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RESEARCH ARTICLE OPEN ACCESS

Potential Assessment of Solar Industrial Process Heating in Dairy Industry in Maharashtra State, India

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ABSTRACT:
The dairy industry is one of the major energy consuming sectors in India. The various processes in dairy industry include pasteurization, cream separation, homogenization, chilling of milk and packaging of milk and value-added products. Currently, the thermal and electrical demand required for various dairy processes is satisfied by conventional fuels like furnace oil, coal, natural gas and electricity. The total electricity consumption is about 53% of total demand, whereas the rest of demand is satisfied by natural gas, furnace oil, coal which accounts for 22 to 25% respectively.
These all non-conventional resources are going to deplete in next 3 to 4 decades, so there is a need to switch the use of conventional resources for process heating and cooling to non-conventional. Further as far as the conventional thermal process is concerned, there is a loss of nutritional values milk and its value-added products to some extent. Therefore, the proper utilization of renewable energy should be incorporated for process heating and cooling application in dairy industry in Maharashtra.

Keywords: Dairy industry, process heating, chilling requirements, pasteurisation, solar based vapour absorption refrigeration system.

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I. INTRODUCTION

The dairying is been practiced in the villages of India to meet the household requirements. There is very small percent of organized sector in India. Dairying started with the British rule by the establishment of the military dairy farms before independence to meet the requirements of the military troops. First cooperative dairy activity started with the establishment of Kaira Cooperative Milk Society, Uttar Pradesh in 1913 at various locations in Uttar Pradesh like Allahabad, Lucknow, Varanasi, Kanpur & Meerut.

The Dairy Development in India has been achieved with the help of "Operation Flood" Programme. The Milk cooperatives collected the milk at village level i.e. locally produced milk. In India, after Independence the Government has launched and implemented the integrated cattle development in Key Village Scheme (KVS) for the betterment of dairy industry respectively. At local village level the milk collection of unorganized sectors is show in flow chart below: -

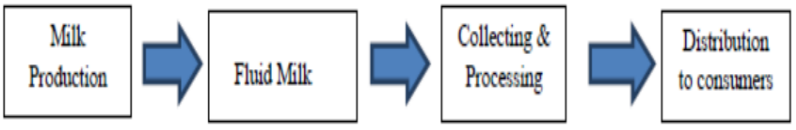

Figure 1. Milk Collection and Distribution Process for Unorganized Sector

II. EVOLUTION OF ANAND PATTERN

After independence till date the major problem faced by the Indian dairy industry is that the link between the milk procurement and milk marketing is weak, due to lack of proper roads connecting between villages and cities. Polson's

dairy- a private dairy sector which was established at Anand, Gujarat state. They used to procure the milk with the help of contractors. The contractors were used to be a link between villages and dairy at Anand. After milk procurement; it was then sent to Mumbai which was 425 km away from Anand. The Kaira district demanded a proportionate share of the trade margin to Polson's dairy which was refused by the management.

Later Kaira district Cooperative Milk Producers Union was established by Milk Producers Society under popular name 'AMUL' (Anand Milk Union Ltd) in year 1946. This laid to the foundation of organised sector in milk procurement and marketing in India. The three main pillars of Anand Pattern constitute: -

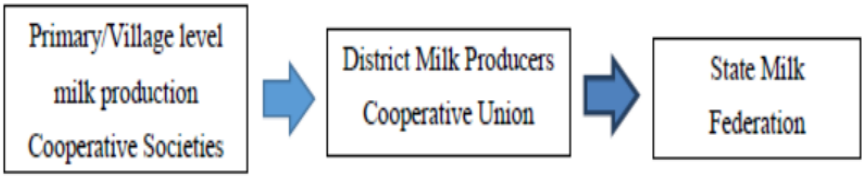

Figure 2. Milk Collection and Distribution Process for Organized Sector

1. Village Level Milk Production Cooperative Societies
The primary function of these co-operative societies was to provide basic facilities to farmers, supplying cattle feeds at subsidized rate, looking after welfare of farmers.

2. District Milk Producers Cooperative Union
They looked after collection, transportation, processing and products manufacturing.

3. State Milk Federations
They looked after marketing of products, control of dairies etc.

OPERATION FLOOD (OF- I) -WHITE REVOLUTION -1970

In year 1965, National Dairy Development Board (NDDB) came into existence, with a view to bring dairy industry under organized sector. Operation Flood (OF) was an approach implemented and conceived by Dr. V. Kurien, the chairman of NDD, whose vision was to increase the milk production on large scale in India. The main aim was to produce milk powder and butter oil, the funds from European Economic Commission (EEC) the sale of 1,26,000 tons of skim milk powder (SMP) and 42,000 tons of butter oil was made. The funds generated from the sale of SMP and butter oil was used for establishment of 27 Rural Milk Union in 10 states and setting up 'mother dairies' in 4 metropolitan cities.

OPERATION FLOOD (OF - II) 1981- 85
In Operation Flood II the main aim was to setup National Milk Grid (NMG) connecting, 136 rural milk union in 21 states and union territories.

OPERATION FLOOD (OF - III) 1985 - 95
The profits earned during OF-I and OF-II was used for self-sustainability of milk union in India.

OPERATION FLOOD (OF - IV) 1996 - 2006
The main aim to, create basic infrastructure and strengthening democratic values. Providing funds on 50: 50 basis to cooperative by central and state dairies. To increase the cooperative education, personnel training, marketing etc. [1]

PRESENT DAIRY SCENARIO
According to Annual Report 2017-18 of National Cooperative Dairy Federation of India Ltd (NCDFI) there are total 24 State Dairy Federations, 218 District Milk Union, 1.77 Lakh Village Milk Societies and 163 Lakh Dairy Farmer Members.

1. West Assam Milk Producers Cooperative Union Ltd - Purabi Dairy
2. Bihar State Cooperative Milk Producers Federations Ltd- Sudha Milk
3. Chhattisgarh State Cooperative Dairy Federations Ltd- Devbhog Milk
4. Goa State Cooperative Milk Producers Union Ltd- Goa Dairy
5. Gujarat Cooperative Milk Marketing Federations Ltd- Amul Milk
6. Haryana Dairy Development Federations Ltd – Vita Milk
7. Himachal Pradesh State Cooperative Milk Producers Federation Ltd-Him Dairy
8. Jharkhand State Cooperative Milk Producers Federation Ltd – Medha Dairy
9. Karnataka Cooperative Milk Producers Federation Ltd (KMF) – Nandini Dairy
10. Kerala Cooperative Milk Marketing Federation Ltd – Milma Dairy

11. Madhya Pradesh State Co-operative Dairy Federation Ltd – Sachi Dairy
12. Maharashtra Rajya SahakariDudhMahasanghMaryadit- Mahanand Dairy
13. Mizoram Multi-commodities Producers Cooperative Union Ltd
14. Nagaland State Dairy Cooperative Federation Ltd
15. The Orissa State Cooperative Milk Producers Federation – OMFED
16. Rajasthan Cooperative Dairy Federation Ltd- Saras Dairy
17. Sikkim Milk Cooperative Milk Producers Union Ltd- Sikkimilk
18. Tamil Nadu Cooperative Milk Producers Federation Ltd- Aavin Milk
19. Tripura Cooperative Milk Producers Union Ltd- Gomati Milk
20. Pradeshik Cooperative Dairy Federation, Uttar Pradesh- Parag Milk
21. Uttarkhand Cooperative Dairy Federation Ltd- Aanchal Dairy
22. West Bengal Cooperative Milk Producers Federation Ltd
23. Delhi Milk Scheme, New Delhi
24. The J&K Milk Producers Cooperative Ltd - Snowcap Dairy [2- 25]

III. MATERIALS AND METHODS

In India total milk produced is either consumed locally or consumed for processing in milk processing plants. Further milk is processed in un-organized dairy sector by local vendors for manufacturing of traditional sweets. The milk processed in organized dairy sector either by pasteurization of liquid milk or by value added products.[26]

The milk procured from the dairy farms is collected at village level, further it been graded, weighing is done at respective local milk unions, sampling is done as per the fat content or as per the type of milk (cow or buffalo). Finally, the milk procured is then transferred to main milk processing plant by tankers, which carry milk at 4 to 6oC, if milk processing plant is far away from the village milk unions. [27]

Now milk from the tankers is feed to the milk processing plants, where initially milk is tested and milk is been dispatched after clarification. After clarification milk is then sent to homogenization, where milk fat is been separated from the milk so that milk fat is evenly distributed evenly. After homogenization, pasteurization process takes place, where milk is heated up to 72^{o}C and then chilled at 4^{o}C. At last milk is sent for deep chilling process.

➢ **PROCESSES IN TYPICAL DAIRY INDUSTRY**

1. MILK COLLECTION

The activities performed at milk collection stage is grading of milk, weighing in kgs, chilling, dumping, sampling, loading in tankers and dispatch to main processing unit for Bulk Milk Processing and storage respectively. This is the initial step in the milk processing plant.

2. PASTEURIZATION

The second most important step after milk collection is pasteurization. Pasteurization is a process that purifies milk and helps it stay fresher, longer. The temperature requirement of pasteurization process is 72 ^{o}C for the duration of 16 seconds, and further it is quickly cooled to 4 ^{o}C.

3. HOMOGENIZATION

Homogenization is process used to spread the fat more evenly in the given quantity of milk. Homogenization process gives milk its delicious flavour and creamy texture. The milk is transferred into a piece of equipment called as homogenizer; fat is then forced under high pressure through tiny holes that break fat cells up into tiny particles i.e. 1/8th of its original size. Now the proteins contained in the milk quickly forms around each particle and these prevent fat from re-joining. Milk fat cells then stay suspended evenly throughout the milk.

4. PACKAGING OF MILK

After homogenization milk is then pumped to automatically filling machine. During the process milk is kept at 1 to 2^{o}C, thus preventing milk from development of extra bacteria and keeps milk fresh for long time.

5. VALUE ADDED PRODUCTS

Milk cream is extracted by machine called centrifuge. Cream can be either supplied by the fluid milk or it can be separated from whole milk by butter manufacturer. Different value-added products are manufactured by adjusting the total fat content. [27]

IV. RESULT AND DISCUSSION

THERMAL ENERGY REQUIREMENTS - PROCESS CALCULATIONS

The process calculations for state and dairy federations have been calculated by using following empirical formulas: -

1. Pasteurisation Process

Heat required for pasteurisation process i.e.

Q = $m \times Cp \times \Delta T$

Where,

Q = Heat requirement in GJ

m = Mass of processed milk in kg
Cp = Specific heat of milk KJ/kg K = 3.93
ΔT = (Tf- Ti) = Final temp – Initial temp (^{o}C) = (72 – 5.5)

2. Evaporation
Heat required for evaporation process i.e. Q = $m \times Cp \times \Delta T$
Where,
Q = Heat requirement in GJ
m = Mass of processed milk in kg
Cp = Specific heat of milk KJ/kg K = 3.93
ΔT = (Tf- Ti)= Final temp – Initial temp (^{o}C) = (80-5.5)

3. Sterilization
Heat required for sterilization process i.e. Q = $m \times Cp \times \Delta T$
Where,
Q = Heat requirement in GJ
m = Mass of processed milk in kg
Cp = Specific heat of milk KJ/kg K = 3.93
ΔT = (Tf- Ti)= Final temp – Initial temp (^{o}C) = (120-5.5)

4. Washing and Cleaning
Heat required for washing and cleaning process i.e. Q = $m \times Cp \times \Delta T$
Where,
Q = Heat requirement in GJ
m = Mass of processed milk in kg
Cp = Specific heat of milk KJ/kg K = 3.93
ΔT = (Tf- Ti)= Final temp – Initial temp (^{o}C) = (50-5.5)

The milk processing capacity of major dairies in Maharashtra state are as follows: -

Table 1. Capacity wise major dairy industry in Maharashtra State.

Sr. No	Name of Dairy	Milk Processing Capacity
1.	Ahmednagar JilhaSahakariDudh Sangh Ltd.- Rajhans Milk	3.10 LLPD
2.	Anant DoodhPvt. Ltd.	1 LLPM
3.	B G Chitale	3 LLPD
4.	Baramati Taluka SahakariDudhUtpadak Sangh Ltd.	1.5 LLPD
5.	Dynamix Dairy Industries Ltd.	10 LLPD
6.	Godavari KhoreSahakariDudhUtpadak Sangh Ltd.	475 LLPD
7.	KoyanaSahakariDudhUtpadak Sangh	1 LLPD
8.	Kolhapur Zilla SahakariDudhUtpadak Sangh Ltd.- Gokul Milk	7 LLPD
9.	Lokmangal Products Pvt. Ltd.	1 LLPD
10.	Malganga Dairy Farm-Kanhaiyya Milk	7 LLPD
11.	Mangalsiddhi Multi-Purpose Multi State Sahakari Sangh Ltd.	1 LLPD
12.	Maharashtra Rajya SahakariDudhMahasanghMaryadit-Mahanand Dairy	80000 LPD
13.	MahanandKokan Dairy Plant	20000 LPD
14.	Mahanand Pune Dairy Plant	30000 LPD
15.	Mahanand Nagpur Dairy Plant	15000 LPD
16.	Mahanand Latur Dairy Plant	15000 LPD
17.	Prabhat Dairy Pvt Ltd	1.5 MLPD
18.	Rajarambapu Patil SahakariDudh Sangh Ltd	1.75 LLPD
19.	Pune ZillhaSahakariDudhUtpadak Sangh Maryadit-Katraj Dairy	2 LLPD
20.	Ranade Dairy	10600 LPD
21.	S R Thorat Milk Products Pvt Ltd	254000Klitsper annum
22.	Shree WaranaSahakariDudhUtpadakPrakriya Sangh Ltd	10 LLPD
23.	Solapur Dist Coop Milk Producers' Union Ltd- Shivamrut	1.2 LLPD

	Milk	
24.	Indapur Dairy and Milk Products	25 LLPD
25.	J. D. Thote Dairy, Sangli	50000 LPD
26.	Mehta Dairy-Sphurti	1 LLPD
27.	Parag Milk	1.2 LLPD
28.	Shivamrut Dairy	1.2 LLPD
29.	Sangamner Taluka SahakariDudhUtpadak Sangh Ltd	6 LLPD
30.	Sonai Dairy	1.5 LLPD
31.	Kate Milk	3 LLPD
32.	Hatsun Dairy-Arokya Milk	900 TPD
33.	Mauli Dairy	60000 LPD
34.	Panchamrut Dairy- Taloja Milk, Mumbai	7.5 LLPD

The thermal energy requirements for various processes in dairy industry in Maharashtra state are as follows:

Table no 2. Thermal demand requirements for various processes in major dairy industry in Maharashtra state.

Sr.no	Name of Dairy	Capacity	Pasteurization (GJ)	Evaporation (GJ)	Sterilization (GJ)	Spray Drying(GJ)	Washi ng and Cleaning (GJ)
1	Ahmednagar JilhaSahakariDudh Sangh Ltd.- Rajhans Milk	3.10 LLPD	83.44	93.48	143.68	143.68	55.84
2	Anant Doodh Pvt. Ltd.	1 LLPM	26.91	30.15	46.34	46.34	18.01
3	B G Chitale	3 LLPD	10.19	11.41	17.54	17.54	6.82
4	Baramati Taluka SahakariDudhUtpadak Sangh Ltd.	1.5 LLPD	40.37	45.23	69.522	69.522	27.01
5	Dynamix Dairy Industries Ltd.	10 LLPD	2691.85	3015.68	4634.84	4634.84	1801.31
6	Godavari KhoreSahakariDudhUtpadak Sangh Ltd.	475 LLPD	12786.3	14324.5	22015.51	22015.51	8556.24
7	Koyana SahakariDudhUtpadak Sangh	1 LLPD	26.91	30.15	46.34	46.34	18.01
8	Kolhapur Zilla SahakariDudhUtpadak Sangh Ltd.- Gokul Milk	7 LLPD	188.42	211.09	324.43	324.43	126.09
9	Lokmangal Products Pvt. Ltd.	1 LLPD	26.91	30.15	46.34	46.34	18.01
10	Malganga Dairy Farm-Kanhaiyya Milk	7 LLPD	88.42	211.09	324.43	324.3	126.09
11	Mangalsiddhi Multi-Purpose Multi State Sahakari Sangh Ltd.	1 LLPD	26.91	30.15	46.34	46.34	18.01
12	Maharashtra Rajya SahakariDudhMahasanghMaryadit- Mahanand Dairy	80000 LPD	21.53	24.12	37.07	37.07	14.41
13	MahanandKokan Dairy Plant	20000 LPD	5.38	6.03	9.26	9.26	3.6
14	Mahanand Pune Dairy Plant	30000					

		LPD	8.07	9.04	13.9	13.9	5.4
15	Mahanand Nagpur Dairy Plant	15000 LPD	4.03	4.52	6.95	6.95	2.7
16	Mahanand Latur Dairy Plant	15000 LPD	4.03	4.52	6.95	6.95	2.7
17	Prabhat Dairy Pvt Ltd	1.5 MLPD	403.77	452.35	695.22	695.22	270.19
18	Rajarambapu Patil SahakariDudh Sangh Ltd	1,75,000 LPD	47.1	52.77	81.1	81.1	31.52
19	Pune ZillhaSahakariDudhUtpadak Sangh Maryadit-Katraj Dairy	2 LLPD	53.83	60.31	92.69	92.69	36.02
20	Ranade Dairy	10600 LPD	2.85	3.19	4.91	4.91	1.9
21	S R Thorat Milk Products Pvt Ltd	254000Kls/ Annum	187.32	209.85	463.48	463.48	125.35
22	Shree WaranaSahakariDudhUtpadakPrakriya Sangh Ltd	10 LLPD	269.18	301.56	463.48	463.48	180.13
23	Solapur Dist Coop Milk Producers' Union Ltd-Shivamrut Milk	1.2 LLPD	323.022	361.88	556.18	556.18	216.15
24	Indapur Dairy and Milk Products	25 LLPD	672.96	753.92	1158.71	1158.71	450.32
25	J. D. Thote Dairy, Sangli	50000 LPD	134.59	150.78	231.74	231.74	90.06
26	Mehta Dairy-Sphurti	1.50 LLPD	40.37	45.23	69.52	69.52	27.01
27	Parag Milk	1 LLPD	26.91	30.15	46.34	46.34	18.01
28	Shivamrut Dairy	1.2 LLPD	32.3	361.88	55.61	55.61	21.61
29	Sangamner Taluka SahakariDudhUtpadak Sangh Ltd	6 LLPD	161.51	180.94	278.09	278.09	108.07
30	Sonai Dairy	1.5 LLPD	40.37	45.23	69.52	69.52	27.01
31	Kate Milk	3 LLPD	80.75	19.47	139.04	139.04	54.03
32	Hatsun Dairy-Arokya Milk	900 TPD	235.21	63.5	404.98	404.98	157.39
33	Mauli Dairy	60000 LPD	16.15	18.09	27.8	27.8	10.8
34	Panchamrut Dairy- Taloja Milk,Mumbai	7.5 LLPD	201.88	226.17	347.61	347.61	135.09

Currently, the thermal demand required for various dairy processes is satisfied by conventional fuels like furnace oil, coal, natural gas and electricity. The total electricity consumption is about 53% of total demand, whereas the rest of demand is satisfied by natural gas, furnace oil, coal which accounts for 22 to 25%respectively.

V. CONCLUSION

The major energy consuming sectors in milk processing plant are thermal demand i.e.

pasteurization and evaporation for various value-added products and electrical demand for refrigeration and chilling process of milk products. This major demand is satisfied by the conventional grid electricity, natural gas, coal, furnace oil etc.

These non-conventional forms of energy have finite life. The thermal demand for milk processing plants can be satisfied by Concentrating Dish Collectors. Whereas electrical demand can be satisfied by grid connected solar Photo voltaic system or Solar based Vapour Absorption system. Thus, there is a need of implementing a proper renewable energy source that can cater the need of the milk processing plants in Maharashtra.

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