Vol. 12, No. 1 (2023) : 139 - 151
DOI : http://dx.doi.org/10.23960/jtep-l.v12i1.139-151

JURNAL TEKNIK PERTANIAN LAMPUNG

ISSN 2302-559X (print) / 2549-0818 (online)
Journal homepage : https://jurnal.fp.unila.ac.id/index.php/JTP

Development of Device for Force Compressive Control System in a Freezer of Pressed-Plate Type

Surya Abdul Muttalib[1], Nursigit Bintoro[1]✉, Joko Nugroho Wahyu Karyadi[1], Arifin Dwi Saputro[1]

[1]Departement of Agricultural Engineering and Biosystem, Fakulty of Agricultural Technology, Universitas Gadjah Mada, Yogyakarta, INDONESIA

Article History :

Received : 19 October 2022
Received in revised form : 17 January 2023
Accepted : 18 January 2023

Keywords :
Arduino,
Control system,
Force Compression,
Force Compression plate,
Setting point

✉Corresponding Author:
nursigit@ugm.ac.id

ABSTRACT

The process of freezing foodstuffs can be done by using a cold metal plate that is in contact with the frozen material (contact plate freezing). The magnitude of contact Force Compressive applied needs to be controlled so as not to damage the frozen material. The purpose of this study was to develop and evaluate the performance of a Force Compression control system on a contact plate freezer. The Force Compression control system was composed of a load cell mounted on a Force Compression device, connected to a set of controllers consisting of an HX711 module, ATM Mega Arduino and a computer using the Borland Delphi 7 language. The results showed that the developed system was able to control the compression process of the equipment by turning off voltage input of the motor when the specified setting point has been reached. The results of Force Compression values when the motor in off position for the setting points of 50, 100, 150, 200, 250, and 300 kg.m/s2 were 58.25, 110.25, 162.67, 213.83, 264.55, and 317.61 kg.m/s2, respectively. There was a difference that gradually increased with increasing setting point value, where the real Force Compression values when the motor off were higher than the setting point values. The relationship between real Force Compression and setting point Force Compression could be given in the form of a linear regression equation y = 1.06897x + 6.14667 with a value of R2 = 0.99, RMSE 1,53 and MAPE 11,75 %.

1. INTRODUCTION

In the process of food freezing, there is a freezing method using a plate freezing (Khan & Mittal, 2017). This method is basically a way to freeze food by clamping the food in between two plates at a very low temperature. In this process, the effectiveness of the food freezing is highly dependent on the temperature of the freezing medium and the Force Compression from the freezing plate on the food to be frozen. To produce low plate temperatures generally requires complicated equipment with very expensive costs.

However, for the purposes of the food cooling process at temperatures that are not too low, a cooling medium in the form of ice flakes can be used which can be pressed directly using a Force Compression plate on the surface of the product being cooled. The use of ice cubes as a cooling medium with the pressing method is very cheap so it is very possible to be adopted by practitioners involved in the food cooling process. For a further reduction in temperature, namely in the process of freezing food, dry ice can be used which has temperatures ranging from -78°C (Aryawan, 2016; Prasetyo *et al*., 2019).

The principle of using Force Compression in the freezing process is the transfer of heat energy from the material to be frozen to the freezing medium. Increasing the Force Compression will be able to increase the rate of heat transfer from the material to the freezing medium so that the freezing process will run more effectively (Beier, 2006). Khan & Mittal (2017) state that the freezing process with the contact plate freezing method is carried out by sliding or pressing the material with a metal plate and the size of the material is no more than 8 cm. Applying Force Compression will tighten the interface between the freezing plate and the material to be frozen. Based on this principle, a Force Compression plate type freezer was developed to speed up the process of freezing food (Muttalib *et al*., 2021). The greater the Force Compression given, the faster the material freezing process will increase. However, increasing the Force Compression uncontrollably can damage the texture of the frozen food. Therefore, to ensure that the equipment can provide the desired Force Compression value, the Force Compression plate type freezer needs to be equipped with a Force Compression measurement system and its control equipment.

The control system is a system that is used to regulate, control or govern the state of a system (Ogata, 1996). The control system is used to maintain an output from the process to match the predetermined setting point. The control system is used to increase accuracy, efficiency and maintain the security of users and processed products (Effendy, 2019). Automatic control has played an important role in the development of science and technology, because automatic settings make it easy to get performance from dynamic systems, increase quality, and reduce production costs (Utama *et al*., 2018). The control system has become a system that is in great demand because it is supported by the development, completeness and availability of various sensors on the market. In this study, the Force Compression control system to be installed on a Force Compression plate type freezing equipment utilizes a Force Compression gauge (load cell) combined with the HX711 module. The HX711 module will record changes in load cell resistance and convert it into a voltage quantity which will later be forwarded to the Arduino Uno-based microcontroller. Lubis *et al*. (2019) made a cooling machine with a variable circuit LM317 based on Arduino uno. Sinaga *et al*. (2019) utilizes load cell sensors to automatically regulate escalator performance by turning on and off the escalator driving motor. Yendri *et al*. (2020) designed a boiler and an automated system for feeding cattle based on weight measurements. Hastawan *et al*. (2021) compared the weight value of the load cell based on the delay time. Jaysrichai (2018) developed a shoe-mounted weighing device that is able to show the user's load. Irwanto *et al*. (2019) designed a tobacco weighing control system using a load cell with an Arduino-based microcontroller. Setiawati *et al*., (2020) created a temperature control system for a rotating rack-type hybrid drying chamber based on the Arduino Mega microcontroller, and conducted performance tests on the designed system. The load cell sensor has been shown to be able to show data that corresponds to the actual load value (Muttalib *et al*., 2021). The purpose of this study was to develop and test the performance of a Force Compression control system in the freezing process using a Force Compression plate type freezer.

2. MATERIALS AND METHODS

2.1. Tools and Materials

The materials used in the study can be divided into three groups, namely materials for the manufacture of Force Compression plate type freezing equipment, materials for the manufacture of Force Compression control devices, and materials for testing the performance of Force Compression control devices.

The materials for constructing a Force Compression plate type freezer are iron plates for the frame with dimensions of 77.34 x 45 x 37.5 cm, screw shaft diameter of 1.2 cm, Force Compression plate 10 x 10 cm, electric motor (DC 12 Volt, 2A, 400 rpm, torque 6.5 kg.cm, length 5 cm, diameter 2.5 cm and weight 0.2 kg), 2 pulleys with diameters of 8 and 12 cm, V-Belt diameter of 25.8 cm; wooden box size 12 x 12 x 12 cm, load cell (40 kg capacity, input impedance 401 +/-10 ohm, output impedance 350 +/-5 ohm, voltage 10-15V DC), relay, and computer.

Materials for making control equipment include Analog Digital Converter (ADC) with Microcontroller ATM Mega Arduino uno (ATmega328 SMD, 5V), HX711 driver module, LCD display, power supply (12 Volt, 10A), 4 units of K-type thermocouple sensor probe (wire length 1 m, model TP-01), 4 units of AD8495 drivers and actuators as current amplifiers and stabilizers.

While the materials for testing the control system were crushed ice cubes measuring approximately 0.05 to 0.5 cm and tuna fish cuts with dimensions of 3 x 3 x 2 cm which were put in a wooden box with an inner side of 15 x 12 x 12 cm as a container.

2.2. Research Methods

2.2.1. Design of A Force Compression Plate Type Freezer

In the process of freezing materials using a Force Compression plate type freezing equipment, the speed of the process in freezing food is greatly influenced by the contact strength between the freezing media and the surface of the material to be cooled. Based on this freezing principle, the speed of freezing will increase as the contact between the freezing medium and the food becomes more intensive. The basic principles in the design of the Force Compression plate type freezer developed can be seen in Figure 1.

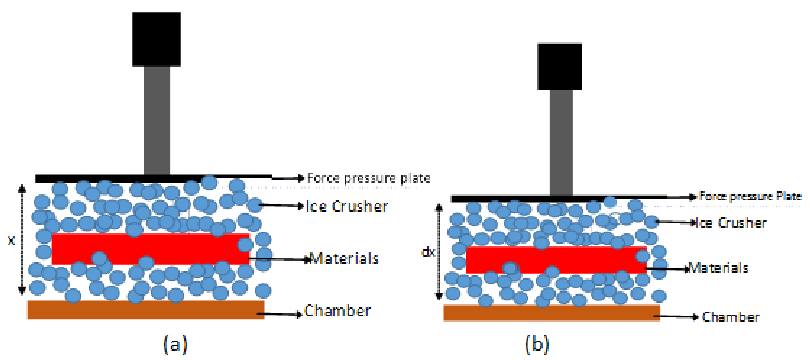


Figure 1. The principle of applying Force Compression in the food freezing process (a) before applying force Force Compression and (b) after applying force Force Compression

The freezing medium in the form of ice flakes is put in a box, then the food to be frozen is placed on top of it and the ice flakes are added on top of the food. The Force Compression force is exerted on the crushed ice using a stainless steel plate measuring 10 x 10 cm which is driven vertically downward by a Force Compression thread connected to a motor with a belt-pulley transmission system. The material to be frozen receives Force Compression from crushed ice as a freezing medium. The addition of Force Compression will increase the rate of heat transfer from the material to the freezing medium. The construction of the complete pressing equipment with its Force Compression control system can be seen in Figure 2.

In general, there are three main components in the construction of the equipment in this study, namely (1) a set of Force Compression plate type freezing equipment, (2) a Force Compression control electronic device and (3) a computer. The control system program installed on the computer is developed and can be used by the user to run the control system.

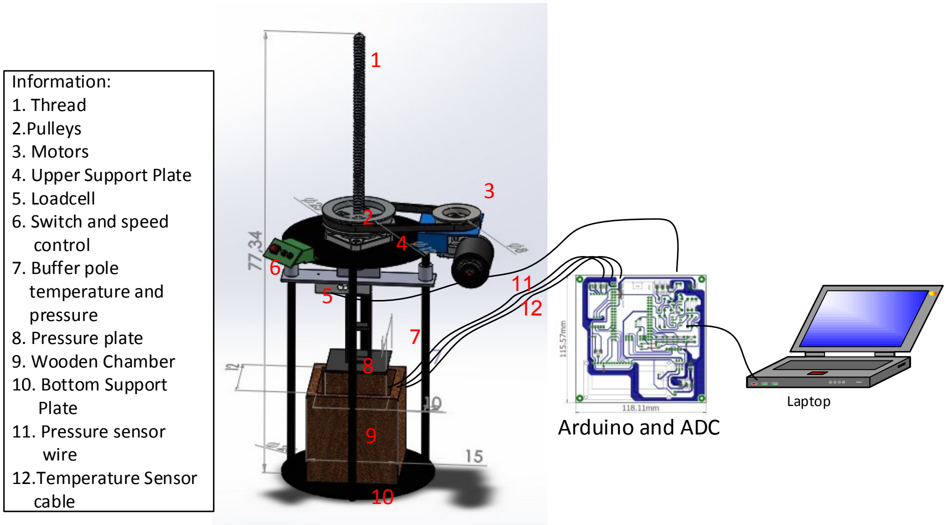


Figure 2. Construction of a Force Compression plate type freezer complete with Force Compression control devices

2.2.2. Force Force Compression Control System Design

The compressive force control system developed in the Force Compression plate type freezing equipment is based on readings of the load cell force compression sensor attached to the appliance. The addition of this control system aims to reduce the risk of excessive Force Compression on frozen materials during the pressing process. Control is carried out by adjusting the amount of compressive force given to match the predetermined initial compressive force value (setting point). The control system will turn off the Force Compression plate driving motor when the desired Force Compression setting point value has been reached. The termination of the driving motor rotation is based on the input signal given by the ATMega Arduino Uno microcontroller which is forwarded to the motor driver to turn off the electric current in the driving motor. This control method will cut off the current in the electric motor when the setting point Force Compression value has been reached, so that the pressing process will stop. The system block diagram can be seen in Figure 3. The working mechanism of the control equipment developed in this study can be seen in Figure 4.

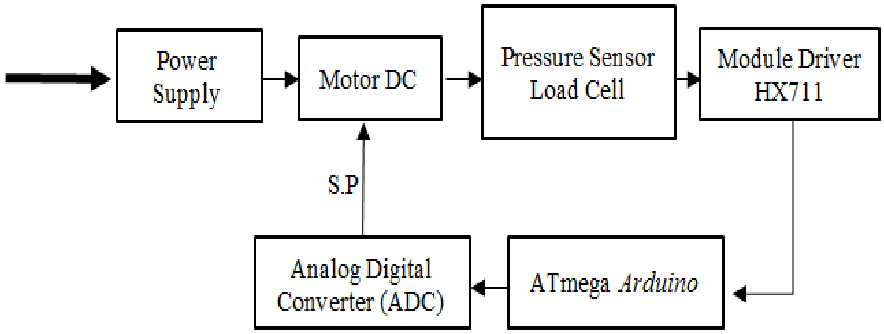


Figure 3. Blog diagram of the pressure control system on a pressure plate type freezing equipment

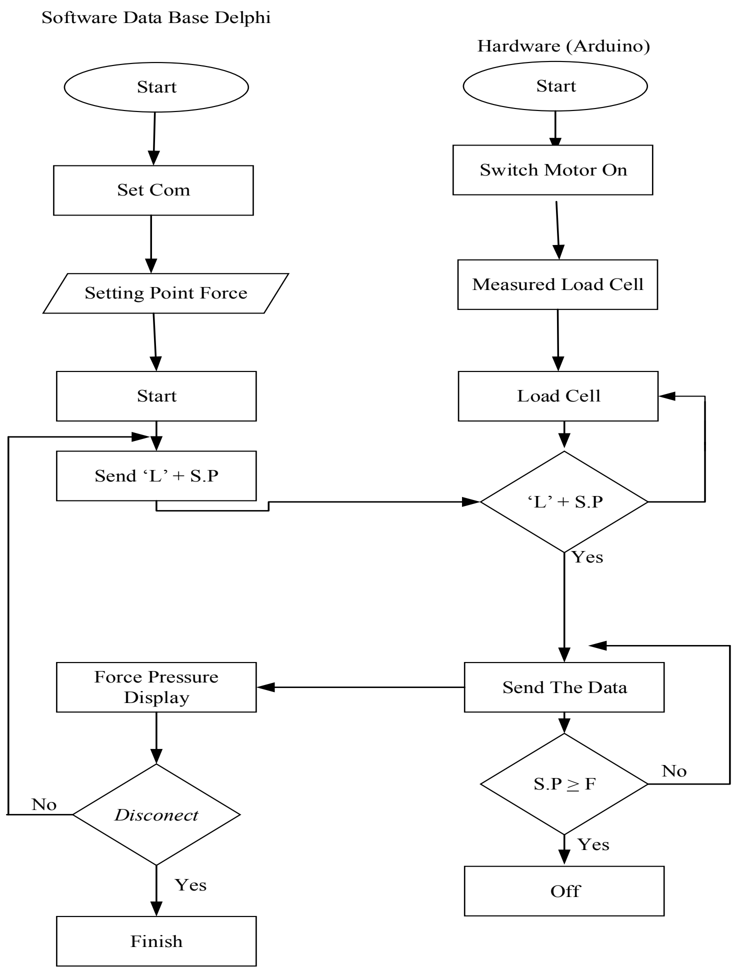


Figure 4. Flowchart of the pressure control system algorithm

The control system algorithm is developed based on input, process and output mechanisms.

1. Data input system

The data input system is a data transfer system from the load cell sensor in the form of a voltage which is then entered into the Arduino ATMega Microcontroller pressure control system via the ADC. The input data in the form of voltage is converted by the

ADC and converted into pressure data. The ATMega Arduino microcontroller will record input data from the ADC continuously and will respond to the pressure input data input. The setting process begins by connecting the pressure equipment with the control device and computer. The graphical User Interface (GUI) program from the ATMega Arduino Microcontroller is then displayed on the computer. The setting point setting is done through the GUI display, namely by clicking the set com button, connecting and setting the setting point value according to what you want, then starting the pressing process by clicking the start button. The drive motor will rotate and the pressure shaft will push the pressure plate and the amount of compressive force will be recorded by the load cell sensor. The magnitude of the compressive force is converted into input pressure data which will be read by the ADC continuously. This pressure data input value will also be displayed on the GUI in the form of graphs or tables.

2. Process system
This process system functions to set the ON/OFF on the pressure plate driving motor. Control system settings are made so that the motor stops moving (OFF) when the setting point pressure value has been reached. This setting is done by setting the desired setting point value through commands on the ATMega Arduino microcontroller software. If the sensor reading input value is still below the setting point value, the motor will continue to live (ON) to apply pressure to the material being cooled. However, if the sensor reading value has reached the set point setting value, the system will turn off the motor (OFF) so that the pressing process will stop. Determination of the setting point value is necessary so that the amount of pressure on the cooled food does not exceed the desired pressure value, so it does not damage the food. If F is the compressive force and SP is the setting point, then the analogy of the system being developed is as follows.

If $F \le SP$ then the driving motor is ON
If $F > SP$ then the driving motor is OFF

3. Output System
The output system is a display on the GUI of the developed pressure control system device. This output system will display data in the form of graphs and tables which are then recorded into a computer using the Excel program. The output data during the pressing process are time, compressive force, stress, and temperature in the form of excel data sheets. At this stage of testing the performance of the pressure control system, the data used are compressive force and stress data while the material temperature data during the pressing process will be displayed in the next article about physical analysis and temperature changes during the freezing process of the pressure plate method. To stop the data recording process, click the disconnect button.

2.1.3. Equipment Testing
This test aims to evaluate whether the value of the compressive force when the motor is off (OFF) is the same as the desired pressure setting point value. After all the equipment is connected and turned on, then the setting point is set through the GUI. In this study, seven setting point levels were used, namely 50, 100, 150, 200, 250, 250, and 300 kg.m/s2. After a setting point value is set, then the driving motor is turned on, the pressing process will run, then wait for the driving motor to stop automatically due to the OFF command from the control system. The observed parameter is the pressure

value displayed on the GUI when the driving motor stops. This value will then be compared with the setting point value for analysis purposes.

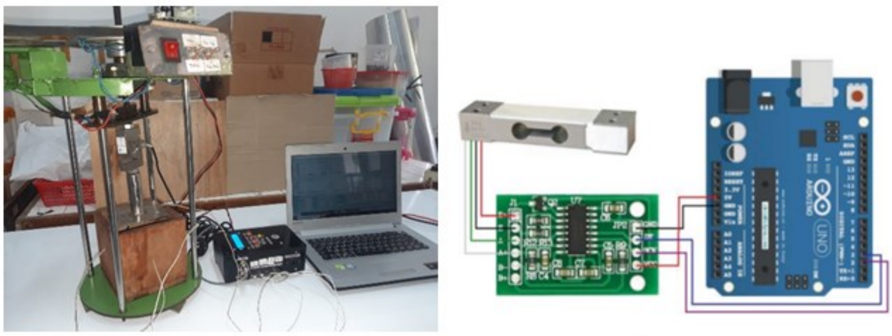
2.2. Data Analysis

Data analysis was carried out by comparing the setting point data with the data read in the GUI when the motor is OFF. The two readings were analyzed and the mathematical relationship was sought using simple linear regression analysis to determine the accuracy of the measurement as the compressive force increases. Assessment of the setting point value with the actual value using MAPE (mean Average Percentage Erors) dan RMSE (Root Mean Squared Erors).

3. RESULTS AND DISCUSSION

3.1. Hardware Manufacture

The initial stage of this research starts from the manufacture and assembly of hardware as shown in Figure 5.



(a) (b)

Figure 5. Hard ware (a) pressure plate type freezing equipment, ADC, computer; (b) load cell, HX711, and Arduino ATMega

The hardware made consists of a pressure plate type freezing equipment, ADC, and an Arduino ATMega microcontroller. This pressure plate type freezing equipment works by pressing a plate mounted on the end of the screw shaft. This screw shaft is rotated by the drive motor via a belt-pulley transmission system. A load cell is installed at the top of the pressure plate to measure the amount of compressive force that occurs. The ADC function is to convert pressure readings in the form of voltage into compressive force values. Meanwhile, the Arduino ATMega control system functions to control the pressing process by adjusting the ON/OFF of the driving motor.

Development of a pressure control system for pressure plate type freezing equipment using the Arduino ATMega microcontroller using the Bordland Delphi 7 language. The use of the Arduino microcontroller as a pressure controller has been widely implemented in cooling systems. Gupta *et al*. (2021) designed an Internet of Things-based smart refrigerator using Arduino uno which is able to determine the weight and temperature of ingredients. Shaleh *et al*. (2022) designed an air pressure measuring instrument with an air pressure sensor based on an Arduino microcontroller. Ariansya (2018) designed an air conditioning system using the Piltier tec-12706 thermoelectric module based on the Arduino Uno microcontroller, the air conditioner developed produced a success percentage of 95%.

For the purpose of converting stress into compressive force, it is necessary to calibrate the load cell. The load cell calibration results used in the pressure control system on pressure plate type freezing equipment can be seen in Figure 6.

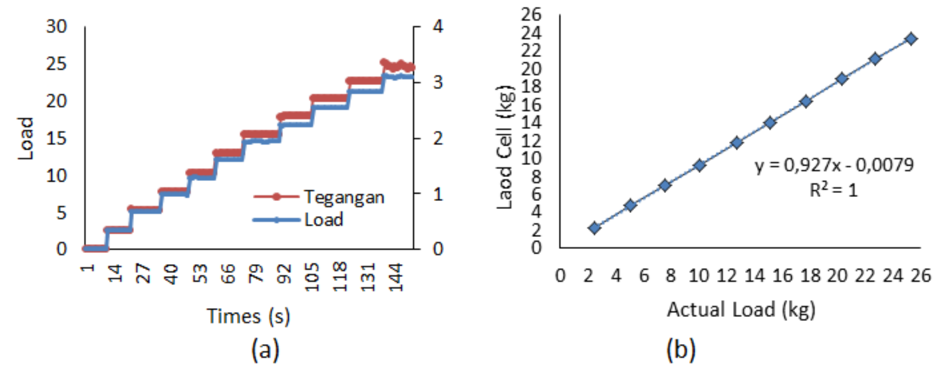


Figure 6. Load cell calibration, (a) the relationship between the voltage value and the load, (b) the calibration equation for the load cell

3.2. Programming

The developed program functions to operate and record the work results of the pressure equipment in the form of compressive force, stress, time and temperature which are displayed in graphical and tabular form in excel data sheets. Program development is carried out using the Bortland Delphi programming language. The appearance of this program is in the form of a GUI that is used for setting up equipment operations and displaying test results. Firdaus *et al*., (2019) succeeded in developing an electronic and GUI system for dual loads and a braking system tester. The program GUI display can be seen in Figure 7.

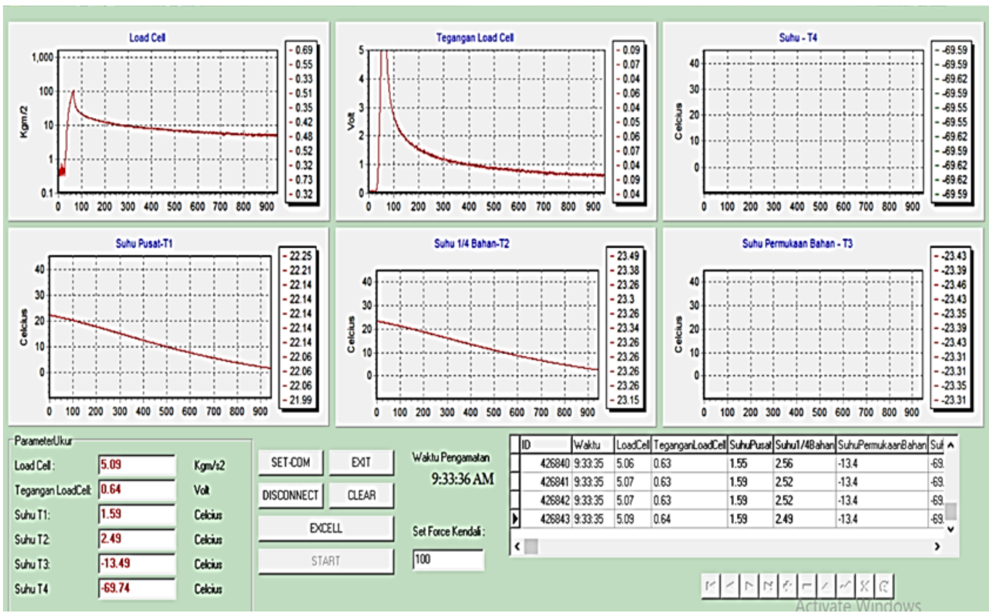


Figure 7. Graph of User Interface (GUI) of pressure control system on pressure plate type freezing equipment

The result of software development is in the form of a program that is able to give commands through a display that is able to make it easy for users to run the program. The operation of the pressure control system is carried out by clicking the command buttons contained in the program display. There are several command buttons to run the program, namely (1) set com; (2) connect/disconnect; (3) control force set; (4) Starts; (5) Excel; (6) Clear; (7) Exit. The set com button functions to connect the program with the ADC and pressure equipment by means of a USB cable inserted into the computer port then clicking on the appropriate port. The connect button functions to enter and record pressure, voltage, temperature and time data that has been connected to the ADC. While the disconnect function is to stop the input process and data recording, the disconnect button will appear when the pressing process is running. The data recording process will continue as long as the user does not press the disconnect button. The set force control button functions to adjust the setting point value or the desired pressure value. There is an input field for the value of the pressure point setting point that can be typed in by the user. The start button functions to start the pressing process or start the motor. The excel button functions to get the data entered and recorded in the program. The data recorded in the system will be obtained by the user in the form of an excel data sheet by clicking the excel button. The clear button functions to delete data recorded by the system. While the exit button functions to stop the program if the program has finished being used.
The procedure for using the pressure control system program is as follows.

1. Connect the USB cable of the pressure control device to the computer, then turn on the equipment and the computer.
2. Click the set com button, click the appropriate port
3. Click the connect button
4. Enter the value of the setting point by entering the value of the force number in the set force column.
5. Click the Start button, then the pressing process will run. Then wait until the pressure plate drive motor turns off.
6. Click the disconnect button to stop the data input and recording process
7. Click the Excel button
8. Click the clear button to delete the previous data
9. Click the Exit button to end the program.

To run the program properly and correctly, the user must carry out the steps according to the procedure so that the program is able to run commands smoothly.

3.3. Pressure Test Results

The test results of the performance of the pressure control system on the pressure plate type freezing equipment can be seen in Figure 8. Based on this figure it can be seen that the developed pressure control system is able to cut off the electric current to stop the motor rotation when the setting point has been reached during the tuna freezing process. From the image of the curve it can be seen that the electric voltage to the driving motor is cut off when the setting point value has been reached. The cutting of the voltage current by the performance of the control system occurs because of the installation of a relay on the input cable to the driving motor. Muchtar & Sumanjaya (2018) use a relay as an automatic switch to cut off electric power from the PLN and function properly to prevent damage to household appliances. Setyadi *et al*. (2017) used relays as an automatic control tool in making control and monitoring applications for applications for auxiliary devices (light centers, condesate tanks and pumps) in a gas and steam power plant (PLTGU).

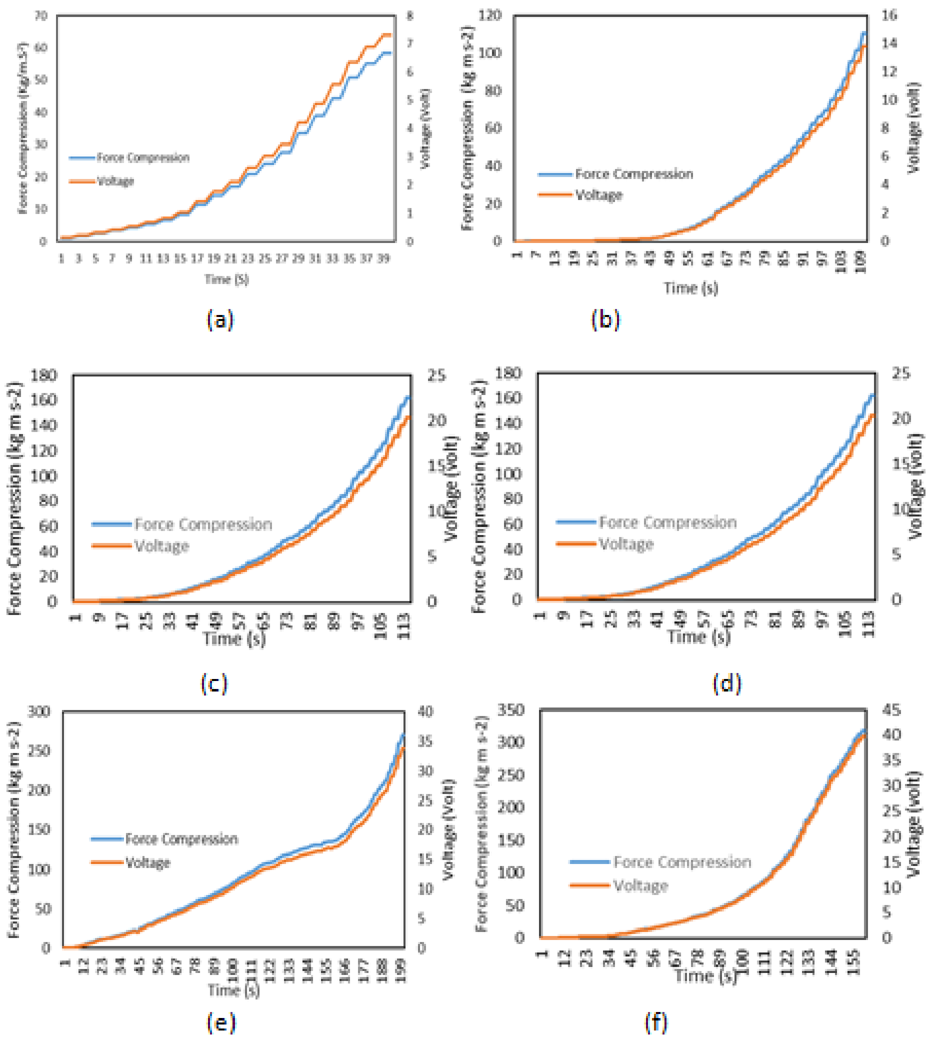


Figure 8. Test results on measuring compression force (kg.m/s^2) and voltage (volts) at the setting point value, (a) 50; (b) 100; (c) 150; (d) 200; (e) 250; and (f) 300 kg.m/s^2

Table 1 shows the real pressure values shown in the GUI when the motor is off at various setting point treatments. It can be seen that there is a difference between the real pressure when the motor is off and the setting point value. The difference in this value is getting bigger with the increasing setting point value set. This difference is thought to be caused by the current still flowing when the current-connecting contacts are turned off by the program. The existence of voltage resistance in the use of the relay system as a circuit breaker device causes the current to still flow for a quarter of a second so that there is a difference in the setting point value with the compressive force when the motor is off. Contacts in the relay bounce when open (off) and during fast operation can be a source of problems (Basri & Irfan, 2018). Relays work based on electromagnetic forces to drive an electronic switch that can be controlled from other electronic circuits by utilizing electricity as a source of energy. The contact will be closed (ON) or open (OFF) due to the magnetic induction effect resulting from the coil (inductor) when an electric current is flowing.

Table 1. The difference between the real compression force value and the setting point when the motor is off (OFF)

Compression Force *Setting Point*	Actual Compression Force	Margin Error	
kg m/dt^2	kg m/dt^2	kg m/dt^2	%
50	58.25	8.25	16.80
100	110.26	10.26	14.20
150	162.67	12.67	11.07
200	213.83	13.83	10.90
250	264.55	14.55	8.28
300	317.61	17.61	9.20
RMSE =1.53			
MAPE= 11.74			

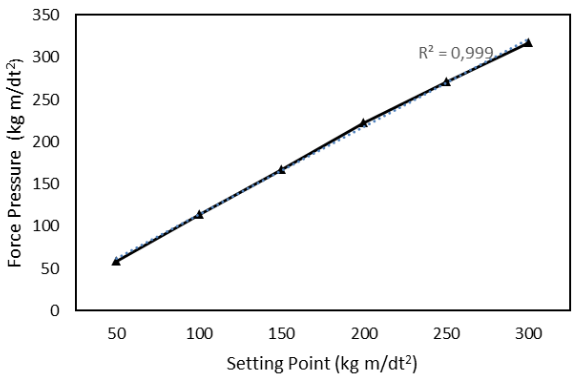


Figure 8. Graph of the relationship between the setting point pressure value and the real pressure when the motor is off

The relationship between the real compression force value (y) shown in the GUI when the motor is off and the setting point compression force value (x) can be expressed in the form of linear regression y = 1.06897x + 6.14667 with a value of R^2 = 0.99. The regression coefficient value is 1.06897 and the intercept value is 6.14667 indicating that each additional setting point value will increase the force value when the motor is off by 1.06897 times and the additional force is 6.14667. The R^2 value of 0.99 (close to 1) indicates the setting point force value affects the real compression force value when the motor is off. But, it can be reported that the RMSE and MAPE values for the real compressive force values with the setting point values were obtained at 1,53 and 11,74%, respectly. This indicates that at each determination of the setting point there will be an additional actual average value of 11.75 % in each process.

4. CONCLUSION

The developed control system is capable of controlling pressure during the process of applying pressure to the developed pressure plate type freezing equipment. There is a difference between the real pressure value on the GUI and the set point setting value and this difference gets bigger as the set point value increases. The relationship between real pressure on the GUI and setting point pressure can be expressed by the linear regression equation y = 1.06897x + 6.14667 with a value of R^2 = 0.99, RMSE 1.53 and MAPE 11.75 %.

REFERENCES

Ariansya, A. (2018). Rancang bangun sistem pendingin ruangan menggunakan modul termoelektrik Piltier Tec-12706 berbasis microcontroller Arduino Uno. [*Undergraduate Thesis*], Jurusan Teknik Informatika Fakultas Sains dan Teknologi, Universitas Islam Negeri Alauddin, Makassar.

Aryawan, I.P.Y., Wijaksana, H., & Suarnadwipa, I.N. (2016). Study eksperimental performa pendingin ice bunker dengan kombinasi massa dry ice dan ice. *Jurnal Ilmiah Teknik Desain Mekanika*, 5(3), 1-5.

Bao, H.N.D., Arason, S., & Þórarinsdóttir, K.A., 2007. Effects of dry ice and superchilling on quality and shelf life of arctic charr (*Salvelinus alpinus*) fillets. *International Journal of Food Engineering*, ***3***(3), . https://doi.org/10.2202/1556-3758.1093

Basri, I.Y., & Irfan, D. (2018). *Komponen Elektronika*. Padang Sukabina Press, 175 pp.

Beier, S., 2006. Transport Phenomena. Bookboon.com.

Effendy, M., 2019. *Pengetahuan Dasar Sistem Kendali*, 1^{st} ed. Surakarta: Muhammadiyah University Press, 326 pp.

Firdaus, R.M., Supriyo, B., & Suharjono, A. (2019). Electronic and GUI developtmen of roller brake tester. *J. Phys.: Conf. Ser*., ***1273***, 012070. https://doi.org/10.1088/1742-6596/1273/1/012070

Gupta, S., Giri, S., Srivastava, T., Agarwal, P., Sharma, R., & Agrawal, A. (2021). Smart refrigerator based on 'Internet of Things.' In: *2021 International Conference on Advance Computing and Innovative Technologies in Engineering* (*ICACITE*). IEEE, Greater Noida, India, pp. 436–439. https://doi.org/10.1109/ICACITE51222.2021.9404612

Hastawan, A.F., Haryono, S., Utomo, A.B., Hangga, A., Setiyawan, A., Septiana, R., Hafidz, C.M., & Triantino, S.B. (2021). Comparison of testing load cell sensor data sampling method based on the variation of time delay. *IOP Conf. Ser*.: *Earth Environ. Sci*., ***700***, 012018. https://doi.org/10.1088/1755-1315/700/1/012018

Irwanto, B., Kabib, M., & Winarso, R. (2019). Rancang bangun sistem kontrol penimbangan tembakau dengan mikrokontroller Arduino Uno. *Crankshaft*, ***2***(2), 27-32. https://doi.org/10.24176/crankshaft.v2i2.3837

Jaysrichai, T. (2018). Load cells application for developing weight-bearing detection via wireless connection. *The Open Biomedical Engineering Journal* (*TOBEJ*), ***12***, 101–107. https://doi.org/10.2174/1874120701812010101

Khan, M.Y., & Mittal, A. (2017). Freezing of food products: A review. *International Journal of Advance Research in Science and Engineering*, ***6***(9), 353-358.

Lubis, Z., Wibowo, A., & Annisa, S. (2019). Metode baru pernacangan mesin pendingin mini menggunakan rangkaian variabel LM317 berbasis Arduino Uno (fokus hardware dan software). *Buletin Utama Teknik*, ***15***(1), 60-65.

Muchtar, H., & Sumanjaya, R. (2018). Control switch otomatis pada tegangan energi alternatif dan tegangan sumber PLN Menggunakan Raspberry Pi. *Resistor*, ***1***(2), 97-102. https://doi.org/10.24853/resistor.1.2.97-102

Muttalib, S.A., Bintoro, N., Karyadi, J.W, Saputro, A.D. (2021). Development of method and apparatus to speed up cooling process of fish products. *The 8th ICETA*

International Conference on Engineering, Technology, and Industrial Application. 15-16 December 2021

Ogata, K. (1996). *Teknik Kontrol Automatik*. Jakarta : Erlangga, 470 pp.

Prasetyo, A., Wijaksana, H., Suarnadwipa, N. (2019). Studi eksperimental penggunaan dry ice untuk konfigurasi inline dengan rasio pengisian tube 50% terhadap performansi dew point cooling sistem. Jurnal Ilmiah Teknik Desain Mekanika, ***9***(1), 785-790.

Setiawati, D.A., Hakim, M.L., & Sukmawaty, S. (2020). Rancang bangun sistem pengendalian suhu ruang pengering hybrid tipe rak berputar berbasis mikrokontroler Arduino Mega. *Jurnal Teknik Pertanian Lampung*, ***9***(1), 1-9. https://doi.org/10.23960/jtep-l.v9i1.1-9

Setyadi, H.J., Taruk, M., Widagdo, P.P., & Pakpahan, H.S. (2017). Sistem kendali untuk monitoring alat bantu (light center, condesate tank and pump) studi kasus : PLTGU Tanjung Batu Kutai Kartanegara. *Prosiding Seminar Ilmu Komputer dan Teknologi Informasi*, ***2***(1), 390-394.

Shaleh, A.I., Bani, A.U., & Sudarsono, B.G. (2022). Design and manufacture of air pressure measuring instruments with Arduino microcontroller-based presure water sensors. *Journal of Mathematics and Technology* (*MATECH*), ***1***(1), 17–28.

Sinaga, F.O., Amdani, K., & Rajagukguk, J. (2019). Rancang bangun miniatur eskalator otomatis menggunakan sensor berat (*load cell*) berbasis mikrokontroler Atmega 2560. *Einstein* (*e-Journal*), ***7***(3), 15-21. https://doi.org/10.24114/einstein.v7i3.15164

Utama, Y., Widianto, Y., Sardjono, A., & Kusuma, H. (2018). *Sistem Pengaturan Dasar*. Mimika Baru, Papua: Aseni, 141 pp.

Yendri, D., Adrizal, Derisma, & Afif, H. (2020). Design of cow cattle weighing system technology and automatic giving feed. *2020 International Conference on Information Technology Systems and Innovation* (*ICITSI*). IEEE, Bandung - Padang, Indonesia, 185–191. https://doi.org/10.1109/ICITSI50517.2020.9264977