"ROBOTICS – AN EMERGING TECHNOLOGY IN DAIRY INDUSTRY"

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Abstract - The dairy and food industry is now highly automated, from the raw material production to the processing and manufacture of products. The implementation of automation in the dairy and food sector offers great potential for improved safety, quality and profitability by optimizing process monitoring and control. Presently, the technology is becoming more affordable and intelligent. It may be feasible to automate many of the complex and repetitive tasks that are carried out in the dairy industry through robotics. The field of robotics is both interdisciplinary and multidisciplinary as robots are amazingly complex systems comprising of mechanical, electrical and electronics hardware and software. Dairy industry has been lagging behind other industrial sectors in implementing robots, as dairy and food products by virtue of their nature differ significantly in consistency and shape. However, there is a broad range of potential applications for robotics in dairy industries. Automatic milking systems or milking robots are one of the most successful and important application of robotics in the dairy industry. Robotics find its application in packaging and palletizing of dairy food products. Its potential application in various sections in dairy processing plant is yet to be explored.

Keywords - Robot, Robotics, Automation, Dairy

I. INTRODUCTION

Automation technology is changing the way the milk is produced and processed. The benefits are far-reaching: improved profitability, milk quality, lifestyle including animal welfare. Automation means every action that is needed to control a process at optimum efficiency as controlled by a system that operates using instructions that have been programmed into it. Automated systems in most cases are faster and more precise (Narendra et al., 2010). Some difficulties encountered in automation are lack of suitable sensors, low profit margins, use of batch/continuous operations and installation of equipment that is not integrated into the whole process. In the dairy and food industry most systems are also isolated, batch type operations that target a specific task.For automation to be successful, it must be integrated into the overall manufacturing system design and provide on-line, continuous control capability. However, the trend is now changing rapidly as more and more dairy operations are being automated. India's first automated dairy plant with handling capacity of 1,000,000 LPD has been established at Gandhinagar near Ahmedabad in Western India.

Dairy & food processing industries is highly labor-intensive, with sometimes labor costs at anything up to 50% of the product cost. Improving productivity and reducing labor costs will therefore have a significant impact on profitability. Much of the manual work in dairy industry requires rapid, repetitive, and monotonous movement and, consequently, low levels of motivation among workers. This leads to poor quality control and a high incidence of industrial accidents. Automating repetitive tasks will improve quality control and efficiency and reduce the high level of accidents. Today, the increasing technological development and sophistication of modern societies impose new quality and safety standards to the food producers. Consumers demand more and more information about the products. They are alwaysdemonstrating clear preferences for well-informed high-quality products. To assure the quality and safety of food products, automation can play a key role.During milk and milk product processing, mostly fluid is transferred from one place to another through pumps, but still there are various operations where some form of solids has to be transferred repetitively. In dairy industry too, there is need for some movement of materials in hazardous atmosphere (as in ice store at -23^{0} C& in ice-cream hardening room at -30^{0} C). At these places, use of robot would be a good alternative. It can be expected that future dairies would be 'smart dairies' employing such robots capable of processing and handling milk and milk products most economically with a through control on quality too.

II. REASONS FOR AUTOMATING PROCESSES

The purpose of automation is to increase process efficiency, safety, productivity and product quality. This is generally achieved by means of a control system that has been 'programmed' with a set of instructions.Followings are the reasons for automating industrial processes.

- Need to reduce direct labor
- Can't get people to do the job
- Need to increase quality
- Difficult to do the job manually
- Need to increase production
- Difficult to meet specifications consistently
- Need to provide flexibility in processes

- Hazardous to personnel
- Eliminates a contamination source.

III. BASIC CONSIDERATIONS ON THE AUTOMATION

One of the most important obstacles in the automation of food manufacturing is the biological variation in size, shape, and homogeneity of the raw materials. Some industry like dairy lendsthem readily to automatic processing because the raw material (milk) has to be handled in bulk. Accordingly, the dairy industry is among the most automated. Butmaterials such as fruits, vegetables, meat, etc., need to be handled on a more individual unit basis. This has hampered automation tremendously. Thus, food industry automation requires a level of flexibility uncommon to other mature industries (Judal&Bhadania, 2015).

IV. ROBOT

Robot, from the Czechoslovakian word, "robota" meaning forced labor. A robot can be defined as a programmable, lf-controlled device consisting of electronic, electrical, or mechanical units. More generally, it is a machine that functions in place of a living agent. According to British Robot specified manufacturing implements through variable programmed motions for the performance of specific manufacturing tasks." The International Standards Organization (ISO) defines a robot as, "An automatically controlled, re-programmable, multi-purpose, manipulative machine with several degrees of freedom, which may be either fixed in place or mobile for use in industrial automation applications." Robots are especially desirable for certain work functions because, unlike humans, they never get tired; they can work in physical conditions that are uncomfortable or even dangerous; they can operate in airless conditions; they do not get bored by repetition; and they cannot be distracted from the task at hand. The robot is powerful, reliable and can be used in hot temperature area where a human after working for so long can become sick and exhausted (Agrawal et al., 2014;Nayiket al., 2015).

V. ROBOTICS

Robotics is the branch of technology that deals with the design, construction, operation, and application of robots, as well as computer systems for their control, sensory feedback, and information processing. These technologies deal with automated machines that can take the place of humans in dangerous environments or manufacturing processes, or resemble humans in appearance, behavior, and/or cognition.

Features	Benefits
Better process control	Easy to clean robot, minimum retention areas, connection protection
High reliability, high speed	Increased productivity
High dexterity, several mounting positions	Compact cell, less room required, simpler mechanical solution
Cleanliness	Better hygiene
Flexibility	Marketing innovative products and packaging
Vision and conveyor tracking	Product picked and controlled in process, in any position

Table 1: Features and benefits of robotics.

VI. PARTS OF A ROBOT

Robots come in many shapes and sizes. Robots consist of a number of components that work together: the controller, the manipulator, end effectors, a power supply, and a means for programming (Schilling, 1990). The relationship among these five components is illustrated in the figure 1.

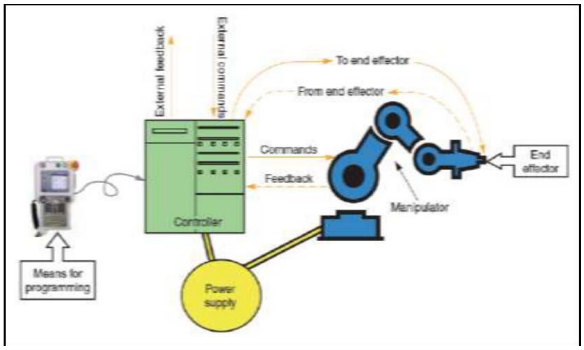


Fig.1: Parts of the robots

An actuator is a motor or valve that converts power into robot movement. This movement is initiated by a series of instructions, called a program, stored in the controller's memory. The manipulator consists of segments that may be joined and that move about, allowing the robot to do work. The manipulator is the arm of the robot which must move materials, parts, tools, or special devices through various motions to provide useful work. The end effector is the robot hand, or the end-of-arm tooling on the robot. It is a device attached to the wrist of the manipulator for the purpose of grasping, lifting, transporting, maneuvering, or performing operations on a work piece.

The power supply provides the energy to drive the controller and actuators. It may convert AC voltage to the DC voltage required by the robot's internal circuits, or it may be a pump or compressor providing hydraulic or pneumatic power. The three basic types

of power supplies are electrical, hydraulic, and pneumatic. The means for programming is used to record movements into the robot's memory. A robot may be programmed using any of several different methods. The teach pendant, also called a teach box or hand held programmer teaches a robot the movements required toper form a useful task. The operator uses a teach pendant to move the robot through the series of points that describe its desired path. The points are recorded by the controller for later use (Judal&Bhadania, 2015).

VII. ROBOTICS IN DAIRY INDUSTRY

The use of robotics in the food industry has increased over recent years, particularly in the field of processing and packaging systems. However, the industry has not taken to the technology with the same enthusiasm as the automotive and other industries. Now that the technology is becoming more affordable and the systems more intelligent, it may be feasible to automate many of the complex and repetitive tasks that are carried out in the food industry. The opportunity still exists to deliver significant benefits in terms of increased food shelf life, cost reductions and flexibility (Wallin, 1997). Dairy industry has been lagging behind other industrial sectors in implementing robots, as dairy food products by virtue of their nature differ significantly in consistency and shape. However, there is a broad range of potential applications for robotics in dairy industries. Automatic milking systems (AMS) or milking robots are one of the most successful and important application of▪ robotics in the dairy industry. The commercial application of robots in dairy industry is also widely spread at the end of processing lines like packaging and palletizing.

VIII. ROBOTIC MILKING

Milking cows by machine, to replace the practice of milking by hand, has been known for more than century. Automatic milking systems (AMS) or milking robots are one of the most successful and important application of robotics in the dairy industry. Automatic Milking Systems also referred to as robotic milkers, were developed in Europe and became available there in 1992. This technology was introduced to the US in 2000. Robotic milking is a voluntary milking system, which allows the cow to set her own milking schedule. following an initial training period, cows are milked with limited human interaction. Each cow on a robotic milking platform is fitted with an electronic tag which allows the robot to identify her. When a cow enters her ID tag is read and she receives a feed reward customized to her level of production, the robot then cleans her teats, attaches the milk cups, and begins the milking processeswhen milking is complete, the cups disconnect as each quarter finishes milking and she exits [Butler et al., 2012; Brogardh, 2007; Higgs & Vanderslice, 1987]. In this type of advanced system milking occurs throughout the day and night.

The world's first commercial robotic milking rotary has been unveiled by Swedish dairy equipment company DeLaval at a pilot farm at Quamby Brook, Tasmania, Australia. Featuring five robots, the rotary has a capacity to milk up to 90 cows per hour, enabling the robots to reach the cow from the side. With the use of laser technology, the robots focus a red light to determine the location of the cow's teats, clean them and attach the cups. The first two robots clean and prepare the teats for milking, the second two attach the cups to the teats, and the last robot sprays the teats to disinfect them before the cows reaches the platform [Khodabandehlco, 1994; Legg, 1993]. Once the milking is done, robotic liquid filling and finishing systems get the product ready for market. These robots handle many types of bottles, vials, bags, and pouches with precision filling from micro liter to multi liter. The containers, once filled, can be closed using a screw cap, stopper, or crimp. They accommodate a variety of products; and deal with fill volumes, dispensing profiles, containers and closure types, making them ideal for clinical trials, full scale production and contract manufacturing [Butler et al., 2012; Tedford, 1990; Yao et al.,2011; Judal & Bhadania, 2015].

IX. ADVANTAGES OF ROBOTIC MILKING

Milking by using robots has various advantages like:
Economic benefit: Labor flexibility and not needing to manage hired labor were the biggest advantages reported by current users of robotic milkers.Increased milking frequency: Milking frequency may increase to three times per day, however typically 2.5 times per day is achieved. This may result in less stress on the udder and increased comfort for the cow, as on average less milk is stored. Higher frequency milking increases milk yield per cow. Management benefit: Management of the herd can be made more efficient. For a farmer who's never managed his cows properly the robot computer will force him to do so. It tells him about blood in the milk, conductivity, and yield per quarter. Cow health and welfare benefits: Producers reported an improvement in cow health and a reduction in instances of mastitis following the transition to robotic milking. This was attributed to less stress on the cows and to have better access to information on their cows. For example, benefits resulting from quarter-by quarter milking, which can help to reduce udder infections.

X. ROBOTICS IN PACKAGING

The commercial application of robots in food industry is widely spread at the end of processing lines like packaging and palletizing. However, there is a broad range of potential applications for robotics in food

processing: in the meat industry, robots are used in slaughtering, deboning, cutting, sorting and packaging applications. Robots can also be used for picking and placing items such as cookies, hamburgers, chocolate pralines, croissants, chicken fillets or pan cakes into primary packing. Additionally, robots are already used in baking lines to handle hot trays. Reducing demands on labour can be a big plus point for robots especially when labour is expensive and in high demand. Moreover, robots minimize the human workers direct contact with the products. In the dairy industry, robots are used in cheese packaging, cheese slicing, and curd slicing etc. In cheese production, robots stir curds, transfer cheese moulds, and turn, cut, portion, package and palletize the cheeses. Integrated sensors and measuring systems enable the simple implementation of complex processes. Blocks of cheese arrive on wooden planks at the robot picking area. The special gripper allows the cheese blocks to be picked and placed onto a conveyor for further processing [Kempthome, 1995].The picking and packing robots are shown in fig. 3.1.



Fig. 2: Picking and Packing robot

CONCLUSION

Robots have potential to change our economy, health, living and the world we live in. It is the technology for the future and with a future. The current research goals and trends indicate that the industrial robots of the future will be more robust, accurate, flexible, mobile with more than one arm and will have many more capabilities. The robots will be human friendly and intelligent, capable of responding to voice commands and will be easy to program. There are several areas in milk processing plants where robots can be utilized such as raw milk receiving dock, ice cream cold store and hardening units, milk products packaging, steam generating unit, dairy floor cleaning and washing etc. The use of robots shall not come by choice but dairy industry has to adopt this modern technique to remain cost efficient.

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