

## **Development of 3 in 1 Chocolate Filling Machine with Variable Volume Using Semi or Full Automatic Process**

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### **Abstract**

Chocolate filling machine is designed to meet the demand of small and medium homemade chocolate industry. A 3 in 1 concept is incorporated in the development of the machine which combined three types of processes specifically chocolate melting, mixing and chocolate filling process. The machine uses volumetric piston filling principle and capable to dispense chocolate into different size of moulds. Extra safety measurement especially in material selection has been taken into account to increase the productivity and quality of the chocolate bar produced. The machine can be operated semi- or fully- automatic

**Keywords:** Chocolate filling machine, melting, mixing, filling process

### **1.0 Introduction**

Homemade Chocolate is becoming a very attractive business for small and medium chocolate confectionery industry. This is further concurred by Malaysian Cocoa Board (2018), where it states there is currently 51 chocolate manufacturers and confectioneries as well as 194 homemade chocolate entrepreneurs, selling about RM1.095bil a year. However, the process of homemade chocolate making is still manually produced and labour intensive. Manual methods often lead to inconsistent quality of the chocolate bar in the aspect of weight, appearance and shelf life (see Figure 1). This is consistent with Afoakwa et al., (2007) where he concluded a well-tempered chocolate will have the following properties: good

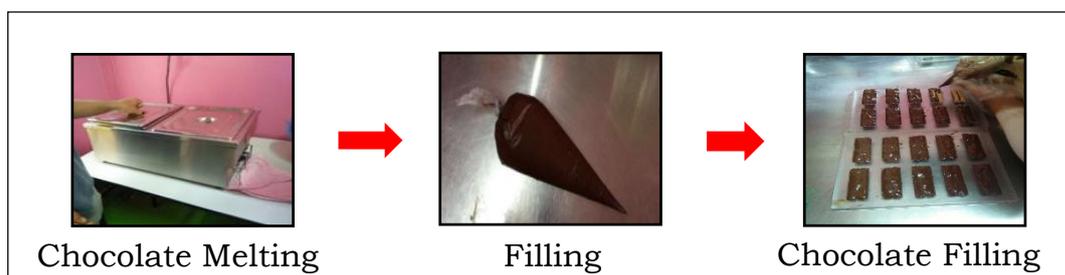
shape, colour, gloss, contraction from the mould, better weight control, stable product – harder and more heat resistant (fewer finger marks during packaging) and longer shelf-life.

Most of the homemade chocolate use compound chocolate because of the cheaper price as compared to the price of couverture chocolate. Chocolate compound is made from a combination of cocoa powder, vegetable fat and sweetener (Dale, 2017). The compound chocolate does not need to go through the tempering process. It can simply be heated at certain temperature until melting and ready for molding process.



**Figure 1:** Inconsistent chocolate weight and shapes

The homemade chocolate production begins by melting the compound chocolate bar. The melting chocolate is semi-fluid and high viscosity. The existing method of a chocolate manufacturing are done manually as shown in Figure 2. Then the liquid chocolate is dispensed into the various size and shape of the molds. To ensure the quality of the chocolate produced, the filled mold need to be vibrated to ensure there is no air bubbles in the mold chocolate. In addition, chocolate should always be in liquid state during the filling process.



**Figure 2:** Existing Chocolate manufacturing process

The design of chocolate filling machine is based on few improvements on the existing methods. Filling machines are one of the major components in the manufacturing industry, particularly in packaging process as well as filling process into molds. The liquid filling machine in the market mostly

works on different working principals depending on the machine's requirements. The main factor in designing filling machine is the liquid viscosity. Therefore, for the design of this chocolate filling machine, the type, shape and content of chocolate are the main factors to be considered. The design also emphasizes safety aspects not only on machine operators, but also on chocolate products.

Thus, this study focuses on designing and developing a cost effective chocolate filling machine that is suitable for small and medium industries to melt, mix and fill the chocolate into the molds that can improve the production rate and quality of the chocolate bar.

## **2.0 Methodology**

The main focus of machine development is for small and medium industries (SME's) to improve the quality and quantity chocolate production. The methodology of machine development described as follows.

### **2.1 Design Principle**

The concept of 3 in 1 was applied in the development of the machine in which the machine combines three types of processes, namely the melting, mixing and filling process of the chocolate. The machine was required to filling the chocolate into various shapes of molds with different volumes.

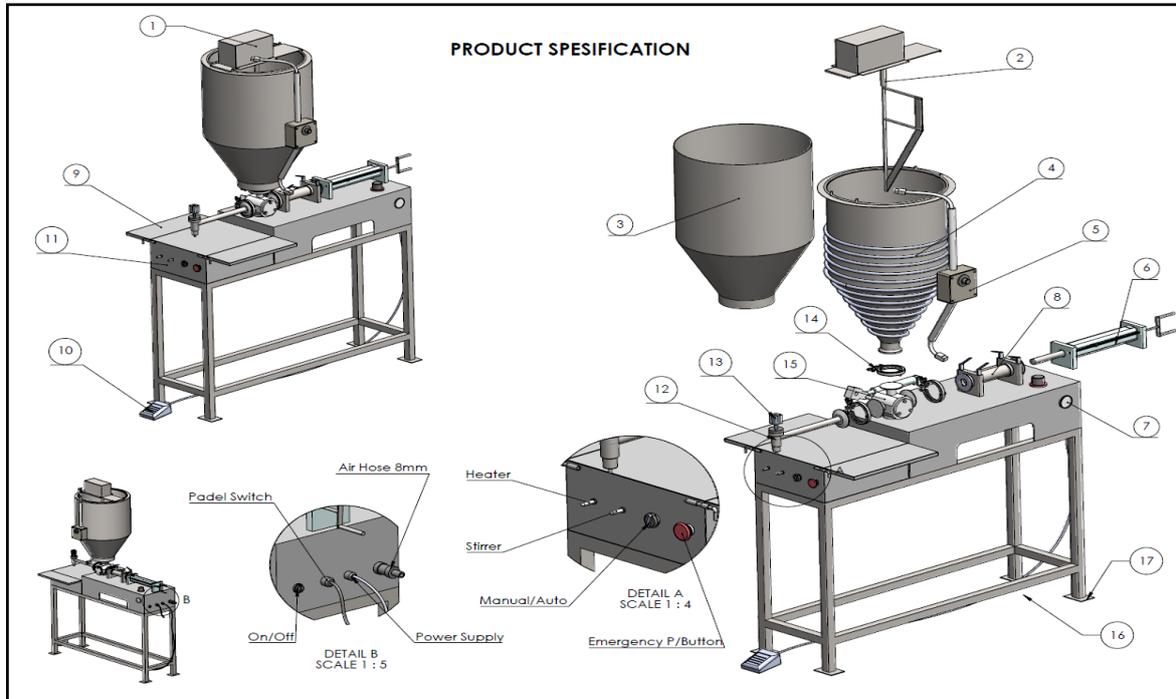
A hopper was used to melt and mix the chocolate. According to Balevičius et al., (2008) the 'V' shape of the hopper helped the smooth flow of the chocolate liquid. The melting process used coiled heater attached to the inner tank. The coiled heater was used to ensure consistent heat was supplied to the molten chocolate. Temperature controller was installed to control and adjust the chocolate temperature in the tank. A slow rotated stirrer mounted to the lid of the hopper to stir up the melted chocolate. The stirring process helped the chocolate to smoothly blended and speed up the melting process.

Semi-Automatic Chocolate Filling Machine used the volumetric piston filling principle. Piston fillers worked very well with thicker and high viscous products such as chocolate (Herman, 1975). The piston cylinder allowed certain volume of chocolate liquid to enter the nozzle from the hopper. The same volume of chocolate liquid was dispensed from the nozzle to the mold. Therefore, the volume of the chocolate liquid could be consistently controlled and adjusted. The pneumatic system was used to control the piston movement and the filling process.

### **2.2 Design Concept**

The Chocolate Filling Machine is design as shown in the Figure 3 and each part is listed in Table 1. The 'V' shape hopper able to hold 3-5 kilogram of chocolate and the maximum chocolate liquid capacity was up to 25 litre. The maximum temperature of the heater was up to 1000C to keep the chocolate in good condition and maintain chocolate liquid viscosity. The temperature of the heater can be controlled and normal temperature of chocolate liquid during the filling process into the mold is 40-50°C (Afoakwa et al., 2007). The appropriate nozzle consists of nozzle having three sizes i.e

1-2mm, 5-6mm, 9-10mm and the suitable nozzle type used is 1-2mm nozzle. This type of nozzle is suitable as most chocolate industries use this nozzle. Chocolate filling process can be adjusted according to the mould size. The design emphasized a safety aspect where Emergency stop push button is provided.



**Figure 3:** Chocolate Filling Machine Design

**Table 1:** Chocolate Filling Machine Design Parts

NO	PART	QUANTITY
1	Motor	1
2	Stirrer	1
3	Hopper	1
4	Heater	1
5	Temperature Controller	1
6	Pneumatic Cylinder	1
7	Air Regulator	1
8	Volumetric Filling Stroke Piston	1
9	Table	2
10	Pedal Switch	1

11	Control Panel	1
12	Nozzle	1
13	Mini Pneumatic Valve	1
14	Ferrule Fitting(Clamp)	3
15	Ball Valve & Mini Pneumatic Cylinder	1
16	Frame	1
17	Castor Wheel( Roda Berkunci)	4

### 2.3 Materials

The materials used to build machine tools especially those having contact with food are of the permissible material and meet the requirements of standards such as 300 series of stainless steel groups. According to Petermann (1996), stainless steel types of 316 and 304 are most suitable for use as a hopper for chocolate filling machines. The hopper is suitable as it will connect directly with chocolate, stainless steel type 316 and 304 is safe to use as it is clean and does not affect the texture and taste of the chocolate itself. Furthermore, this type of iron is usually used in food products manufacturers.

### 2.4 Fabrication and Assembly

The fabrication process was done parts by parts. The first parts are assembling of the mechanical component such as a machine main body follows by electrical parts such as heating components. Heater cables of 4 meter length as a heater component assemble to the hopper. The complete chocolate filing machine is shown in Figure 4.



**Figure 4:** Chocolate Filling Machine

## 2.5 Performance Testing

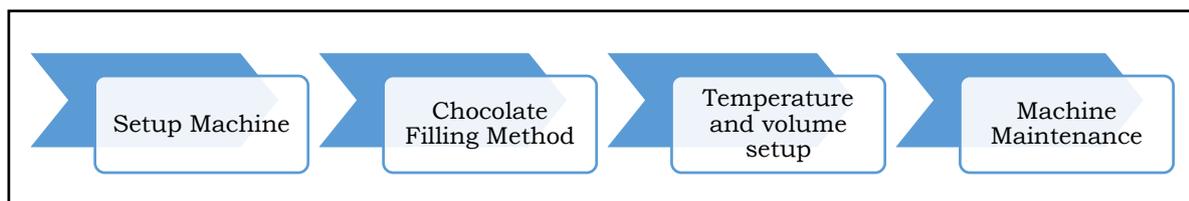
The performance of machine is tested step by step follows the standard operating procedure as illustrated in Figure 5.

The Chocolate Filling Machine can be operated either manual or automatic production process. At the beginning, installed the air supply from the compressor to the machine and set the air pressure at 0.5 MPa. Next, switch ON the power supply and heater. Set the hopper temperature up to 100°C to maintain the viscosity of chocolate liquid. Switch ON rotated stirrer mounted to the lid of the hopper to stir up the melted chocolate. The stirring process helped the chocolate to smoothly blended and speed up the melting process. For safety, emergency STOP push button is provided.

The machine is filling the chocolate into various shapes of molds with different volumes used the volumetric piston filling principle. The volume of chocolate for each mold are calculated based on volumetric piston cylinder length define as

$$H = \frac{\pi R^2}{V} \quad (1)$$

where V denoted as volume (ml), R is cylinder diameter (mm) and H is stroke length (mm).



**Figure 5:** Flowchart Performance Testing

## 3.0 Results and Discussion

The machine was design and fabricate to filling the chocolate into various shapes of molds with different volumes. The adjustable volumetric piston filling is calculated using Equation (1.0) and used as control volume of the chocolate liquid. The machine was successfully dispensed the same volume of chocolate liquid from nozzle to the mold. The high accuracy of filling volume was found with 99% accuracy. The volumetric piston cylinder with stroke length of various chocolate types and molds are listed in Table 2.

**Table 2:** Volumetric piston cylinder stroke length of various chocolate types and molds

CHOCOLATE MOLD	CHOCOLATE VOLUME (ml)	STROKE LENGTH,H (mm)
COKLAT BULAT OREO	7	14.30
COKLAT KITKAT	9	18.30
COKLAT LOLIPOP	14.5	29.50
COKLAT BAR (KOSONG)	53	107.80
COKLAT BAR (MARSHMALLOW)	7	14.30
COKLAT BAR (CORNFLAKES)	24.5	50.00

**Table 3:** Production of 15 kg chocolate in 90 minutes

CHOCOLATE TYPES	CHOCOLATE VOLUME (ml)	PRODUCTION QUANTITY
COKLAT BULAT OREO	7	7497
COKLAT KITKAT	9	5831
COKLAT LOLIPOP	14.5	3619
COKLAT BAR (KOSONG)	53	2016
COKLAT BAR (MARSHMALLOW)	7	7497
COKLAT BAR (CORNFLAKES)	24.5	2142

**Table 4:** Comparison of conventional and automatic chocolate production in 1 hour

CHOCOLATE TYPES	CONVENTIONAL TECHNIQUE	MACHINE
COKLAT BULAT OREO	1000	4998
COKLAT KITKAT	777	3887
COKLAT LOLIPOP	483	2413
COKLAT BAR (KOSONG)	269	1344
COKLAT BAR (MARSHMALLOW)	1000	4998
COKLAT BAR (CORNFLAKES)	322	1608

The production capacity is increased from 1 kg to 5 kg chocolate in 30 minutes depending on the chocolate size. The quantity of chocolate

production of for 15 kg chocolate in 90 minutes is listed in Table 3. The result shows high production quantity of each types of chocolate which may suitable for chocolate mass production. Table 4 shows the comparison of production quantity using conventional technique and chocolate filling machine. It is show that the chocolate production using chocolate filling machine is increased approximately 400% compare to the conventional technique. This gives a strong recommendation that filling machine is suitable for mass production which is beneficial to the SME's. Besides, the quality of chocolate also increases with constant weight and reduces the bubble contain that may reduce chocolate life time.

#### **4.0 Conclusion**

Semi or full automatic chocolate filling machine has been successfully developed in 3 in 1 process starting from chocolate melting process, mixing and filling as shown in Figure 5. The hopper able to accommodate a maximum of 25 litre melted chocolate with controlled temperature. Compare to the conventional processes, the temperature of melted chocolate cannot be controlled, thereby preventing mass production. The production capacity is increased from 1 kg to 5 kg chocolate in 30 minutes depending on the chocolate size. The quality of chocolate production also increases with constant weight and reduces the bubble contain that can reduce chocolate life time.

This machine is less maintenance and easy to use with simple cleaning procedure. Each parts of the machine can be clean easily using pure water added with vinegar to keep the quality and lifetime of the machine.

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