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Energy assessment of milk pasteurization in dairy plant

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■ **ABSTRACT :** Energy is critical component of dairy industry. Dairy industry depends on fossil fuels for energy supply. Energy conservation in dairy plant means to develop a methodology to achieve energy saving to reduce energy costs in processing system. The aim of experiment was to investigate average quantity of milk, electricity consumption in per day. The data was analyzed of November 2016, December 2016 and January 2017 for old alfa pasteurizer in Parag dairy Meerut. The highest average quantity of milk, electricity consumption and thermal energy in shift B of November was 520.17 kg, 17.36 (KW) and 144.08(KJ×10^3), respectively. The lowest average quantity of milk, electricity consumption and thermal energy in shift A of November was 14 kg, 0.47 (KW) and 3.88 (KJ×10^3). Followed by The highest average quantity of milk, electricity and thermal energy consumption in December was 224.80 kg, 7.50 (KW) and 62.0 (KJ×10^3) in shift B and the lowest collection of milk 14.04 kg, electricity consumption average 0.47 (KW) and thermal energy consumption 3.78 (KJ×10^3) in shift A of old alfa pasteurizer. Old alfa pasteurizer's highest average quantity of milk in January (2017), 111.78 kg, electricity consumption average was 3.73 (KW) and thermal energy consumption 31.07 (KJ×10^3) in shift B while lowest average collection of milk, electricity and thermal energy consumption was 42.26 kg, 1.41 (KW) and 11.79 (KJ×10^3) in shift C, respectively.

■ **KEY WORDS :** Energy audit, Dairy plant, Electrical energy, Thermal energy

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The competition and quality aspect limited the profitability of the milk dairy plant. The milk dairy processes are fast growing business but high energy cost is a serious problem. In the current scenario to understand the problems related to high energy consumption of the milk processing and to suggest methods for their active reduction with the help of different approaches needed proper management of the all processes used in the plant. Major emphasis of the paper is to utilize the waste heat of the process which otherwise goes to the atmosphere and to control the pollution depending upon regulatory context. The major considerations are the product type and resource cost. By help of energy audit technique a most economical method is suggested for preservation of milk, with the lowest possible investment and energy expenditure and minimum performance variation (Modi and Prajapat, 2014). Milk flash pasteurization by the microwave and study its chemical, microbiological and thermo physical characteristics the study included pasteurization of cow's milk by the flash pasteurization method and using temperature of 100°C for a period of 0.01 seconds (Singh *et al.,* 2017). Today, Energy is the major concern for every industry as the conventional sources of energy are depleting and at the same time there is a significant growth in the industrial loads. To link this gap there is need to search all possible energy saving alternatives. A lot of awareness has been generated in the conducting energy audits to achieve energy conservation. With the beginning of energy crisis and increase in energy cost, energy audit is proving its importance in various sectors. Dairy industry uses electrical energy and thermal energy as main energy source (Yadav *et al.,* 2016). Energy is one of the essential requirements for the economic growth of developing countries. India has 8.6 per cent of the world coal reserves and is the fourth largest producer of coal and lignite meet nearly 50 per cent of commercial energy requirements in the country. Natural gas accounts for about 8.9 per cent of energy consumption in the country. The current demand for natural gas is about 96 million cubic metres per day as against availability of 67 (Desai and Zala, 2010). The major commercial energy consuming sectors in the country are classified into five major sectors namely agriculture, domestic, industry, transport and others (Chaudhari and Upadhyay, 2014). Energy is critical component of dairy industry. Dairy industry depends on fossil fuels for energy supply. It is known fact that our fossil fuel reserves are finite and we should utilize these resources judiciously. Energy conservation is only route that can get better mileage out of the available resources. The need is to evolve an appropriate strategy for energy conservation to achieve economical and environmental benefits. Energy conservation in dairies is not the suppression of demand for energy use, but efficient use of energy and steep rejection of energy wastage. Energy is one of the fourth pillars for production of dairy products in addition to land, labour and capital. In dairy industry, processing of milk and milk products require considerable amount of energy in the forms of the heat and electricity. A major amount of electrical energy is used for running auxiliary equipments while heat energy is used for heat treatments of milk and milk products in the plant. The cost related to this energy consumption is entitled as overhead cost. One often overlooked, but major overhead is energy costs. Dairy producers are looking the ways to reduce these overheads. Energy conservation will help to reduce the energy costs which will reduce the processing costs. It leads to develop capable processing system with optimum energy consumption in dairies which will result into the performance enhancement of dairy plant **(**Jadhav *et al.,* 2015). Food production affects the environment in numerous ways and energy use and pollution occur at many stages in a food product's life cycle. Thus, intensifying the agricultural practices more, without occupying the remained on energy sources (e.g. fossil fuels), either directly for plowing and industrial processes, or through the application of energy-intensive inputs such as synthetic fertilizer and packaging materials. Thus, the need exists to address these contributions more holistically and in an integrated product oriented manner, and to succeed in that, the responsibility of food industry should be expanded from the production site to the whole product chain. In this alternative it is suggested to utilize the energy wasted in the form of heat carried by the heated milk going into the chiller unit. The suggested alternative plans to use this heat and the same is used to preheat the milk coming from the supply and hence reduce the heating load required for the purpose of milk processing. This can be done by using a plate type heat exchanger the suggested alternative design to use this heat and the same is used to preheat the milk coming from the fresh supply and hence reduce the heating load required for the purpose of milk processing in chilling unit (Modi and Prajapat, 2014).

Data collection:

The work was carried out in Gangol Sahkari Dugdh Utpadak Sangh (Parag Dairy) Meerut and data analyzed in the Department of Agriculture Engineering, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (India) during the month of November, December (2016) and January 2017.

Old alfa / IDMC pasteurizer:

The IDMC means Indian Dairy Machinery Company Ltd. This pasteurizer was manufactured by Vithal udyog nagar Gujarat India. IDMC pasteurizers are extensively used for pasteurization of milk and cream in dairy and food industries. Heat exchangers based pasteurizer offer enormous convenience for processing milk, cream with flexibility, high thermal efficiency and effective heat transfer. The system is compact, requires minimal space and is very easy to expand capacity. The capacity of the IDMC pasteurizer has 20,000 lit/hr. It has high capacity compare new alfa pasteurizer.

Thermal energy:

Thermal energy is energy possessed by an object or system due to the movement of particles within the system. Thermal energy is one of various types of energy, where 'energy' can be defined as 'the ability to do work.' Work is the movement of an object due to an applied force. A system is simply a collection of objects within some boundary. Therefore, thermal energy can be described as the ability of something to do work due to the movement of its particles.

$$Q = m.\ c_p.\ \Delta T$$

where,

Q = Thermal energy (kj)

m = Quantity of milk (kg)

Cp = Specific heat (kj/kg, k)

ΔT = Temperature difference (°C)

Specific heat:

The ratio of the amount of heat needed to raise the temperature of a certain amount of a substance by one degree to the amount of heat needed to raise the temperature of the same amount of a reference substance, usually water, by one degree. Because molecules of different materials have different weights and sizes, they require different amounts of energy to be heated to a given temperature. Knowing the specific heat of a material makes it possible to calculate how much energy is needed to raise the material's temperature by a given number of degrees. The amount of heat, measured in calories, needed to raise the temperature of one gram of a substance by one degree celsius.

$$Cp=1674.72F+837.36SNF+4186.8M$$

where,

Cp = Specific heat (kj/kg, k)

F = Fat (%)

SNF = Solid not fat (%)

M = Moisture, (water) (%)

Electricity:

Amount of electric city was calculated by the using formula as fallow.

$$\text{Electricity used in per day (KW/kg)} = \frac{\text{Average electricity used in per day}}{\text{Quantity of milk kg per day}}$$

■ RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

November (2016) :

In November 2016, the Old Alfa pasteurizer, pasteurized average highest quantity of milk 520.17 kg/day in shift B followed by 30.0 kg/day in shift C and lowest 14.0 kg/day in shift A (Fig.1a-f). Electricity consumption was depends upon quantity to be pasteurized. In November it was calculated highest in shift B (17.36 KW) followed by shift C (1.1 KW) and lowest in shift A (0.47 KW). Average specific heat used was calculated highest in shift B (3.19 KJ/kg./k) followed by shift A (3.43 KJ/kg./k) and lowest in shift C (0.13 KJ/kg./k).Thermal energy consumption in milk pasteurization was highest in shift B (144.08 KJ×10^3) followed by shift A (8.32 KJ×10^3) and lowest in shift C (3.84 KJ×10^3).

December 2016:

In December 2016, the Old Alfa pasteurizer pasteurized average highest milk 224.80 kg/day in shift B followed by 42.75 kg/day in shift C and lowest 14.04 kg/day in shift A (Fig. 2a-f). Electricity consumption was depends upon quantity to be pasteurized. In December was calculated highest in shift B (7.50 KW) followed by shift C (1.43 KW) and lowest in shift A (0.47 KW). Average Specific heat used was calculated highest in shift A (3.44 KJ/kg/k) followed by shift B (1.07 KJ/kg/k) and lowest in shift C (0.72 KJ/kg/k). Thermal energy consumption in milk pasteurization highest average in shift B (62.00 KJ×10^3) followed by shift C (12.33 KJ×10^3) and lowest in shift A (3.78 KJ×10^3).

January (2017):

In January 2017, Old Alfa pasteurizer pasteurized average highest milk 111.78 kg/day in shift B followed by 71.46 kg/day in shift A and lowest 42.26 kg/day in shift A (Fig.3 a-f). Electricity consumption was calculated highest average in shift C (3.72 KW) followed by shift A (2.39 KW) and lowest in shift C (1.41 KW). Average Specific heat used was calculated highest in shift A (2.38 KJ/kg/k) followed by shift C (1.90 KJ/kg/k) and lowest in shift B (1.08 KJ/kg/k).Thermal energy consumption in milk pasteurization highest average in shift B (31.07 KJ×10^3) followed by shift A (19.88 KJ×10^3) and lowest in shift C (11.79 KJ×10^3) (Singh *et al.*, 2017 and Yadav *et al.*, 2016).

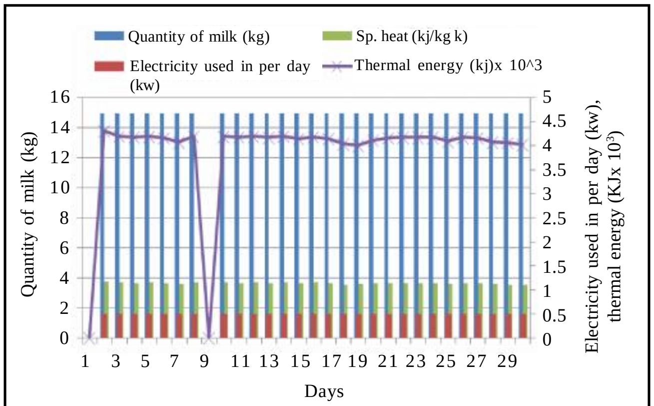

Fig. 1 (a) : Quantity of milk, electricity and thermal energy in shift A

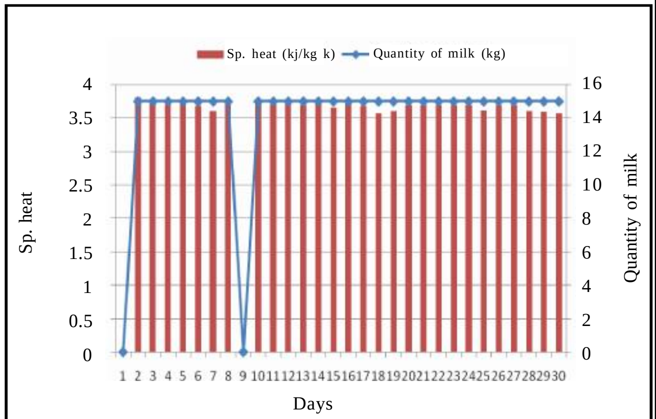

Fig. 1 (d) : Specific heat and quantity of milk in shift A

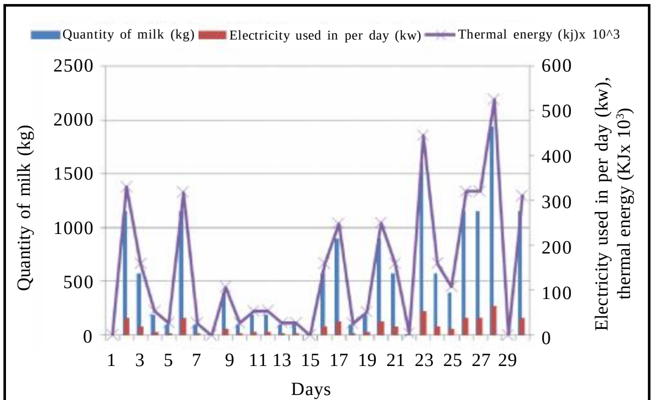

Fig. 1 (b) : Quantity of milk, electricity and thermal energy in shift B

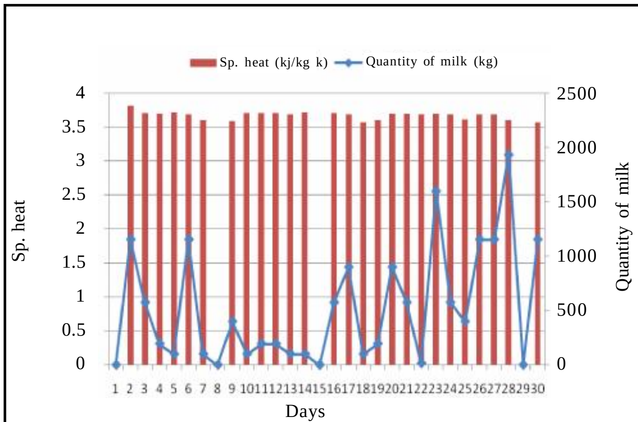

Fig. 1 (e) : Specific heat and quantity of milk in shift B

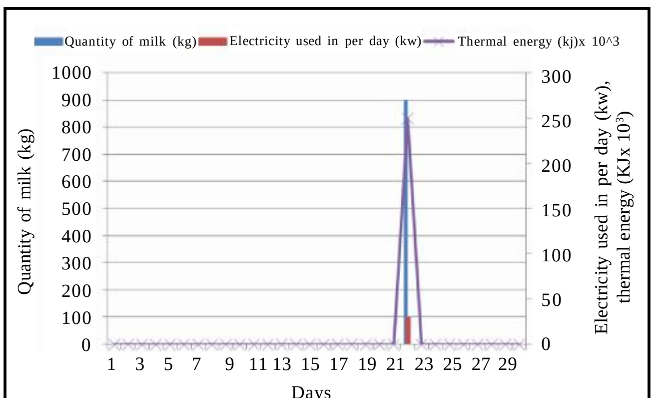

Fig. 1 (c) : Quantity of milk, electricity and thermal energy in shift C

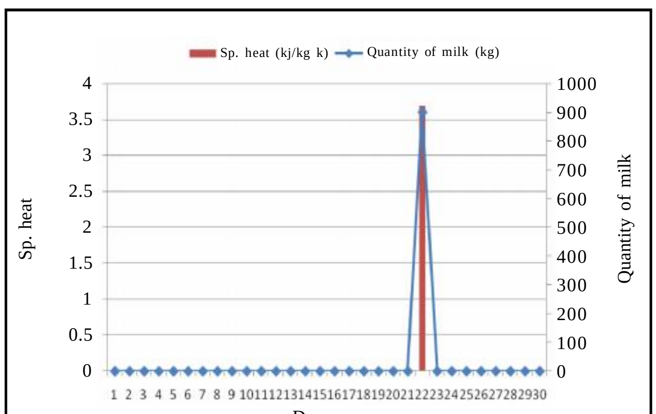

Fig. 1 (f) : Specific heat and quantity of milk in shift C

Fig. 1: Date and shift wise data distribution of old alfa pasteurizer for November month

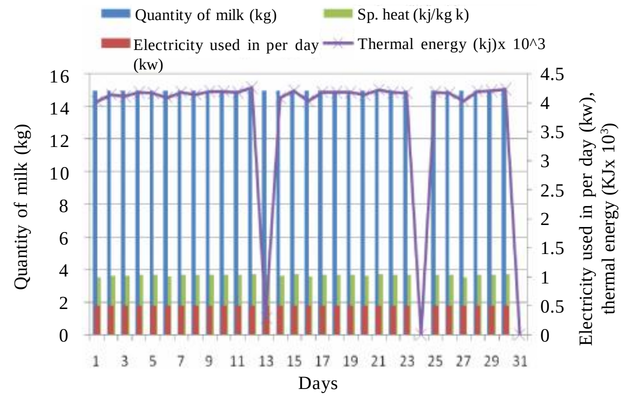

Fig. 2 (a) : Quantity of milk, electricity and thermal energy in shift A

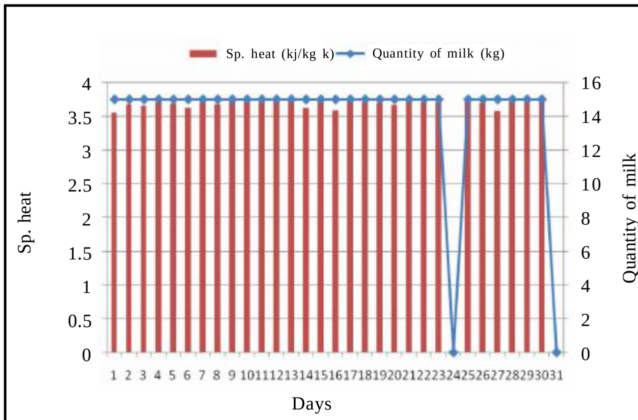

Fig. 2 (d) : Specific heat and quantity of milk in shift A

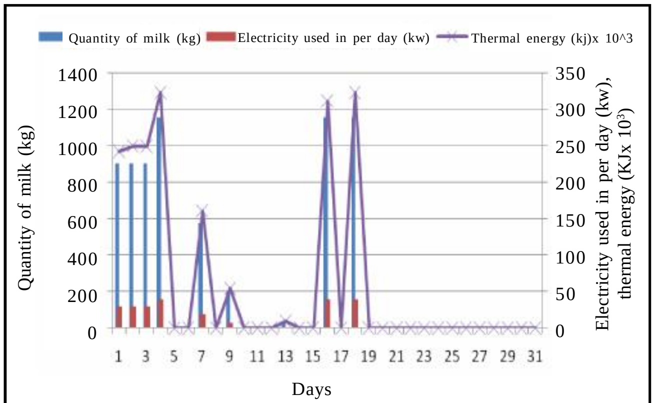

Fig. 2 (b) : Quantity of milk, electricity and thermal energy in shift B

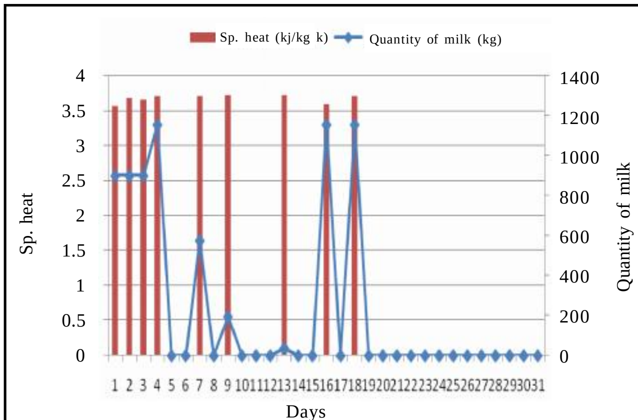

Fig. 2 (e) : specific heat and quantity of milk in shift B

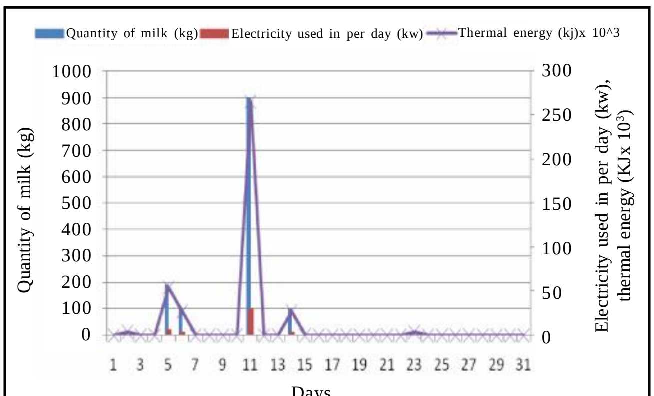

Fig. 2 (c) : Quantity of milk, electricity and thermal energy in shift C

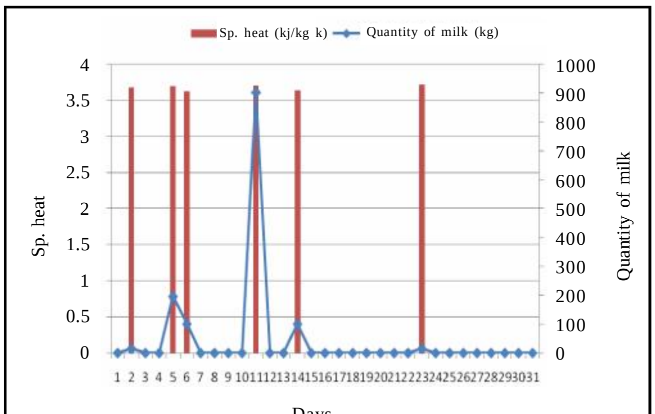

Fig. 2 (f) : Specific heat and quantity of milk in shift C

Fig. 2: Date and shift wise data distribution of old alfa pasteurizer for December month

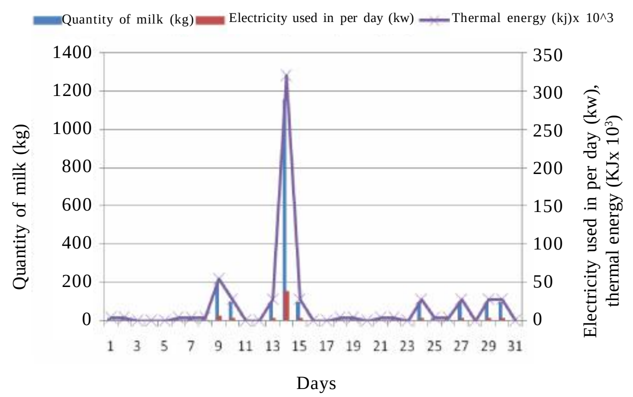

Fig. 3 (a) : Quantity of milk, electricity and thermal energy in shift A

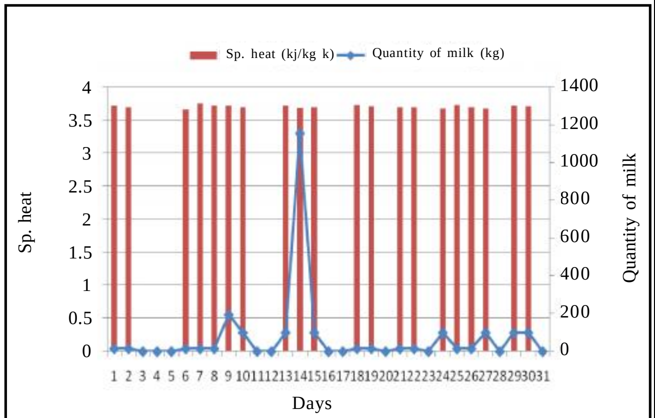

Fig. 3 (d) : Specific heat and quantity of milk in shift A

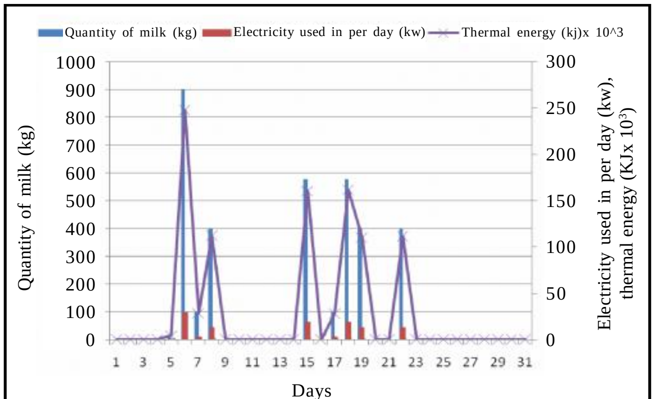

Fig. 3 (b) : Quantity of milk, electricity and thermal energy in shift B

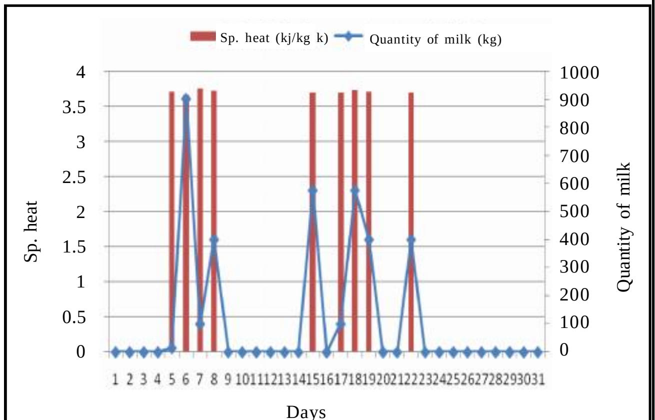

Fig. 3 (e) : Specific heat and quantity of milk in shift B

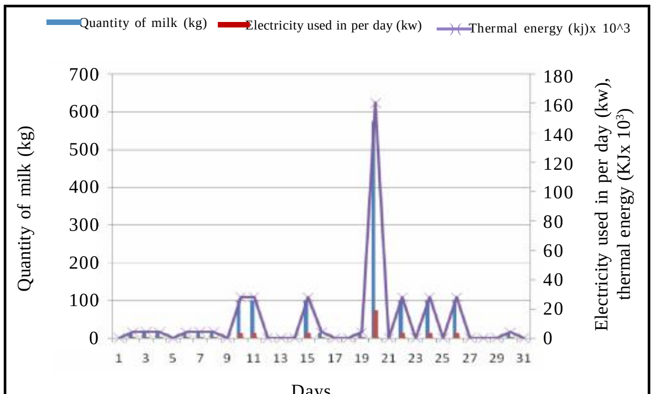

Fig. 3 (c) : Quantity of milk, electricity and thermal energy in shift C

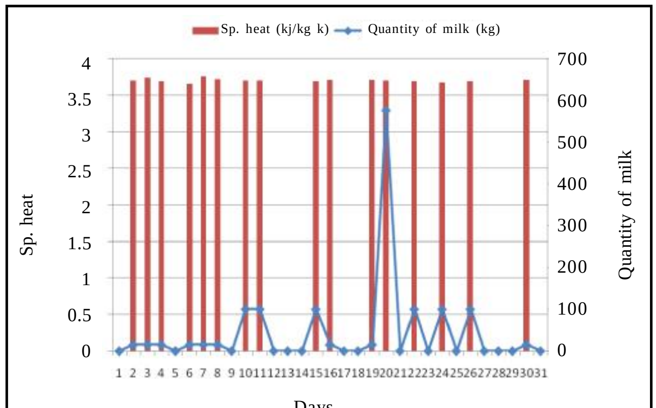

Fig. 3 (f) : Specific heat and quantity of milk in shift C

Fig. 3: Date and shift wise data distribution of old alfa pasteurizer for January month

Conclusion:

The objective of this study is to provide resources and methods to reduce energy use and energy related costs in dairy processing facilities. Using this study, dairy processing facility managers will learn how to manage energy in their facility and uncover opportunities to significantly reduce facility energy consumption. Applying these good management practices will reduce energy costs. It is known that energy audit is one of the most comprehensive methods to attain energy savings by dropping unnecessary energy consumption. We conclude that's in November (2016) the milk quantity to be pasteurized was highest in shift B and lowest in shift A. In December (2016) the milk quantity to be pasteurized was highest in shift B and lowest in shift A. During January (2017) the milk quantity to be pasteurized was highest in shift C and lowest in shift A. The specific heat consumption was highest in shift B in November and December 2016 in shift B also in January 2017 in shift B. The electric energy and thermal energy are also depends upon quantity of milk. So the quantity of milk which will be higher in the shift all the parameters will be more in the same shift.

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■ REFERENCES

Chaudhari, A.G. and Upadhyay, J.B. (2014). Study on thermal energy scenario for in selected dairy products. *Internat. J. Agric. Engg.,* **7**(2) : 467-472.

Desai, H.K. and Zala, A.M. (2010). An overview on present energy scenario and scope for energy conservation in dairy industry. *Souvernir national seminar on energy management and carbon trading in dairy industry,* Published by SMC College of Dairy Science, Anand, 1-7.

Jadhav, Rohan, Achutan, Chandran, Haynatzki, Gleb, Rajaram, Shireen and Rautiainen, Risto (2015). Risk factors for agricultural injury: A systematic review and meta-analysis, *J. Agromedicine,* **20** (4) : 434 - 449.

Modi, A. and Prajapat, R. (2014). Pasteurization process energy optimization for a milk dairy plant by energy audit approach. *Internat J. Sci. & Technol. Res.,* **3** (6): 181-188.

Singh, B., Chandra, S., Chauhan, N., Samsher, Singh, B.R. and Kumar, Mukesh (2017). Energy consumption during pasteurization of milk. *South Asian J. Food Tech. Environ.,* **3**(2) : 538-545.

Yadav, R.H., Jadhav, V. V. and Chougule,G.A. (2016). Performance analysis of a dairy plant through electrical energy audit. *Internat. J. Engg. Sci. &Comput.,* **6**(6):720- 725.

Yadav, R.H., Jadhav, V. V. and Chougule, G.A. (2016). Review paper on performance enhancement of dairy industry by energy conservation analysis. *Internat. J. Engg. Sci. & Res. Technol.,* **5** (7): 439-450.