

DESIGN OF HARD ICE CREAM FILLING MACHINE

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Abstract: The scope of this study focuses on designing and developing of hard ice cream filling machine which is meet for small and medium industries. Filling hard ice cream recently being done manually with limited human source, thus limiting the capability to fulfill market demand. To automate the whole process of filling hard ice cream, the filling ice cream machine was designed. It will control the output of hard ice cream from the discharge nozzle to the filling nozzle. This new design will replace the manual filling of ice cream which will result the consistency quantity of ice cream. In the other hand, it will upgrade production efficiency as well as ultimate employee comfort. This innovation also will boost up the total production of company in order to meet the increasing demand in the market. The productivity increases from 600 cups (3.5 oz) to 2400 cups in one hour.

Keywords: Hard ice cream, filling machine, nozzle, cup holder.

1.0 INTRODUCTION

Ice cream is a multifarious colloidal emulsion containing proteins, globules, ice crystals and air bubbles spread in an aqueous phase characterized by a concentrated sugar solution [1]. The chemical composition of ice cream governs some important structural and sensory parameters involved in the quality of the final product [2, 3]. There are two types of ice cream which are hard and soft ice cream. This study focuses on designing and developing of hard ice cream filling machine. According to the International Dairy Foods Association, ice cream must be at least 10% milk fat and 20% cream [4]. Most hard ice cream contains about 10% to 18% milk fat. It also uses corn syrup or other sweeteners like sugar, air and non-fat milk solids like proteins. Hard ice cream is more likely to contain other flavourings, like pieces of chocolate, fruit, nuts, and other sweets. Ice cream starts as a liquid base that is pasteurized and homogenized to eliminate any harmful bacteria. Hard ice cream is then cooled and frozen, while blended and aerated, creating overrun or the amount of air in the product. It is stored at about -15° Celsius.

In this project, it is aimed to automate the whole process of filling hard ice cream from discharge nozzle with the right quantity. It will control the output of ice cream from the freezer to the ice cream cup (size 3.5 oz). The processes consist of five station positions

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which are cup holder, ice cream filling, chocolate/fruit syrup topping, lid placing and push out cup. These stations are hold on the rotational plate which will rotate from one station to another station process. The processes are fully automatic using Programmable Logic Controller (PLC) system which is industrial digital computer that has been adapted for the control of manufacturing processes such as assembly lines, robotic devices and any activity that requires high reliability control and ease of programming and process fault diagnosis [5, 6].

2.0 DESIGN PRINCIPLES

The process of filling hard ice cream using rotary concept was chosen to reduce space consumption in the production area. The machine is designed for production of 2400 cups of 3.5 ounce ice cream in one hour as compared to the current production of 600 cups. The design of each part is drafted using Autodesk Inventor software version 2016. Full design of hard ice cream filling machine is presented in Figure 1.

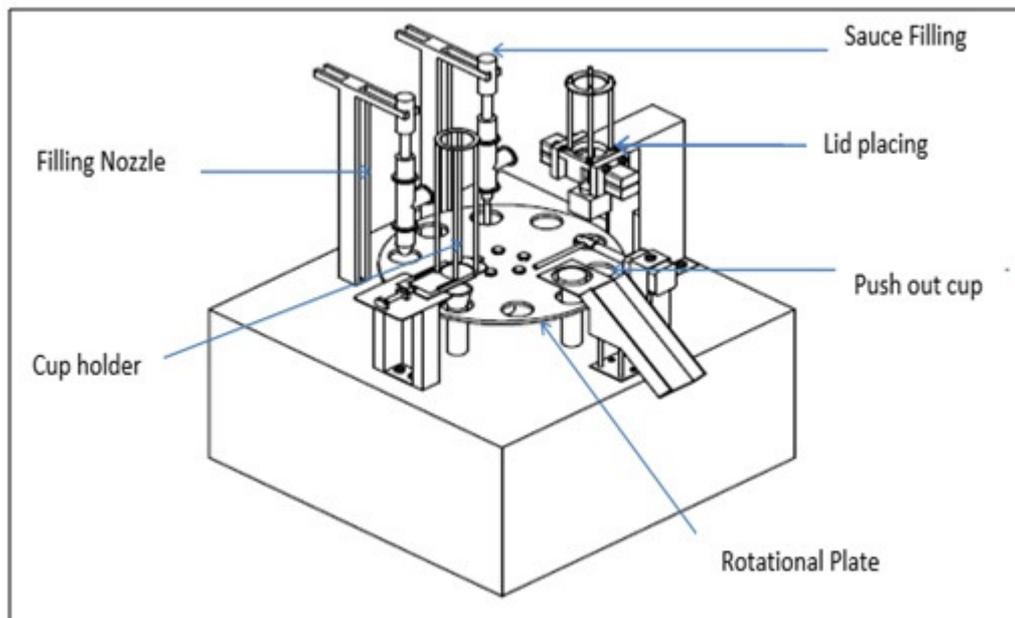


Figure 1: Full design of hard ice cream filling machine

2.1 Cup Holder

Cup holder is one of the five parts of the machine which function as a tool to drop the ice cream cup on the rotational plate with precise and systematic. It is controlled by a pneumatic system where the top of the cup should be stacked vertically and arranged. The ice cream cup will be held with a tool that was installed at the bottom of the cup to avoid the cup from fall down. Next a vacuum funnel controlled using pneumatic system will move from the bottom

to the top and it will inhale the cup, and then it will go back down and it will put the cup into rotational plate. Figure 2 shows a sketching of cup holder.

2.2 Filling nozzle

Filling nozzle is a tool that serves to fill the ice cream into the ice cream cup. Ice cream is prepared in the process will move into the filling nozzle through a hoses from the discharge nozzle. Next the filling nozzle will move from the top to down and it will close to the inside of the cup. Volume of 10 ml ice cream is measured using a valve located at the top of the ice cream filling where it works with pneumatic system. Next the filling nozzle will move from the top to down and will move closer to the inside of the cup. Finally the ice cream will come out and fill up into the ice cream cup. Figure 3 presented a drawing of ice cream filling nozzle.

2.3 Sauce filling

Sauce filling nozzle is a tool that function to fill the sauce into the ice cream. The drawing of sauce filling nozzle is shown in Figure 4. Sauce that was prepared in the process such as strawberry and chocolate will move into the sauce filling nozzle through the hose. Next the sauce filling nozzle will move from the top to the bottom near the top of the ice cream cup. The volume of the sauce was measured as much as 2 ml using a valve which are in the sauce filling nozzle and it works with pneumatic system.

2.4 Lid placing

Lid placing is a tool that servers to put cover into the top of the ice cream cup. The cover of the ice cream cup will be arranged vertically on the top of the lid placing. The cover will be hold with a tool that was installed at the bottom of the lid to avoid it from fall down. The sketching of lid placing is presented in Figure 5. Next a funnel which is controlled using pneumatic system will move from the bottom to the top and it will inhale the ice cream cover, next it will go back down and put the ice cream cover to the top of the ice cream cup.

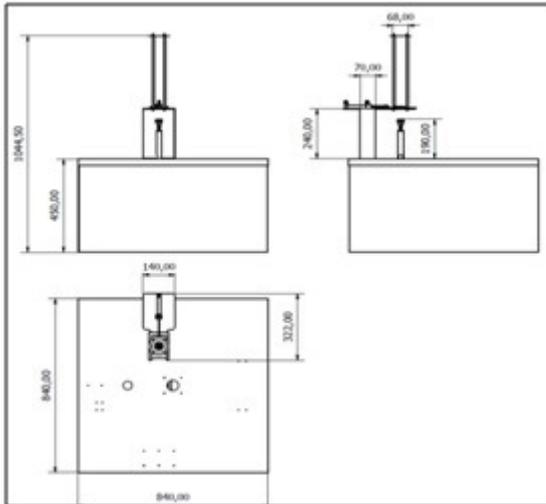


Figure 2: Cup holder sketching

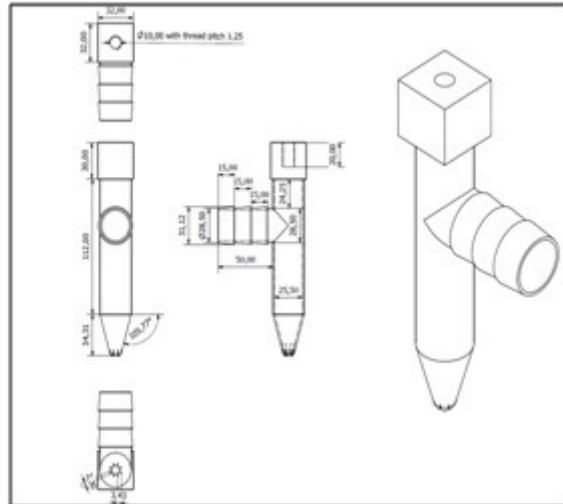


Figure 3: Drawing of ice cream filling nozzle

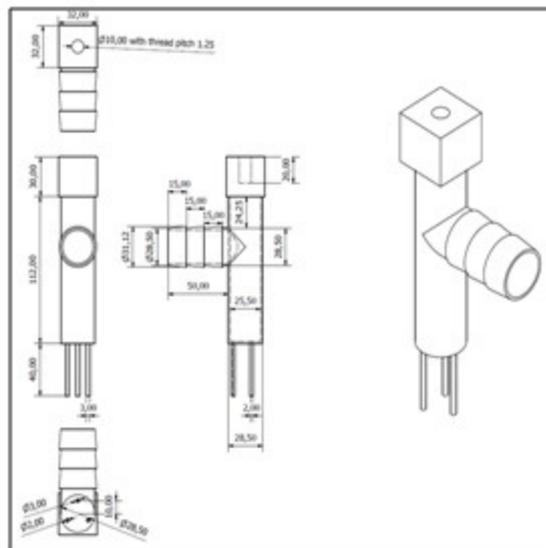


Figure 4: Drawing of sauce filling nozzle

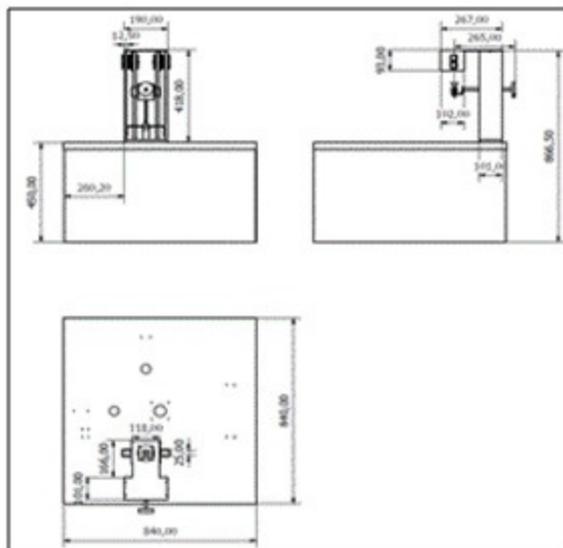


Figure 5: Sketching of lid placing

2.5 Push out cup

Push out cup is a tool which purpose to push out the ice cream cup from the rotational plate. The ice cream cup which is at the top of the rotational plate will be push by the cylinder that located at the bottom of the cup. The cylinder will move from the bottom to the top and it will push the ice cream cup out totally from the rotational plat. At the same time a rod that was located at the back of the ice cream cup will move from the back to onward and it will push the ice cream cup out from the rotational plat to the slider. Figure 6 represents the drawing of push out cup.

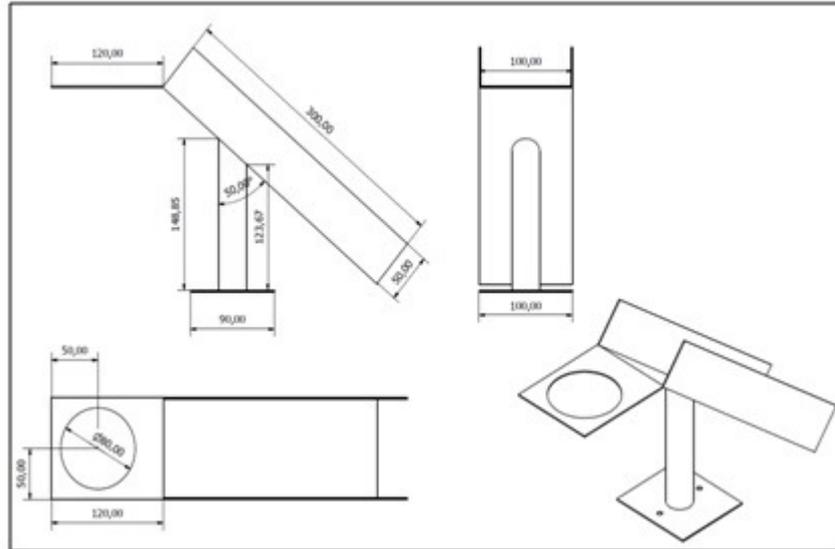


Figure 6: The drawing of push out cup

2.6 Rotational plate

Rotational plate is a part which function to hold the ice cream cup and rotate it from the part to another part process. The rotational plate was rotate by using the motor that located at the bottom of the rotational plate.

3.0 METHOD AND MATERIAL

The design of project consists of PLC (Figure 7) and it functions as a controller for most part of the machine. Beside that the pneumatic system as shown in Figure 8 was used as a power transmits to most part of the machine. Pneumatic system is a power systems using compressed air as a working medium for the power transmission. Their principle of operation is similar to the hydraulic power systems. Then, the pneumatic cylinder as in Figure 9 was used to animate the nozzle and the other part of the machine. Pneumatic cylinder is a mechanical device which uses the power of compressed air to produce a force in a reciprocating liner motion [7].

This project also involves the use of motor (Figure 10) inside the body of the machine which function to rotate the rotational plate. An electric motor is an electrical machine that's converts electrical energy into mechanical energy. The use of outlet valve as presented in Figure 11 is to measure the volume of ice cream and ice cream sauce. Valve outlet is a valve that controls the escape of fluid or gas from a pipe [8].



Figure 7: Programmable Logic Controller

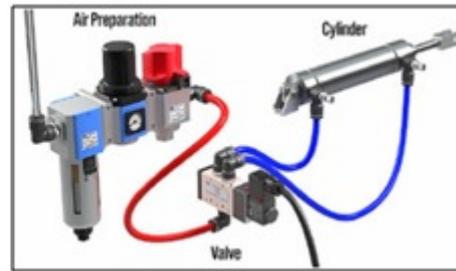


Figure 8: Pneumatic system



Figure 9: Pneumatic cylinder



Figure 10: Motor



Figure 11: Outlet valve

The selection of the right material is very important to create a good and effective project. The structure of the design in this project is using stainless steel (SS304) for outside and inside sauce container and rotational tray. Whereas aluminium was used for the machine body. Stainless steel (SS304) contains 18% of chromium and 8% of nickel as the main non – iron constituents. It is an austenite steel which is not very electrically or thermally conductive and is non-magnetic. It is suitable for food industries [9]. Aluminium was selected because it is remarkable for the metal low density and its ability to resist corrosion through the phenomenon of passivation.

4.0 RESULT

Hard ice cream filling machine has successfully fabricated and meet the objectives of the project and outcome of small and medium industry. The concept idea of this design is the filling nozzle is connected to the discharge nozzle that will control the output of ice cream. It

is automated the process of filling ice cream into small cups (3.5 oz) at accurate quantity desired by the manufacture therefore will increase the total production. Ice cream filling machine is presented in Figure 12.



Figure 12: Ice cream filling machine

The topping/sauce dispensing on top of the ice-cream is also automated by installing sauce outlet nozzle to the machine and finally to the lid placing rack. Movement of ice-cream cups is controlled by the motor-powered rotational tray. Rotational movement production line is chosen to reduce space consumption in the production area. The machine consists of five stations position.

4.1 First station

The first station is a cup holder which it will pull out cup from tray, it has vacuum and the stroke of vacuum is 130mm with the pressure of 2 bar. The function of vacuum is to pull out the cup from tray with height of tray is 35450 mm. There will be 40 cups in the tray and it has a cylinder to control output and input cup with stroke of cylinder is 60mm. Figure 13 shows the first station of machine.

4.2 Second station

Second station is filling ice cream which functions to fill the ice cream into cup of 3.5oz as shown in Figure 14. The cylinder move up and down with stroke of cylinder is 70 mm. It consists of nozzle to fill and shape the ice cream out, and valve to limit the ice cream out to look more commercialize.



Figure 13: First station (cup holder)



Figure 14: Second station (ice cream filling)

4.3 *Third station*

Third station is sauce filling of ice cream topping such as chocolate and strawberry. The cylinder will move up and down with the stroke of cylinder is 70 mm. This station comprise of nozzle to place the topping like tornado shape to look commercial compared to foreign ice cream company. Figure 15 shows the third station of machine.

4.4 *Fourth station*

Fourth station is a lid placing to covering the cup, it has a cylinder to make the movement up and down, the stroke of cylinder is 200mm supported by two shaft left and right, and the height of shaft is 41800mm. Fourth station of the machine is presented in Figure 16. At the middle of shaft it has a bearing and at the bearing centre it has one shaft with 2 bar of vacuum pressure. The function of vacuum is to take the cup cover at the top and to put cup cover at the rotary plate. At the back it has a gear to make the rotation 180 degree when cylinder moves up and down. At the bottom of rotary plate it has a cylinder to push cup to make the cup tightly closed with the stroke cylinder of 20mm. At the top of station it also has a pair of cylinder with functioning to open and close the cup cover.



Figure 15: Third station (sauce filling)



Figure 16: Fourth station (lid placing)

4.5 Last station

Last station is to push out cup of ice cream from machine into boxes for packaging. It has cylinder at the bottom to push up product with stroke cylinder of 150mm. It also has a cylinder to push out product from machine with stroke cylinder of 70mm. The product will go through slide with specific angle of 40° to make sure the ice cream cup slide easily. Figure 17 shows the last station of machine.



Figure 17: Last station (push out cup)

Conclusion

The objectives of the project were achieved with successfully fabricated the machine. The process of filling hard ice cream is fully automated started from the discharge nozzle to the push out cup. It will control the output of ice cream from the freezer to the ice cream cup (size 3.5 oz) with the right quantity. The operation procedure of hard ice cream filling machine is very easy and could be operated by a single user. This new innovation is replaced the manual filling of ice cream which will result the consistency quantity of ice cream. This innovation also will help the small and medium industries to boost up the total production of company in order to meet the increasing demand in the market. The productivity increases from 600 cups (3.5 oz) using manual filling to 2400 cups in one hour. This project as well can provide a way to practice hygiene in the process of filling ice cream in the other it can solve the problem of food poisoning.

Acknowledgment

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