International Journal of Advance Research and Innovation
Vol. 4(4), Oct-Dec 2016, pp. 55-60
Doi: 10.51976/ijari.441610

Article Info
Received: 25 Jan 2016 | Revised Submission: 20 Jul 2016 | Accepted: 28 Nov 2016 | Available Online: 15 Dec 2016

Engineering Interventions for Technological Advancements in Dairy Industry

IA Chauhan, AtanuJana**, AK Mackwana*** and AG Bhadania**

ABSTRACT

India today is already the worlds' largest producer of milk but the country is not a dominant force in the world market of milk and milk products. The growth potential of Indian Dairy Industry is enormous and challenges exist in improving the efficiency level and quality in complete chain of milk processing at every stage. The production of quality milk and milk products begins on the farm and continues through further handling, processing, packaging and distribution. One of the most important tasks amongst the quality control is to control and follow up regularly the fulfilment of quality standards at every stage of process flow in order to guarantee the best possible quality of end products through technological advancements. Engineering interventions have vital role to play in achieving this objective. Milk production, reception, processing, packaging, quality assurance, storage and distribution have been selected for engineering interventions for technological advancement in dairy industry.

Keywords: *Engineering Intervention; Dairy Technology. Quality Analysis; Milk Processing.*

1.0 Introduction

India today is already the worlds' largest producer of milk but the country is not a dominant force in the world market of milk and milk products. The growth potential of Indian Dairy Industry is enormous and challenges exist in improving the efficiency level and quality in complete chain of milk processing at every stage. The production of quality milk and milk products begins on the farm and continues through further handling, processing, packaging and distribution. One of the most important tasks amongst the quality control is to control and follow up regularly the fulfilment of quality standards at every stage of process flow in order to guarantee the best possible quality of end products through technological advancements.

Engineering interventions have vital role to play in achieving this objective [1]. Following fields have been selected for engineering interventions for technological advancement in dairy industry.

2.0 Engineering Interventions Practice in Dairy Industry

2.1. Dairy farming

Good quality raw milk is very essential for production of good quality milk product. Hygienic condition is very important for production of good quality of raw milk which is very difficult with human interference. Robotics in milking is very novel engineering intervention in which complete milking done by machine or robotics arms [2]. Large scale mechanized dairy sheds are designed for clean milk production at large scale. Shed is designed with good ventilation, comfortable flooring, automatic watering system, automated feeding system, mechanized manure scrapping, automated grooming system and automated robotic milking system. A voluntary milking system or milking robot is a cow is milked completely automatically. The cow is lured with food and then submits to the robot voluntarily. When the cow enters the robot, it is recognized and the entry gate

**Corresponding Author: Dairy Engineering Department, Sheth MC College of Dairy Science, AAU, Anand, Gujarat, India (E-mail: istiyakhusen@gmail.com)*
***Dairy Technology Department, Sheth MC College of Dairy Science, AAU, Anand, Gujarat, India*
****Dairy Business Management Department, Sheth MC College of Dairy Science, AAU, Anand, Gujarat, India*

closes behind the cow. Based on the last milking and other information about the animal from the sensor with individual coves, the robot decides if the cow should be milked or not. When this is the case, the cow receives a small amount of feed to keep her calm and quiet during connecting cups and milking. The milking process begins with pre-milking. Pre-milking is the connection of a cup on the teats of the udder, washing and stimulating the teats. This promotes the release of oxy-toxin hormone which stimulates the release of milk. This pre-milking cup is connected to all four teats by the robot arm using a 3D vision system. When the pre-milking is done, the robot arm connects the four milking cups after which the actual milking process starts. The milk is subsequently checked on several points by the milk analysis technique in the robot. When this is considered right, the milk is pumped to the milk storage tank that is situated in a separate space. The milk is kept cool and pumped to milk tanker and driven to the milk factory. A milking robot is fitted with a cleaning system which cleans teats, important components of the milking system after each milking as well as the entire milking system. This greatly reduces manpower, chance of bacterial contamination, growth, ensuring food safety, increase the milk yield and increase the milking speed [3].

2.2. Milk reception

Milk is received in cans at village co-operative societies (VCS) where it is stored in Bulk Milk Coolers (BMC) and that milk is transferred to milk chilling centres and dairy factories in tankers. Now a days mobile BMCs are provided at VCS which reduces the temperature of raw milk immediate after milking, store the milk at lower temperature and when enough amount of milk collected, it is transferred directly to Dairy. Milk pilferage at collection centre, milk theft during transit, milk adulteration and loss of life are the burning issues faced by dairy industry which estimated annual loss of over 36 million. To overcome these losses, new engineering interventions in selected brands of BMC are automated volume measurements, theft protection, alert for tank tilting, modular attachments to BMC, Automatic start up of generator during failure of grid power, self-powered with in-built battery charging, two way access to data, multiple outputs, continuous monitoring of compressors, daily machine data backup in storage media, etc. [4]. Double plate types of evaporators are provided in place of traditional coil type of evaporators. Two small capacity refrigeration plants are practiced instead of single big capacity plant and based on level of milk inside BMC, starting and stopping of second refrigeration plant is done. The Direct Current (DC) motor is provided to rotate the shaft of agitator in BMC which runs continuously. In this manner saving of electricity is done. To avoid the milk theft in milk tankers, security system is provided in many road tankers. The security system is based on temperature, vibratory, light, infra-red and pressure sensors. Addition to these sensors, milk tankers are made GPS enabled to know the location of tanker. The new engineering interventions in BMC are also applied to milk tankers also [5]. Application of these sensors and GPS system, reduces the milk theft and improve the milk quality. Computerized data entry of milk reception, continuous and mechanized can washing system and clarifier are new advancements at milk chilling centres. Glycol chilling is also provided to reduce the temperature of chilled milk near to zero degree centigrade which avoid the raise in temperature of raw milk during transit.

2.3. Milk processing

Self-cleaning clarifier, bacto-therm, new generation cream separators, in line standardization [6], new generation HTST pasteurizers, aseptic homogenizers are mechanized production of traditional Indian dairy products are the main selected technological advances in milk processing area. Impurities and foreign matters are separated from milk in clarifier based on centrifugal force. Self-cleaning clarifiers remove the extra materials deposited at the wall of the clarifier bowl at some intervals automatically by opening and closing of sludge removing ports with the help of hydraulic pressure [7]. Bactofuge is used for separation or removal of bacteria and spores from raw milk which can be used for manufacture of cheese and UHT milk [8]. The overall efficiency of new generation cream separator is increasing by changing of power transmission mechanism from gear and belt type system to direct drive type

system. We can get the efficiency of power transmission in gear type less than 80 % while in direct or integrated drive more than 90% [9]. The direct or integrated drive system also reduce the maintenance cost also as compared to traditional system in cream separator [10]. Advancements in HTST pasteurizers are improvement in component design, easily opened and closed hydraulically driven twin screw frames that improve worker safety while easing the burden of field inspecting, automation, instruments and process controls, skid mounted pasteurizer modules, two flow diversion valves (FDV) after holding tube as well as at the end of pasteurizing system and chart recorder. In line standardization is done by connection of different product lines through different valves with the help of automatic opening and closing of different valves in sequence [11]. Aseptic homogenizers and aseptic storage tanks are used in UHT milk processing and storage in which inlet, outlet valves, the pump block, piston seal and cooling system are designed for aseptic processing and storage. All these parts are provided with steam jacket to avoid contamination from external media. India's annual milk production is 137.7 MMT (2013-14) from which liquid milk, Western dairy products and Traditional Indian Dairy products (TIDPs) share is 46% (~61.64 MMT), 04% (~5.36 MMT) and 50% (~ 67 MMT) respectively [12]. So, 50 % of total milk production is converted to TIDPs. The total value of TIDPs is more than 750 million. The limitations for manufacture of TIDPs are time and labour consuming manufacturing process, large variation in quality, poor keeping quality, small scale production and burnt flavour. To overcome these issues, large scale mechanized production of TIDPs is very useful [13]. Many scientists have developed different types of scraped surface heat exchangers (SSHE) and other engineering interventions for continuous and semi continuous manufacturing of TIDPs from which few designs are very successfully work in different dairies. Mechanized production of khoa at Sabar Dairy, Himatnagar, Gujarat, India is done by concentration of standardized pasteurized milk in rising film evaporator and the condensed milk is fed in inclined SSHE having different pressure adjusting valves at different part of jacket. The khoa is collected in trays from outlet valve of ISSHE which is immediately cooled in vacuum tray cooler. For mechanized manufacture of gulabjamun, all the required ingredients are mixed properly in planetary mixture, the dough prepared is fed in portioning unit in which mass is pushed through augurs, sensor based cutting is done and that cut portion is transferred to ball forming unit through belt conveyor. After formation of ball, the ball transferred to frying unit where frying is done and followed by sugar syrup soaking and packaging. Paneer is manufactured mechanically by transfer of pasteurized milk from HTST pasteurizer to coagulation tank in which proper strength of acid solution is transfer from acid tank. After coagulation of milk, whey is separated out through pump and chhanna is transferred to panner press. The paneer block obtained from paneer press is transferred to pneumatic paneer dicer where dicing of paneer is done.

2.4. Cleaning

Cleaning is very important process in dairy industry to maintain hygienic condition of equipment and dairy. Cleaning in place (CIP) is a common unit operation in any industry. Many engineering interventions are done in many industries in the field of CIP for automatic operation. Application of instruments and process control is very important for automation of any process. Application of pigging system for CIP as well as for recovery of product in pipe line is very new concept in dairy industry. Double ball pig and ice pigging systems are the main in the CIP. In double ball pigging system, there are pre conditions like product should be in liquid state, same internal diameter of entire pipeline, no deformation of pipe or bends, no sharp edge of welding, etc.

Pumping of an engineered 2-phase ice-water-slurry through a pipe which is typically 50 – 90% ice fraction and flows like a plug wherever possible. A freezing point depression is used to retard the aging process of the ice slurry and to stop the crystals freezing into a solid plug [14]. Application of ice pigging system for CIP having advantages like it can flow through any type of pipeline with different types of fittings, no chances of blockage, efficient removal of material at slow speed and ease of operation for introduction and removal of pigging ice.

2.5. Quality Analysis

Quality assurance is the process of assuring the safe milk and milk products for human consumption. Majority of chemical analysis of food products is done by accurate and precise instruments. Sensory quality of dairy product is one of the most important criteria for the acceptability of the product by the consumers. Sensory evaluation of milk and milk products is normally done by expert judges in terms of flavour, body & texture and colour & appearance scores. However, it requires technical skill and experience and many times leads to human error. The sensory scores of the same products differs person to person and also mood, location and preference of judges and it is time consuming. The various instruments using different types of sensors and transducers have been developed to evaluate the sensory profile of various food products. The newer developments such as electronic tongue, electronic nose, machine vision and textural profile analyser have been developed for sensory analysis of dairy products [15]. The odour and taste of the product can be sensed by instruments by volatile components and dissolved components present in food. The e tongue and e nose are one type of system which needs training for identification of good or bed quality sample. As per the feedback of the expert judges, the data to be entered in computer system and by sensing the food, the final result of quality of sample is to be given by machine [16].

2.6. Packaging

Antimicrobial packaging is one of the many applications of active packaging [17]. Active packaging system possesses attributes beyond basic properties, which are achieved by adding active ingredients in the packaging system and/or using actively functional polymers [18]. Antimicrobial packaging is the packaging system that is able to kill or inhibit spoilage and pathogenic microorganisms that are contaminating milk and milk products. The new antimicrobial function can be achieved by adding antimicrobial agents in the packaging system and/ or by using antimicrobial polymers that satisfies conventional packaging requirements. When the packaging system acquires antimicrobial activity, the packaging system or material limits or prevents microbial growth by extending the lag period and reducing the growth rate or decreasing the live counts of microorganisms [19]. The primary goals of an antimicrobial packaging system are safety assurance, quality maintenance and shelf-life extension which is the reverse order of the primary goal of conventional packaging system. Nowadays security is a big issue and antimicrobial packaging could play a food security assurance.

Generally food is preferred for consumption in hot condition. Ready to eat foods is one of the major categories of foods in market today. Requirement of suitable heating gadgets to warm the food in pouch is still a difficult task. There were long lasting problem of convenience, palatability, long shelf life of food. These disadvantages pave way in introducing shelf heating systems for heating foods and beverages. Product with shelf stability of greater than one year is quite convenient and handy for use [20]. The only viable form of heat engine for self-heating is an exothermic chemical reaction [21]. A number of options are available with varying degrees of heat output, but the most reactive are also the most dangerous, using potentially toxic chemicals and produce undesirable gaseous by-products. The exothermic chemical reaction of choice for consumer packaging is lime reacted with water because it generates substantial heat output, lime is cheap and readily available, and the by-products of the reaction are environmentally acceptable [22]. An alternative reaction is the hydrolysis of calcium chloride, which has the advantage of producing no reaction by-products, but generates a lower heat output.

2.7. Storage and distribution

Storage and distribution plays very important role in final quality of product. In the era of social networking and online shopping, automatic milk vending machine (AVM) is very good concept for selling of loose milk as well as packed milk. AVM is being used for selling pasteurized & homogenized loose milk in the market. It ensures the accurate as well as hygienic vending of the milk and designed to vend only single type of milk. Milk is stored at ideal temperature for fresh milk preservation and guarantee certified safe milk quality. The entire

equipment is made up of stainless steel. The advantages of AVM are to dispense pasteurized & homogenized loose milk directly to the end user, to save cost of packaging material, avoid the leakage from milk sachets, small, compact, can be installed using very less space and any time milk is available [23].

3.0 Conclusions

Engineering intervention is very significant tool for technological advancement in any segment of dairy industry. It is very important to increase production capacity, to reduce manpower, to improve the product quality and many more.

We have discussed many engineering applications in different field of dairy industry, but there is no end of it.

It is continuous process and based on requirements in various field changes take place through research and development.

References

[1] Ayyappan S. Message, 9th National convention of Indian dairy engineers association and national seminar on 'Engineering interventions for global competitiveness of Indian dairy Industry' at NDRI, Karnal held on September 8-9, 2014. 3.

[2] Robert AG. A primer on robotic milking system, Agricultural and biological engineering, College of Agricultural Sciences, U.S. Department of Agriculture and Pennsylvania Counties, 2002.

[3] http://rotec-engineering.nl/en/portfolio-item/voluntary-milking-system/

[4] Krish Industries Pvt. Ltd., Bulk milk cooler automation pamphlet.

[5] Krish Industries Pvt. Ltd., Milk security system pamphlet.

[6] Ravi P et al. In-line standardization technique: An alternative concept for milk standardization, 9th National convention of Indian dairy engineers association and national seminar on 'Engineering interventions for global competitiveness of Indian dairy Industry' at NDRI, Karnal held on September 8-9, 2014. 36-41.

[7] De Laval separator manual.

[8] Self-cleaning hermetic bactofuge, Alfa-laval, Food engineering.

[9] Lanjewar P et al. (2014). New generation cream separators, 9th National convention of Indian dairy engineers association and national seminar on 'Engineering interventions for global competitiveness of Indian dairy Industry' at NDRI, Karnal held on September 8-9, 2014. pp. 153-159.

[10] GEA estfalia separator manual, 2012.

[11] Christian I, Andreas Mansson. Automation for standardization and blending system. Tetra Pak Dairy & Beverage systems AB, Department of Industrial Electrical Engineering and Automation, Lund University, 2006, 3-9.

[12] Dutta S, Bakshi S. Importance of traditional dairy products in India. Bulletin of the international Dairy Federation No. 451, 2011, 68-73.

[13] Singh AK, Dodeja AK. Manufacture of Basundi using three stages SSHE. Indian J. Dairy Science. 65, 2012, 197-213.

[14] Rao BP. Innovations in process engineering solutions for dairy industry, 9th National convention of Indian dairy engineers association and national seminar on 'Engineering interventions for global competitiveness of Indian dairy Industry' at NDRI, Karnal held on September 8-9, 2014.

[15] Sachin T. Application of sensory instruments in dairy and food industry, 9th National convention of Indian dairy engineers association and national seminar on 'Engineering interventions for global competitiveness of Indian dairy Industry'

at NDRI, Karnal held on September 8-9, 2014, 117-120.

[16] Sachin T. Instruments for sensory evaluation, 9th National convention of Indian dairy engineers association and national seminar on 'Engineering interventions for global competitiveness of Indian dairy Industry' at NDRI, Karnal held on September 8-9, 2014, 121-123.

[17] Floros JD, Han J N. Casting antimicrobial packaging films and measuring their physical properties and antimicrobial activity. Journal of plastic films and sheeting, 13, 1997, 287-98.

[18] Han JN, Rooney ML. Personal communications. Active food packaging workshop, Annual Conference of Canadian Institute of Food Science and Technology (CIFST), May 26, 2002.

[19] Han JH, Rodriques ET, Holly RA. Optimized antimicrobial edible whey protein films against spoilage and pathogenic bacteria. In Book of abstracts (2002 IFT annual meeting), Chicago, Institute of Food Technologists. 2002, 252.

[20] Pickard WD, Robert LT. Self-Heating group meal Assembly & Method for using same, US Patent 5355869, 1994.

[21] Butler P. Self-Heating & Self-Cooling Packaging – Latest Developments & Future Directions, Packaging Materials & Technologies, University of Oxford. 2008, 8-17

[22] Anonymous. www.Hotcan.com 2016