An Advance Development of 'Zero contact' Smart Milk-Vending Machine

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Abstract

In December 2019, Covid-19 come to picture in People's Republic of China, and mushrooming all around the world and also has large impact on India. This pandemic is spreading so fast and till now there is no antiviral drug or vaccine available. To slow down the rate of transmission government has lockdown the whole country which impact every person. A big example is small farmers and milk diaries which are unable to sell milk during the lockdown, as consumers are concerned about hygiene of milk. Therefore, authors aimed to tackle the current pandemic situation to increase the sale of milk with 'Zero Contact' milk vending machine. It is a robust hygiene solution by obsolete the human contact from Milk distribution process. This paper is related to the development of 'Zero Contact' milk vending machine. It correspondingly solves the major milk distribution issues that are faced by distributer and customer such as the supply-transportation cost and time as well as hygiene of milk.In vending machine,RFID card and reader used to make the machine ready to operate. The milk directly goes for pasteurisation and the whole system is kept at refrigeration temperature of 6°C.The payment is done through the Paytm and Google Pay to reduce the virus transmission through money exchange contact and also it builds the transparency between customer and vendor.

Keywords: COVID-19, Human machine interface, Hygiene, Milk vending machine, Programmable logic controller, Zero Contact

1. Introduction

In December 2019, an unexpected outburst of disease found i.e. COVID-19 which is a highly communicable and contagious, with serious acute respiratory syndrome[1]. Wuhan City, Hubei Province in the People's Republic of China is stated as the epicentre of COVID-19 and later it starts spreading all around the world [2-3].

On11th November, 2020, a total confirmed case of SARS-CoV-2 (COVID-19)noticed all around the world is 51861437 including 1280549 deaths in 213 countries, reported by world health organization (WHO). This disease is spreading so fast that it has found one of the greatest challenges to human beings.Since, the number of cases of COVID-19 is increasing abruptly the World Health Organization (WHO) declared this disease as a global pandemic on 11th March, 2020[4.] The source of origin and the modes of transmission to the humans are not known, however human to human transfer is confirmed widely[5]. According to various observations, different modes of transmission of this virus includes when a person comes in close contact with an infected person, exposed to coughing, sneezing, respiratory droplets or aerosols [6]. It is the biggest battle since there is no clinically approved antiviral drug or vaccine available to be used against COVID -19 [2,7]. The transmission is so fast that India has also comes to the exposure of virus.Particularly in India, corona virus starts showing its effects from January 2020 and so on; total numbers of confirmed cases are in lakhs with thousands of causalities. Although, along with rest of the world, India has taken many steps to control or slow down the rapid transmission of corona virus among humans such as lockdown, avoid social distancing and rapid test and screening to find the infected person and their close contacts, quarantine and providing the guidelines how to maintain hygiene including wearing masks and washing hands frequently [8, 9].But still, the pandemic is spreading so fast and still there is no antiviral drug or vaccine available. Also, the closure of workplaces, industries and markets is affecting the economy very badly. Closure of workplaces and markets is a big concern to the labourer and farmers [10].Many diary milk-firms and milkman are concerned because of low consumption and demand of their milk during the lockdown. Though milk is considered as one of the basic immunity boosters yet consumers are refusing to buy milk because of the fear of virus infection as people are concerned about the milk hygiene.

To conquer this panic,author's present an alter solution in form of 'Zero contact' advanced automatic milk vending machine. The automated 'Zero contact' Milk vending machine could provide milk of desired amount, ensuring the correct quantity and quality. The Milk vending machine can be usable as:'Stationary' and 'Portable' machines. Hence, authors have been developed advanced 'Zero contact' Milk vending machine based upon programmable logic controller (PLC) and human machine interface (HMI). The PLC used is relay type PLC with high durability and can be programmed using dedicated software with ladder logic and functional block diagram programming languages and the operator screen is designed by using HMI designing software (V-soft) which gives user friendly interface.

The objective of the study is to tackle current pandemic situation to increase the sale of milk with 'zero contact' and full proof hygiene milk. The main configuration part consists of: PLC, HMI, Milk container vessel and the software parts are: Fuji SX programmer for programming and TIA-Portal for the display screen. Finally, the cost efficient and compact milk vending machine has been proposed.

2. Material and Methods for Milk Vending machine production

The complete detail of Milk vending machine is categories in two sub-sections. First section contains mechanical configuration of the machine and second section having electrical arrangement. The Mechanical and electrical systems of machine with real time pictures is explained with specification chart of each component

2.1 Mechanical configuration of Milk Vending machine

The selection of Milk container vessel is based upon required characteristics: that is resistance from acidity and chlorides formation. Therefore, food grade quality Stainless steel of grade 316 is selected for the container vessel. The reason of selecting Stainless steel 316 is anti-corrosion persistence and increase in strength even at high temperature. The Major composition of Stainless steel 316 is Iron (Fe) - 50 %, carbon (C) - 0.03 %, chromium (Cr) - 18 %, nickel (Ni) - 12 %, Molybdenum (Mo) - 2 % and less than 1 % of other elements (Manganese, silicon, phosphorus and sulphur). The container can be work up to high temperature of 800°c. The overall measurement coverage of machine is 370*380*1000 (l*b*h) mm^3 with capacity of 10 litres. Figure 1 shows the pictorial view automated 'zero contact' milk vending machine. Table 1 represents the detail specification used in mechanical configuration. Figure 2 Complete internal view of smart milk vending machine
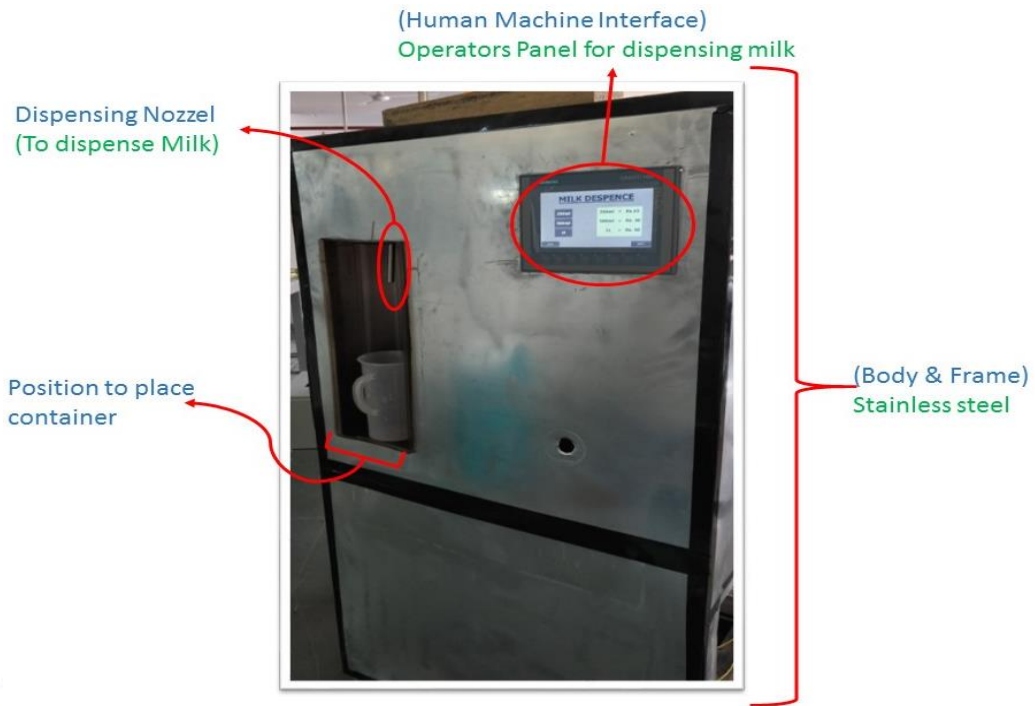
Figure 1 Illustration of automated 'Zero contact' Smart milk vending machine.

Table1 Mechanical component specification.

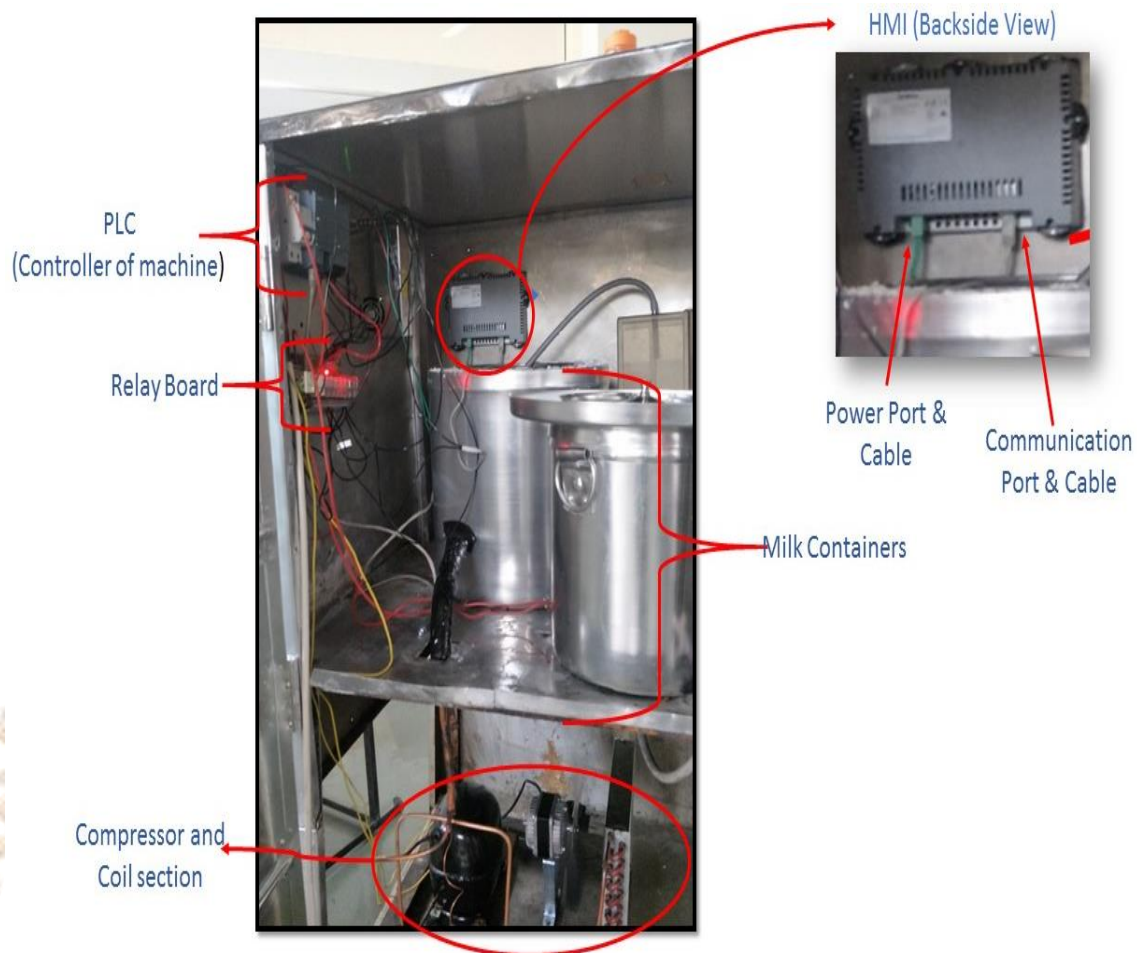| S no.	Name of equipment	Quantity	Specification
1	Milk container	2 (no's)	5 litres each
2	Copper pipe	12 meters	3/8" diameter
3	Volume of Machine (Frame + Body)	-	370*380*1000 (l*b*h) mm^3

Figure 2 Complete Internal view of smart milk vending machine.

2.2 Electrical systems of Milk vending machine

Programmable Logic Controller (PLC) is the brain of the milk vending machine which makes its control user friendly and easy to modify if required in near future and all the input and output devices are connected input/output card of PLC. The machine is powered by 230VAC supply. Table 2 shows the List of Electrical equipment and its function. The main switch is used to fed supply to system. Main switch is assisted by emergency switch which can be pressed to avoid undesired situation. Further, the single phase (230VAC) supply converted to 24VDC using switch made power supply, to power up control system components such as PLC and Human Machine Interface. Ultrasonic sensor is used to show level of milk in container, if level of milk is low in container according to logic it shows alarm message on HMI as *"Refill Container -level is critically low"*. To achieve pasteurisation process, control system uses temperature controller and sensor.

Table 2 List of Electrical equipment and its function.

S.no.	Name of equipment	Function
1.	Programmable Logic Controller (PLC)	Brain of plotter
2.	Human Machine Interface (HMI)	Control & Monitoring
3.	Switch Mode Power Supply (SMPS)	For 24VDC power supply for equipment based on DC supply
4.	Main Switch (MS)	Power Up system
5.	Ultrasonic Sensor (US)	Level of milk in container
6.	Emergency Switch (ES)	To cut off supply in emergency situation
7.	DC solenoid Valve (DV)	To dispense milk
8.	Temperature controller (TC)	To maintain milk at particular temperature
9.	Temperature sensor (TS)	To read temperature of milk container
10.	Hot container (HC)	To hot milk upto certain temperature
11.	Cold container (CC)	To cool milk upto certain temperature

Temperature controller is directly communicated with HMI via Modbus communication protocol to set desired high and low temperature settings. Automatically temperature controller controls the control circuits of cold and hot container system. The dispenser solenoidal valve is controlled to output of plc, which operates on ladder logic when customer gives command for particular quantity through HMI. PLC is interfaced with HMI via Modbus Communication protocol. HMI act as a user interface for customer. Whereas RFID tag and card act as key to operate machine by milkman and machine operator Block diagram is shown below of system architecture Figure3, Table 3 shows the complete electrical system parts and detailed specifications.
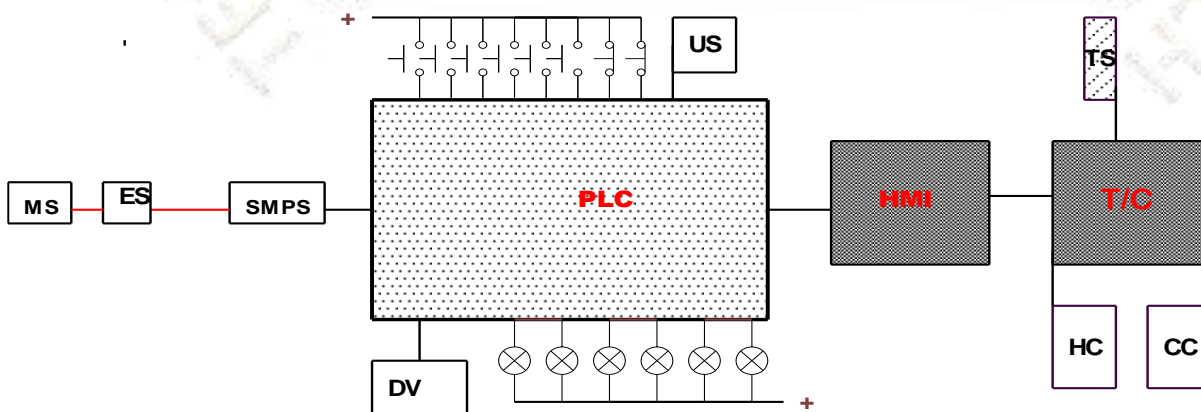

Figure 3 Block diagram system architecture.

Table 3 Complete electrical system parts and detailed specifications.

S no.	Name of equipment	Specification	Quantity
1	Programmable logic controller (PLC)	Fuji SPF- NA0PA24T- 34C [15] (24VDC supply, 24VDC digital input 14 pins) (high speed: 200KHz, 4 pins Medium-speed: 20KHz, 4 pins; Medium-speed 16.6KHz, 6 pins), Transistor sink output 10 pins (High-speed: 200KHz, 4 pins; Medium-speed: 20KHz, 4 pins), Detachable terminal block) [13]	1
2	Human machine interface (HMI)	Siemens KTP-700, 7 inches, coloured [14]	1
3	RFID card + Reader	13-26mA / DC 3.3V, Idle Current :10-13 mA/ DC 3.3V 13.56MHz, 40mm × 60mm, 10Mbit/s	1
4	Heating element	110V to 220V, 60W, 2 Wires	1
5	Compressor unit	DFB35T 220-240V AC Single phase, Thermally Protected	1
6	Temperature controller	-10 °c to 90°c AC Input: 240V AC	1
7	Temperature sensor	3 wire class A PT-100 Temp Range: 0-100 degree Celsius, Output: 4 – 2mA, Power Supply: 10-30 V Material: Stainless Steel	2
8	Solenoid valve	Parker Hannifin, Port size: ½" 201LG4UKG7A Power: 9W	2

After arranging the mechanical and electrical parts to assemble the smart Milk Vending machine, the working

of the milk vending machine is discussed in detail with its programming logics.

3. Working of Automated 'No contact' smart Milk Vending machine

Pasteurisation is the first process that is done after pouring the raw milk into the machine by the Milkman. Milkman provided with the RFID tag which gives him the authentication to operate machine and pour milk in machine. The purpose of pasteurisation is to increase milk safety for the consumer by destroying disease causing microorganisms. Which is done by heating the milk to required amount of temperature for some time and second is to increase keeping the quality of milk products by destroying spoilage microorganisms and enzymes that contribute to the reduced quality and shelf life of milk, which is done by storing the milk immediately after heating process in the cold storage of temperature below 6̊c. Therefore, after pouring the milk to the machine it goes to the hot container which heats it to the temperature 72 ̊c for 15 seconds and after that it is made to discharge to the cold container for storage at 5 ̊c. User can dispense milk with the help of user-friendly interface after paying money by mobile by using any application. Then according to the need quantity of milk is selected through the HMI screen and milk is dispensed of same amount [11].

The programmer can build the logic in the software used for particular PLC. The input signal from temperature controller and RFID are fed to the PLC to control Heating element, cooling element and the Valves. First the raw milk is poured to the machine which directly goes to the hot container. Then Start button is pressed which turns on the heater for heating the milk. Temperature controller (used for hot controlling temperature of Hot container) controls the Hot-valve and the Heating element. After milk is discharged to the Cold container milk is stored and dispensed through the Cool-valve.Figure 4shows the flow chart of step-by-step operating procedure of Automated 'No contact' smart milk vending machine.
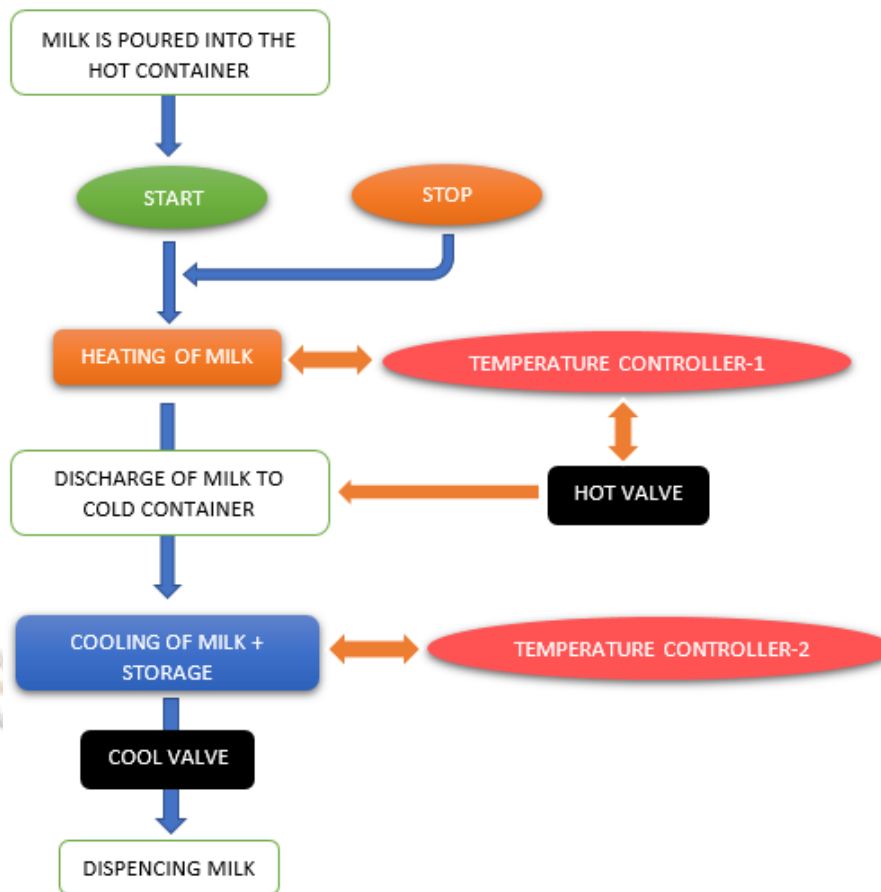
Figure 4 Flow chart of step-by-step operating procedure of Automated 'No contact' smart milk vending machine.

3.1 Programming Code

PROCESS START/STOP: This code executes the process. By pressing START button the heater gets on. STOP button is provided to stop the process in between.

TEMPERATURE CONTROLLER: This code controls the working of heating element through temperature controller. SET_PT is the set value of temperature (i.e.: 72°C) which turns on the timer (TON_1) for 30 seconds after which the heating element turns off. The temperature value is also visible on the HMI screen (Figure 7). The green and red indicator below hot container indicates, whether the heating element is ON or OFF.

HOT VALVE OPERATION: When heating element gets off it turns on the second timer (TON_2) which is used to control the time duration of working of Hot Valve. The timer is set for 50 seconds. In this period of time the heated milk gets transferred to the cold container.

COOLING OPERATION: This code ensures the execution of cooling process immediately when heating process gets off. The temperature is maintained 5°C by the cooling unit itself, so there is no need to control the cooling temperature. There is only need to turn on the cooling element. The green and red indicator below cold container indicates, whether the cooling element is ON or OFF (Figure 7).

DISPENSING OPERATION: In ladder block helps in dispensing the selected amount of milk, selection of which is providing on the HMI screen (Figure 7). Here 'AML 'is used for selecting 500ml of milk. When this button is pressed the timer gets on for 10 seconds which is the time of operation of Cold valve. Hence the 500ml of milk will get discharged in 10 seconds.
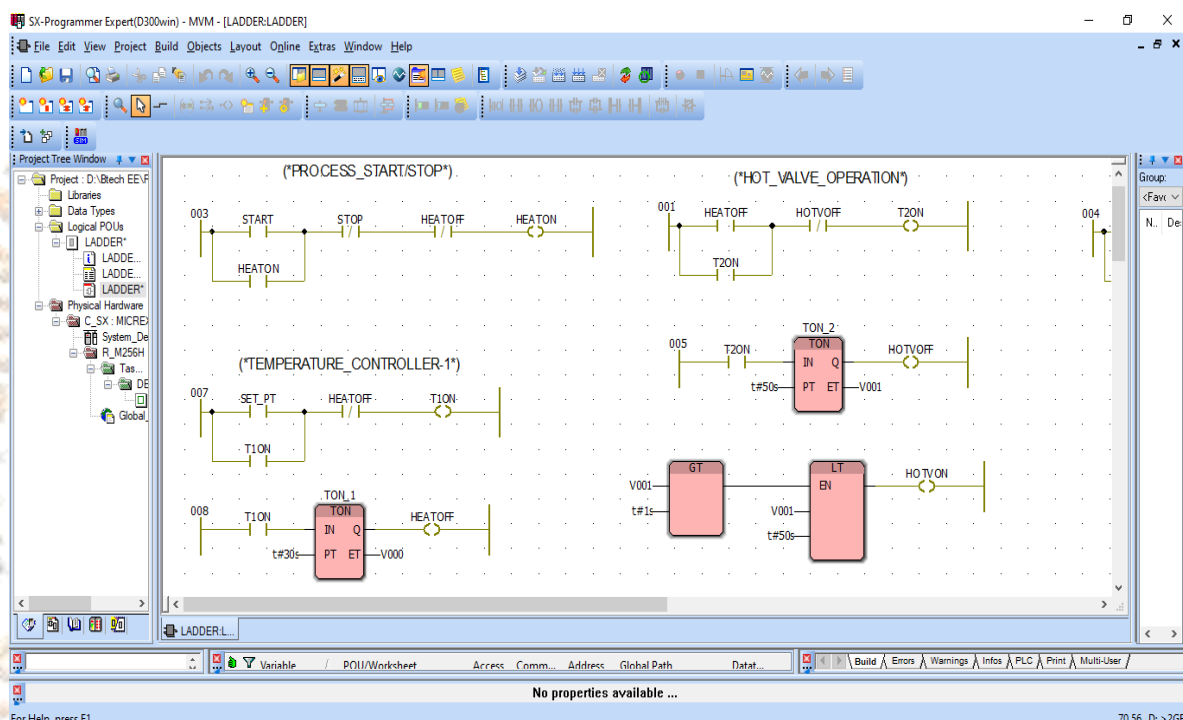

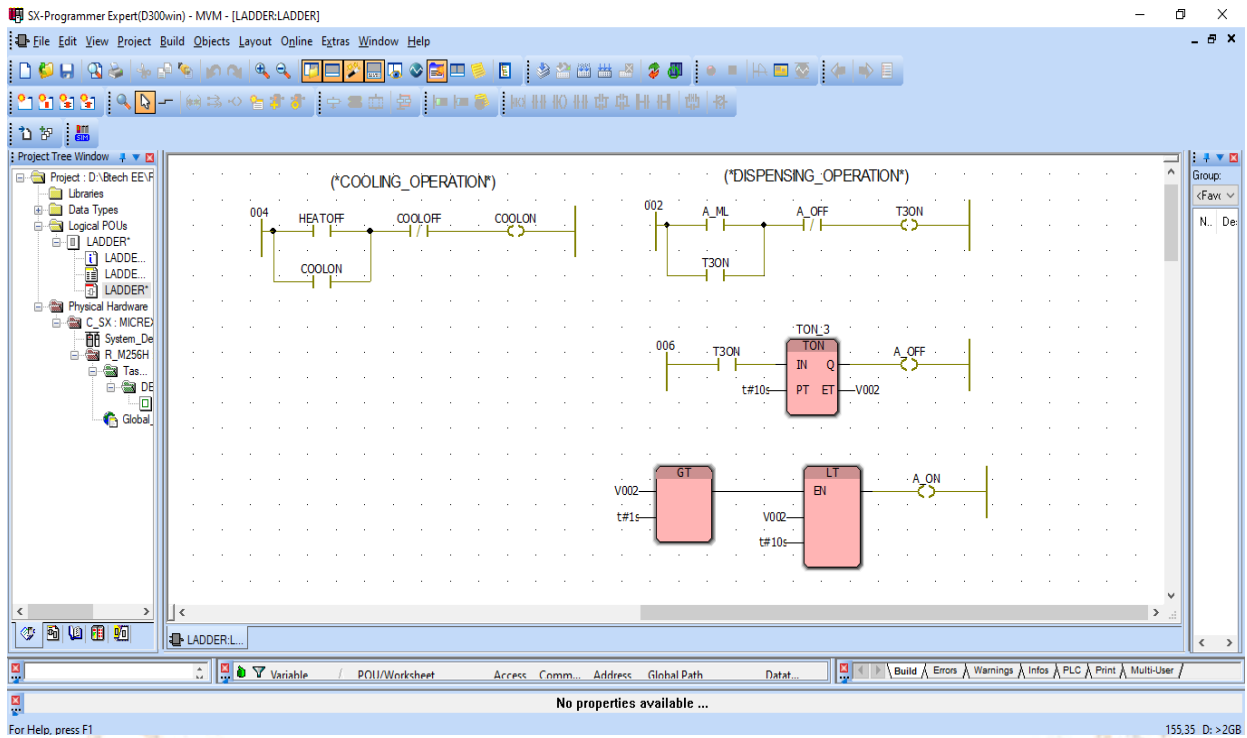**Figure 5** Control logic-1(ladder logic) of Milk vending machine.

Figure 6 Control logic-2(ladder logic) of automated Milk vending machine.
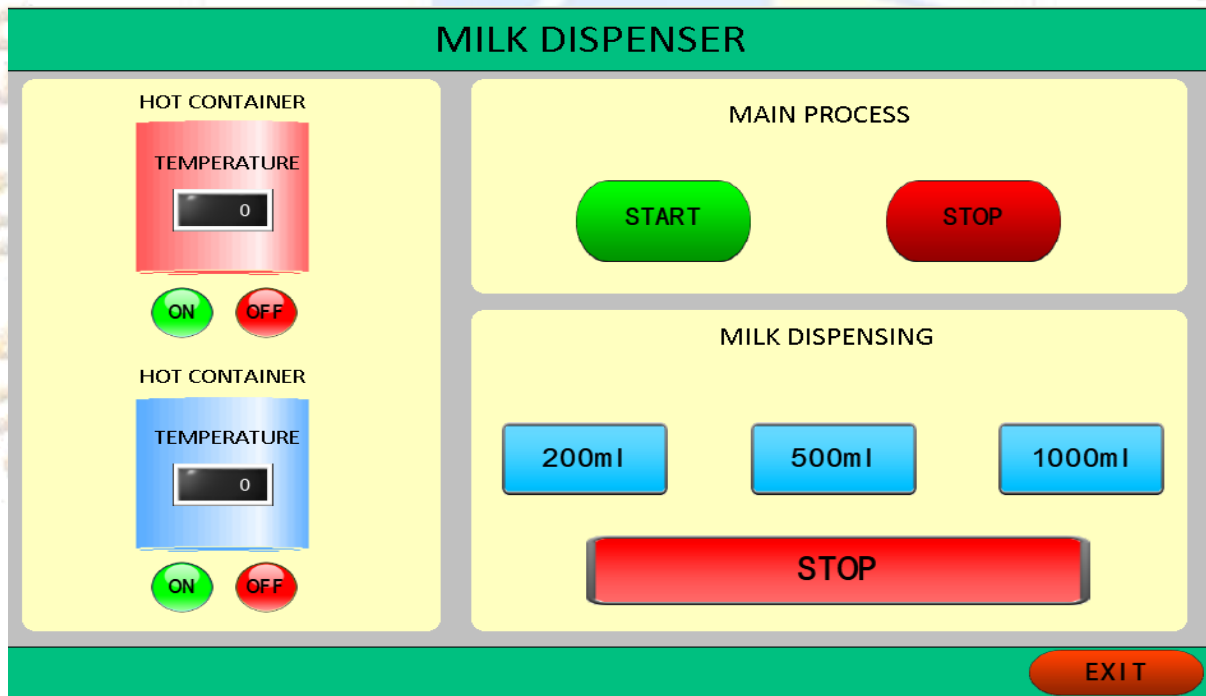

Figure 7 HMI user interface of Milk vending machine.

4. Results and Discussion

The Milk vending machine would reduce the transmission of COVID-19 with zero contact. The machine consumes exceptionally less space around 370*380*1000 (l*b*h) mm^3 with quantity of 10 litres. The machine can preserve milk for longer span and keep up cleanliness of milk. Milk vending machine is move able in nature. Another study mentioned about the development of milk vending machine which is in stationary position. The temperature controller is aided to continuously monitoring the temperature of milk. Also, the machine consequently shows a caution message when level of milk is low. The structured machine framework is easy to understand, protected and secure.

The client can utilize shrewd compensation technique and the dairy proprietor can get advance instalment for the equivalent and the client can administer the milk through prepayment and same sum can be deducted from their financial balance straightforwardly and the proprietor is liberated from costs, for example, commercials, promoting cost or to pay eminences and the milk is sold on 100% development instalment and there is no danger of credit deals [16]. Thus, it very well may be considered as the most ideal approach to convey milk at door steps. These machines are exceptionally simple to oversee and can be introduced at shops or distinctive reasonable destinations. It empowers the proprietor not to rely upon the sales representative. The machine can be topped off according to request of market. It very well may be conveyed simply like an ATM and furthermore can be versatile by putting it on vehicle [12].

Since the machine utilizes the food grade excellent compartments to store the milk, the cleanliness is itself kept up on the grounds that milk is less presented to the hands or some other material utilized for transportation. Additionally, from the Milk plants it is conveyed to the client in the wake of experiencing different procedures, which thus lessens the supplement substance of the milk, yet in the machine the milk straightforwardly poured to the machine which does the sanitization itself and stores it at required ecological conditions. We have utilized RFID to prepare the machine to work. Perhaps the most serious issue of the merchant is additionally illuminated here, which is assortment of cash and the transmission of infection through cash trade. There is no center gathering, consequently the instalment is done through the Pay-tm or however card, which fabricates the straightforwardness among client and merchant. Hence, that would lead significantly reduction in transmission of infection.

5. Conclusion

The COVID-19 is an epidemic that is spreading very fast and caused great impacts to the people's daily life. The proposed 'Zero contact' milk vending machine is a smart solution to tackle this pandemic situation all around the world. As the machine helps in providing the safe environment and maintain the hygiene of milk as it is less exposed to the people. It also preserves milk for longer duration as it uses high-grade food container and it's been pasteurised at high temperature and stored at low temperature in cold container. The machine uses digital payment method which reduces the transmission of deadly corona virus (COVID-19). Smart milk vending machine helps the small farmers and diary firms to sell their milk and indirectly reduce the transmission of infection.

6. References

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