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Energy Systems Management of Low Impact Manufacturing of Milk

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***Abstract*-Milk producers are productive by world standards, and average agricultural productivity has increased significantly in recent years. This is achieved by increasing land use for livestock, improving pastures and feeding management, and increasing machinery, agrochemicals and irrigation areas. Also, farms are often located in beautiful environments that are frequently visited by members of non-agricultural communities, and farms can be found in receiving areas that supply water to the landfill in the city. High rates of environmental concerns within the Community Life cycle analysis has been widely used in the assessment of industrial production systems and has increased interest in the implementation of agricultural production in recent years. This focuses on the initial assessment of the life cycle of the milk production systemconcerning energy management used in farms milk. Problems related to life cycle assessment methods and methods used in the application of high-level agricultural production systems with the energy required.**

***Keyword*-Milk production; Energy systems; low impact**

I. INTRODUCTION

Milk is one of the major food products consumed by millions of people in the world every day. In 2016, it was predicted that 816million tonnes of milk were produced [1]. Milk has perishable characteristics, and as a result, it is processed into other forms like butter, cheese yoghurt and dry milk. Dry milk is produced through a process of dehydration. The water is removed to improve shelf life and storage in room temperature [2,3].

The production of dry milk from raw milk is achieved through a thermal process such as cooling, and heating and a large amount of energy are required. Hence, in the dairy industry, energy consumption is an essential issue from an environmental and economic perspective. Because the dairy industry is a sector with intense energy and excellent capability for energy efficiency, it is cognizant that manufactures adapter new able energy sources to their production to protect the global environment and reduce greenhouse emission [4].

The need for renewable energy has been on the increase, and the present situation suggests that soon, fossil fuels reserve will not be enough. Hence, the use of renewable energy sources like geothermal energy, biomass energy, wind energy and solar energy is inevitable [5].In this report, the five most significant energy using process in milk production will be examined, quantifying the energy used in each process. Also, an illustration of the leading energy flow within and out of the facility, energy conversions and energy losses will be shown using a Sankey diagram. Lastly, the suitability of renewable energy for this kind of production will be examined, and ways of energy reduction for milk production will be suggested. Proceeding from this is the examination of the five most significant energy using process in milk production [6].

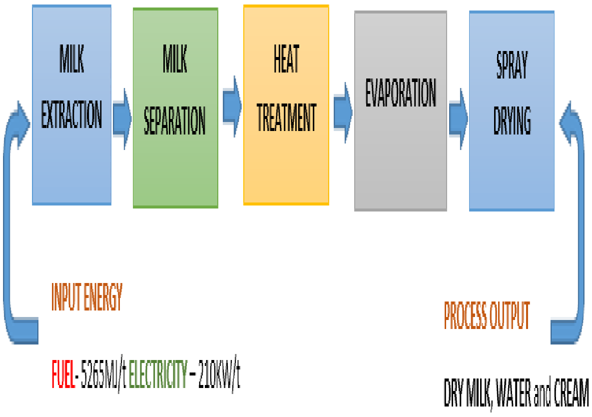

Figure 1 Flow chart of significant energy using Processes.

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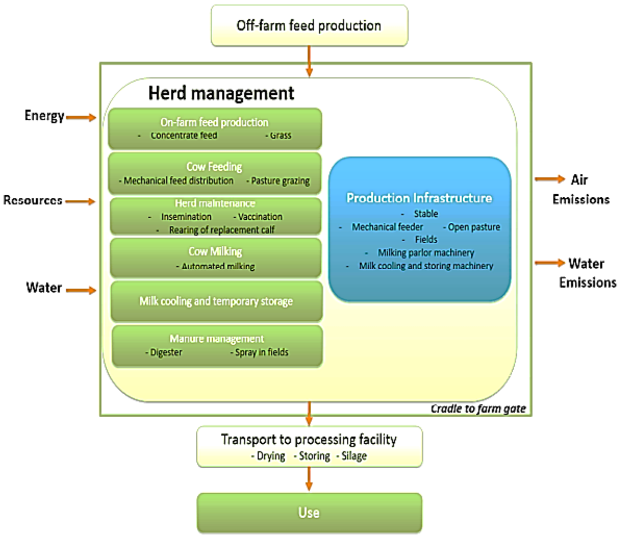

Figure 1 Industrial energy systems for dry milk production[10].

II. METHODOLOGY

1. Milk extraction and separation process

The process of milk extraction involves harvesting the milk from the dairy cows using a vacuum pump and transferring it to a storage tank. This can be done two or three times per day while some dairies might carry out regular lactations all through the year. Milk extraction utilises about 18% of the electrical energy that is consumed in the dairy farm (Walmsley et al., 2018). A vacuum pump is used to extract the milk by creating a negative air pressure that extracts the milk from the cow. The extracted milk is drawn into a milk receiver or transferred to a bulk tank.

During the milk separation process, the raw milk is separated into cream and skim milk at a temperature of 8°C. The energy required for this process is about 10 MJ/tp for the hot water and 10 MJ/tp for the chilled water. This energy is quite insignificant as it represents only 3% use of the overall energy required for the production [7,8].During the process of heat treatment, microorganisms both spoilage and pathogenic are destroyed to ensure the safety of its consumption and duration of shelf-life. The heat treatment is carried out at a temperature between 80°C and 120°C within a time of 1 to 6 sec, and the degree of protein denaturalisation is also influenced by [8,9].

The milk goes into the treatment process at 8°C and its heated until a suitable temperature is reached, but it should be noted that at a temperature range of 45°C to 60°C, thermopile growth occurs [10]. The amount of energy used for the heat treatment represents 10% of the overall energy used for the entire production processAfter the heat treatment; the evaporation process follows immediately as the two processes are tightly integrated. It involves the removal of about 60% of the water content in the milk. The process of evaporation is carried out under vacuum at a pressure of 35.3kPa and temperature of 73°C to reduce the boiling point because milk is heat sensitive.The components used for this process include heat exchangers, vacuum, vapour separator and condenser. The energy consumed during this process accounts for about 10% of the energy required for the entire production process.

Spray drying is the final processing step, and this accounts for about 51% at 3036MJ/tp of the energy used for the entire production process. After the evaporation, the milk is heated at a temperature of 75°C, and it is homogenised. It is then atomised, and spray dried simultaneously at a temperature of 210°C. After this, the partially dried powder is removed from the spray dryer chambers, and it is cooled from 80°C to about 35°C in the main chamber.

Table 1 Summary of the energy consumption for the productionprocesses.

Production Process	% Energy Consumed
Milk Extraction	14.5%
Milk Separation	3%
Heat Treatment	10%
Evaporation Process	10%
Spray Drying	51%
Other Utilities	3.5%
Total	100%

III. RESULT

By using renewable energy technologies, we can reduce the impact of manufacturing activities such as burning of fuel, on our environments. Examples of renewable energy technology applicable to dry milk production are Solar Thermal Collectors, Solar Concentrators and Geothermal Energy using Solar Heat Pumpstheparabolic solar concentration captures the sunlight and heat in 3D and focuses the parabolic reflector on the area of high temperature to produce heat and electricity.

This is an effective way to reduce carbon emission and cost of production.To maintain the low temperature required for production, a heat pump is used to generate higher temperatures by pumping the heat from a lower temperature source to raise the temperature of the fluid in the ground to temperature we can use for the industrial process. Hence the ground serves as a source of heat. This is very suitable for milk production factories.Solar dehydrators can be used during the evaporation process for dry milk production. Present day milk producers dispense a significant amount of energy on evaporation alone, and this can be reduced by using solar dehydrators which is a cheaper alternative. However, there are concerns about the duration it will take to dehydrate a large amount of milk during production.

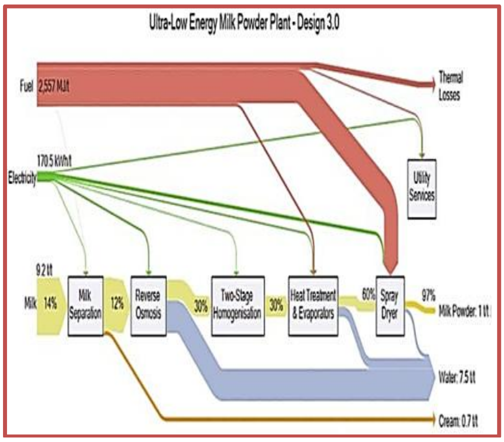

Figure 2. proposed a Sankey diagram showing energy conservation and efficiency using reverse osmosis and homogenisation.

Solar air heating is a method that can be employed to heat the factory and maintain the desired room temperature needed for production. It will reduce the cost of using thermal heaters, and it is very compactable with this dry milk production factory.

2. Cost reduction methods

Four energy efficiency opportunities within various process and utility can be used to reduce the cost of production. The increasing boiler efficiency through condensing economisers and waste heat recovery from the chiller unit. The recycling of air in the building HVAC system help combined Heat and Power for electricity production.Increasing boiler efficiency through condensing economisers give a modern Industrial steam boiler used in powdered milk manufacturing operate at 40 bar 250^{o}C saturated, and economisers are incorporated into the system. The economiser warms pressurised boiler water feed before the water gets into the primary evaporation tubes. Boiler design may vary, but the flue gas flows into the economiser at up to 350OC and exit above the acid dew point at 140OC.

Usually, the extra condensing economiseris mounted to trap more flue gas heat to increase boiler efficiency. The natural gas boiler considered has a water dew point to be about 60OC while the coal-fuelled boiler is 40OC. Boilers that extract and utilises heat both sensible and latent maximises the efficiency of the system and reduces fuel consumption, hence encourage low detrimental impact from manufacturing.Waste heat recovery is an important phenomenon that can contribute to energy cost reduction by maximising the energy from chiller units. This phenomenon might require more compressor or more powerful ones to amplify the pressure from the chiller's condenser, to improve the extracted heat till the extracted possesses enough energy that can replace the steam boiler and produce the required heat energy needed to heat the system.

3.Recycling of air in the building HVAC system

In the milk powder plant's Heating, Ventilation and Air Conditioning (HVAC) system. The technique currently applied is a single pass with a steam heater installed to warm up received air to 28OC that was having an average temperature of 15OC, bypassing warmed up air through the building air exhausts that operates at about 33OC. Finally, a portion of this air may be recycled to the inlet to reduce thermal energy use (Walmsley et al., 2014).

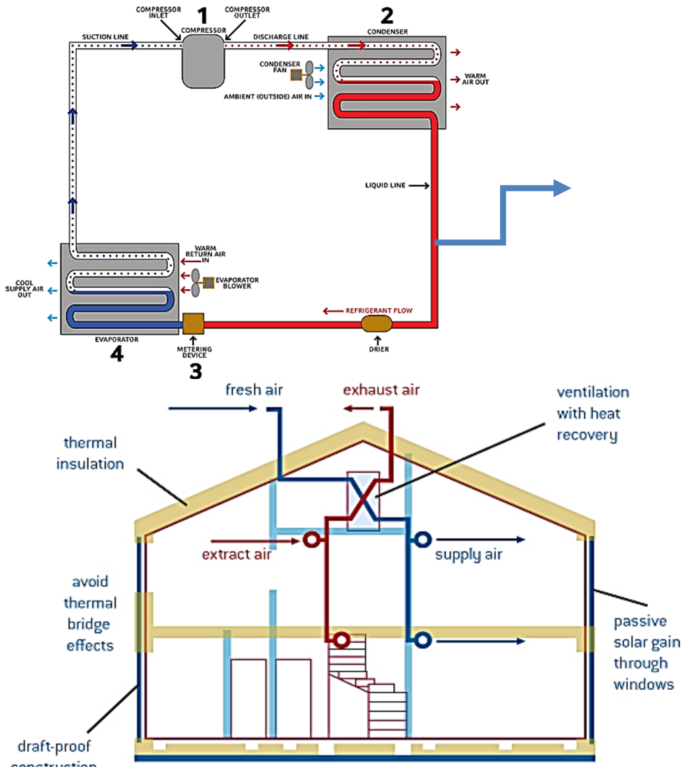

Figure 3 A Water-Cooled HVAC System and Energy Efficiency in Commercial industries[6,7]

The ducts take in fresh air from the outside and stale air from inside the home cross by each other in the heat exchanger core of the Heat Recovery Ventilator control

4. Combined Heat and Power for electricity production

Combined Heat Power is industrially applied recently; the system usually utilises heat from a higher source is combined with heat from a lower heat source. It is used to drive mechanical drive engines and a steam engine of the thermal sensor system to convert energy derived from the combination of both high and low heat source to generate the energy of electricity required to complete work in other systems.Combined Heat Power can be improved by including a VHPS level with superheat and an LPS level. The LPS level requires extra piping running from the boiler house into the process house. Combined Heat Power system using a profile obtained from an industrial site, the implementation of Combined Heat power shows that the steam system increases electricity production by 133% equivalent to 108.1kWh/tp(30.0MJe/tp), which can be translated as CHP reduced electricity drawn by 49% from the grid supplied (Walmsley et al., 2018).

Other Cost Reduction methods Include the Reverse Osmosis of Two-Staged Homogenisation. The insulating the factory to avoid heating and reheating all the time with Using Low energy Lightenings and continuous maintenance of equipment's to avoid energy waste and maximise energy efficiency. Also, buying renewable energy from renewable energy dealers who would be cheaper than the use of fuel and Generating own energy using Solar PVs or Solar Thermal Panels.

IV. CONCLUSION

According to REN21 report in 2015, the estimated renewable energy share of total final energy consumption for fossil fuel is 78.4%, nuclear power is 2.3%, and renewable energy is 19.3%. More than ever, it is cognisant that manufactures such as present-day dry milk producers reduce the amount of energy expelled on fossil fuel and invest in renewable energy.

Also changes in the production process and optimising the utility systems can reduce the thermal energy consumption by 51.5%, electricity by 48.6% and carbon emissions use by 19.0%. Some implementations are needed to achieve this level of energy efficiency. Two-Staged Homogenization withreverse Osmosis of Air in the HVAC system within the building can be recycled,and an ultra-low energy MVR evaporation system can be introduced. Also, the condensing economiser for a boiler can be installed,and Heat from dryer exhaust can be recovered. All of these mentioned improvements can reduce energy consumption, but there is still work to be done in the area of de-risking these proposedimprovements and also carrying out a detailed cost-benefit analysis.

REFERENCES

[1] Dincer, I. (2000). Renewable energy and sustainable development: a crucial review. Renewable and Sustainable Energy Reviews, 4(2), pp.157-175.

[2] Duić, N. and Rosen, M. (2014). Sustainable development of energy systems. Energy Conversion and Management, 87, pp.1057-1062.

[3] B.I. Oladapo, A.V. Balogun, S.O. Afolabi, M.T. Azeez, P.S. Asanta, Simulation model to explore the characteristic pump curve of an injection moulding machine: a case study of ABUAD water plant, Int. J. Eng. Bus. Enterprise Appl., 13 (1) (2015), pp. 63-68

[4] Hepbasli, A. (2008). A key review of energetic analysis and assessment of renewable energy resources or a sustainable future. Renewable and Sustainable Energy Reviews, 12(3), pp.593-661.

[5] Oladapo, B. I., Balogun, V. A., Oyegoke, S., Adeoye, A. O. M., Ijagbemi, C. O., Afolabi, S. O., … Uchegbu, I. D. (2016). Experimental, analytical design of CNC machine tool SCFC based on electro-pneumatic system simulation. Engineering Science and Technology, an International Journal, 19, 1958–1962. doi:10.1016/j.jestch.2016.08.010

[6] Mekouar, M. (2012). 15. United Nations Food and Agriculture Organization (FAO). Yearbook of International Environmental Law, 23(1), pp.585-597.

[7] Bankole I. Oladapo, V.A. Balogun, A.O.M. Adeoye, C.O. Ijagbemi, Afolabi S. Oluwole, I.A. Daniyan, A. EsosoAghor, Asanta P. Simeon, Model design and simulation of automatic sorting machine using proximity sensor, Eng. Sci. Technol. Int. J., 2 (2016), p. 2

[8] Oldfield, D., Taylor, M. and Singh, H. (2019). Effect of preheating and other process parameters on whey protein reactions during skim milk powder manufacture.

[9] Christian O Ijagbemi, Bankole I Oladapo, Harold M Campbell, Christopher O Ijagbemi, Design and simulation of fatigue analysis for a vehicle suspension system (VSS) and its effect on global warming, Procedia engineering 159, 124-132.

[10] Schlesser, J. (2007). Dairy Science and Technology, Pieter Walstra, Jan T.M. Wouters, Tom J. Geurts (Eds.). 2nd ed. CRC Press, Taylor & Francis Group (2006). 782 pp. Food Microbiology, 24(7-8), pp.802-802.

[11] Walmsley, T., Atkins, M., Walmsley, M., Philipp, M. and Peesel, R. (2018). Process and utility systems integration and optimisation for ultra-low energy milk powder production. Energy, 146, pp.67-81.