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Automatic Door using Pneumatic System on Bus

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Abstract: *One of the body bus companies that have been operating in the commercial bus industry for quite a long time. This company produces bus design products that are sent both domestically and abroad. Each type of bus has its own features and uniqueness. On buses which have the Cityline-2 model, the bus door system uses pneumatics in its operation. This system is equipped with an air tank, a lubricant regulator filter, an emergency valve, a solenoid valve as a pneumatic cylinder controller, a soft brake sensor, a pressure switch sensor, and a 5 km/hour sensor. The cylinder used is a dual action which can move in both directions to open and close the door. The Bus has 5 doors so there is 1 master controller and 5 sub-controllers at each door.*

Keywords— Pneumatic System, Controller, Bus Door

1. INTRODUCTION

One of the efforts to improve the quality of service, especially for the security and safety of bus passengers, is to review the problem of vehicle construction. Good vehicle construction can minimize the occurrence of passenger accidents. As one example is the bus door. Many people assume that the bus door is part of the bus that functions as a complement[1].

In fact, the purpose of making a bus door is for the safety and security of its passengers. In order for the bus door to function properly according to its purpose, it is necessary to make a good bus door construction. Most of the existing bus door constructions still use a manual system, so there are still many shortcomings, including manual systems that require human power to open and close them.

Manual system door construction is easily damaged when opening and closing it too hard. Passenger safety and security is not guaranteed. Given the shortcomings that exist in the manual system bus door construction, it is necessary to consider a better construction so that the deficiencies in the system can be overcome. One of them is to design an automatic bus door construction with a pneumatic system, namely an automatic bus door that is controlled by a pneumatic control system.[2] [3]

The pneumatic control system that uses a controller as a sender and receiver of digital signals also provides a significant advantage to the user because it can replace relay and cable functions which are expensive and quite complicated to install.[5][6]

2. LITERATURE REVIEW

2.1 Manual bus construction system

Good vehicle construction can minimize the occurrence of passenger accidents. For example, the bus door. Many people assume that the bus door is part of the bus that functions as a complement. This can be seen from the not functioning of the bus doors properly. Even though the purpose of the bus door is for the safety and security of its passengers. In order for the bus door to function properly according to its purpose, it is necessary to make a good bus door construction.[5]. Most of the existing bus door constructions still use a manual system so that there are still many shortcomings, including:

- Manual system requires human power to open and close it.
- The construction of the manual system door is easily damaged when opening and closing it too hard. Passenger safety and security is not guaranteed, considering the shortcomings that exist in the manual system bus door construction, it is necessary to consider a better construction so that the deficiencies in the system can be overcome. One of them is to design an automatic bus door construction with a pneumatic system, namely an automatic bus door that is controlled by a pneumatic control system [7].

2.2 Pneumatic Cylinder

Fig. 1. *Pneumatic Cylinder*

A pneumatic cylinder is an actuator or mechanical device that uses the power of compressed air (compressed air) to produce force in a linear reciprocating motion of the piston

(movement in and out). Pneumatic cylinders are tools or devices that we often encounter in industrial machines, be it in the automotive industry, packaging industry, electronics, and various industries and other agencies [8]. Pneumatic cylinders are commonly used for clamping objects, pushing cutting machines, pressing pressing machines, vibration dampers, sorting doors, and so on. **Fig. *1*** is an example of Pneumonic Cylinder.

2.3 Air Tank

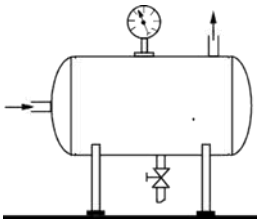

Fig. 2. *Air Tank*

The air tank in **Fig. 2** can be installed vertically or horizontally. The output air is drawn from the top of the tank, while the air enters through the bottom of the tank.

2.4 Solenoid Valve

Fig. 3. *Solenoid Valve 5/2-way*

Solenoid valve is a valve that is driven by electrical energy through a solenoid, has a coil as its driver which functions to move a piston that can be driven by AC or DC currents, pneumatic solenoid valves or solenoid valves have output holes, input holes and exhaust holes. The example of Solenoid Valve is show in **Fig. *3***.

The input hole serves as a terminal / place for compressed air to enter or supply (service unit), while the output hole serves as a terminal or outlet for air pressure connected to pneumatics, and the exhaust hole serves as a channel to remove compressed air trapped when the plunger moves. or change positions when the pneumatic solenoid valve is operating [9].

The solenoid valve is the most frequently used control element in fluid flow. The job of the solenoid valve is to shut off, release, dose, distribute or mix fluids.Valve

2.5 Pressure Regulator

Fig. 4. *Pressure Regulator*

The regulator functions as an adjuster or to adjust the wind pressure needed to enter the pneumatic unit according to the needs of the workpiece. On average or usually, the pressure used is around 0.4 Mpa to 0.6 Mpa or in other calculations, which is about 4 Bar – 6 Bar. The example of Solenoid Valve is show in **Fig. 4**.

2.6 Controller Module

Fig. 5. *Controller Module*

The controller module as in **Fig. 5** is the controller in the operation of this system. The controller acts as a data signal sender for communication between the local master and the controller module at each door. Inside the bus door, there are two types of controller modules, including:

- Master controller

This controller is in charge of receiving signal data from sensors > 5km/h, signal data from soft brake sensors, and signal data from step lamp on/off. This controller also sends signal data to the controller per door unit according to orders from the switch or from the connected sensors.

- Controller per door unit

This controller is in charge of receiving signal data from the master controller or from the pressure sensor when the door cannot be closed. This controller also sends signal data to the solenoid valve to open/close the door, turn on the light when the door is open, stop the brake pedal function when the door is open, and turn on the buzzer when an emergency occurs.

2.7 Pneumatic Emergency Valve

Fig. 6. *Emergency Valve*

As in **Fig. 6**, emergency valve used to dissipate air pressure so that the door can be opened manually. Passengers can use an emergency valve during an emergency, for example: when the vehicle door cannot be opened.

3. ANALYSIS AND DISCUSSION

3.1 Compressed Air Line Design in Pneumatic Systems

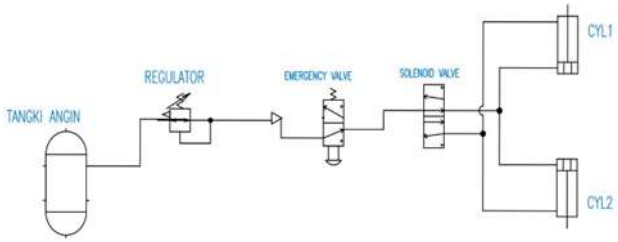

Fig. 7. *Pneumatic system path circuit drawing on the door*

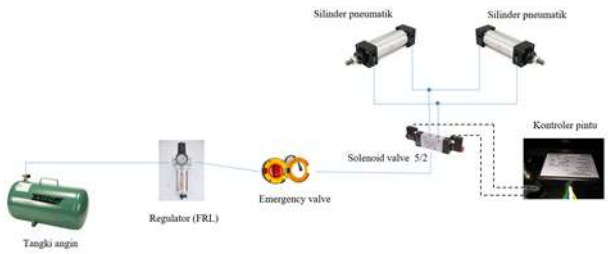

Fig. 8. *Pneumatic system component design drawing*

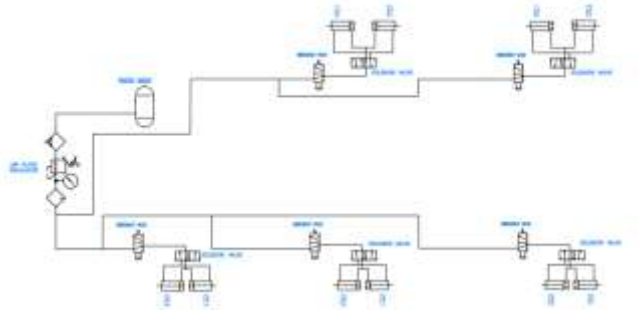

Fig. 9. *Complete line of compressed air systems on buses*

In the compressed air bus system, there are five doors that are installed using a pneumatic system, there is 1 compressed air tank and a filter regulator that regulates the amount of pressure that enters each pneumatic door. Implementation design of compressed air bus system as shown in **Fig. 7**, **Fig. 8**, and **Fig. 9**.

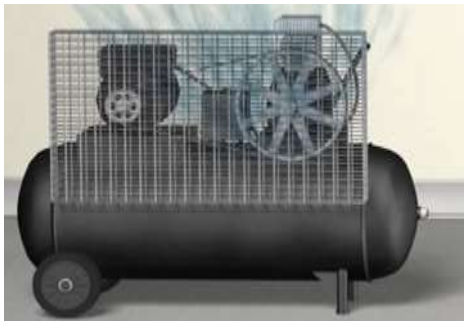

Fig. 10. *Illustration of compressed air entering the tank*

In the process, Compressed Air is generated by the compressor, by taking air from outside through a filter, compressing it and storing it in a tube or pressure vessel for a positive compressed air system. Usually before being put in the pressure vessel, the compressed air passes through the air dryer or dryer first. The goal is that the stored air does not contain water, so that the pneumatic components do not rust. For buses, the compressor used is usually a piston type and the air is drawn from the air supply system for the engine as shown in **Fig. 10**.

Fig. 11. *Illustration of compressed air flowing into the pressure regulator*

Next, the air from the tank is flowed through the pressure regulator. Inside the pressure regulator, the air will be filtered first using a filter, the flow pressure is regulated with a regulator, and lubricating / lubricating oil is added. Because pneumatic equipment, especially valves and actuators, are sensitive to dirt and water, a combination or one of these tools is needed.

Then the air will enter the emergency valve. The emergency valve is installed before air enters the solenoid valve because this valve will close the compressed air rate to the solenoid valve if the bus switch cannot be used or there is a malfunction in the system which makes compressed air cannot be discharged from the pneumatics automatically. Illustration of pressure regulator and solenoid valve as shown in **Fig. 11** and **Fig. 12** .

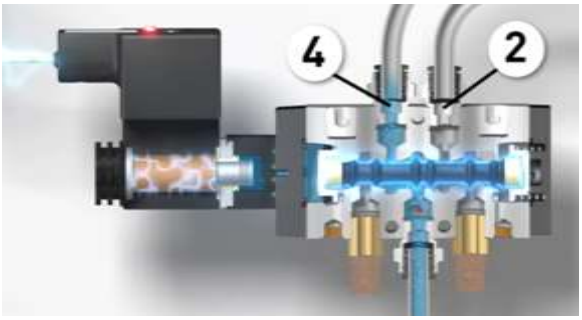

Fig. 12. *Illustration of compressed air flowing through a solenoid valve*

Air flows into the solenoid valve with the desired pressure. The solenoid valve will regulate when the air enters the pneumatic and when the air exits the pneumatic. After the air enters the solenoid valve, the air will be held in the pipe until there is an electric current that stimulates and moves the separator gate between the valves inside the valve so that the path to one of the valves opens [10]. The air will flow into the flow of the valve which is open and into the pipe which is connected to the pneumatic cylinder.

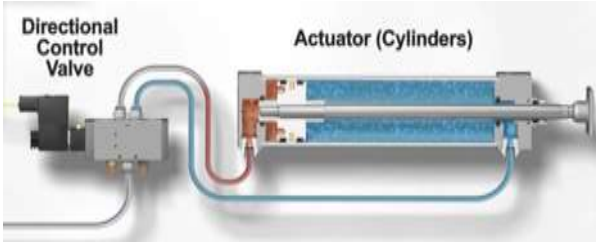

Fig. 13. *Illustration of compressed air entering pneumatic*

As shown in **Fig. 13**, the air entering the pneumatic cylinder must pass through the conditioning on the solenoid valve first. When the switch button to open the door is pressed, the pneumatic will dump the remaining air that is still stored in the pneumatic to the exhaust valve on the solenoid valve while sucking air from the solenoid as well to shift the piston inside the pneumatic. The same way of working also applies to closing the bus door. When the switch to close the door is pressed, the pneumatic will blow the remaining air that is still stored in the pneumatic into the exhaust valve on the solenoid valve while sucking air from the solenoid as well as to shift the piston inside the pneumatic.

To control the compressed air used control components that can:

- Directing compressed air flow
- Adjusting the amount of compressed air aliran
- Adjusting the compressed air speed
- Regulating the reaction time of the compressed air flow.

The controller components used on the bus doors are solenoid valves (valves), sensors, switches, dividers / distributors.

There is a pressure sensor that is connected to the controller module of each door where when the door does not close tightly / there is an object or something blocking the door, the air pressure on the rubber side of the door that hits the object will provide air pressure to the pressure sensor. The pressure sensor will convert the wind pressure into electrical signal data that is sent to the controller module for each door. The module will retransmit the signal data to the light switch to turn on and transmit electric current to drive the limiting gate on the solenoid valve.

In this automatic door system using pneumatics, there are several sensors including:

- Sensor pressure switch which aims to provide feedback when the door is known to be unable to close tightly due to various reasons.
- 2. 5 km/h sensor which has a working method where the bus door cannot be opened if the bus is traveling more than 5 km/h. This sensor becomes a system controller variable because the input signal will disable and activate the controller.

Soft brake sensor, where when the bus door opens, the valve in the braking system will open and air fills the pneumatic brake so that the bus will slowly reduce its speed until it stops and the driver cannot run the bus even if the gas pedal is pressed before the door is closed again.

Operational data for fuel stroke reference (FSR) was obtained through historian data on May 16, 2021 at 21.28 WIB to 21:42 WIB. The data contains the actual values of FSR StartUp, FSR Acceleration, FSR Speed, FSR Temperature, FSR ShutDown, and FSR Manual. The data will then be analyzed for its value when the FSR condition is the minimum value. The following is the operational data of the Fuel Stroke Reference (FSR), which is sampling data.

3.2 Design of Electric Wiring System on Bus Door

On buses, the use of controller modules to send electrical signals for data communication between doors and related sensors is very useful. In addition, the use of controllers greatly reduces the use of electronic components such as relays and cables. The controller module is divided into the main controller and sub-controller for each door. In total there is 1 main controller and 5 sub-controllers on each door.

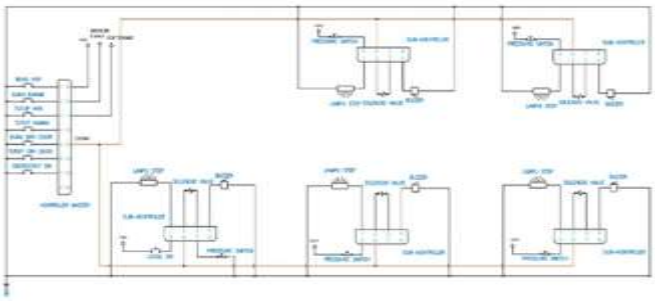

Fig. 14. *System wiring diagram*

Based on **Fig. 14**, inputs and Outputs on the main controller and the uses of each line include:

- Comm : data signal communication path to be sent to each door sub-controller
- 5km/h sensor: The 5km/h sensor is connected to the Transmission Control Module (TCM). This sensor will send data to the main controller. When the bus speed is above 5 km/h, a signal will be sent from the TCM to the main controller. The microcontroller on the main controller will process the signal to deactivate the switch input so that the push button to open the door cannot work if the bus speed is above 5 km/h.
- Soft brake sensor: this sensor will open the valve on the bus brake system so that smooth braking occurs on the bus. This sensor is active when the bus door is open and will make the bus slowly decelerate until it finally stops. The bus will still maintain air in the bus brake cylinder so that it cannot move even on the gas until the bus door is closed again.
- Open SW DRV : Switch path to open the driver's door.
- Close SW DRV : Switch path to close the driver's door.
- Open SW LH: Switch path to open 2 doors on the left.
- Close SW LH: Switch path to close 2 doors on the left.
- Buzzer: a path to turn on the buzzer which is installed close to the door.
- Open SW RH: Switch path to open 2 doors on the right.
- Close SW RH: Switch path to close the 2 doors on the right.
- Open/Close All Doors: Switch path to open all right, left and driver doors.

The inputs and outputs of the sub-controller for each door and the uses of each line include:

- Open solenoid: pin 2 on the controller is used as a voltage supply to open the valve on the solenoid and make the door open automatically.
- Close solenoid: pin 3 on the controller is used as a voltage supply to replace the valve on the solenoid that is open and makes the door close automatically.
- Step light: pin 1 is connected to the light above the bus door and will light up when the door is opened.
- Buzzer: pin 4 on the controller is connected to the buzzer above the bus door and lights up when the door is opened.

Pressure switch: pin 5 on the controller is connected to the pressure switch sensor. The pressure switch activates when something is blocking the door and presses the air chamber on the side of the door leaf when the door is about to be closed. The signal from the pressure switch will be sent to pin 2 to open the door again.

3.3 Design of Electric Wiring System on Bus Door

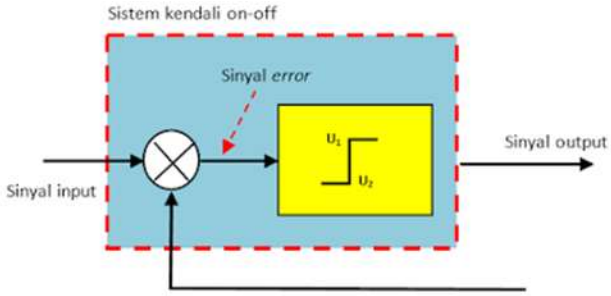

Fig. 15. *On-off control system block diagram*

As shown in **Fig. 15** in this system, the input signal is the speed of the bus when it is running. The error signal which is the difference between the input signal and the sensor feedback signal will be processed by the controller to produce system output.

Fig. 16. *Transmission control module bus*

The signal is sent through the Transmission Control Module unit as input to the door master controller as shown in **Fig. 16**. The signal from this controller will be used to turn on the door master controller or turn off the door master controller. When the bus speed is below 5 km/h, a high or on signal will be sent to the bus door master controller to turn on the system, while if the bus speed is above 5 km/h, a low or off signal will be sent to the bus door master controller to turn it off [11].

3.4 Door Opening System Flowchart Design

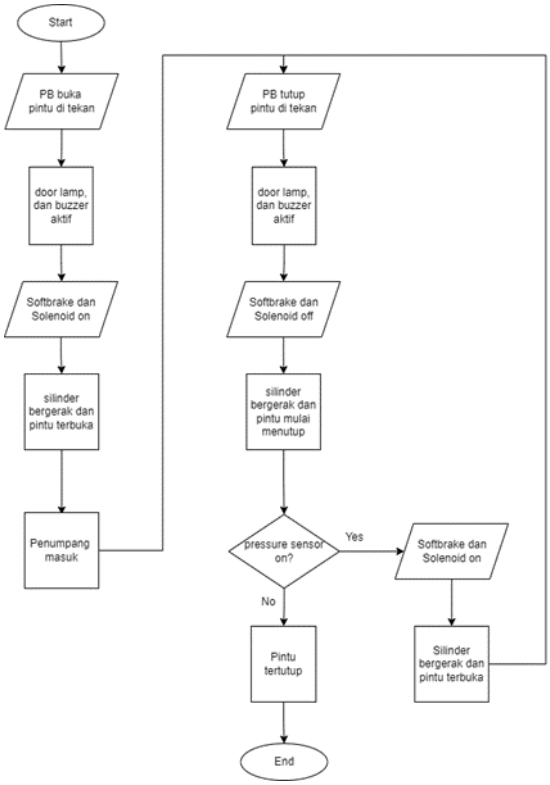

Fig. 17. *Pneumatic door system workflow flowchart*

Fig. 17 is a workflow flowchart of an automatic door system using pneumatics. This path begins by activating the bus ignition switch via the car key so that a voltage of 24 volts Tong, M., Xiu, S., Chen, X. and Chen, S., 2021. Door sealing mechanism and process in vehicle engineering. Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering, p.09544070211059899.flows throughout the bus system, including the bus door system. If the bus is running below 5 km/h, the bus door system on the controller will be active. The driver will choose which door to open or close, then a signal will be sent from the master controller to the corresponding sub controller so that the sub controller gets a trigger to open or close the door. In the case of a door that cannot be closed because something is blocked, there is a pressure switch sensor that triggers the door sub controller to reopen the blocked door.

4. CONCLUSION AND SUGGESTION

4.1 Conclusion

The conclusions from the discussion of the report carried out are as follows:

- The pneumatic system can be used as a bus door driver because it is more efficient in its use. This system uses air as the working fluid in the sense of compressed air as a support, carrier, and energy provider.
- The automatic door system has advantages over ordinary automatic door systems because it uses a lot of sensors such as pressure sensors to reopen the door when something is blocking the door from closing tightly, soft brake sensor where braking will occur when the door is open, sensor 5 km/ h where this sensor signal will be the control input to the bus door system.
- The controller in the automatic door bus system consists of a master controller located at the front of the bus near the driver and a sub-controller installed at each door. This controller will read which switch is pressed by the driver and give a command to the corresponding door to open or close the door.for two affiliations.

4.2 Suggestion

For further development, the following suggestions can be given:

- The communication integration of the door controller is currently only connected to the Transmission Control Module. Increased integration needs to be done to other Electronic Control Unit modules such as the Airbag Control Module or Electronic Braking System to provide a safer system and more responsive to driver negligence.
- The use of ultrasonic sensors to count the number of incoming and outgoing passengers will make the bus more compliant with current health protocols. With the sensor as a calculating device, the conductor does not need to calculate the total number of passengers

on the bus and passengers feel safer because they are not too close together on the bus.

5. REFERENCES

[1] Tong, M., Xiu, S., Chen, X. and Chen, S., 2021. Door sealing mechanism and process in vehicle engineering. Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering, p.09544070211059899.

[2] S. Stefanovic, "Pneumatic - logic synthesis of bus door from aspect of automation," vol. 3, no. 1, pp. 5–10, 2015.

[3] S. Narayanan, A. Manikandan, P. Praveenraj, D. Shri Bharath, and C. Duripandi, "Automatic Emergency Exit in School Bus," *J. homepage www. ijrpr. com ISSN*, vol. 2582, p. 7421.

[4] S. R, N. N.A, P. M, and S. M, "Automation of Vehicle Door," *Int. Res. J. Automot. Technol.*, vol. 3, no. 1, pp. 1–5, 2020, doi: 10.34256/irjat2011.

[5] P. Wos and R. Dindorf, "Adaptive Control of the Electro-Hydraulic Servo-System with External Disturbances," *Asian J. Control*, vol. 15, Jul. 2013, doi: 10.1002/asjc.602.

[6] D. N. Gayathri, R. Manjunathan, M. Akash, S. B. Kumar, and P. Bharathi, "Design and Analysis of Automated Pneumatic Door System," *Int. J. Res. Appl. Sci. Eng. Technol.*, vol. 10, no. 2, pp. 1081–1084, 2022, doi: 10.22214/ijraset.2022.40458.

[7] Pravilonis, T. and Sokolovskij, E., 2020. Analysis of composite material properties and their possibilities to use them in bus frame construction. Transport, 35(4), pp.368-378.

[8] Zhao, L., Zheng, C., Wang, Y. and Liu, B., 2019. A finite-time control for a pneumatic cylinder servo system based on a super-twisting extended state observer. IEEE Transactions on Systems, Man, and Cybernetics: Systems, 51(2), pp.1164-1173.

[9] Angadi, S.V. and Jackson, R.L., 2022. A critical review on the solenoid valve reliability, performance and remaining useful life including its industrial applications. Engineering Failure Analysis, p.106231.

[10] Mathai, V., Das, A., Bailey, J.A. and Breuer, K., 2021. Airflows inside passenger cars and implications for airborne disease transmission. Science advances, 7(1), p.eabe0166.

[11] Fang, F., Zhao, Z.J., Huang, C., Zhang, X.Y., Wang, H.T. and Yang, Y.J., 2019. Application of reliability-centered maintenance in metro door system. IEEE Access, 7, pp.186167-186174.