

# Glue Pellet Control System for Assembly of Electronic Components on Printed Circuit Boards

Chadaporn Wongsri<sup>1</sup>, Phammatorn Intorn<sup>2</sup> and Chonlatee Photong<sup>1,\*</sup>

<sup>1,\*</sup> Faculty of Engineering, Mahasarakham University, Kham Rieng, Kantarawichai, Maha Sarakham, 44150, Thailand

<sup>2</sup> Sony Technology (Thailand) Co., Ltd., 140 Bangkadi Industrial Alley, Bang Kadi, Mueang Pathum Thani District, Pathum Thani, 12000, Thailand

chadapornwongsri25@gmail.com, phannathon.me@gmail.com, and chonlatee.p@msu.ac.th\*

**Abstract.** *This paper presents a glue pellet control system for assembly of electronic components on printed circuit boards, which has an objective to control silicone glue to achieve constant volume and helps to reduce wastes as required by the company using the motor control technique. The experimental results of the proposed system were evaluated and compared to the previous system, which was the air compressing system. The test results were found that the weight and volume of the silicone glue using the proposed system providing more accuracy and precision than the pneumatic by 0.0013 compared to 0.0021; 38%. In addition, the system also provided better full usage of glue from the tube compared to the previous system.*

Received by	16 March 2019
Revised by	5 May 2019
Accepted by	1 June 2019

## Keywords:

Glue pallet control, assembly of electronic components, silicone glue

## 1. Introduction

Silicone glue is popular material widely used in the industries for assembling the manufacturing parts together. Silicone glue used in the industries could be classified into 3 types: fluid, sealant and elastomer silicone glue [1]. The fluid silicone glue has special characteristics in that it is clear liquid glue and does not change its state even if the temperature changed. However, the fluid silicone glue could be used only for the products that require softness such as lotion or hair conditioner [2] etc. The sealant silicone glue has high flexibility and changeable material states between liquid and solid; therefore it is often used as the adhesive glue such as grouting the tiles and roofs, etc. In addition, the sealant silicone glue is also used mostly in the computer industries for draining heat from the Integrated Circuit (IC) devices [3]. On the other hand, the elastomer silicone glue, also known as the rubber silicone glue, has high viscosity and looks like the clear gel. The elastomer has its own unique advantage over other types; hence it is commonly used in cosmetic industries such as skin care cream, sunscreen cream, and etc. [4].

Sony Technology (Thailand) Co., Ltd. is one of the companies that utilize the silicone glue in the assembling processes for the mobile phone products. The glue used is called Thermal Gap Filler (TGF), which is the glue that is used for dissipating heat from the mobile phone. In production process, the assembling of the CPU chip of the mobile phone with the main board requires small amount of the silicone glue but could have capability of effective heat draining so that the microchip is always running at its top performance, as well as, avoiding shut down of the chip or causing other relevant problems. Unfortunately, when leaving the silicone glue with the natural air for a long time, it will turn to dry at the tip of the dropping glue tube and then cause the glue tube to not to be able to apply silicone glue out even if high pressing force applied. The current solution that the company uses to eliminate these problems is only by using the silicone glue just for specified duration of time under controlled air pressure while the out-of-time glue is not allowed to be used in the production processes even if the previous glue tubes still have good conditions. These issues then could lead to a number of wastes and thus the production costs.

The researchers have a chance to work in the Sony Technology (Thailand) Co., Ltd. Therefore, we are interested to create a prototype machine for silicone glue dropping processes in order to provide constant volume of silicone glue to be within the specified range of production standards. Additionally, this machine could also prevent the damage of the CPU chip that could be caused by bad heat dissipating glue, as well as, increase accuracy and precision of the glue volume for the machine at the same time.

According to the previous study, the researchers in [5] found that the damage occurred in the dropping glue process could be caused by bubbles generated from the manufacturing processes. Therefore, the company could use the glue spinning process to improve the quality. By using this technique, the damage could be reduced while improved the glue loss around 99.60%. The research study in [6] has used the statistical control technique and designed the experiment to reduce the deformation of the holding frame in the display part assembling process. The research work [7] pointed out that the quality of products

could be improved by using DMAIC method that could be able to reduce problems of unmatched position of the magnets in hard drive assembling process from 0.043 % to 0.000%. The research work [8] proposed the new glue dropping system by using an electric motor with a gear box to drive the glue dropper. The research [9] proposed that in assembling process of the silicone glue dropping on an electronic plate using the specific designed machine to operate precisely. The research work in [10] proposed many types of the 3-axis glue dropping machine; where each type has its unique control method.

Regarding the above research works and studies, besides using of the air compressing system for dropping the silicone glue for the Sony Technology Company, there still have some other equipment and tools that could be used to control the volume of the glue. One of the most popular techniques is by using electric motor controls [11]-[16]. These techniques are popular for the modern machines and the most popular type of the motor used is a servo motor and a stepper motor. This is because of the fact that both of these motor types can control compressing distance precisely and efficiently. Based on the findings, the servo motor would be more preferable than the stepper motors; but, would have significant higher cost. In this research, the servo motor was used, which has technical description in the following sections.

## 2. Experimental Equipment and Methodology

### 2.1 Experimental Equipment

This section described the equipment of the proposed system; having detailed equipment as follows:

#### 2.1.1 JANOME JR2200N Mini Machine

A JANOME JR2200N mini machine is a new low-cost, high-performance robot. This type of the machine has been used in the silicone glue dropping process in Sony Technology (Thailand) Co., Ltd. The structure of machine is shown in Fig. 1 [17].



Fig. 1: JANOME JR2200N mini machine structure [17]

#### 2.1.2 Ley16c-100 Actuator

A ley16c-100 actuator is a pressing machine that has physical feature and installation position as shown with the number 2 in Fig. 1. it consists of a pressing set and a servo motor controller.

#### 2.1.3 Motor Driver

A motor driver is a driver set designed by the researchers for controlling the motor (number 3 in Fig.1). The main components within the motor driver are the controller set, the interfacing set and the computer.

The communication of motor driver is using a teaching box (number 4 in Fig. 1) to change the mode of the JANOME machine, using APC Controller program to set the appropriate values of actuator parameters through communication cable.

#### 2.1.4 Teaching Panel

A JANOME JR 2200N mini teaching panel is a machine step position setting device located as shown with number 4 in Fig.1. This device has the core functions for position adjusting as well as relevant variables, which works together with the programming unit of the JR2200 mini machine aforementioned in Section 2.1.1.

#### 2.1.5 Thermal Gap Filler Silicone Glue

The thermal gap filler silicone glue is the glue commonly used for draining heat for electronic components such as printed circuit boards, etc. The glue is installed at the location shown with number 5 in Fig. 1. There is only one glue tube that is allowed to be used for one working shift (6-8 hours).

#### 2.1.6 Silicone Glue Dropping Tube

a silicone glue dropping tube is a tube that contains silicone glue for the assembling (number 6 in Fig.6). The tube has special design and been used only at Sony Technology (Thailand) Co., Ltd.

#### 2.1.7 NBL 623e ADAM 3 Decimal Places Digital Weighing Machine

The NBL 623e ADAM 3 decimal places digital weighing machine is a weighing machine; having feature as shown by number 7 in Fig. 1. This machine is used for measuring weight of the silicone glue in the quality control processes of the company. The standard maximum weight for one single pellet silicone glue is 620 g. with the resolution of 0.001 g. (1 mg.). Weighing plate is stainless steel with a diameter 16 cm.

## 2.2 Methodology

The proposed silicone glue pallet control system was designed to control the pressing distance and the time for the servo motor. Detailed designs are described as follows:

### 2.2.1 Design of Transfer Function for Silicone Glue Weight Control

There are 2 control parameters for the silicone glue weight control system: the pressing distance (x) and time (t); where the weight (W) can be expressed as a function of these parameters  $W=f_1(x, t)$ , which is to convert the pressing distance and the time from the actuator to the glue weight and then bring the acquired glue weight convert with the functions f2 and f3 in order to convert back into the reference glue weight to the pressing distance and time for getting these two values into the controller and thus to get the reference x and t values for the control system as shown in Fig.2.

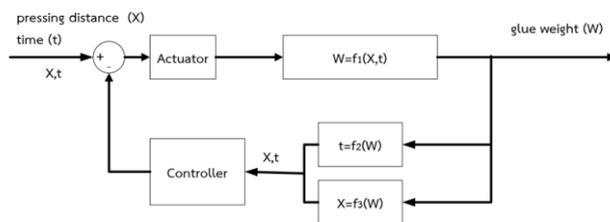


Fig. 2: Designed Transfer Function for the glue weight control

By using the information regarding the standard silicone weight control of the company, the functions f1, f2 and f3 could be determined; using data of glue weight, pressing distance and time, and thus the relationship with regression line as shown in Fig.3.

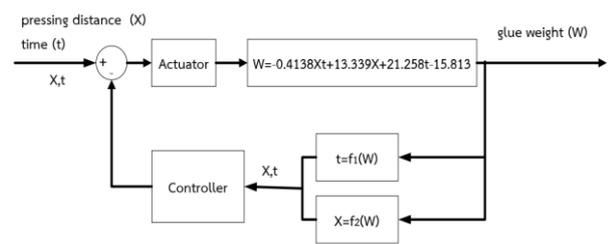


Fig. 3: Transfer function using Sony standard information

From Fig. 3, the control system provides determined values of time and pressing distance for ordering the actuator to operate using information from the controller subtracted by the actual measured values. The resultant values: pressing distance (x) and time (t) then are converted into the glue weight (W) and then getting glue weight to function f1 and f2 for converting as the new reference for pressing distance and time to calculate in the controller to get the appropriated value of silicone glue weight.

### 2.2.2 Experiment 1

The experiment 1 was conducted in order to determine the relationship between the glue weight and the time of conventional control system using the materials and equipment as follows:

- using the weighing machine
- repeating the experiment for 8 times to calculate average value apart for 1 hour by recording the glue weight for 10 times per cycle.
- to determine the relationship between the glue weight and the operating time of the machine by using  $R^2$

### 2.2.3 Experiment 2

The experiment 2 was created in order to determine the relationship between the glue weight and the time of the proposed control system that uses the servo motor to press the glue. The materials and equipment used are as follows,

- using the weighing machine
- repeating the experiment for 8 times to determine average value apart for 1 hour by recording the glue weight for 10 times per cycle.
- to determine the relationship between the glue weight and the operating time of the machine by using  $R^2$

## 3. Results

The experiments 1 & 2 as mentioned above have the purposes to provide the following results:

1. Comparison of the glue weight control performance between the previous system (air pressure control) and the proposed system (servo motor control).
2. Comparison of the glue utilization performance between the previous system (air pressure control) and the proposed system (servo motor control). The test was done by applying the pressing distance of 2 mm. for 1 second and then recording experimental results for 3 days (from 11 to 13 November 2018). The same lots of silicone glue and containing in dropping tubes were used for both techniques. The experimental test results were recorded at the same time for both techniques for 10 times to determine the average values.

### 3.1 Result #1

This result was recorded at the first day (of 3 days), which is 11 November 2018. The same amounts and lots of the silicone glue, as well as, the same pressing heads were used for the tests for both previous and the proposed techniques as shown in Figs.4-6.



Fig. 4: Photo of glue tubes in experiment (Day#1)



Fig. 5: Type of pressing head used for pressing silicone glue



Fig. 6: sampling glue on silicone weighing machine (Day#1)

1) The experimental results of air compressing and motor pressing in production line according to Table 1 and Table 2 and graphs plotted in Fig. 7. The graph shows trend of the silicone glue weight compared with time between air compressing system and motor pressing system as follows,

Date/Time	Silicone weight (mg)										Air Presser		
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10		Average	
11/11/2561													
8:00	33.0	32.0	26.0	33.0	32.0	31.0	37.0	38.0	30.0	31.0	32.3	0.345 MPa	
9:00	31.0	30.0	30.0	33.0	30.0	31.0	30.0	34.0	33.0	32.0	31.4		
10:00	29.0	30.0	31.0	28.0	32.0	32.0	34.0	30.0	31.0	30.0	30.7		
11:00	30.0	31.0	31.0	33.0	31.0	29.0	32.0	28.0	31.0	29.0	30.5		
1:00	28.0	29.0	30.0	27.0	32.0	29.0	28.0	30.0	31.0	30.0	29.4		
2:00	30.0	28.0	28.0	26.0	29.0	27.0	26.0	31.0	29.0	27.0	28.1		
3:00	29.0	27.0	31.0	29.0	31.0	26.0	26.0	26.0	28.0	29.0	28.2		
4:00	27.0	26.0	25.0	28.0	24.0	25.0	28.0	28.0	27.0	29.0	26.7		
5:00	26.0	27.0	25.0	24.0	24.0	26.0	27.0	28.0	26.0	26.0	26.0		
Standard Deviation (SD)											2.2		

Table 1 Experimental result of air compressing in production line, 1st experiment in 11 November 2018

Date/Time	Silicone weight (mg)										Average	Press distance/ Time	
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10			
11/11/2561													
8:00	30.0	33.0	31.0	31.0	32.0	31.0	30.0	31.0	30.0	33.0	31.2	Press distance = 2 mm. Time = 1 s	
9:00	34.0	31.0	32.0	31.0	32.0	30.0	33.0	30.0	31.0	30.0	31.4		
10:00	29.0	31.0	30.0	30.0	31.0	32.0	31.0	30.0	29.0	31.0	30.4		
11:00	31.0	29.0	30.0	32.0	29.0	32.0	30.0	33.0	31.0	31.0	30.8		
1:00	32.0	31.0	31.0	30.0	30.0	33.0	32.0	30.0	31.0	29.0	30.9		
2:00	30.0	29.0	31.0	30.0	29.0	30.0	31.0	28.0	30.0	29.0	29.7		
3:00	31.0	30.0	28.0	29.0	31.0	29.0	30.0	29.0	30.0	31.0	29.8		
4:00	30.0	29.0	29.0	31.0	27.0	31.0	32.0	31.0	28.0	29.0	29.7		
5:00	28.0	31.0	30.0	29.0	30.0	29.0	28.0	32.0	29.0	31.0	29.7		
Standard Deviation (SD)											0.7		

Table 2 Experimental result of motor pressing machine, 1st experiment in 11 November 2018

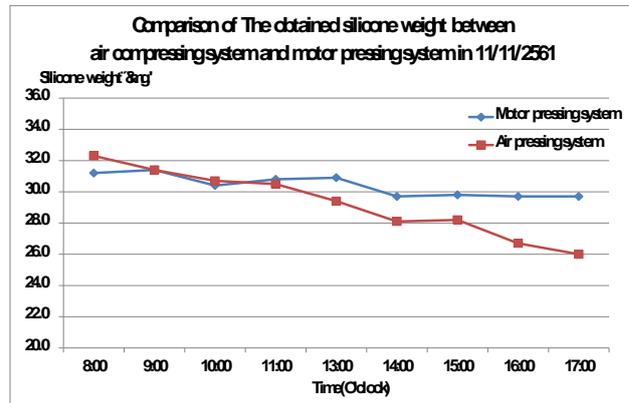


Fig. 7: Differentiation of silicone glue weight compared with time between air compressing system and motor pressing system in 11 November 2018

It can be seen from Table 1-2 and Fig. 7 that:

1. The glue weight resulted from the experiment of the air compressing was decreasing gradually while using air pressure at 0.345 MPa. Meanwhile, the glue weight resulted from the experiment of servo motor control is just slightly changed as shown in Fig. 7.

2. The weight distribution of the air compressing system is 2.2 while of the motor pressing system is 0.7 as shown in Table 1 and 2.

### 3.2 Result# 2

This result was recorded at the second day (of 3 days), which was in 12 November 2018. The same amount and lots of the silicone glue, as well as, the same pressing heads were used for the tests for both previous and the proposed techniques as shown in Figs.8-9.

1) Experimental result of air compressing and motor pressing in production line according to Table 3 and Table 4 and graph plotting in Fig. 10 graph shows trending of silicone glue weight that compared with time between air compressing system and motor pressing system as follows:



Fig. 8: Photo of glue tube in experiment in 12 November 2018



Fig. 9: sampling glue on silicone weighing machine in 12 November 2018

Det/Time 12/11/2561	Silicone weight (mg)										Air Presser	
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10		Average
8:00	28.0	32.0	31.0	29.0	28.0	30.0	31.0	30.0	33.0	30.0	30.2	0.325MPa
9:00	32.0	29.0	28.0	31.0	29.0	30.0	32.0	29.0	27.0	29.0	29.6	
10:00	29.0	28.0	30.0	27.0	31.0	31.0	29.0	27.0	26.0	29.0	28.7	
11:00	26.0	25.0	24.0	26.0	25.0	27.0	26.0	24.0	23.0	26.0	25.2	
1:00	24.0	26.0	26.0	25.0	24.0	26.0	22.0	25.0	26.0	25.0	24.9	
2:00	31.0	32.0	31.0	30.0	30.0	29.0	31.0	29.0	32.0	28.0	30.3	0.335 MPa
3:00	29.0	31.0	27.0	30.0	31.0	27.0	29.0	29.0	28.0	27.0	28.8	
4:00	32.0	29.0	30.0	27.0	32.0	29.0	30.0	28.0	27.0	29.0	29.3	
5:00	26.0	24.0	29.0	26.0	25.0	28.0	27.0	26.0	28.0	29.0	26.8	
Standard Deviation (SD)											2.1	

Table 3 Experimental result of air compressing in production line, 2nd experiment in 12 November 2018

Date/Time 12/11/2561	Silicone weight (mg)										Press distance/ Time	
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10		Average
8:00	29.0	30.0	30.0	31.0	32.0	33.0	31.0	32.0	31.0	30.0	30.9	Press distance = 2 mm.  Time = 1 s
9:00	30.0	31.0	33.0	31.0	31.0	30.0	29.0	33.0	30.0	31.0	30.9	
10:00	30.0	28.0	29.0	32.0	33.0	31.0	31.0	30.0	29.0	31.0	30.4	
11:00	28.0	30.0	28.0	31.0	30.0	31.0	32.0	30.0	31.0	31.0	30.2	
1:00	33.0	31.0	30.0	32.0	31.0	31.0	30.0	28.0	30.0	32.0	30.8	
2:00	31.0	28.0	26.0	33.0	27.0	29.0	30.0	32.0	31.0	28.0	29.5	
3:00	29.0	28.0	31.0	32.0	30.0	29.0	30.0	27.0	29.0	28.0	29.3	
4:00	30.0	29.0	24.0	29.0	30.0	25.0	27.0	31.0	28.0	30.0	28.3	
5:00	26.0	31.0	27.0	30.0	28.0	29.0	32.0	30.0	26.0	29.0	28.8	
Standard Deviation (SD)											1.0	

Table 4 Experimental result of motor pressing, 2nd experiment in 12 November 2018

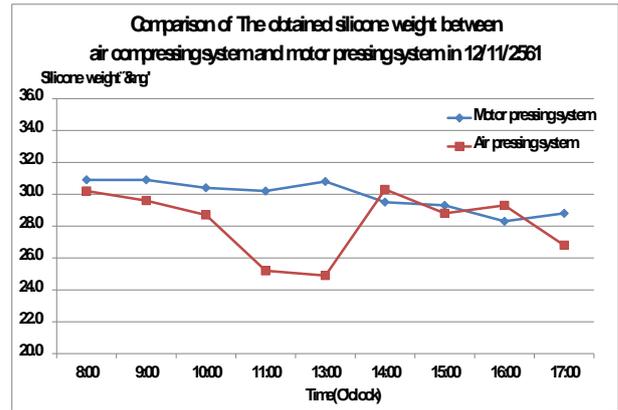


Fig. 10: Graph shows differentiation of silicone glue weight compared with time between air compressing system and motor pressing system in 12 November 2018

It can be seen from Table 3-4 and Fig. 10 that:

1. The glue weight from the experiment of the silicone glue pressing with the air compressing system was decreasing under standard value while using air pressure at 0.325 MPa in same value due to the tip of glue tube stuck and air bubbles within the glue tube. Therefore, a new glue tube was used for next experiment. Meanwhile, the glue weight from the experiment when using the servo motor is significantly changed, but still under control to be within the standard range of the company as shown in Fig. 10.

2. The weight distribution of the air compressing system is 2.1 while weight distribution of the motor pressing system is 1.0 as shown in Table 3 and 4.

### 3.3 Result# 3

This result was recorded at the third day (of 3 days), which was in 13 November 2018. The same amount and lots of the silicone glue, as well as, the same pressing heads were used for the tests for both previous and the proposed techniques as shown in Figs.11-13.



Fig. 11: Photo of glue tube in experiment in 13 November 2018



Fig. 12: Silicone glue dropping



Fig. 13: sampling glue on silicone weighing machine in 13 November 2018

1) Experimental result of air compressing and motor pressing in production line according to Table 5 and Table 6 and graph plotting in Fig. 14 graph shows trending of silicone glue weight that compared with time between air compressing system and motor pressing system as follows:

Det/Time 13/11/2561	Silicone weight (mg)										Average	Air Presser
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10		
8:00	32.0	32.0	33.0	31.0	33.0	31.0	32.0	31.0	31.0	29.0	31.5	0.330 MPa
9:00	31.0	32.0	31.0	32.0	30.0	31.0	30.0	31.0	30.0	31.0	30.9	
10:00	32.0	30.0	31.0	31.0	28.0	30.0	29.0	30.0	29.0	30.0	30.0	
11:00	30.0	27.0	29.0	28.0	30.0	25.0	27.0	26.0	28.0	29.0	27.9	
1:00	27.0	26.0	26.0	29.0	26.0	25.0	27.0	24.0	27.0	25.0	26.2	
2:00	29.0	27.0	27.0	29.0	30.0	27.0	28.0	29.0	30.0	28.0	28.4	
3:00	30.0	28.0	29.0	26.0	24.0	25.0	27.0	28.0	29.0	27.0	27.3	
4:00	28.0	29.0	25.0	21.0	25.0	26.0	29.0	30.0	27.0	26.0	26.6	
5:00	26.0	25.0	28.0	26.0	27.0	24.0	25.0	21.0	25.0	29.0	25.6	
Standard Deviation (SD)											2.1	

Table 5 Experimental result of air compressing in production line, 3rd experiment in 13 November 2018

Date/Time 13/11/2561	Silicone weight (mg)										Average	Press distance/ Time
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10		
8:00	30.0	31.0	33.0	31.0	30.0	31.0	29.0	30.0	31.0	31.0	30.7	Press distance = 2 mm.  Time = 1 s
9:00	32.0	31.0	31.0	28.0	27.0	29.0	31.0	32.0	32.0	29.0	30.2	
10:00	33.0	29.0	34.0	30.0	31.0	33.0	28.0	30.0	29.0	32.0	30.9	
11:00	27.0	30.0	29.0	31.0	28.0	30.0	29.0	27.0	31.0	28.0	29.0	
1:00	31.0	30.0	31.0	28.0	30.0	32.0	28.0	30.0	33.0	30.0	30.3	
2:00	30.0	29.0	32.0	31.0	28.0	30.0	29.0	30.0	32.0	29.0	30.0	
3:00	26.0	31.0	25.0	24.0	29.0	31.0	27.0	29.0	26.0	30.0	27.8	
4:00	31.0	25.0	24.0	20.0	31.0	32.0	28.0	24.0	29.0	27.0	27.1	
5:00	25.0	29.0	26.0	31.0	23.0	21.0	24.0	26.0	30.0	26.0	26.1	
Standard Deviation (SD)											1.7	

Table 6 Experimental result of motor pressing, 3rd experiment in 13 November 2018

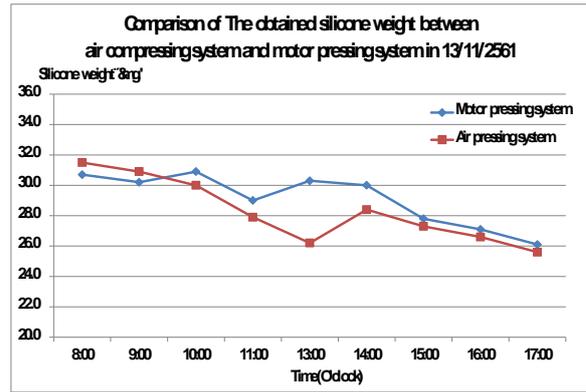


Fig. 14: Graph shows differentiation of silicone glue weight compared with time between air compressing system and motor pressing system in 13 November 2018

From Tables 5-6 and Fig. 14, it can be seen that:

1. The glue weight from the experiment of silicone glue pressing with the air compressing system was decreased slightly when using the air pressure at 0.330 MPa. Therefore, a new glue tube has to be used for the next experiment. On the other hand, the glue weight measured from the experiment of the proposed servo motor control is changed slightly; but still within the standard range of the company.

2. The weight distribution of the air compressing system is 2.1 while the weight distribution of the motor pressing system is 1.7 as shown in Tables 5-6.

### 3.1 Overall Comparison of Silicone Glue Weight Control

This section, the performance comparison is analyzed and examined in terms of the distribution of the silicone glue weight between the previous air pressing control system and the proposed servo motor control system using the data obtained from aforementioned experiments. The statistical analysis: Standard Deviations (SD) was used to justify the performance of both systems. The results are shown in Table 7a-b for the previous and the proposed systems, respectively.

According to Table 7, the data of the silicone glue weight of the air compressing system in production line and the data of the proposed motor pressing system for all 3 days were analyzed. It can be seen that the proposed system provided more constant glue weight and volume when compared to the previous control system; reflected by could control the volume of the glue better than the conventional system by 38% as calculated by Eq. (1)

$$\left| \frac{0.0021 - 0.0013}{0.0021} \right| \cdot 100\% = 38\% \quad (1)$$

วันที่/เวลา	น้ำหนักซิลิโคน (mg)										Average	Air Presser	
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10			
11/11/2561	08:00 น.	33.0	32.0	26.0	33.0	32.0	31.0	37.0	38.0	30.0	31.0	32.3	0.345 MPa
	09:00 น.	31.0	30.0	30.0	33.0	30.0	31.0	30.0	34.0	33.0	32.0	31.4	
	10:00 น.	29.0	30.0	31.0	28.0	32.0	32.0	34.0	30.0	31.0	30.0	30.7	
	11:00 น.	30.0	31.0	31.0	33.0	31.0	29.0	32.0	28.0	31.0	29.0	30.5	
	13:00 น.	28.0	29.0	30.0	27.0	32.0	29.0	28.0	30.0	31.0	30.0	29.4	
	14:00 น.	30.0	28.0	28.0	26.0	29.0	27.0	26.0	31.0	29.0	27.0	28.1	
	15:00 น.	29.0	27.0	31.0	29.0	31.0	26.0	26.0	26.0	28.0	29.0	28.2	
16:00 น.	27.0	26.0	25.0	28.0	24.0	25.0	28.0	28.0	27.0	29.0	26.7		
17:00 น.	26.0	27.0	25.0	24.0	24.0	26.0	27.0	27.0	28.0	26.0	26.0		
12/11/2561	08:00 น.	28.0	32.0	31.0	29.0	28.0	30.0	31.0	30.0	33.0	30.0	30.2	0.325 MPa
	09:00 น.	32.0	29.0	28.0	31.0	29.0	30.0	32.0	29.0	27.0	29.0	29.6	
	10:00 น.	29.0	28.0	30.0	27.0	31.0	31.0	29.0	27.0	26.0	29.0	28.7	
	11:00 น.	26.0	25.0	24.0	26.0	25.0	27.0	26.0	24.0	23.0	26.0	25.2	
	13:00 น.	24.0	26.0	26.0	25.0	24.0	26.0	22.0	25.0	26.0	25.0	24.9	
	14:00 น.	31.0	32.0	31.0	30.0	30.0	29.0	31.0	29.0	32.0	28.0	30.3	
	15:00 น.	29.0	31.0	27.0	30.0	31.0	27.0	29.0	29.0	28.0	27.0	28.8	
16:00 น.	32.0	29.0	30.0	27.0	32.0	29.0	30.0	28.0	27.0	29.0	29.3		
17:00 น.	26.0	26.0	29.0	26.0	25.0	28.0	27.0	26.0	28.0	29.0	26.8		
13/11/2561	08:00 น.	32.0	32.0	33.0	31.0	33.0	31.0	32.0	31.0	31.0	29.0	31.5	0.330 MPa
	09:00 น.	31.0	32.0	31.0	32.0	30.0	31.0	30.0	31.0	30.0	31.0	30.9	
	10:00 น.	32.0	30.0	31.0	31.0	28.0	30.0	29.0	30.0	29.0	30.0	30.0	
	11:00 น.	30.0	27.0	29.0	28.0	30.0	25.0	27.0	26.0	28.0	29.0	27.9	
	13:00 น.	27.0	26.0	26.0	29.0	26.0	25.0	27.0	24.0	27.0	25.0	26.2	
	14:00 น.	29.0	27.0	27.0	29.0	30.0	27.0	28.0	29.0	30.0	28.0	28.4	
	15:00 น.	30.0	28.0	29.0	26.0	24.0	25.0	27.0	28.0	29.0	27.0	27.3	
16:00 น.	28.0	29.0	25.0	21.0	25.0	26.0	29.0	30.0	27.0	26.0	26.6		
17:00 น.	26.0	25.0	28.0	26.0	27.0	24.0	25.0	21.0	25.0	29.0	25.6		
Standard Deviation (SD)											11/11/2561	2.2	
											12/11/2561	2.1	
											13/11/2561	2.1	
											รวม	2.1	

(a)

วันที่/เวลา	น้ำหนักซิลิโคน (mg)										Average	ระยะกด/ เวลา	
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10			
11/11/2561	08:00 น.	30.0	33.0	31.0	31.0	32.0	31.0	30.0	31.0	30.0	33.0	31.2	ระยะกด = 2 มม. เวลา = 1 วินาที
	09:00 น.	34.0	31.0	32.0	31.0	32.0	30.0	33.0	30.0	31.0	30.0	31.4	
	10:00 น.	29.0	31.0	30.0	30.0	31.0	32.0	31.0	30.0	29.0	31.0	30.4	
	11:00 น.	31.0	29.0	30.0	32.0	29.0	32.0	30.0	33.0	31.0	31.0	30.8	
	13:00 น.	32.0	31.0	31.0	30.0	30.0	33.0	32.0	30.0	31.0	29.0	30.9	
	14:00 น.	30.0	29.0	31.0	30.0	29.0	30.0	31.0	28.0	30.0	29.0	29.7	
	15:00 น.	31.0	30.0	28.0	29.0	31.0	29.0	30.0	29.0	30.0	31.0	29.8	
16:00 น.	30.0	29.0	29.0	31.0	27.0	31.0	32.0	31.0	28.0	29.0	29.7		
17:00 น.	28.0	31.0	30.0	29.0	30.0	29.0	28.0	32.0	29.0	31.0	29.7		
12/11/2561	08:00 น.	29.0	30.0	30.0	31.0	32.0	33.0	31.0	32.0	31.0	30.0	30.9	ระยะกด = 2 มม. เวลา = 1 วินาที
	09:00 น.	30.0	31.0	33.0	31.0	31.0	30.0	29.0	33.0	30.0	31.0	30.9	
	10:00 น.	30.0	28.0	29.0	32.0	33.0	31.0	31.0	30.0	29.0	31.0	30.4	
	11:00 น.	28.0	30.0	28.0	31.0	30.0	31.0	32.0	30.0	31.0	31.0	30.2	
	13:00 น.	33.0	31.0	30.0	32.0	31.0	31.0	30.0	28.0	30.0	32.0	30.6	
	14:00 น.	31.0	28.0	26.0	33.0	27.0	29.0	30.0	32.0	31.0	28.0	29.5	
	15:00 น.	29.0	28.0	31.0	32.0	30.0	29.0	30.0	27.0	29.0	28.0	29.3	
16:00 น.	30.0	29.0	24.0	29.0	30.0	25.0	27.0	31.0	28.0	30.0	28.3		
17:00 น.	26.0	31.0	27.0	30.0	28.0	29.0	32.0	30.0	26.0	29.0	28.6		
13/11/2561	08:00 น.	30.0	31.0	33.0	31.0	30.0	31.0	29.0	30.0	31.0	31.0	30.7	ระยะกด = 2 มม. เวลา = 1 วินาที
	09:00 น.	32.0	31.0	31.0	28.0	27.0	29.0	31.0	32.0	32.0	29.0	30.2	
	10:00 น.	33.0	29.0	34.0	30.0	31.0	33.0	28.0	30.0	29.0	32.0	30.9	
	11:00 น.	27.0	30.0	29.0	31.0	28.0	30.0	29.0	27.0	31.0	28.0	29.0	
	13:00 น.	31.0	30.0	31.0	28.0	30.0	32.0	28.0	30.0	33.0	30.0	30.3	
	14:00 น.	30.0	29.0	32.0	31.0	28.0	30.0	29.0	30.0	32.0	29.0	30.0	
	15:00 น.	26.0	31.0	25.0	24.0	29.0	31.0	27.0	29.0	26.0	30.0	27.8	
16:00 น.	31.0	25.0	24.0	20.0	31.0	32.0	28.0	24.0	29.0	27.0	27.1		
17:00 น.	25.0	29.0	26.0	31.0	23.0	21.0	24.0	26.0	30.0	26.0	26.1		
Standard Deviation (SD)											11/11/2561	0.7	
											12/11/2561	1.0	
											13/11/2561	1.7	
											รวม	1.3	

(b)

**Table 7** the data of silicone glue weight of air compressing in production line (7.a) and data silicone glue weight of motor pressing machine (7.b) from 11 to 13 November 2018

## 4. Conclusions and Suggestions

### 4.1 Conclusions

1. The proposed servo motor control with the close-loop controller provides better silicone glue than the previous air pressing system approximately by 38 %.

2. The proposed system could reduce the glue wastes from the production lines, which was approximately by 26.80\$US/day or 6566.00 \$US/day per one production line.

As the price of one cartridge tube of the silicone glue is 156.20\$US can be divided into 7 sub-tubes of syringe and thus gave results in 22.31\$US per tube. As a result, for the previous system, the amount of the wasted glue accounted for 4/10 per tube and used 4 glue tubes that accounted for 22.31x1.6 = 35.70\$US per day. On the other hand, the proposed motor pressing system, the amount of the wasted glue accounted for 1/10 per tube and used 4 glue tubes per day that accounted for 22.31x0.4 = 8.90\$US per day. Therefore, the difference of wasted expense was 35.7-8.9 = 26.80\$US per day or 26.80x245 = 6566.00\$US per year (245 working days per year).

3. From the whole 3-day experiment records, it could be concluded that the proposed glue control system could not cause any downtime problem due to the air bubbles in the glue as well.

### 4.2 Suggestions

1. This research was carried out on only one type of products of Sony Technology Company. It would be more preferable if the proposed system can be implemented with other product types.

2. As the servo motor used in this research was the collection of the company; therefore, it would have some limitation in the motor specification. The proposed system would provide higher efficiency and performance if proper servo motor as tight design could be used.

3. Transfer Function that obtained from experiment is the consequence of the parameters and values with only 3 day observation. The more precise Transfer function would be by using the data from a longer test time.

## Acknowledgements

The authors would like to express our sincerely gratitude to the National Science Technology and Innovation Policy Office, Thailand, for the financial support and the Sony Technology (Thailand) Co., Ltd. and the Faculty of Engineering, Mahasarakham University, Thailand, for the experimental equipment, as well as, the technical supports.

## References

- [1] Klinpeng, W., *Study process condition to optimize silicone appearance for silicone fluid case study silicone manufacturing*, Thesis of Master of Engineering, King Mongkut's University of Technology North Bangkok, 2012.
- [2] <https://www.chemipan.com> (Accessed on June 2018)
- [3] <http://trendypangzon.blogspot.com> (Accessed on June 2018)
- [4] <http://www.phitsanuchemicals.com> (Accessed on June 2018)
- [5] Khanthong, T., *Productivity Improvement by TQM and Lean Manufacturing: Case Study RTV Dispensing Process*, 2011.
- [6] Sumali, W., *Reduction of Deformation in Mobile Phone Display Component Assembly Process by Design of Experiments Technique*. Diss. Rajamangala University of Technology Thanyaburi, Industrial Engineering, 2018.
- [7] Sathittham, A., *Process Improvement using Six Sigma Concept: case Study of Hard Disk Manufacturing by DMAIC.*, 2013.
- [8] Hautau, L., *Adhesive dispensing machine*, 14 August 2018
- [9] <https://www.youtube.com/watch?v=0u5IGayh0BM>. (Accessed on 17 July 2018)
- [10] [Online] Available: <https://www.alibaba.com/showroom/silicone-dispensing-machine.html>
- [11] Wangsilabat, B., Jitsanit, T., *The Simple Position Controlling System of DC Servo Motor using Pulse Width Modulation.*, Pathumwan Academic Journal, 2.3, 2012, pp. 60-67.
- [12] Inthusoma, R., Metkarunchit, T., Owen, A. *Fuzzy logic inverted pendulum control by DC servo motor*, 2013.
- [13] Ruangsathienont, P., Tankun, L., Khemchinda, W., *Experimental Kit for Teaching The Basic of Servo Motor Driving System*, Srinakharinwirot University, Bangkok, 2005.
- [14] Kachaphum, P., Seripattananon, A., Namhomchan, T. *Distribution of Light Apparatus by Stepping Motor Control.*, EAU Heritage Journal Science and Technology, 6.2, 2012, pp.110-116.
- [15] Romphutthat, A. *The Development and Applying of Low Cost Data Acquisition Using LabVIEW.*, Srinakharinwirot University, Journal of Science and Technology, 7.14, 2015, pp. 75-86.
- [16] Suathed, S., *The Study of Painting Machine on The Wall with The Wheels to Movement in A Horizontal Axis by a Computer Numerical Control*, 2016.
- [17] Sony Device Technology (Thailand) Co. Ltd.,



**Phammatorn Intorn** received his M.Eng. in Industrial Production Technology from Kasetsart University, Thailand, in 2019. His research interest is automation machine design and smart farming technology.



**Chonlatee Photong** received his B.Eng. from Khon Kaen University, Thailand in 2001. He has been worked at Sony Device Technology (Thailand) Co., Ltd. and Seagate Technology (Thailand) Co., Ltd. for 3 and 2 years, respectively, after that. He received his M.Sc in Power Electronics and Drives and Ph.D. in Electrical and Electronic Engineering from University of Nottingham, UK, in 2013. He is currently the bachelor program director of Practical Engineering (Continuing Program) and a lecturer in Power Electronics and Drives at the Faculty of Engineering, Mahasarakham University, Thailand. His research interests include power electronics, power converters for renewable energy conversion, and electrical machines and drives.

## Biography



**Chadaporn Wongsri** was born in January 25, 1994, at Udonthani, Thailand. She received her bachelor degree in Electrical Engineering, Mahasarakham University, Thailand in 2017. In 2017, she continued her study in Master degree in Electrical and Computer Engineering, Mahasarakham University, Thailand, under the scholarship of the Work Integrated Learning (WIL) while working at Sony Technology (Thailand) Co., Ltd.