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Solar energy utilisation for milk pasteurisation: A comprehensive review

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ABSTRACT

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 researchers from all around the world are searching for the sustainable solution through non-conventional sources of energy like wind, biomass, solar energy etc. Among all non-conventional sources of energy, solar energy is prevalent. Pasteurisation is a process of heating of food or liquid for the killing of bacteria. For pasteurisation of milk, dairy industries require boiler or heat exchanger, and it consumes energy, and sometimes they need fossil fuels. Hence, a primary aim of this review paper is to discuss various research works have conducted by researchers on milk pasteurisation system so an appropriate best solution can be found for sustainable development.

1. Introduction

Thermal processing is a reliable food pasteurisation process that is required by law in various countries, but changes in the food quality brought about by thermal processing include the loss of subtle aroma and flavour components, the loss of vitamins and natural antioxidants, the loss of texture and freshness, and the denaturation of proteins. Nonthermal processing, which leads to minimizing degradation of these food qualities, is an attractive alternative for the food industry. There are various processes have used by different researchers an alternative to traditional to conventional Pasteurisation system [1–10].

Solar energy is the renewable source of energy, and it is available freely. Nowadays due to the global warming and many other reasons, solar energy is very much familiar. It can be harnessed either by solar thermal and solar photovoltaic technologies. Solar thermal technologies can supply hot water or steam for cooling and heating purposes. To provide hot water or steam thermal collectors are used [11–14].

Milk is a required liquid for humanity for the nutrition and growth purpose. Milk is obtained by Cow, buffalo, goat and goat. The milk obtained from the animals cannot consume directly by humanity. Hence, first heating of milk is required. Heating of milk at precise temperature kills bacteria and harmful microorganisms. Capturing the sun's energy may be a logical solution to solve the energy problem caused by scarce fuels. It is free and has an adverse impact on the environment. Gujarat is situated in areas where solar energy is abundant [15,16]. Solar radiation incident in Gujarat is ranged from 3 to 4 kW h/m^2/day; with about 300 sunshine days [17]. Thus, the abundance of solar energy paired with the concept of milk pasteurisation encourages a new result to purify unsafe milk. A solution has the many advantages: environment conservation, ensure a better human health in remote areas, address the problem of energy and reduce costly, a new use of solar energy applications and the cost of such energy is low which is required only for the necessary apparatus to establishing it. Long distances between the production areas and the markets, adverse road conditions and high ambient temperatures make the development of a dairy industry to be a particularly arduous task. Therefore, this research aims to apply solar energy for pasteurising the milk at remote areas and in village communities which are deprived of the availability of electricity and gas, where the small quantities of milk are delivered by individual producers [18,19]. The solar energy collectors are special kind of heat exchangers that transform solar radiation energy to internal energy of the transport medium. The flat-plate solar collector is one of the most important types of solar collectors because it is the simplest one and has a wide range of important potential applications [20–23]. The average daily milk production of cows is about 4 kg per head in the winter and about 2.8 kg in the summer. For the buffalo, the average daily milk in the winter is about 6.6 kg per head and about 5.2 kg per head in the summer. The average annual productivity is about 3.1 kg per cow and about 5.9 kg per buffalo. Temperature requirement of pasteurisation process required less than 80 °C, hence Flat

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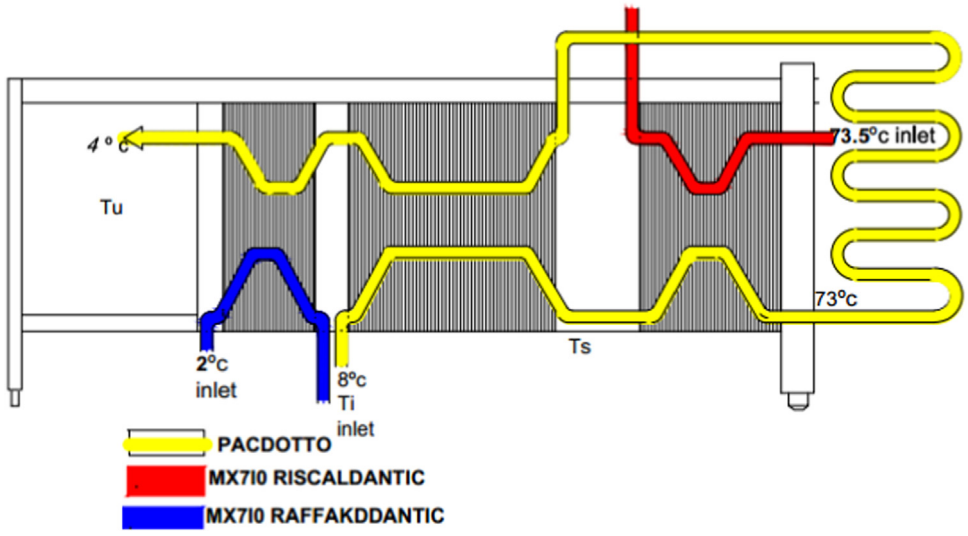

Fig. 1. Thermal cycle of solar pasteurisation process.

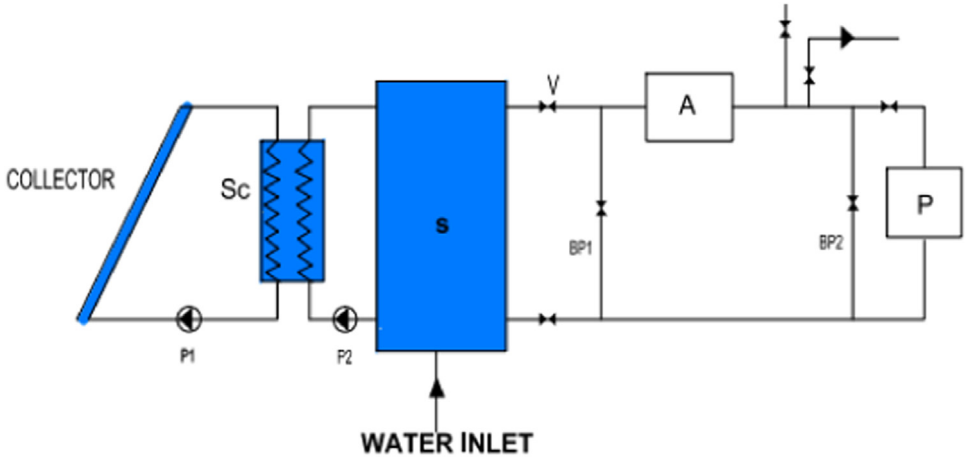

Fig. 2. Dairy plant scheme for simulation purpose.

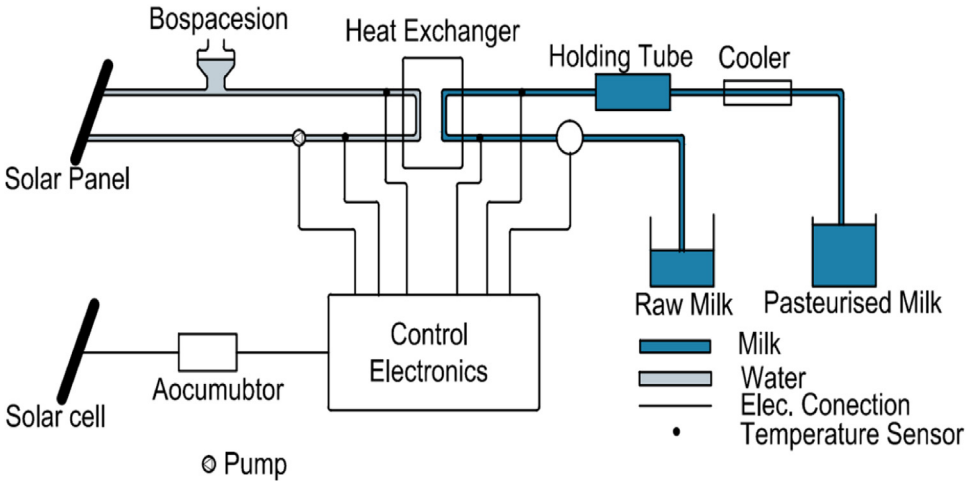

Fig. 3. Diagram of pasteurisation process based on solar panel.

plate collector is a suitable option [24–26]. Recently researchers have used toxin inside pasteurised milk [27], model predictive control of Pasteurised milk [28], usage of geothermal energy for pasteurisation process [29] and microbiological inactivation in pasteurised milk [30].

From the literature review, it has been found that the pasteurisation process is essential for humanity. At present, conventional thermal systems are used for the pasteurisation process. But due to increment in global warming and pollution in the environment, it is necessary to use alternative energy instead of other conventional thermal energy sources. Pasteurisation temperature range is between 60 °C and 70 °C