Preliminary Design of a Test Rig for Dodol Conching Process

K.J. Wei and M.A. Rahim
School of Mechatronic Engineering, Universiti Malaysia Perlis, 02600 Arau, Perlis, Malaysia.
muhajir@unimap.edu.my

***Abstract*—Conching is a well-known modern method used in making chocolate, which involves a long process of intense mixing, agitating and aerating of heated liquid chocolate. However, this conching method has not been tested yet in the dodol production. The work presented in this paper concerns the development of an experimental rig for dodol conching process. Analysis of the range of conching displacement is made based on two parameters changes. Firstly, the height of roller from the centre point of the rotational driving disc. Secondly, the distance between the attachment joint of roller arm and rotational driving disc. The speed of conching process is controlled by DC motor based on Pulse-width-modulation (PWM) technique. The results have shown the desired speed response can be controlled accordingly through the adjustment of the input signal.**

***Index Terms*—Conching; Dodol; Motor Control.**

I. Introduction

Dodol is one of the very popular Malay traditional snack food. It is made from coconut milk, glutinous rice, sugar and sometimes with the addition of permitted food additives. Traditionally, the dodol is prepared by stirring process for around 7 to 8 hours until the liquid dodol mixture turns into a sticky condition or gelatinised [1]. This method is time-consuming and required a lot of human energy since it is done manually using human power.

Currently, electrical mixer machine is widely used in commercialising dodol production, in order to replace human energy during the stirring process. Even though, this conventional method is very popular, the time taken to stir the liquid dodol mixture is still unchanged [2].

Conching [3-4] is a well-known modern method used in making chocolate, which involves a long process of intense mixing, agitating and aerating of heated liquid chocolate. In the conching process, the chocolate mass is “kneaded” in conches with heavy rollers, which moved back and forth through the chocolate at a regulated speed. Many chocolate manufacturers used this method in the chocolate production since it can produce the smoother texture of chocolate within a shorter time compared to the stirring process [5-6].

However, to the best of our knowledge, the application of conching method in dodol production has not been reported in any literature to date. Therefore, the main objective of this project is to design a preliminary test rig for the dodol conching process to be used for the study on the effect of conching process in the dodol production.

The structure of this paper starts in section 2 which provides a brief description of the designed test rig. Section 3 presents the analysis on the range of conching displacement based on two different parameter variations of the test rig. Section 4 discusses the motor control for output profile of the conching process based on the designed input signal profile. Finally, the conclusion of this project is given at the end of this paper.

II. Description of The Designed Rig

The design of the dodol conching test rig is based on two main components. Firstly, is the mechanical component which consists of driving disc, roller arm, stove and roller as shown in Figure 1. All of these components are made of steel and placed on foundation base with dimensions of 0.22m x 0.55m x 0.06m. The details of stove dimensions, roller arm and roller, are presented in Figure 2, Figure 3 and Figure 4 respectively.

The second component is the motor controller which is used to actuate the conching process. The motor controller component consists of Arduino microcontroller, 12 V DC brushed motor, motor driver, and DC power adapter. The primary function of DC motor is to control or regulate the desired conching speed and operating time-based on Pulse-width-Modulation (PWM) technique using simple coding applied to the Arduino Uno board. The details of the motor control will be discussed in section 4.

Figure 1: The designed test rig for dodol conching process.

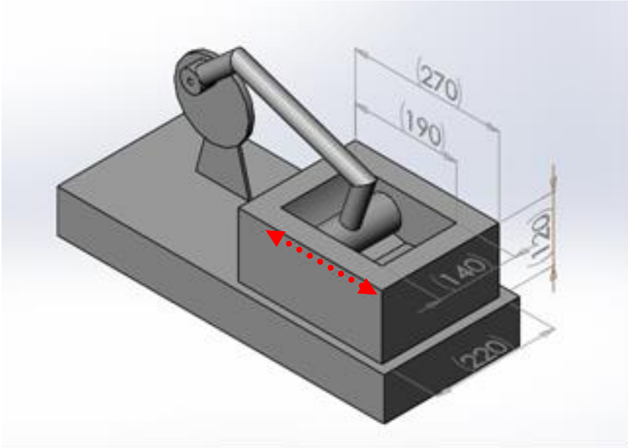

Figure 2: Dimensions (in mm) of the rig

Figure 3: Dimensions of the roller arm

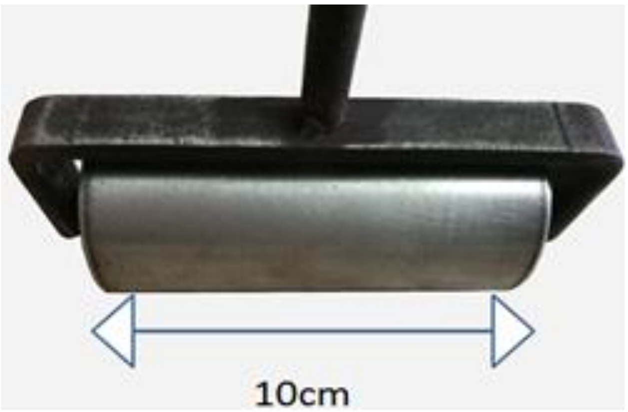

Figure 4: Length of the roller.

III. ANALYSIS OF THE RANGE OF CONCHING DISPLACEMENT

The primary objective of this analysis is to study the range of conching displacement as presented by the red arrow in Figure 2, based on two variations of parameters. The first variation is the change of the height of the roller from the centre of the driving disc as shown in Figure 5. Initially, the height of the roller is set at 15cm from the centre of the driving disc, and the distance of the roller arm joint is set at 5cm from the centre of the driving disc as illustrated in Figure 6. Based on this initial settings, the measurement of the conching range is recorded. Then, the same experiment is repeated but with the height or location of the roller is moved upward to be 11cm, 5cm and 0cm.

The second variation is the change of distance between the joint of roller arm to the centre point of driving disc to be at 6.5cm. Then, the measurement of the conching range is recorded, and the same experiment is repeated but with the height or location of the roller is moved upward to be 11cm, 5cm and 0cm. All the recorded measurements are presented in Table 1.

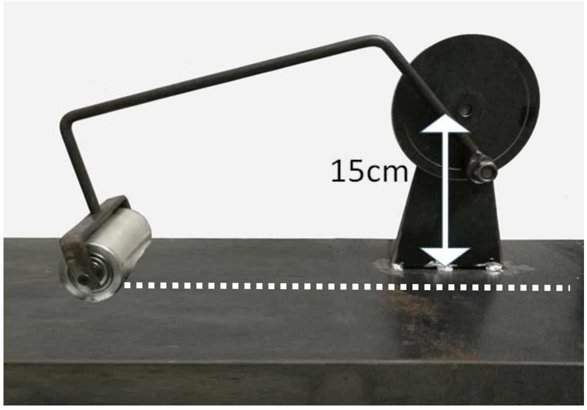

Figure 5: Height or location of the roller from the centre of driving disc.

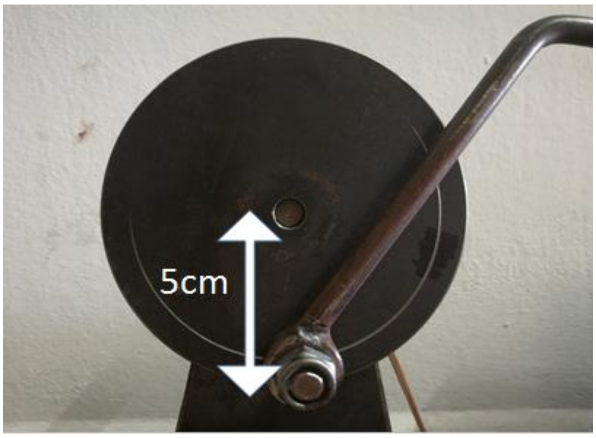

Figure 6: Distance between the joint of roller arm to the centre point of driving disc.

Table 1
The range of Roller Displacement in cm.

	The height of roller from the centre of the driving disc (cm)			
The distance between the joint of roller arm to the centre of the driving disc (cm)	15	11	5	0
5	16	15.5	15	15
6.5	19.5	18.5	18	18

From Table 1, it can be observed that the range of roller displacement is maximum when the height of the roller from the centre of the driving disc is at 15cm, and the distance between the joint of the roller arm to the centre of driving disc is at 6.5cm.

However, it can be seen that the change of height of the roller from the centre of the driving disc is not significantly affected the roller displacement as demonstrated in Table 1. Only 1cm increment of the range of roller displacement as the height of the roller is changed from 0cm to 15cm which is the case of 5cm distance roller arm joint to the centre of driving disc.

IV. Analysis of The Motor Control

The motor controller in this study is based open loop system where the output response will be determined solely by PWM input signal. In this case, the desired output profile can be obtained by adjusting the PWM input profile.

Figure 7 presents the sample of the desired output profile of the motor corresponding the conching process. The conching process is divided into four segments. The A segment represents a constant conching process where the motor has a constant speed at 40rpm for 20 seconds. Meanwhile, segment B demonstrates an accelerating conching process for 5 seconds to 60rpm. Afterwards, the conching process regulates at a higher speed which is at 60rpm for 20 seconds as shown in segment C. Finally, segment D represents the conching process slowing down or decelerate before fully stop the process at 50 seconds.

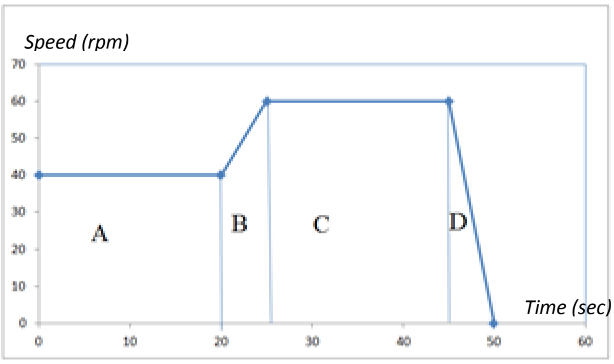

Figure 7: Desired conching process output profile.

The corresponding PWM input signals are used to obtain the desired output profile in Figure 7 are shown in Figure 8-11. Figure 8 and 10 represent the constant conching process with low and high speed respectively. It can observe that the duty cycle for both of PWM input signals in Figure 8 and Figure 10 are similar which represent a constant speed. However, the magnitude of PWM signal in Figure 10 is higher than Figure 8 in order to produce a constant conching process as demonstrated in segment C but with higher speed than segment A.

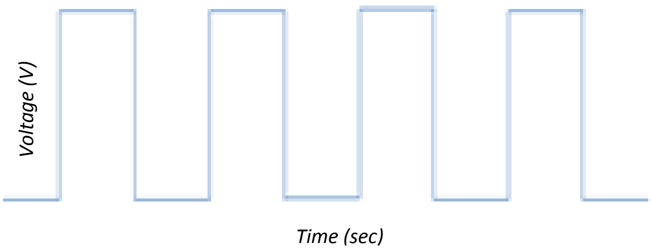

Figure 8: PWM input signal for segment A (constant low speed)

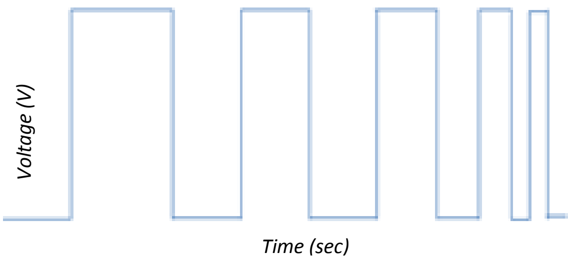

Figure 9: PWM input signal for segment B (acceleration)

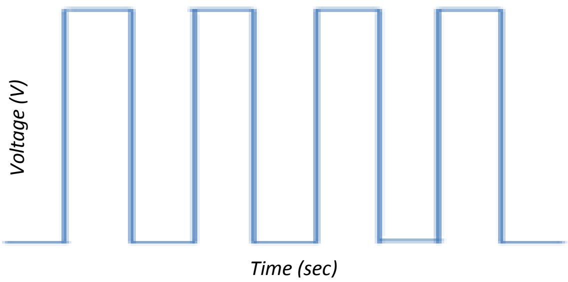

Figure 10: PWM input signal for segment C (constant high speed)

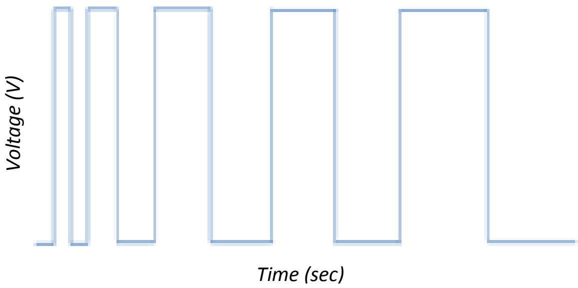

Figure 11: PWM input signal for segment D (deceleration)

Figure 9 represents the PWM input signal for accelerating conching process as illustrated in segment B in Figure 7. It can be seen the duty cycle of the PWM input signal in Figure 9 is reducing as time increases which shows the motor speed is changing from low speed to a higher speed. In contrast, the duty cycle of PWM input signal in Figure 11 is increasing as time increases. This shows that the motor speed is changing from high speed to a lower speed as represented in segment D.

V. Conclusion

In this paper, a design of a test rig for dodol conching process has been presented. An analysis of the range of roller displacement has been performed, and it has been observed that the location or height of the roller from the centre of the driving disc is not significantly affected the range of the roller displacement. Therefore, the result has justified that the variation of these parameter values is not critical in the conching process. The study also has demonstrated that the desired output profile of the conching process can be obtained based the adjustment of PWM input signal profile due to the variations of duty cycle and voltage magnitude.

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