International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 12 | Dec 2022 www.irjet.net p-ISSN: 2395-0072

A REVIEW ON SOLAR OPERATED MILK PASTEURIZATION SYSTEM

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Abstract - *The analysis and performance testing of milk pasteurization system that is based on the solar energy as a thermal source for pasteurizing the milk . This is adapted for using at remote areas and villages, communities where the small quantities of milk delivered by individual producers who are deprived of the availability of gas and electricity. A solar parabolic dish collector is used for heating milk and PV solar plates setup used for cooling purpose of milk. Milk pasteurization is a process which involves heating of milk to a temperature that kills diseases causing microorganisms and substantially reduces the level of spoilage organisms. In dairy the pasteurization of milk is very very important process. All milk produced at a processor and intended for consumption must be pasteurized, legally requiring it to be heated to at least 73°C then cooling it to 4°C to ensure any harmful bacteria are to be destroyed. For this process, heating of milk is necessary and it done by diesel energy or electric energy. The sources of this energy are very limited and currently India is facing with shortage of about 21% of electric energy. Hence solar energy is good option for this process. The changes in intensity of solar radiation had a direct impact on solar milk pasteurizer.*

Keywords:-Solar Energy, Chilling Plant, Milk Pasteurization, Micro-organisms, Heater.

1.INTRODUCTION

The term 'solar energy' refers to energy generated from capturing the sunlight and heat from the Sun. Technology has developed several ways to utilize this abundant resource. It is considered as a green technology because of it does not emit greenhouse gases. Solar energy is abundantly available on earth and it has been utilized since long time for both as electricity and as a source of heat. The usage of this renewable energy sources can reduces the pollutant emissions into the atmosphere. Solar energy, especially when used efficiently, can play a crucial role in developing and developed nations alike.

Solar energy has been used since pre-historic times, but in a most primitive manner. Before 1970, some researches and development works were carried out in a few countries to exploit solar energy more efficiently, but most of this work remained mainly academic. After the dramatically rising in oil prices in the 1970s most of the countries began to formulate and extensive research and development programs to exploit solar energy. Whenever we hang out our clothes to dry in the sun, we use the energy of the sun. In the same way solar panels absorb the energy of the sun to provide heat to the system.

Solar energy is the energy from the sun in the form of radiated heat and light. It drives the climate and supports life on earth. Solar energy is freely available source of energy. It does not belong to anybody. It is the most important non-conventional source of energy because it does not pollute environment and it helps in reducing the greenhouse effect. Solar energy is the clean and natural source of energy and it is available in huge amount.

The development of inexhaustible, affordable and clean solar energy technologies will have been huge longer-term benefits. It will increase countries energy security through reliance on an inexhaustible, indigenous and mostly import-independent resource, enhance sustainability, reduce pollution, lower the costs of mitigating, reduce global warming and keep fossil fuel prices lower than otherwise.

Solar energy is the radiation from the Sun capable of producing heat, causing chemical reactions, or generating electricity. If suitably harnessed, solar energy on the earth has the potential to satisfy all future energy needs to entire earth. India is a country in which solar energy is available in massive amount and also favorable place for the use of that solar energy.

The consumption of non-renewable sources like oil, gas, wood and coal are increasing at higher rate. The time has finally come to look after some other renewable sources of energy like solar, wind and geothermal energy. Many countries have started utilizing solar energy can cover mostly their demands but they still have to go a long way to exploit this renewable energy to fulfill their daily needs.

Some people create a completely wrong picture of the relevance, requirement and importance of solar energy for India. They usually focus on the cost and affordability in a short-sighted way and ignore the larger issues of energy availability and environmental health. India has a massive

advantage in terms of geography. Solar power is free and forever.It is clean and available everywhere.

In the desert zone is having abundant solar energy available and it is suitable for harnessing solar energy for several applications. In areas with similar intensity of solar radiation, solar energy should be easily harnessed. Solar energy can also be used to meet our electricity requirements through solar photovoltaic (SPV) cells and that solar radiation gets converted into dc electricity directly. This electricity can either be used as it is or it can be stored in the battery. This stored electrical energy then can be used at night but such systems are costlier one & restrict the application of solar for producing electricity. This energy can be used for cooking, heating, drying, distillation, power.

There is a urgent and general need for rapid procedures, applicable to monitor, to control, to process food safety and quality. Pasteurization is a process in which certain packaged and non-packaged foods (such as milk and fruit juice) are treated with mild heat, usually less than 100 °C (212 °F), to eliminate pathogens and extend shelf life. The process of safeguarding foods by destroying or inactivating organisms that contribute to spoilage, including vegetative bacteria but not bacterial spores.

Pasteurization is the process of heating a liquid to below the boiling point to destroy micro-organisms. It was developed by Louis Pasteur in 1864 to improve the keeping qualities of wine. The process of heating milk for health benefits has been recognized since the early 1800's was used to reduce milk borne illness and mortality in infants in the late 1800's. As society industrialized around the turn of the 20th century, increased milk production and distribution led to outbreaks of milk borne diseases. Common milk borne illnesses during that time were typhoid fever, septic sore throat, scarlet fever, diphtheria, and diarrheal diseases. These illnesses were virtually eliminated with the commercial implementation of pasteurization in combination with improved management practices on dairy farms. In 1938, milk products were the source of 25% of all food and water borne illnesses that were traced to sources, but now they account for far less than 1% of all food and water borne illnesses.

Commercial pasteurization of milk began in the late 1800s in Europe and in the early 1900s in the United States. Pasteurization became mandatory for all milk sold within the city of Chicago in 1908 and in 1947 Michigan became the first state in the world to require that all milk for sale within the state to be pasteurized. In 1924 the U.S. public health service developed the standard milk ordinance to assist states with voluntary pasteurization of milk programs. The grade A pasteurized milk ordinance (PMO), as it is now called a administered by the U.S. departments of health and human services and public health and the food safety and drug administration and provides practices relating to milk parlor and processing plant design, milking practices, milk handling, sanitation, and standards for the pasteurization of grade a milk products. Each state still regulates milk processing within their own state but dairy products must meet the regulations stated in the PMO for dairy products.

Initial pasteurization conditions known as flash pasteurization, were to heat the milk to 68.3°C to 81°C for an instant followed by cooling. Pasteurization conditions were adjusted 61.7°C for 30 minutes or 71.1°C for 15 seconds to inactivate my urobacterium bevies, the organism responsible for tuberculosis. However, in 1957 these conditions were shown to be inadequate for the inactivation of coxiella burnetiid which causes fever in humans.

There is a dire need for reformulation of the environmental impact of traditional fossil fuel industries. Deforestation, global warming, CO_2 emissions, air pollution, and global warming are just a few of the negative consequences of traditional fossil fuels. Additionally, fossil fuel reserves are depleting day by day and the supply is limited.

Normally for heating of milk, the fuels such as diesel or coal energy or electric energy are required, but these energy sources are going to deplete in the coming future days. With the increase in fuel costs as well as their decreasing availability, and with the rapid growth in the Indian population, solar energy is becoming more and more important. In this study, efforts are directed towards alternative methods for heating of milk for industrial processes through thermal route.

In India, the proposed system may present the possibility of saving a significant amount of liquid and gaseous fossil fuels used in industrial processes, as well as electricity used in such processes, which are useful for reducing the overall shortage of energy are experiencing at present.

2. LITERATURE REVIEW

It has been reported on numerous occasions that there are different types of techniques used for pasteurization of milk and their uses for various applications. In this study, the construction, results and conclusions of such papers are discussed.

Mekhilef. S et al. [1] have concluded that presently, solar energy conversion is widely used to generate heat and produce electricity. It has founded that solar thermal

is getting remarkable popularity in industrial applications. Solar thermal is an alternative to generate electricity, process chemicals or even space heating. It can be used in food, textile, non-metallic, chemical, building or even business related industries. On the other hand, solar electricity is wildly applied in telecommunication, agricultural, water desalination and building industry to operate lights, pumps, engines, fans, refrigerators and water heaters. The present work aimed to study of the solar energy systems utilization in industrial applications and looked towards into the industrial applications which are more compatible to be an integrated with the solar energy systems.

Panchal H. et al. [2] have concluded that solar pasteurization system is used to kill harmful bacteria present in the raw milk. It is carried out that in the dairy industries with the help of boiler and using wood or coal for heating of the milk. Due to the regularly increment of global warming and its harmful effects, coal or wood should not be used for milk pasteurization system. Hence, researchers had been started working on renewable energy sources like solar energy for pasteurization system. Many scientists or researchers from all around the world have attempted to use solar energy for milk pasteurization system. The present paper shows the research works carried out by researcher on milk pasteurization system. After several reviews, it has been found that the solar energy is the best solution for milk pasteurization system

Thu S. M. et al. [3] have concluded that refrigeration is the process of removing heat from substance or space to reduce its temperature and transferring that heat to another substance or refrigeration is providing and maintaining the temperature below that of the surrounding atmospheric temperature. Design calculation of evaporator, compressor and cop of existing ice plant are determined. Ammonia(NH4) is used as refrigerant in this ice plant and to improve cop of ice plant, refrigerant changing can be considered.

Hafez A.Z. et al. [4] have concluded that the effect of solar dish design features and factors such as material of the reflector concentrators, the shape of the reflector concentrators and the receiver, the intensity of solar radiation at the concentrator, diameter of the parabolic dish concentrator, sizing the aperture area of concentrator, sizing the aperture area of receiver, the focal point diameter, focal length of the parabolic dish, geometric concentration ratio and rim angle had been studied.

Wankhede U.S. et al. [5] has concluded that for the chilling plant or ice plant prefer ethylene glycol is the better option as a secondary refrigerant as per the requirement of the system. The reason behind choosing ethylene glycol as a secondary refrigerant because it has excellent thermodynamic and physical properties over the conventionally used brine solution.

Sunaris M. L. et al. [6] have concluded that pipe is a closed conduit, usually of circular section, which is used for carrying fluids under pressure. The pipe running partially full, in such a case atmospheric pressure exists inside the pipe and also behaves like an open channel. In general, energy or head losses on pipe consisted of minor energy losses due to sudden enlargement of pipe, sudden contraction of pipe, bend in pipe, an obstruction in pipe, pipe fittings etc. and major energy losses due to friction to analyze energy losses in smooth pipes. There are several steps for analysis such as calculation of Reynolds number (Re) in order to determine flow type, calculation of friction factor by using several formulas, and calculation of roughness value (k) on smooth pipe with different various scenarios.

Vincent E. et al. [7] have concluded that despite the existence of pasteurization and its advocacy worldwide, most marketed milk in a developing country like Nigeria are sold raw by the locals. It costs hundreds of millions of nigerias money to set up a conventional pasteurization plant in Nigeria. Boiled milk ends up curdling which results in to a loss of nutrients from the milk, so it is not beneficial to treat milk by this method.

Raibhole V. N. et al. [8] have concluded that ice plant works on the principle of vapor compression cycle using eco-friendly refrigerant R134a. The refrigerant R134a is used as it is best alternative to R12 has zero ozone depletion potential (ODP) and have similar thermodynamic properties to R12. Performance of ice plant is very very much sensitive with operating parameters, so that continuous monitoring for this process is very much needed with the provision of data backup.

Panchal H. et al. [9] have concluded that due to use of fossil fuels for the human activities found a significant effect on the environment as well as people's health. Hence, the research peoples from all around the world are searching for the sustainable solution through non-conventional sources of energy like biomass, wind, solar energy etc. Among all the non-conventional sources of energy, solar energy is prevalent. Pasteurization is a process of heating of food or liquid for the killing of bacteria. For pasteurization of milk, dairy industries require boiler or heat exchanger and it consumes energy and sometimes they need fossil fuels.

Yadav J. P. et al. [10] have concluded that refrigeration may be defined as the process of achieving and maintaining a temperature below that of the

surroundings, the aim being to freeze ice, cool some product, or space to the required temperature. The basis concept of modern refrigeration system is the ability of liquids to absorb enormous quantities of heat as they boil and evaporate. One of the major important applications of refrigeration is an ice making plant. In ice plant most of the times vapour compression cycle is used. The vapor compression cycle comprises four process compression, condensing, and expansion and evaporation process.

Farjana S. H. et al. [11] have concluded that in developing countries, industries and manufacturing sectors consume a major portion of the total consumption of energy, where most of the energy is used for low, high or medium temperature heat generation to be used for process applications known as process heat. The necessity to be commercialize clean, cheap and efficient renewable sources of energy in industrial applications emerges from increasing concerns about greenhouse gas emissions and global warming and decreasing fossil fuel use in the commercial sectors. Due to abundant and massive source of energy, solar energy technologies have been proven potential.

Igweonu E. I. et al. [12] have concluded that solar energy as a source of renewable energy has been acknowledged to be a potential source of heat for domestic and industrial purposes. Efficiency of different types of solar collectors and the determining factors affecting the efficiency of collectors, and presents them as predeterminied factors in the choice of collectors at the user end for cost and operational effectiveness.

Alarcon J. A. et al. [13] have concluded that the development of a solar parabolic dish collector prototype for rural areas with high solar resource availability which have no access to electricity service or budget resources to purchase of stove (electric or gas). The solar collector prototype proposes a solution for the to solve these kinds of problems and use sunlight to work it. Through a polished stainless-steel parabolic dish collector, solar radiation is concentrated into a specific area called as focus.

Sah R. P. et al. [14] have concluded that as there is a time gap between milking and storage, milk spoilage is more in remote areas in India, hence, immediate pasteurization and storing facility is required. For pasteurization heating is compulsory. In India most of the villages face scarcity of electricity, hence, solar related and biomass heat (easily available) is a good option for milk pasteurization system.

Mohammed I. L. et al. [15] has concluded that for effective performance the design requires that parabolic dish collector track the sun continuously and an automatic electronic control circuit was designed and developed for this purpose. The use of a linear actuator (Super jack) to track the sun eliminates the need for constant monitoring by a human operator and, thus, reduces the cost of labor.

Rabab Zahira et al. [16] have calculated and discovered different techniques have been developed to make use of solar radiations such as solar milk pasteurizer and it is possible to pasteurize milk using solar energy with careful operation and the actual definition of pasteurization is; the heating of milk to a specific temperatures for a specific time to reduce undesirable enzymes and bacteria to negligible levels.

Muhammad Azam et al. [17] have told that today the use of modern fuel is so expensive and even count as one of the major pollution sources. In areas where sunlight is plentiful the use of sunshine to cook the food and pasteurize contaminated water and milk require our more concentration on industrial level to develop cheap and pollution free technology and their system is capable as to reduce the pollution and electricity consumption.

Zorraquino et al. [18] have told that the milk is a natural liquid food, is one of our most nutritionally complete foods. Milk contains bacteria when improperly handles create conditions where bacteria can be multiply Antibiotic residues inside milk due to use of antibiotics widely in food producing animals, supposed problems for the both dairy industries and consumers. To kill that bacteria's or microbes which develop slowly or create pores, suitable standerd temperature and time must be applied for processing and they applied same temperature then they got the desirable result.

Table 2.1. Standardization of pasteurization requirements for milk.

Requirement	30 min	15 sec
Kill TB germ	138°F	158°F
Phosphate inactivation	142°F	160°F
Pasteurization requirement	145°F (63°C)	161°F (72°C)
Creamline reduction	146°F	162°F

Marco Lucentini et al. [19] have analyzed that technical and economic feasibility of an innovative plant, through the operational simulations of each machinery, related to different radiation conditions during the year. The economic analysis has shown that this solution is worth-while, especially taking advantage from the

incentives offered by the national campaign of renewable energy diffusion Moreover, For a correct sizing of a solar plant it is necessary to resort to economic evaluation methods, where the plant is to be considered as an integral part of the conventional plant. An accurate analysis of costs and proceeds of the integrated plant must be carried out in all its planned life cycle. Income and expenditure over the various years must be actualized and an appropriate economic variable, such as the recovery time, must be taken into account. The main research parameters, like the collector's area and the storage tank capacity, are to be determined so as to minimize the economic variable chosen.

Atia et al. [20] they have described the application of solar collector in milk processing that involves liquid milk movement and it is an important operation which cannot be overlooked. The flowability of milk within a system is determined by its density and viscosity. The physics of these properties go a long way in the determination of developing a heat exchanger. Since in the food and dairy industry consumables are produced, paramount importance is placed on the materials and the thermal treatments of these foods. Through the thermal bacterial destruction kinematics studies, the time required for a specific fraction of pathogenic organism destruction has been examined.

Muhammad Usama Yaseen et al. [21] have fabricated a solar milk pasteurizer from standard appliance shipping card board with multiple layers of the regular aluminum foil glued onto cardboard which was insulated with a large card board box which contains the rectangular area and a removable glass window has been used for work. The inner box having volume (52.5×24×36) cm covered on both sides with aluminum foil. A metal tray painted black. This experiment was done at temperature ranging between 65 to 75 ˚C.

Nielsen et al. [22] have designed and developed a prototype solar panel-based pasteurization system. The system has been tested in the laboratory using a solar panel of 10 kW. They had found 71° is the best temperature for pasteurization process. They had also been concluded that the energy payback time is around 20 years. In this research a design process for solar base pasteurizer is presented. Different concept designs are generated and evaluated. Effect of tilt angle on solar pasteurizer is also studied.

Virgiliu et al. [23] have studied that, for better utilization of solar energy two components namely collector and storage unit are required. The collector absorbs the sun light that falls on the collector and sends it to other forms like electricity, heat etc. The power storage unit is essential for the collection of energy because during cloudy days, the energy generated is small. The storage unit can store energy during the periods of maximum radiation and Solar milk pasteurization is the process of killing bacteria from milk and making it free of micro-organisms by using the sun rays. The sun rays are utilized to produce the steam with the help of solar vacuum tube collector which produces hot water at very high temperature.

Duffie et al. [24] have concentrated solar thermal energy system that is designed and constructed with the conventional parabolic concentrator. The receiver is placed along the line between the centre of the concentrator and the sun. The receiver used for this is coiled helically with specific design so that all the solar rays concentrated at centre have received without shadow. Manual tracking has been used during evaluation stage. This allows for effective collecting and concentrating of the incoming solar irradiation and they hot as required temperature to run the system.

Sharma A et al. [25] have described in their paper the effectiveness of a chiller is dependent on the ratio of flow in-between the product and the cooling media. A higher coolant flow rate gives as a greater average temperature difference between the milk and coolant and a higher coolant velocity between the plates that is increases the heat transfer coefficient of process. Many manufacturers suggest that minimum ratio of 2 is essential, it means the water flow rate doubles the milk flow rate. The flow of the milk from milk pump to a receiver is intermittent. Whenever the level of milk in the receiver reaches at the upper probe, then the pump starts. The milk flow could be at least 25 gpm for the few seconds and after that stop for a minute. Tests on the two conventional receivers pumps in a double parlor shows that the average milk flow rate during the milking process was about 12 gpm. Both the receiver pumps operated 26 percent of the time, meaning that the mean flow rate of the milk when a pump was operating was 44 gpm. To achieve a flow ratio of 2, the chilled coolant flow rate while the milk pump was operating should be 88 gpm which is much more difficult to achieve this on a dairy farm.

Hegde V. et. al. [26] have investigated that milk should be chilled to 10 °C inside four hours or less in any case bacterial development expands subsequently cutting down the milk quality. Most appropriate refrigeration framework is mechanical refrigeration framework for Indian conditions. The significant favorable position of this undertaking is that the milk chilled in the van can be utilized for optional preparing if bundling unit is found even at 4 - 5hr excursion time. Chilling plants are not vital which can be supplanted by portable chillers. The concentrated solar thermal energy system is designed and

constructed with the conventional parabolic concentrator. The receiver is placed along with the line between the centre of the concentrator and the sun. The receiver used is coiled helically with the specific design so that all the all solar radiations/rays concentrated at centre have received without shadow. Manual tracking has been used during evaluation stage. This allows for effective collecting and concentrating of the incoming solar irradiation (Duffie and Beckman, the concentrated solar thermal energy system is designed and constructed with the conventional parabolic concentrator. Receiver is placed along the line between the centre of the concentrator and the sun. This receiver used is coiled helically with the specific design so that all the solar rays concentrated at centre have received without shadow. Manual tracking has been used during the evaluation stage. This is allowing for the effective collecting and concentrating of the incoming solar irradiation/rays.

Bhadania et al. [27] have discovered dairy industry consists of various sections like raw milk reception, products section, processing section, production section storage and dispatch section. It is estimated that one third of the energy used by the dairy industry is actually in the processing operations and the refrigeration plant accounts about 50-60% of total electrical power consumption so that they installed Solar system then saved up to 50% of energy while on working or running project or plant.

Janzekovic et al. [28] have discovered that by applying solar parabolic dish collector and related green energy techniques in the dairy industries, the cost of dairy products can be reduced. The new technological equipment like CIP technology system in food processing industry, replacing the depreciated one, will have to improve the competitiveness and efficiency of the companies, the business activity plans and will promoting to fulfillment of the requirements of the district European Union (EU) legislation also.

Srivastav P.P. et al. [29] have define the purpose behind the energy optimization and management for dairy plant is to control the energy consumption for getting the overall maximum efficiency. For the case study of the energy consumption in manufacturing of dairy products, a multi-product dairy plant was selected. The product, technology and dairy operations of different dairy products were explored under the batch process to identify the high energy consuming centers termed as a critical control point (CCPs). Various equations for heat and mass transfer, electrical consumption, flow rate, were used to find the actual utilities consumption (water, steam, electrical energy) in dairy operations. The data of this case study was compared with the previous studies and found that the energy conserving status was declining.

Raymond F- Fuerschbach et al. [30] have told that their paper chiller has an inlet and outlet which is for a first fluid and there is a passage network there between the passage network being started comprised of various network defining structure, e.g., openings, being present in the flow and heat transfering plates. A similar type of inlet and outlet and passage network arrangement is provided for a second fluid. Each turbulator member is located in the passage network of one of the fluids with the network so arranged that there is heat transfer between the fluids passing through them. The stacked plates and turbulators are sealing interconnected to form them together in unitary structure form and the assembly can be provided with top and bottom plates.

3. CONCEPT OF SOLAR MILK PASTEURIZATION SYSTEM

Pasteurization was invented by a French scientist called Louis Pasteur during the nineteenth century. Pasteur discovered that the heating of milk to a high temperature and then quickly cooling it before bottling or packaging it could keep it fresh for longer.The process of pasteurization involves heating milk to 71.7°C for at least 15 seconds (no more than 25 seconds). Because of the nature of the treatment of heat it sometimes referred to as the 'high temperature short time' (HTST) process. Once the milk has been heated, it is then cooled very quickly to less than 4°C. The equipment which is used to heat and cool the milk is called a 'Chilling plant'. When the milk has been pasteurized, it is bottled or packaged to be sold to consumers. The following figure shows that solar operated milk pasteurization system.

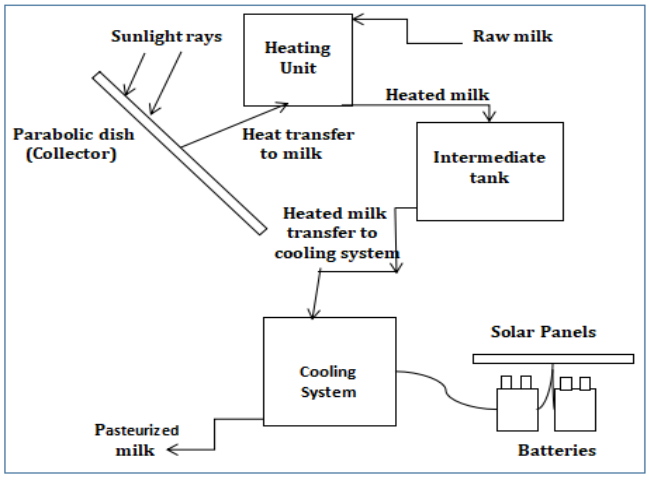

Fig. 3.1 Layout of milk pasteurization system

Above model shows working cycle of solar operated milk pasteurization system. Whole system contains parabolic dish collector, receiver, intermediate receiver, raw milk storage tank, compressor, air cooled condenser, expansion valve, evaporator, solar panels, control panel, pump, testing and packing unit with some purpose. As pasteurization process involves heating of milk up to a specific temperature in order to kill harmful bacteria's which are harmful to human being and cooled at specific temperature to increase its life which indirectly means to stop bacteria growth.

3.1 Heating Unit(Receiver Tank)

Solar collectors convert solar radiation energy into energy stored in the transport medium by means of heat exchange shown in above fig. 3.1. The major component of any solar system is the solar collector.

3.2 Solar parabolic dish(Collector)

This is a device which absorbs/collect the incoming solar radiation, converts it into heat, and transfer this heat into a fluid (usually air, water, or oil) flowing through the collector. The solar energy thus collected is carried from the circulating fluid either directly to the hot water or space conditioning equipment or to a thermal energy storage tank that is backup energy setup from which can be drawn for use at night and cloudy days. A parabolic dish solar generation unit is as like as small power plant with a reflector like a large satellite antenna like a solar tower it is a point focusing concentrator[31,32] but it can achieve an even higher concentration ratio, theoretically as high as 2000 and an efficiency of up to 40%. Here, using the solar parabolic dish collector for collecting sun radiations and concentrating those radiations on receiver to heat milk up to desired temperature as required in pasteurization process.

3.3 Cooling System

A cooling system cools heated milk that's been transferred from an intermediate receiver/storage tank and the temperature has dropped to near 35°C. Purpose of chilling plant is prior to cool and maintain milk about 4°C. As similar to every cooling system, chilling plant includes compressor, condenser, capillary tube, and evaporator. R22 and glycol are the two refrigerants/coolants are used in chilling plant to cool the milk and cooling fan is used to cool the condenser.This is the Actual section where exchange of heat between refrigerant and milk happens. It is main section of system where all the heated milk is cooled at about 4°C.

3.4 Solar Panel and Batteries

The purpose of installing solar system is to fulfill the electricity need required for the chilling plant. The whole chilling system runs on solar system.This solar panel contains energy that is received from the sun and stored in a battery as DC. This energy should be used for cooling system to run the cooling process.

3.5 Pasteurized Milk

Pasteurization makes sure milk is safe to drink (by killing any bacteria) and also helps to prolong its shelf life.When the milk has been pasteurized, it is bottled or packaged to be sold to consumers.

CONCLUSION

As per the analysis this research is practically possible. With the development of this small size solar operated milk pasteurization unit people from rural background where sufficient amount of electricity, milk collection dairies, transportation facilities such things are not available can pasteurize their own cows, buffalo's milk with less cost required. In such a system, people can eliminate the need for electricity for the pasteurization process by using renewable energy sources like solar energy. These units help milk-producing individuals from rural areas start their own businesses, which leads to economic support for their families. According to the material selection for the research, its physical properties, durability, structural analysis, and thermal analysis of selected parts, the further conclusions are made. We can cut off the cost of electricity required for process. Selection of parts helps to reduce the overall cost. Payback period is near about 5years.

ACKNOWLEDGMENT

This review paper was supported by Solar research laboratory of N K Orchid's college of engineering & technology, Solapur.

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