RESEARCH ARTICLE

Performance Evaluation of Three-stage Scraped Surface Heat Exchanger (SSHE) for Continuous Manufacturing of *Burfi*

I. A. Chauhan[1], A. K. Dodeja[2]

10.18805/ajdfr.DR-1468

Abstract

Burfi was manufactured in three-stage scraped surface heat exchanger by adding sugar directly into preheated milk by varying scraper speed in all three stages with different steam pressure in all three stages. The performance evaluation of the machine was evaluated during continuous mechanized manufacturing of *Burfi*. The average overall heat transfer coefficient were 1600, 950, and 410 W/m^{2}K for first, the second and third stage of thin-film scraped heat exchanger (TFSSHE), respectively. The specific steam consumption was found out to be 1.12 to 0.93 kg steam per kg of milk processed with mean value of 1 kg steam per kg of milk processed. The electricity consumption was found out to be 6.0 to 8.34 KWh per 1000 kg of milk processed with a mean value of 6.83 kWh per 1000 kg of milk processed. The sensory evaluation score of the *burfi* manufactured in the SSHE was obtained 20.6 out of a total of 25.

Keywords: *Burfi*, Energy analysis, Mechanization, Performance evaluation, SSHE

Asian Journal Of Dairy and Food Research (2019)

Introduction

Traditional Indian dairy products are highly valued in the society as a source of nutrition and are an inseparable part of wedding ceremonies, feasts, festivals, and religious occasions. The flavor of the new millennium is India's ethnic milk-based sweets, desserts, and puddings (Minz PS and Shingh RRB, 2016). Many traditional dairy products, particularly *khoa* based sweets, *Chhanna* based sweets, and *Paneer*, have an enormous market presence and tremendous consumer base in India and overseas as well. The other popular indigenous milk products such as *rabri, shrikhand, basundi, palada payasam*, etc. are region specific (Dairy India, 2007). As the growth rate of the dairy industry in India is increasing, the demands for energy-efficient and highly sophisticated mechanized systems are also growing. Besides higher profitability, traditional dairy products have acquired an interest in large scale production of these products. Therefore the large scale manufacture of conventional milk products will enable the dairy plant more economically viable due to their higher profitability and export potential. It is, therefore, necessary to give top priority to work on the design and development of mechanized systems for the manufacture of traditional dairy products.

Traditional Indian Dairy Products (TIDP) accounts for over 90% of all dairy products consumed in the country. The economic significance of conventional dairy products can be realized from the fact that they have huge market size estimated of more than Rs.1000 billion; the approximate share of individual products being *ghee/makkhan*, Rs. 310 billion; fermented products (*dahi, chakka, shrikhand*), Rs.180 billion; paneer, Rs. 20 billion and *chhana* and *khoa* based sweets, Rs 520 billion (Anon 2007). *Gulabjamun, khurchan, kalakand, peda, kunda, dharvad peda*, and *Burfi* are the main *khoa* based products. *Burfi* is the most popular *khoa* based traditional confection all over India. The generic nomenclature "*Burfi*" covers a wide range of product variations that include plain, danedar, dudh, chocolate, fruit, and coconut *Burfi*. It has variation in flavor, color, body and texture. *Burfi* is a popular milk-based sweet in which the base material is essentially *khoa*. Sugar is added in different proportions and other ingredients incorporated according to the demand of consumers. *Burfi* is prepared by heating a mixture of milk solids (*khoa*) and sugar to a homogenous consistency followed by cooling and cutting into small cubes (Khojare *et al*., 2003)

Even today, regardless of the volume of production, *Burfi* is manufactured primarily in jacketed kettles by *halwais*, which inherently suffers from several disadvantages such as low heat transfer rates, high fouling behavior, batch to batch variation in product quality, poor hygiene and sanitary conditions. The demand for efficient and labor saving processing of *Burfi* in the dairy industry attracts the application of continuous processing methods. SSHE is the

[1]Sheth M C College of Dairy Science, Anand Agricultural University, Anand -388110 Gujarat, India

[2]Dairy Engineering division, ICAR-National Dairy Research Institute, Karnal, Haryana, India

Corresponding Author: Istiyakhusen A Chauhan, Sheth M C College of Dairy Science, Anand Agricultural University, Anand -388110 Gujarat, India, Email: istiyakhusen@gmail.com

How to cite this article: Chauhan, I.A. and Dodeja, A.K. (2019). Performance Evaluation of Three-Stage SSHE for Continuous Manufacturing of *Burfi*. Asian Journal Of Dairy and Food Research, 38(3): 178-185.

Source of support: Nil.

Conflict of interest: None

Submitted: 07-08-2019 **Accepted:** 25-09-2019 **Published:** 24-10-2019

most suitable heat exchanger for handling high viscosity and heat sensitive products, which tend to foam and foul heat transfer surface (Devaraju *et al*., 2013). Some unique characteristics of thin-film scraped surface heat exchanger are energy conservation, suitable for heat sensitive products, high heat transfer coefficients, narrow residence time, minimum surface fouling, better to control and optimize the process.

The commercial large scale production of *Burfi* with very good sensory properties has necessitated sincere efforts in developing suitable equipment for the manufacture of *Burfi*. Looking over the performance characteristics of TFSSHE, it can also be used for the manufacture of *Burfi*. It has been proved very successful for the continuous production of *Khoa* and *Basundi*. The investigation is taken to explore its potential for continuous manufacture of *Burfi*.

Materials and methods

Experimental set-up and accessories: The experimental set up is shown in Figure 1.

Experimental set up

The experimental set up was three-stage scraped surface heat exchanger developed by Dodeja *et al.* (2007). The system includes the following components.

TFSSHE

The unit has consisted of three thin-film scraped surface heat exchanger (TFSSHE). All heat exchangers are identical in length, diameter, and effective heating length. The rotor assembly of the first two heat exchangers is identical but altogether different from the rotor assembly of third TFSSHE. The details of the different parts of the TFSSHE is given in Table 1.

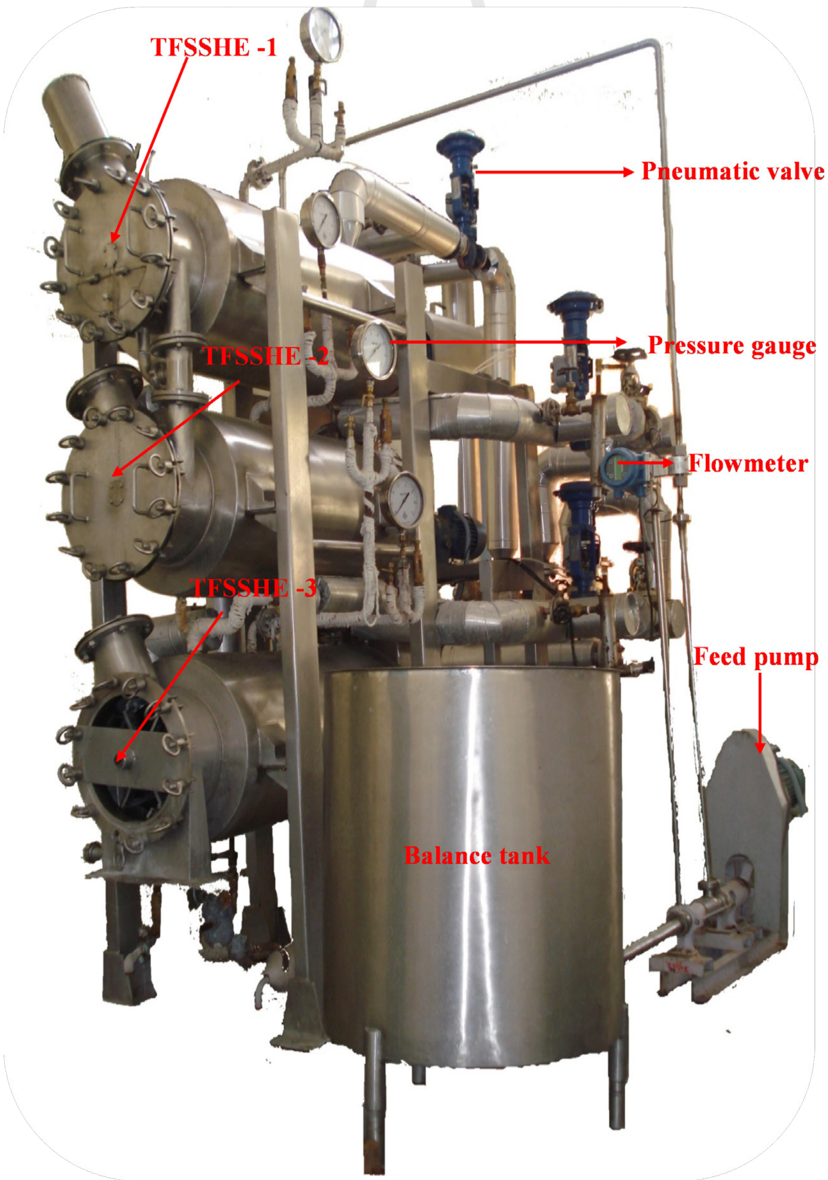

Figure 1: Experimental set up–three-stage thin film SSHE

Table 1: Different parts of the TFSSHE

Sr. No.	*Name and details of the different parts of the TFSSHE*
1.	Variable speed drives: The driven end of the scraper assembly was coupled to a variable speed drive through a flexible coupling. The drive consisted of geared three-phase, fan-cooled induction motor. The required speed adjustment was done with the help of gear units, which are splash-lubricated. With the help of these arrangements, the rotor speed of first, second stage, and third stage TFSSHE rotors as well as augur speed was adjusted from 20 to 200 rpm.
2.	Balance Tank: A cylindrical SS tank with a capacity of 250 L was used as the feed tank. It was connected to the feed pump through a SS pipe. The outlet of the pump is connected to the first TFSSHE
3.	Feed pump: Screw type 'FAS' Series ROTOMAC progressive cavity pump, a special type of positive displacement pump, in which flow through the pumping element is truly axial was used. The flow of milk through the pump was regulated by varying the speed of feed pump with the help of a frequency controller provided on the control panel.
4.	Valves for steam supply: Steam supply valves were provided at the inlet of each TFSSHE.
5.	Magnetic flow meter: To measure the flow rate of the working fluid, a magnetic flow meter that works on Faraday's Law of electromagnetic induction. The Rosemount magnetic flow meter specifically designed for food, beverages, and pharmaceutical application.
6.	Pressure gauges: Pressure gauges are used to indicate the steam pressure inside the shell maintained to carry out the present investigation at different locations of the three-stage TFSSHE.
7.	I/P converter: The electro-pneumatic signal converter is used as a linking component between electric or electronic and pneumatic systems. It converts standard electric signals (mA) into standard pneumatic signals (psi or kg / cm^2). Due to its innovative construction principle based on a fixed coil and a low- mass moving permanent magnet, it is highly resistant to shock and vibration.
8.	Transmitters: The transmitter was used to transmit the converted pneumatic signals from I/P converter to the controller to convey the message for the variation of process variables to optimize the whole process.
9.	Pneumatic valves: A control valve positioner is the heart of most accurate and efficient control systems, by ensuring the valve responds to the controller commands and adopts the precise position. It works on the principle of force balance to position the control valve stem in accordance to a pneumatic signal received from a controller or manual loading station. The instrument signal is applied to the signal diaphragm. An increasing signal will derive the diaphragm and flapper – connecting the stem to the right. The flapper–connecting stem will then open the supply flapper admitting supply pressure into the output, which is connected to the actuator diaphragm. The exhaust flapper remains closed when the flapper is connected to the right. The effect of an increasing signal is to increase the pressure in the actuator. When the valve reaches the position called for by the controller, the compression in the range spring will give a balancing force resulting in the closure of both the flapper.
10.	Air pressure indicators: The air pressure indicators are used to indicate the pressure supplied to the pneumatic valves to regulate the steam pressure in the cylinder shell.
11.	Digital panel meter: The digital panel meter was used to indicate the readings of rpm of all the three rotors of the three-stage TFSSHE unit.
12.	Process controller: The process controller of YOKOGAWA is an integral part of the automatic process control system assembled on the control panel of three-stage TFSSHE. It had three different modes such as operator mode (standard controller, heat/cooler controller, remote setpoint controller, profile controller), set up mode (level 2 –tuning, level 3–set points, level 4 profile) and configuration mode and is used for observing the process variable value that was attained during investigation and control setpoint value that is fixed by the operator according to the requirement so that the process variable value can't exceed this limit.
13.	Energy meter was used to measure the electrical power consumed during the experiment.

Experimental accessories

Containers: The containers were used to collect the condensate coming from each stage steam jacket to measure the steam consumption during the operation.

Others: Digital weighing balance, milk can, a milk container, etc.

Selection of raw material

Milk: Fresh buffalo milk and Skimmed milk was procured from Experimental Dairy National Dairy Research Institut, Karnal. Standardization was done to 6% Fat and 9% SNF. As small grains are desirable in the final quality of *Burfi* and grain size depend on initial acidity of the milk, the acidity of the milk has been increased up to 0.17% LA for fine grains formation in the product.

Sugar: Commercial grade white crystalline sugar purchased from the local market has been used in this present investigation.

Caustic Solution: Caustic solution of 0.75% strength was prepared by using sodium hydroxide flakes LR grade for CIP of TFSSHE.

Water: Water available at Dairy Engineering Division was used for washing and cleaning.

Burfi manufacturing method: First, the buffalo milk was taken, filtered, and standardized to a fat 6.0% and SNF 9.0%. This milk was mixed with white crystalline sugar in the balance tank. Then the steam valves of the steam header were opened manually. The feed pump was then started, and flow was varied between 155-205 kg/h with the help of electromagnetic flowmeter by controlling the rpm of the feed pump from the control panel. The rotor blade assembly of first, second, and third TFSSHE was switched on, and the speed of all three TFSSHE`s were kept fix by a control panel. The Steam pressure was fixed in the first and second stage 4 kg/cm^2 and 2 kg/cm^2, respectively. In the third stage of the SSHE, the product contains very less moisture, which may lead to the burning of the product. So, the range of pressure 1.5 to 2 kg/cm^2 was kept in the third stage of SSHE. Milk was first concentrated in first stage TFSSHE and then enters into the second stage where it was further concentrated. In third stage, the steam pressure was adjusted between 1.5 kg/cm^2 to 2.0 kg/cm^2 according to observing the body of product coming to the third stage, from the second stage. The mass flow rate was adjusted to get the concentration required in the *Burfi*. From the third stage, a homogenous mixture of the final product was collected in well-greased plates and spreading into a thick uniform layer. Then cooling and storage was done at refrigerated temperature. When *Burfi* got properly cooled, it cut into pieces and analysis was done.

Analytical procedures

Analysis of milk: Initially the raw milk was tested for Organoleptic Quality, Fat, SNF and acidity by using standard methodologies

The Fat content was determined by the Gerber method. (FSSAI, 2016)

The SNF content was determined by the lactometer. (FSSAI, 2016)

Titratable acidity was determined by a method described in the FSSAI manual, 2016.

Analysis of *Burfi*

Sensory Evaluation: The *Burfi* made from fresh standardized buffalo milk have typical sensory attributes, which depends on the process variables under study, viz., steam pressure, rotor rpm, type of sugar dosing method, and mass flow rate. The *Burfi* samples were subjected for sensory evaluation by a panel of 5–7 judges selected from the Dairy Technology and Dairy Engineering Division. A 25 point descriptive scale was used for panel of judges.

Thermal Analysis of the SSHE

Overall heat transfer coefficient: It was calculated using the following formula:

$Q = U \times A \times \Delta T$

$U = Q / (A \times \Delta T)$

Where U = Overall heat transfer coefficient

A = Heat transfer area of a cylinder

ΔT = Logarithmic mean temperature difference (LMTD)

Q = Quantity of heat used = condensate flow rate × latent heat

Steam Consumption: The condensate was collected in each stage of SSHE from the steam trap to measure the steam consumption in a different stage during the manufacture of the *Burfi*.

Electrical Power consumption: The energy meter was installed to measure the electrical power consumption in each scrapper motor and feed pump.

Technical program: There are various process variables of three-stage scraped surface heat exchangers that were selected for the designed research project are shown in Table 2 with trial codes for the manufacture of *Burfi* based on factorial design. The investigation was carried out to evaluate the thermal performance of all three scraped surface heat exchangers for the continuous manufacturing of *Burfi*.

Results and discussion

Effect of scraper speed on overall heat transfer coefficient

Table 3 indicates the effect of scraper speed on the overall heat transfer coefficient at a constant heat transfer area. It is evident that as scraper speed increases overall heat transfer coefficient also increases at a constant heat transfer area. It can be observed from Table 3 that U value is higher for lower scraper speed of the previous stage at a constant heat transfer area. This is because increasing scraper speed increases turbulence and hence led to higher heat transfer rates.

But increasing scraper speed of previous stage causes most of heat transfer to take in previous stage only and much more concentrated and viscous product is delivered to next stage from which evaporation rate decreases due to high concentration and viscosity. Hence it reduces heat transfer leading to comparatively lower overall heat transfer coefficient (Dodeja *et al.*, 2012). Table 3 reveals that U Value for first stage, second stage and third stage varied from 1450 W/m^{2}K to 1775 W/m^{2}K; 758.36 W/m^{2}K to 1157.71 W/m^{2}K and 376.30 W/m^{2}K to 451.62 W/m^{2}K respectively.

Effect of Scraper Speed on Electric power Consumption

Table 4 indicates the effect of scraper speed on electric power consumption. It is evident that as scraper speed increases electric power consumption also increases in all three stages. It can be observed from the Table 4 that electric power consumption is higher for higher speed of previous stage. This is because increasing scraper speed increases work load on scraper motor and hence led to higher power consumption. But increasing scraper speed of previous stage causes most of heat transfer to take in previous stage only. Hence, much more concentrated and viscous product is delivered to next stage. Thus reduces the amount (volume) of product to be handled (conveyed and scrapped) which reduces power consumption (Dodeja *et al.*, 2012).

Table 2: Trial codes with scraper speed and steam pressure

Trial Code	*Milk flow rate (kg/h)*	*Scraper speed (rpm)*			*Steam pressure (kg/cm^2)*		
		1st Stage	*2nd Stage*	*3rd Stage*	*1st Stage*	*2nd Stage*	*3rd Stage*
T 1	205	200	200	25	4	2	1.6
T 2	205	200	200	20	4	2	1.6
T 3	205	200	200	15	4	2	1.5
T 4	200	200	175	25	4	2	1.7
T 5	200	200	175	20	4	2	1.6
T 6	200	200	175	15	4	2	1.6
T 7	195	200	150	25	4	2	1.9
T 8	195	200	150	20	4	2	1.8
T 9	195	200	150	15	4	2	1.6
T 10	200	175	175	25	4	2	1.8
T 11	200	175	175	20	4	2	1.7
T 12	200	175	175	15	4	2	1.6
T 13	190	175	150	25	4	2	1.8
T 14	190	175	150	20	4	2	1.7
T 15	190	175	150	15	4	2	1.7
T 16	175	175	125	25	4	2	2
T 17	175	175	125	20	4	2	2
T 18	175	175	125	15	4	2	1.9
T 19	185	150	175	25	4	2	1.6
T 20	185	150	175	20	4	2	1.6
T 21	185	150	175	15	4	2	1.6
T 22	170	150	150	25	4	2	2
T 23	170	150	150	20	4	2	1.9
T 24	170	150	150	15	4	2	1.9
T 25	155	150	125	25	4	2	2
T 26	155	150	125	20	4	2	2
T 27	155	150	125	15	4	2	1.9

Table 3: Effect of scraper speed on 'U' value

Trial Code	*U Value (W/m^{2}K)*			*Condensate Flow (kg/h)*	*kg steam consumed per kg Milk*
	1st Stage	*2nd Stage*	*3rd Stage*		
T 1	1657.381	974.0792	422.429	192.94	0.94
T 2	1657.022	957.0927	416.5545	192.058	0.93
T 3	1657.022	957.0927	390.1165	192.418	0.93
T 4	1775.381	873.0266	437.2268	197.763	0.98
T 5	1657.022	870.486	423.8023	188.048	0.94
T 6	1672.955	882.5167	420.3691	189.879	0.94
T 7	1714.161	847.6924	439.8895	191.405	0.98
T 8	1748.617	855.6519	438.592	194.792	0.99
T 9	1697.438	859.0392	426.7014	190.666	0.97
T 10	1681.037	830.8711	397.7355	189.427	0.94
T 11	1618.487	1008.354	387.0532	193.792	0.96
T 12	1618.487	1008.354	381.8417	193.355	0.96
T 13	1689.198	878.6012	398.2278	192.837	1.01
T 14	1697.438	889.4905	395.2448	194.197	1.02
T 15	1697.438	927.3168	382.9574	196.048	1.03
T 16	1689.198	758.3595	440.1603	186.193	1.06
T 17	1689.198	758.3595	407.1482	185.773	1.06
T 18	1689.198	758.3595	398.1309	186.062	1.06

Contd...

Contd...

T 19	1449.895	972.2498	421.3609	176.7	0.95
T 20	1449.895	946.5738	408.5439	175.068	0.94
T 21	1449.895	1157.713	378.1034	185.436	1.00
T 22	1449.895	928.4631	429.1563	177.452	1.04
T 23	1449.895	1043.088	418.5357	172.564	1.01
T 24	1610.994	991.7361	376.3025	184.36	1.08
T 25	1449.895	797.3036	451.6228	169.054	1.09
T 26	1449.895	797.3036	438.7848	168.838	1.08
T 27	1449.895	797.3036	412.3668	168.742	1.08

* Each value is average of three replications.

Table 4: Effect of scraper speed on power consumption of the SSHE

Trial Code	*Electricity consumption (Wattage)*				*Electricity (kWh per 1000 kg milk processed)*
	1st Stage	*2nd Stage*	*3rd Stage*	*Feed pump*	
T 1	468	876	108	288	8.48
T 2	480	600	84	288	7.08
T 3	480	600	60	288	6.96
T 4	480	732	114	276	8.55
T 5	468	528	72	276	6.72
T 6	450	552	54	270	6.63
T 7	456	480	96	258	6.61
T 8	456	480	66	252	6.43
T 9	456	594	54	252	6.95
T 10	408	624	192	288	7.56
T 11	420	600	180	282	7.41
T 12	420	600	156	288	7.32
T 13	396	492	180	240	6.88
T 14	396	492	168	240	6.82
T 15	396	492	132	234	6.6
T 16	408	408	168	204	6.78
T 17	408	408	144	210	6.68
T 18	408	408	114	204	6.48
T 19	372	468	120	222	6.38
T 20	372	462	108	216	6.25
T 21	372	480	90	216	6.25
T 22	372	432	108	198	6.52
T 23	372	432	96	204	6.49
T 24	372	432	84	198	6.38
T 25	372	360	96	180	6.50
T 26	372	360	90	180	6.46
T 27	372	360	78	174	6.34

* Each value is average of three replications.

Table 4 reveals that electric power consumption for the first stage, second stage, and third stage varied from 372W to 480W; 360W to 876W and 54W to 192W respectively, and for feed pump, it varied from 174W to 288W.

Calculations for Specific Energy consumption in processing of milk during *Burfi* manufacturing using TSSHE

Table 5 summarizes on specific steam consumption in the processing of one-kilogram milk into *Burfi*. Firstly condensate flow rate was calculated for each stage, then total condensate flow rate (kg/h) was calculated by summing up condensate flow rate from all stages which was later divided by milk flow rate (kg/h) to obtain specific steam requirement (kg steam per kg milk). Specific steam consumption was found out to be 1.12 to 0.93 kg steam per kg of milk processed (Dodeja *et al.*, 2012).

Table 5 summarizes on specific electricity consumption in the processing of milk into *Burfi*. Firstly electricity consumption was calculated for induction motor for scraper

Table 5: Effect of scraper speed on power consumption of the SSHE

Trial Code	*Steam consumption (kg/h)*				*Steam consumption (kg steam per kg milk processed)*
	1st Stage	*2nd Stage*	*3rd Stage*	*Total*	
T 1	132.46	50.99	9.49	192.94	0.94
T 2	132.96	50.10	9.36	192.42	0.93
T 3	132.96	50.10	8.38	191.43	0.93
T 4	142.46	45.70	10.25	198.40	0.98
T 5	132.96	45.56	9.52	188.05	0.94
T 6	134.24	46.19	9.45	189.88	0.94
T 7	137.55	44.37	11.12	193.04	0.98
T 8	140.31	44.79	10.69	195.79	0.99
T 9	136.20	44.96	9.59	190.76	0.97
T 10	134.89	43.49	9.69	188.07	0.94
T 11	129.87	52.78	9.07	191.72	0.96
T 12	129.87	52.78	8.58	191.23	0.96
T 13	135.54	45.99	9.71	191.24	1.01
T 14	136.20	46.56	9.26	192.03	1.02
T 15	136.20	48.54	8.98	193.72	1.03
T 16	135.54	39.69	11.52	186.76	1.06
T 17	135.54	39.69	10.66	185.89	1.06
T 18	135.54	39.69	10.07	185.31	1.06
T 19	116.34	50.89	9.47	176.7	0.95
T 20	116.34	49.55	9.18	175.07	0.94
T 21	116.34	60.6	8.50	185.44	1.00
T 22	116.34	48.6	11.23	176.17	1.04
T 23	116.34	54.6	10.58	181.52	1.01
T 24	129.27	51.91	9.52	190.69	1.08
T 25	116.34	41.73	11.82	169.89	1.09
T 26	116.34	41.73	11.48	169.56	1.08
T 27	116.34	41.73	10.43	168.50	1.08

* Each value is average of three replications.

of each stage and induction motor of feed pump, then total wattage (kW) consumption was calculated by summing up power consumption from all motors (namely scraper 1, 2, 3, feed pump motors) in kilo watts which was later divided by mass flow rate (kg/h) to obtain specific electric power consumption (kWh or Unit). The specific electricity consumption was multiplied by 1000 to get electricity consumption in terms of Unit per 1000 kg of milk processed into *Burfi*. Electricity consumption was found out to be 6.0 to 8.34 units per 1000kg of milk processed (Dodeja *et al.*, 2012).

3.4 Overall acceptability of the *Burfi*: Effect of scraper speed on the quality of *Burfi* was checked in different 27 scraper speed combinations. The scraper rpm of first, second, and third stage 150, 150, and 15 respectively found the best (maximum average score of 21.12 out of 24) for the manufacture of the product in relation to sensory quality of *Burfi*.

Conclusions

The performance of three stages SSHE was evaluated in different combinations of scrapper speed and pressure in terms of overall heat transfer coefficient, steam consumption, and electricity consumption. The overall heat transfer coefficient increases with increase in scraper RPM, which varied from 1450 W/m^2K to 1775 W/m^2K; 758.36 W/m^2K to 1157.71 W/m^2K and 376.30 W/m^2K to 451.62 W/m^2K for first, the second and third stage of TFSSHE respectively. The Steam consumption increases with an increase in scraper speed, which varied from 142.45 kg/h to 116.34 kg/h; 60.6 kg/h to 39.69 kg/h and 11.82 kg/h to 8.37 kg/h for first, second and third stage respectively. The electric power consumption increases with an increase in scraper speed, which varied from 372W to 480W; 360W to 876W; 54W to 192W and 174W to 288W for first, second, third stage and feed pump motor of TFSSHE respectively. The specific steam consumption was found out to be 1.12–0.93 kg steam per kg of milk processed with mean value of 1 kg steam per kg of milk processed. The electricity consumption was found out to be 6.0 to 8.34 kWh per 1000 kg of milk processed with a mean value of 6.7 kWh per 1000 kg of milk processed. The scraper rpm of first, second, and third stage 150, 150, and 15 respectively found the best for a sensory score of the product.

References

Anon. (2007) Managing growth is the challenge. In: Dairy India 2007, 6th Edn. Dairy India Yearbook, New Delhi, 15-42.

Dairy India. (2007), sixth edition, Dairy India Year book, New Delhi, India: 20-34.

Devaraju R, Lal Mohanjee Kumar, Mahesh G and Kholi RK. (2013). Process optimization for mechanized production of *Doda Burfi* using scraped surface heat exchanger. *Internat. J. Proc. and Post Harvest Technol.*, 4 (2), 86-89.

Dodeja AK and Deep A. (2012). Mechanized manufacture of danedar khoa using three stage SSHE. *Indian journal of dairy science*, 65(4).

FSSAI manual of methods of analysis of foods milk and milk products available at old.fssai.gov.in/Portals/0/Pdf/Draft_Manuals/MILK_AND_MILK_PRODUCTS.pdf

Khojare A and Kumar B. (2003). Process engineering studies to upgrade *Burfi* production. *Journal of Food Science and Technology*, 40 (3), 277-279.

Minz PS and Singh RRB. (2016) Modernization of Manufacturing Process for Traditional Indian Dairy Products. In: McElhatton A., El Idrissi M. (eds) Modernization of Traditional Food Processes and Products. Integrating Food Science and Engineering Knowledge into the Food Chain, vol 11. Springer, Boston, MA.