becoming more vital to meeting the issues. Based on the modern heat exchange technology and cheap, renewable resources, the innovative system of milk pre-cooling is developed. It allows extension and preservation of the shelf life of this product while preserving its quality and decreasing energy consumption thousands of times. This means that this pre-cooling system offers a viable and environmental solution for the small to medium dairy farms since it’s cheaper while at the same time being friendly to the environment.

1.2 Problem Statement

A challenge that small scale dairy farmers face is high cost and energy consumption of normal cold milk storage facilities which is very important in maintaining safety of the milk as well as its quality. These are marked by high operating costs and impacts on the greenhouse gas since most of them are economically unfeasible and environmentally unsustainable. A very viable method of reducing temperatures at which milk is stored immediately after milking is therefore required to be cost effective and energy efficient in order to minimize wastage through spoilt milk. It should also be affordable and can be used by small-scale farmers since they are the most affected by biotic factors. This programme aims at developing and implementing a model that could address these environmental and economic challenges, enhancing the sustainability and profitability of small scale milk production.

1.3 Project Objective

The objective of the project is to design and integrate an efficient low-cost milk precooling system into small-scale dairy farms. The primary objective are:

a) To engineer a stable solution that efficiently cools raw milk, and manages fluctuating quantities of milk together with varying conditions that can go hand in hand with the milk; it has to meet the set standard and ensure it doesn't compromise the quality of the milk that enters the next stages of production.

b) Optimizing energy and operative expenses by adopting new technologies, increasing the effectiveness of the energetic system, and lowering the ecological footprint.

c) In fulfilling the set goal the system shall have to meet food safety and quality requirements in the industry with easy maintenance and operation supported by training to farm staff.

1.4 Scope of Project

The research for this project will include an assessment of cooling needs and challenges of small-scale dairy farmers and get feedbacks from the regulatory body, industry, and farmers. It aims at developing a pre- cooling system that meet these specifications while considering the Production Standards and the Food Safety measures in the industry. But before these prototypes are deployed in the real and actual environment on some farms, they are going to be tested in ways that will ensure that they meet both design and legal specifications. Data collected from field tests will be useful for making enhancements to the system design that will enhance the systems productivity. For potential cost reduction and environmental benefits, an analytical assessment of the energy utilized by the system and cost incurred against traditional refrigeration methods will also be made. Measures for ensuring the deployment and operation will include training materials and continuing help and preparation for scaling and adaptations to diminish dependency on shifting agricultural requirements and environmental conditions in the future. Therefore, the general objective of the project is to support the dairy farmers on their endeavour to make their business more financially sustainable and environmentally friendly by providing a practical, cost efficient,

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

An important aspect to consider when buying milk form dairy farmers is to ensure the milk does not spoil, for this purpose an effective cooling technique must be employed urgently, the different cooling techniques are discussed in the literature review of the milk pre-cooling system. It begins by specifying on the need to cool milk immediately after extracting it to ensure it does not go off quickly and its shelf life is extended. In this introductory literature review, the author describes the challenges S-M DFs face in employing traditional cooling methods such as high energy costs and continuous expenses included in the operation of refrigerated equipment. It also put emphasis on the drawbacks associated with traditional techniques in cooling, which includes water consumption and greenhouse gas emissions, these have called for innovative ways of cooling. Subsequently, the paper reviews current development and studies of milk pre-cooling systems for modern dairy industries and pay particular attention to recent efforts, aimed at the development of new approaches designed to mitigate the weakness inherent to prior approaches. It accentuates information on integration of renewable energy resources like ambient air and ground-source cooling; advancements in heat exchange technology; and insulated cooling tanks. The effectiveness of these technologies is judged by how fast and how well they can solve the problem of reducing and stabilizing the temperature of the milk product while at the same time preserving the quality of the product, reducing energy costs, operating costs and being eco-friendly. However, the review identifies that the current scientific studies of pre-cooling systems may not accurately reflect the dairy farm conditions in terms of effectiveness, In addition to ascertaining field tests as well as performance measurements. This literature review presents comprehensive information on the subject of pre-cooling systems of milk to fill the existing gaps in knowledge and present key ideas for developing an effective, simple, and cost-effective technique for entrepreneurs in the dairy industry. This review provides the design and optimization of a pre-cooling system that addresses the need of the small to medium- scale dairy enterprise while establishing and strengthening the existing knowledge base of a more general concern of efficiency, sustainability and milk quality preservation for pre-cooling systems in the dairy sector through identifying and interpreting available literature and development features.

2.2 Milk

Milk is a liquid secretion that is secreted by the mammary glands in mammals for feeding their young and it is a basic food ingredient that people consume globally. The substance composition involve water, protein, fat, carbohydrates, vitamins and minerals thus categorizing it under foods. Other molecules found commonly in milk include the proteins commonly referred as casein and whey, both of which are considered critical for growth and tissue remodelling. Protein help to support growth and repair body tissues, fat supplies energy and essential fat soluble vitamins and lactose, a type of carbohydrate, supplies energy also helps the body absorb calcium. Vitamins present in milk includes; vitamin A, D, E, K and vitamin B complex while the minerals available in milk include calcium, phosphorus, potassium, magnesium and zinc.

Skim milk is one type of milk which has been processed to remove all the fats and all the other types of milk are available in the market are categorized according to their fat content. 3. 5% of milk fat and therefore, replacing it with skim milk which is low in fat content is a significant change on the nutrient composition of the food product being manufactured. The mild flavor comes from its low fat five percent, which makes it an excellent source of energy and fat-soluble vitamins. Slim milk has 2% fat while the low fat milk has 1% fat and they contain lower calories yet they conduct important micro nutrients into our body. This includes products such as skim milk which contains less than 0. 5% fat, contains the lowest calories but most of the nutrients preserved in canner biscuits are within this category. Lactose free milk has lactose in it reduced so that it is ideal to be taken by people with intolerances to it. The copy shows that vegetable milks like soy, almond, oat, and rice milk exist for those who have dumped animal milk and those with sensitive system to dairy, although they contain variable nutrients compared to animal milk.

Milk itself is good for our health in many different ways. Presence of calcium and vitamin D to facilitate the health of bones and to avoid such diseases as osteoporosis and existence of strong teeth. It consists of proteins that help build muscles in the body for growth and repair, which is preferred for children, athletes, and the elderly. Milk also provides water in the diet because it contains water in a large quantity. Furthermore, two categories of products, low-fat and skim milk, should be also appreciated as important for weight control as they contain fewer calories but have all the necessary nutrients.

Total Plate Count (TPC) is one of the most common and important microbiological parameters for the assessment of the number of pathogenic microorganisms in the milk. TPC reflects the quality of milk and the levels of hygiene and sanitation practiced during the milking process as well as the efficiency of processing. High TPC values are associated with low hygiene levels, poor processing methods, and unsuitable storage conditions, thus making the milk unsafe for consumption and having a shorter shelf life. This involves sampling, using sterile containers, dilution of milk samples through a series of dilutions, plating it on agar surfaces, incubating the samples at 32 degrees Celsius for 48 hours, and counting the number of bacterial colonies which can be used to estimate the number of bacteria in a milliliter of milk (cfu/mL).

TPC is a measure of the number of bacteria in a given sample and dependent on the type of milk being measured, raw milk should contain not more than 100,000 cfu/mL whereas pasteurized milk should contain lower count, often below 20000 cfu/mL. Potential measures that reflect TPC include the level of hygiene in the milking process, milking paraphernalia, udder film, storage conditions, temperature, and time, efficiencies in pasteurization and handling procedures. These include washing the udders and teats before milking, thoroughly washing hands and utensils before and during milking, and proper milking and processing techniques to maintain low TPC levels.

Pre-cooling milk is an additional step in the dairy processing chain that plays a critical role in maintaining milk quality and safety. Pre-cooling involves rapidly cooling the milk immediately after it is collected from the cow, typically to temperatures below 40°F (4°C). This process slows down the growth of bacteria, thereby helping to keep the TPC low before the milk undergoes pasteurization. By minimizing bacterial proliferation early on, precooling helps preserve the freshness and extends the shelf life of milk. It also ensures that the subsequent pasteurization process is more effective, as it starts with milk that has a lower bacterial load.

2.3 History of Milk Pre-Cooling System

In the past, milk was mainly cooled with ice or cold water, but technology has advanced extensively, and pre-cool systems are now critical for preserving milk quality and shelf life. At first, cows milk was cooled just by naturally available means and methods but with the advancement in civilization more elaborate methods were invented. The advancements achieved in the genetic selection process, known as breeding, also contribute to the upliftment of the various prospects linked to rearing of milk producing animals like the dairy farming as it pertains to its economic and even its environmentally friendly character besides enhancing on the safe and quality yield of the dairy products.

2.3.1 Natural Cooling Method

Before modern technology, farmers used natural cooling methods like storing milk in shaded, cool areas or submerging containers in cold water from streams or wells. These methods depended heavily on environmental conditions and were limited in their effectiveness.

2.3.2 Ice Storage

Ice harvesting became common. Large blocks of ice were cut from frozen lakes or rivers during the winter and stored in icehouses. This ice was used to cool milk during warmer months, providing a more consistent cooling method than natural cooling

2.3.3 Bulk Tank with Built-in Cooling System

The introduction of mechanical refrigeration, leading to the development of bulk tanks with integrated cooling systems. These tanks used refrigerants to lower the milk's temperature directly, enabling more efficient and consistent cooling of larger milk quantities.

2.3.4 Direct Expansion Cooling System

Direct expansion systems, where refrigerants cooled the milk directly within bulk tanks. While effective, these systems were energy-intensive, prompting further advancements in cooling technology.

2.3.5 Plate Heat Exchangers

These systems emerged in the mid-20th century, utilizing metal plates through which milk flowed, with chilled water or refrigerant running in the opposite direction. This setup allowed for efficient heat transfer, rapidly cooling the milk before it entered bulk storage tanks.

2.3.6 Tubular Heat Exchangers

Similar to plate heat exchangers, tubular heat exchangers used tubes for the heat exchange process. Milk flowed through the inner tubes, with the cooling medium circulating around the outer tubes. These systems were particularly effective for larger dairy operations due to their capacity for handling greater milk volumes and providing faster cooling rates.

2.3.7 Instant Cooling System

Developed in the late 20th century to present, instant cooling systems can reduce milk temperature to near freezing almost immediately after milking. These systems often integrate advanced refrigeration technologies with automated milking processes, preserving milk freshness and quality by rapidly slowing bacterial growth.

2.3.8 Solar-Powered Cooling System

Emerging in the 21st century, solar-powered cooling systems utilize renewable energy for the cooling process, offering an eco-friendly alternative. These systems are especially beneficial for remote dairy farms with limited access to conventional power sources, reducing energy consumption and environmental impact.

2.3.9 Heat Recovery Unit

Also a 21st-century innovation, heat recovery units capture and reuse the heat generated during the cooling process. This technology improves energy efficiency by reducing overall energy consumption and supporting sustainable dairy farming practices.

The history and development of milk pre-cooling systems highlight the continuous innovation and improvement in dairy farming practices. From early natural methods and ice storage to advanced mechanical refrigeration, heat exchangers, and modern sustainable solutions, each advancement has contributed to better milk quality, more efficient operations, and enhanced economic and environmental sustainability

2.4 Literature Review

Table 2-1: Literature Review

No.	Title	Literature Review Summary	Methodology	Conclusion
1	Effectiveness of Milk Pre-cooling Techniques by J. Swith, A. Brown	Plate heat exchangers and ice banks as pre-cooling techniques. Reviews energy efficiency and milk quality.	Comparative study on various pre-cooling methods, measuring milk temperature and energy use.	Plate heat exchangers were most efficient in energy use and maintaining milk quality.
2	Energy Efficiency in Milk Pre-cooling by M. Johnson	Sustainability of pre-cooling methods; energy consumption analysis.	Three-factor study with energy meters on different systems over six months.	Ice bank systems had lower long-term energy use compared to direct expansion systems.
3	Impact of Pre-cooling on Milk Quality by S. Lee, K. Patel	Studies impact on bacterial load and shelf life.	Field study measuring bacterial load reduction in pre-cooled milk.	Pre-cooling reduces bacterial load, extending shelf life. Plate coolers were very effective.

4	Comparative Analysis of Pre-cooling Systems by L. Wang	Summarizes studies on effectiveness and profitability of different systems.	Operational data from multiple dairy farms with different pre-cooling systems.	Plate heat exchangers were highly efficient but costly for small-scale farmers.
5	Innovative Approaches in Milk Pre-cooling by D. Garcia, H. Kim	Examines renewable energy-based pre-cooling systems.	Experiments with solar-powered systems.	Solar-powered systems promise energy savings but have high initial costs.
6	Sustainability in Dairy Farming: Pre-cooling Solutions by R. Martinez	Reviews sustainable pre-cooling techniques.	Case studies on farms using eco-friendly systems.	Sustainable systems reduced dairy farm carbon footprints significantly.
7	Milk Pre-cooling and Bacterial Growth Inhibition by K. Johnson	Highlights the importance of rapid cooling for bacterial growth inhibition.	Laboratory simulations of various pre-cooling conditions.	Rapid pre-cooling significantly reduced bacterial growth, improving milk safety.
8	Economic Analysis of Milk Pre-cooling Technologies by P. Singh	Evaluates cost-benefit and return on investment of pre-cooling technologies.	Financial modeling using dairy farm data.	Plate heat exchangers provided better long-term economic benefits despite high initial costs.

9	Milk Pre-cooling and Energy Consumption by N. Green	Compares energy usage of different pre-cooling techniques.	Year-long energy assessments on dairy farms.	Ice bank systems were energy-efficient, affected by external factors like climate.
10	Innovative Milk Pre-cooling Technologies by Y. Chen	Focuses on automation and smart pre-cooling systems.	Pilot testing in dairy environments.	Automation improved milk quality and operational efficiency.
11	Pre-cooling and Milk Storage by M. Clark	Examines links between storage conditions and pre-cooling efficiency.	Field investigations on post-pre-cooling storage conditions.	Proper pre-cooling and storage maintained milk quality effectively.
12	Integration of Renewable Energy in Milk Pre-cooling by S. Rivera	Explores renewable energy integration in pre-cooling.	Case studies of farms using renewable energy for pre-cooling.	Renewable energy reduced costs and environmental impact.
13	Impact of Ambient Temperature on Pre-cooling Efficiency by J. Lee	Reviews how ambient temperature affects pre-cooling efficiency.	Controlled experiments measuring cooling performance in various temperatures.	Efficiency decreased in higher ambient temperatures, calling for climate-specific solutions.

14	Comparative Cost Analysis of Pre-cooling Methods by R. Kumar	Economic research on the costs of pre-cooling methods.	Financial analysis of installation and operational costs.	Plate heat exchangers were more cost-effective long-term despite high setup costs.
15	Milk Quality Preservation through Pre-cooling by L. Brown	Discusses pre-cooling's role in quality preservation.	Comparative analysis of milk quality across techniques.	Plate heat exchangers were best for preserving milk quality.
16	Pre-cooling Systems for Small-Scale Dairy Farms by S. Williams	Addresses challenges and solutions for small-scale farms adopting pre-cooling systems.	Case studies on small-scale farms using various systems.	Simpler options like ice banks were better for small-scale farmers.
17	Evaluating the Performance of Pre-cooling Systems by H. Nguyen	Summarizes performance assessments of various systems.	Field evaluations measuring cooling speed and energy consumption.	Plate heat exchangers excelled in energy efficiency and cooling speed.

18	Pre-cooling and Dairy Farm Sustainability by T. Jones	Highlights pre-cooling's role in sustainable dairy practices.	Case studies on sustainable dairy production using pre-cooling.	Effective pre-cooling systems increased farm sustainability and reduced waste.
19	Milk Pre-cooling and Farm Economics by G. Martinez	Examines pre-cooling's financial impact on dairy farms.	Financial analysis from farms with varying systems.	Effective systems improved milk quality and profitability.
20	Innovative Milk Pre-cooling Technologies by Y. Chen	Explores new pre-cooling advancements.	Pilot programs testing new technologies in practical environments.	Smart systems showed promise for efficiency and cost savings.

CHAPTER 3

METHODOLOGY

3.1 Introduction

Another vital process in the dairy enterprise refers to milk pre-cooling, that is the preliminary cooling of milk after it has been milked. Prior to other processing, including pasteurization, this process is paramount in avoiding bacterial growth and formation, maintaining quality of the milk product as well as enhancing its shelf life and safety. As crimping techniques can be expensive and require much energy, more efficient and less expensive methods should be developed. This is in a bid to reduce the operating costs where the economical milk pre-cooling system could be installed to significantly lower the costs of production while still offering high quality milk.

This paper covers the designing and utilization of a cheap Milk Pre-Cooling System using copper tubing in conjunction with r-134a refrigerant. Copper has good thermal conductivity hence making it suitable for heat exchange process while R-134a is known refrigerant that is environmentally friendly as well as highly effective. The ability of the system to maintain the temperature of milk below or equal to 40 °F (4 °C) is as well used to judge the effectiveness of the system on grounds of TPC. The materials used, the flow chart, the block and the circuit diagram for the recommended pre-cooling system are graphically illustrated in the subsequent sections.

3.2 Materials and Component

3.2.1 Compressor suitable for R134a

The core of the cooling system is the compressor, which raises the temperature and pressure of the R134a refrigerant by compressing it. At that point, the high-pressure gas is prepared for condensation. Choosing a compressor made especially for R134a guarantees efficiency and compatibility. It must be able to sustain the pressure levels required for efficient heat transmission. To provide quick and even cooling, the compressor's capacity must also correspond with the cooling load demands of the milk pre-cooling system.

3.2.2 Condenser

The condenser's job is to turn the high-pressure gas into a high-pressure liquid by dissipating the heat that the refrigerant took up from the milk. Usually, this part has a fan and fins to improve heat exchange effectiveness. Making the right choice means making sure the condenser can manage the heat load produced by the compressor, which is essential to preserving the overall efficiency of the system. In order to get the best possible heat dissipation, the condenser needs to be positioned to allow for sufficient airflow and be built to function effectively with R134a refrigerant.

Figure 3-1: Condenser

3.2.3 Expansion Valve

The flow of liquid refrigerant into the evaporator is controlled by the expansion valve. The refrigerant cools and expands as it moves through the valve, lowering its temperature and pressure. This procedure is necessary to provide the evaporator's cooling effect. To ensure that the evaporator continues to be efficient in absorbing heat from the milk, the valve has to be carefully tuned to manage the refrigerant flow rate. Whether it's an electronic or thermostatic expansion valve, selecting the proper one is essential to preserving system efficiency and stability.

Figure 3-2: Expansion Valve

3.2.4 Evaporator Coils

The refrigerant absorbs heat from the milk in the evaporator, causing the milk to evaporate and cool as a result. This part can be made to resemble coils or plates that touch the milk directly. To maximize cooling efficiency, the design must provide the highest surface area for heat exchange. To ensure long-term durability and cleanliness, the evaporator must be constructed from materials that are suitable to use with food items and resistant to corrosion.

Figure 3-3: Evaporator Coil

3.2.5 Insulated Milk tank

To keep the milk at the proper temperature as it cools, an insulated milk tank is necessary. The effectiveness of the cooling system is increased when the surrounding air is kept at a minimum by using proper insulation. Materials suitable for food preparation that are simple to clean and sterilize should be used to build the tank. It should also be built to fit the evaporator and make milk circulation simple. The efficacy of the system's functioning and energy usage are directly impacted by the quality of the insulation.

Figure 3-4: Insulated Milk tank

3.2.6 Milk Pump

To provide equal cooling, the milk pump moves the milk through the cooling system. In order to transfer the milk over the evaporator coils or plates effectively, it must be able to handle the necessary flow rate and pressure. To avoid contamination, the pump should be constructed from materials that meet food safety regulations and be simple to clean. Durability and dependability are essential as the pump runs constantly while the cooling operation is underway.

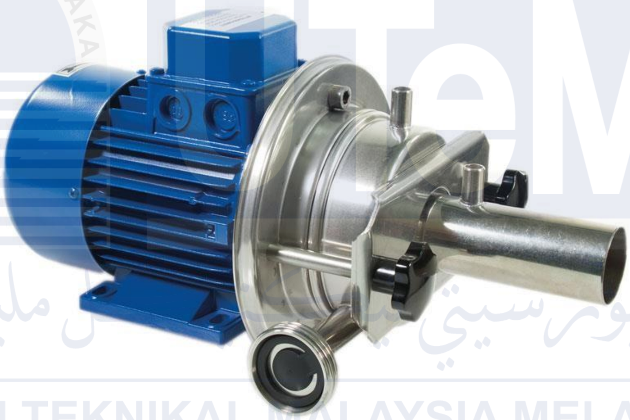

Figure 3-5: Milk Pump

3.2.7 Temperature Sensor

Temperature sensors are crucial for monitoring the milk's temperature and controlling the cooling process. Accurate sensors ensure that the milk is cooled to the desired temperature without freezing or overheating. These sensors feed real-time data to the control system, enabling precise adjustments to the compressor and pump operations. They should be highly sensitive, reliable, and made from materials suitable for food applications. Proper placement within the milk tank is essential for accurate temperature readings.

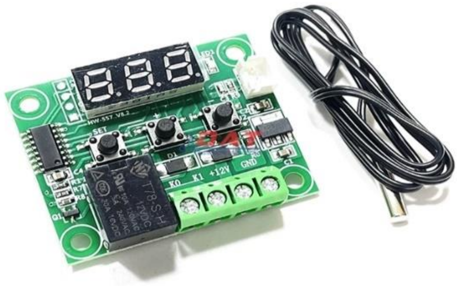

Figure 3-6: Temperature sensor

3.2.8 Tubing and fittings

The cooling system’s numerous components are connected by tubing and fittings, which makes it easier for milk and refrigerant to circulate. They need to be made to endure extreme pressure and temperature swings and compatible with R134a refrigerant. To ensure longterm dependability, tubing should be constructed from materials that are resistant to leaks and corrosion. Fittings are required to offer safe, leak-proof connections in order to preserve system integrity. For effective refrigerant flow and system performance, tube size and routing are critical.

Figure 3-7: Tubbings

3.2.9 Electrical wiring and control system

The core of the cooling system's operation consists of electrical wiring and control system components. These consist of controllers that operate the compressor, pump, and sensors as well as relays and circuit breakers. To avoid short circuits, the wire needs to be insulated and strong enough to support the electrical load. In response to sensor inputs, control components have to be programmable and able to make modifications in real time. Safety features are essential for preventing accidents and guaranteeing dependable operation. Examples of these features are overload protection and emergency shutdown.

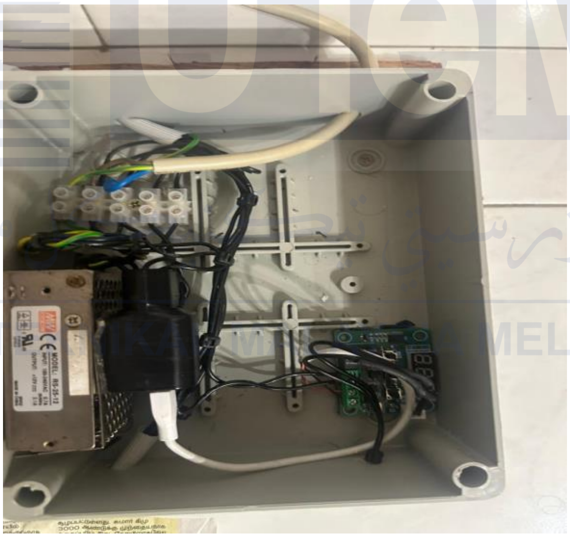

Figure 3-8: Wiring Box

3.3 Flow Chart

The milk pre-cooling arrangement works in a systematic and organized manner to effectively cool the milk to a required temperature from the identified source before it reaches other processing stages. The procedure first commences with the start-up of all the units such as temperature instruments, the milk pump besides the control system preceding operations. This initialization steps is important as it helps to set the parameter when true temperature is to be determined together effective control of the cooling down process. Once the system is activated, the fixed point is with reference to the current temperature of the milk. This is made possible by miniature temperature sensors, which feed back information to the control system. If the temperature of the milk increases and is found to be higher than the optimal temperature set in the control system, this initiates the cooling process. This entails operating the compressor which compresses the refrigerant R134a and the milk pump that circulates milk over the evaporator. The refrigerant in the evaporator coils draws heat from the milk, which turns the refrigerant into a gas and then cools the milk. This stage is very important since it helps in equal a rapid cooling down of milk to a certain degree since the growth of bacteria is rife hence compromising the quality of the milk.

At the end of the process of pasteurization, the temperature of the milk being cooled is being checked to see whether the cooling process is effective. It enables a comparison of current temperature with a set target temperature all the time. After the milk has heated or cooled to the required temperature, the parts that are used in cooling are turned off to avoid further cooling of the milk to the required temperature. This deactivation entails standing the compressor off and milk pump; the milk must be retained at the correct temperature it must not freeze nor should it be too cold. But, if the cooling is not up to the targeted temperature, the system commences the cooling process again alongside the compressor and pump until the wanted temperature is attained. This continuous monitoring as well as controlling cycle ensures that the temperature of the milk is kept intact to the expected level thus works out the best energy consumption and makes the cooling most efficient. By achieving this level of tolerances, the system not only maintains the quality of the milk but also directly prepares it for storage or the next level of processing. The fact that it starts with the initialization and then passing through the heating, holding and subsequent cooling stages, enables the milk to be processed in a safe, efficient and reliable manner in order to meet the required standard of quality and safety in the dairy products industry.

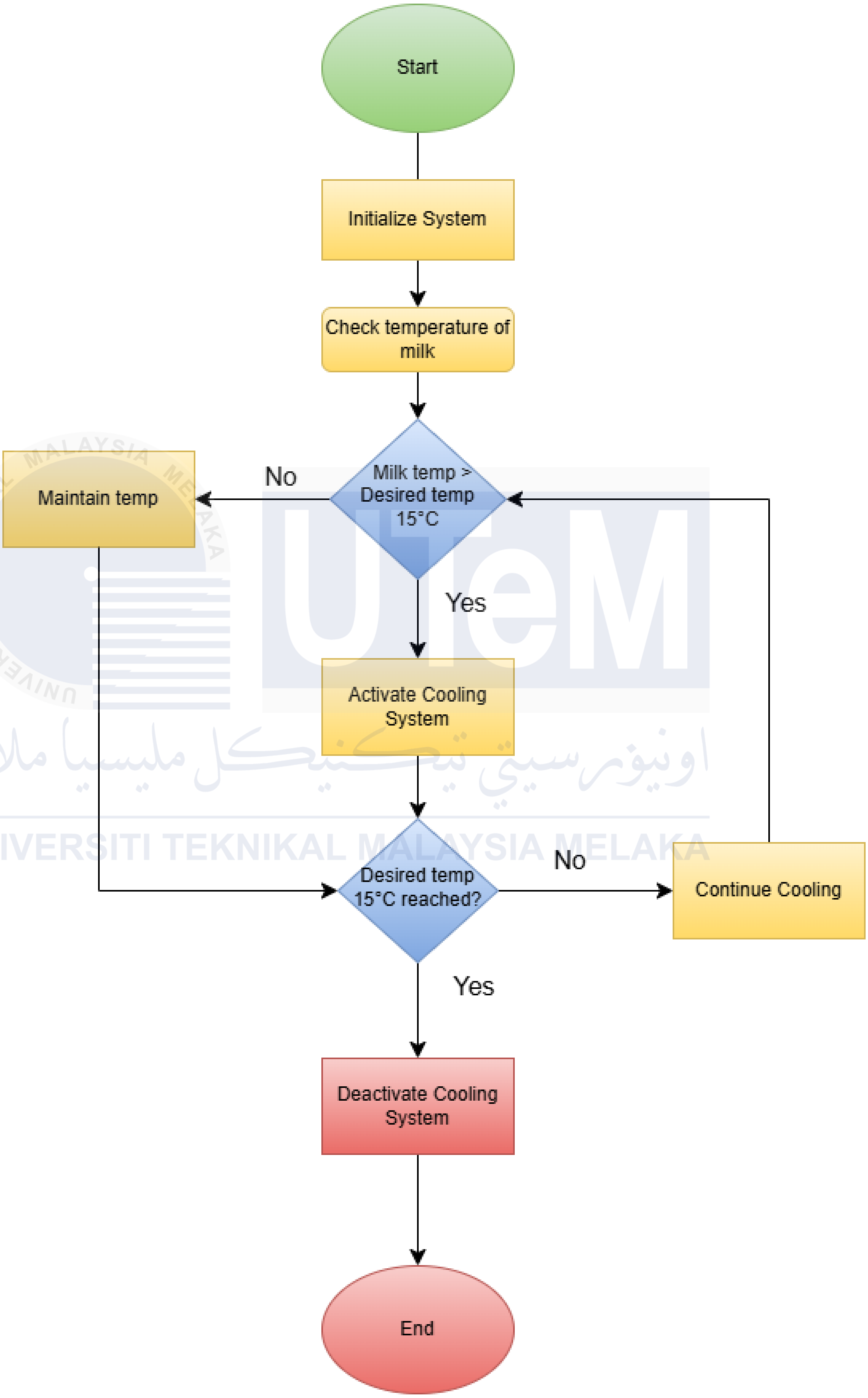

Figure 3.9: Flow Chart

3.4 Cost Analysis

Table 3-1: Cost Analysis

Component	**Quantity**	**Cost per Unit (MYR)**	**Total Cost (MYR)**
Compressor	1	150	150
Condenser	1	40	40
Expansion Valve	1	30	30
Evaporator	1	20	20
Milk Pump	1	40	40
Temperature Sensors	1	20	20
Electrical Component	1	50	50
Tubing and Fittings	1	150	150
Total estimated cost			500

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

Ensuring the safety and quality of milk from farm to consumer is critical to the dairy business. The quick chilling of milk just after milking is essential to preserving its quality. In addition to preserving freshness, this method stops bacteria from growing, which can have a negative impact on the shelf life and consumer safety of the milk. The Total Plate Count (TPC) measures the amount of live bacteria in one milli litre of milk and is a critical metric for evaluating milk quality. Bacterial contamination decreases with decreasing TPC, indicating improved milk quality and cleanliness.

The outcomes and analysis of a milk pre-cooling system without heat plates that uses R134a refrigerant are covered in detail in this chapter. By effectively lowering milk temperature after milking, the device seeks to decrease bacterial growth and extend the shelf life of milk. By tracking changes in TPC before and after the milk goes through the chilling procedure, the assessment focuses on how successful this pre-cooling method is. We hope to learn more about how well the technology inhibits bacterial development and raises milk quality requirements in dairy businesses by examining these outcomes.

4.2 Results

The TPC of milk samples is compared before and after they go through the precooling system as the main focus of the examination. To achieve quick and effective milk cooling, every part of the system from the compressor and condenser to the evaporator and control system is essential. We may evaluate the system's effectiveness in upholding milk quality and safety requirements by measuring the decrease in TPC post-cooling. An outline of the anticipated outcomes shown in a thorough study is provided below:

Table 4.1: Expected Result

Parameter	Before Pre-cooling	After Pre-cooling
Total Plate Count (TPC) (cfu/mL)	≥1,000,000	≤500,00
Reduction in TPC	-	≤500,000

Explanation:

- **Before Pre-cooling**: This column represents the initial Total Plate Count (TPC) of milk samples collected before they enter the pre-cooling system. The value of more than equal 1,000,000 denotes the TPC in colony-forming units per milliliter (cfu/mL).
- **After Pre-cooling**: This column shows the TPC of milk samples after passing through the pre-cooling system. The value of less than equal 500,000 represents the expected TPC after the milk has been cooled using the designed system.
- **Reduction in TPC**: This is the difference between the initial TPC (≥1,000,000) and the TPC after pre-cooling (≤500,000), indicating the effectiveness of the pre-cooling system in reducing bacterial contamination in the milk.

4.3 Analysis

4.3.1 System Performance Evaluation

The performance of the milk pre-cooling system hinges on several factors, including the efficiency of the compressor, condenser, evaporator, and control system. The compressor, responsible for compressing the R134a refrigerant, initiates the cooling process by circulating the refrigerant through the condenser, where it releases heat absorbed from the milk. The cooled refrigerant then flows through the expansion valve into the evaporator, where it absorbs heat from the milk, rapidly reducing its temperature. Throughout this process, the control system monitors and regulates the temperature, ensuring optimal cooling without over-chilling the milk.

4.3.2 Impact on Milk Quality

The reduction in TPC post-pre-cooling directly correlates with improved milk quality and safety. Lower TPC indicates fewer viable bacteria in the milk, which not only extends its shelf life but also enhances its nutritional value and consumer appeal. By maintaining stringent hygiene standards and employing efficient cooling methods, dairy farms can mitigate risks associated with bacterial contamination, meeting regulatory requirements and consumer expectations for high-quality dairy products.

4.3.3 Comparative Analysis

Comparing TPC levels before and after pre-cooling provides insights into the system's effectiveness in bacterial inhibition. A significant reduction in TPC demonstrates the system's capability to rapidly cool milk, thereby minimizing bacterial growth during critical post-milking stages. This comparative analysis not only validates the system's design and operational efficiency but also underscores its role in optimizing dairy farm operations and ensuring consistent product quality.

4.3.4 Practical Implications

In fact, this paper sought to assess the milk pre-cooling system in realizing improved efficiencies on the farm. The system therefore saves time and energy because it only takes a short time to dispel heat and cool the milk to the requisite safe storage temperature which makes the quality of the milk to increase significantly. This has significant consequences for the long-term viability and profitability of dairy farms since it encourages proper utilization of resources and responsible environmental management.

4.4 Summary

In conclusion, the analysis and outcomes of the experimental work and results of TPC-based milk pre-cooling system stress on the enhancement of food safety and quality of milk. This is to underline the effectiveness of the given system’s method of a wide and quick chilling, which contributes to decrease the bacterial contamination, and consequently improves the aspects of milk hygienical quality and its shelf life. For the projected end results, the research establishes its applicability in managing bacterial growth risks, meeting the regulation requirements, and fulfilling the clients’ standard quality dairy products demands. In this chapter, key findings that are expected from the system are presented along with potential implications for manufactured dairy farms and overall assurance of milk quality.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

In this chapter, it will discuss about the conclusion made from implementing this project. This chapter will conclude the overall scope of the project report which was made from the first chapter to the previous chapter. It will ensure that the objectives of the project which is stated is achieved and the problems are solved by implementing this project.

5.2 Conclusion

Among the technological advances in the field of milk production to enhance its quality and safety, one can mention the development of a milk pre-cooling regime that does not involve the use of heat plates. Milk chilling process reduces the bacterial count effectively as evident from TPC reduction after milking, and R134a refrigerant helps to cool the device quickly in this process, as observed in the case of efficient bacterial count reduction. This enhancement also ensures that quality nutrient values are achieved and customer satisfaction is also achieved apart from improving on the shelf life of milk. Since the system overall seeks to conserve energy and also obtain the most out of its processes, the system argues for environmentally-friendly agriculture. It is to be noted that it has flexibility in terms of the size of the farm as well as the production capacity of the farm which elucidates its role in multiple forms of farming. In sum, this project demonstrates how important technical advance must be from to fill the high standards of the dairy industry and enhancing the standard deviation and Caliber of dairy farm.

5.3 Future Works

As for the future prospects for increasing the effectiveness of the chosen economical milk pre-cooling system, it is possible to identify the following options. One of the approaches is the use of smart sensors and internet of things (iot) technology to constantly monitor and control the performance parameters of the system as well as the milk temperature. This might help in terms of energy conservation, efficient cooling cycle and timely maintenance. Further, studying new refrigerants and advanced refrigeration technology can extend sustainability and effectiveness of the system. Researches specific to the dynamics of milk production and fluctuations throughout the year would ensure that the system is optimized for its performance regardless of a number of conditions. In the course of the system's life cycle, incorporation of renewable energy sources such as solar and wind energy may as well enhance the sustainability and reduce operational expenses. Routine milking with robots, application of advanced analysis for future in the handling of milk, and other procedures can enhance the dependability of the whole system and at the same time, make it less complicated. Large-scale cooperation and the highly detailed field test would prove the feasibility of the system and further direct the enhancements in the system layout and the related managerial processes ensuring the constancy of the system development for dairy sector at the cutting edge.

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APPENDICES

Appendices 1 : Project Picture