Implementation of an Automated Vacuum Elevator System

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Abstract

Pneumatic vacuum elevator (PVE) has become a popular choice for our homes and low-rise buildings in recent years. The Pneumatic vacuum elevator represents a new concept evolved from the idea of pressed air applied in the pneumatic elevator replaced by a vacuum air idea. The pneumatic vacuum elevator is able to transport people between building floors without using any cables, counterweight, or pulleys. A simple and low cost construction and implementation for an Electro-pneumatic vacuum elevator system prototype is presented in this paper. The elevator system prototype is constructed with three floors to elevate a maximum load of 6kg. Programmable Logic Controller (PLC) of (LS\GLOFA-G7M-DR30U) series with (16) inputs and (12) outputs programmed with Ladder diagram software is used for the fully automated the elevator system. The idea of the proposed elevator system may be predicted to be widely spread in the low-rise residential buildings.

Keywords: Electro-pneumatic; Vacuum elevator; PLC.

1. Introduction

Elevators grown as a modest rope or chain hoists. The elevator is basically a platform, either pushed up or pulled by a mechanical ways. Today the modern elevator comprises a cab (also named cage or car) fixed on a platform within an enclosed space known as a shaft or more correctly a hoist way (2010) [1]. Today, there are three commonly elevators types used: Hydraulic elevators, geared traction elevators, and gearless traction elevators. The traction elevators are lift up and down with a rope linked to a motor with a counter-weight. Geared and gearless elevators have the same work principle. The only difference is that the geared elevator is provided with a gearbox between the motor and the sheave. Hydraulic elevators are employed today for both passenger and freight services in buildings have height ranging (2-6) stories and has a velocity from (0.125 - 1) mps (2013) [2].

Nowadays, revolutionary vacuum technology is available for residential elevators. One type of the elevators utilized in residence of up to four floors is a pneumatic elevator, also known as a pneumatic vacuum elevator PVE (1992) [3]. This elevator does not need a machine room, because it moves using a driving machine consisting of turbines that remove air from the top of the elevator car.

The development of this kind of systems can increase the availability for blind or physically impaired people. This makes it a perfect choice to be used in homes or small buildings not more than four floors in height.

Automation is a particular process control technology to increase the system efficiency and reliability via executing programmed commands integrated with automatic feedback control. A Programmable Logic Controller PLC is a digital computer utilized for electromechanically automated processes. The PLC has many advantages over other control systems, related to its low cost, flexibility, reliability, operational speed, ease of programming, security, it is easy to implement changes and correct errors, as well as, it now has a much longer service life; so, low maintenance is needed (2010) [4]. Mostly in any production line, machine process or function could be automated by using a PLC. The elevator is a suitable system that could explore a lot of the advantages of the PLC. The PLC has several input terminals, through which, high and low logical states from switches and sensors are interpreted. Ladder diagram is representing the more common program language between other programming languages (2011) [5], especially for the electro-pneumatic systems. The automation systems that utilize Electro-pneumatic vacuum technology are mainly constituted from three elements: actuators or motors, sensors or buttons and control elements like valves (2005) [6].

There are few studies in the literature that deal with the pneumatic elevators. Matous'ek (2009) [7] designed and built an Electro-pneumatic model controlled by a mobile phone on the Applied Cybernetics Department. This model served for student's education in that department, programming of microprocessors and it also helped them to practically realize the pneumatic components as well as sensors. The model based on a PLC remote control using a short message system SMS technique was projected for the electro-pneumatic elevator application. This technique might be also used in training to control or signal the state of the machine or the technological process. Mohammed et al. (2017) [8] presented a new construction of an Electro-pneumatic elevator system fully automated with PLC technology. The elevator system prototype constructed with three floors to elevate a 5kg payload with 1bar pressure had been proposed and controlled via a PLC controller of (LS-GLOFA-G7M-DR20A) with 8 inputs, and 12 outputs. The PLC was programmed with Ladder diagram software. This prototype might be employed as a teaching tool for the engineering undergraduates. Hussein et al. (2015) [9] presented a pneumatic system controlled using a PLC to execute the pneumatic elevator orders that received via using push button switches. This model is suitable for the educational purposes, such as learning the students about the programming the PLC and Arduino as well as building the pneumatic circuits. The test work of this system might be carried out in the real world to serve special buildings with height not exceed four stories. The pneumatic elevator performance had been studied. The test results gave the best parameters.

For the simulation research on the synchronization control for a pneumatic elevator, an AMESim software model was built by Xing et al. (2015) [10]. The simulations were utilized to study the effect of synchronous control strategy. The results of simulation clarified that there are good synchronizing effects by implementing pneumatic proportional technology and synchronization control with master-slave mode based on PID control. Some theoretical guidelines had been given to synchronously control the real system. Ali (2016) [11] presented an improved electro-pneumatic elevator, simulating the real one used in low-rise buildings such as homes consisted of three or four floors as maximum. This elevator does not include electric motor, counter weight and ropes. It comprises on two parts: pneumatics part with cylinders, valves and pipeline and distributors and electric part of PLC, sensors, push bottoms, floors numbers and connectors. A PLC type SL / GLOFA-G7M-DR20A and an assistant controller as G7E-DR10A expansion model with 14 inputs 16 outputs were used. This system was used as an elevator educational model the in the electromechanical laboratory for undergraduate classes /Electromechanical Eng. Dep. in the University of Technology in Baghdad. Morse (2017) [12] described a large-scale pneumatic lift in which a person sitting on a board atop a plastic garbage bag is lifted when the bag is connected to the exhaust port of a vacuum cleaner, which easily lifts the person. This article described the construction and the use of an inexpensive hand-held pneumatic lift to demonstrate the same principle.

All the aforementioned researches focused on building pneumatic elevator systems on the principle of "pressure" action. In this study, a PVE elevator controlled on the principle of "vacuum" action is suggested; the compressed pressure air is replaced by a vacuum air. This elevator has a vertical shaft; tube with a smooth interior surface. This tube is preferably constructed in the form of cylinder, has straight axle, and the transport cab or car moving inside such tube is a piston with vertical movement, with minimum play inside the tube. The tube is equipped with air suction devices at its upper end, capable of generating an enough pressure differential to move such piston in controlled ascending and descending movement; completed with an air entry or intake in the lower end of the tube. The elevator system has been controlled by a PLC. The PLC works according to signals coming from the load cell and sensors, necessary to operate a vacuum pump with suitable power to maintain the elevator work at fixed speed.

This paper aims to construct prototype model of an Electro-Pneumatic Vacuum elevator consisting of three (floors) controlled by using a PLC. This elevator could be invested as low-cost solutions for a wide range of low-rise buildings not exceed four stories.

2. Elevator Model Construction

The overall setup of the electro-pneumatic vacuum elevator EPVE elevator prototype model is shown in Fig. (1). It has been built to simulate the actual elevator in the real life. The EPVE is modeled as a laboratory model of an elevator that combines the pneumatic and electronic components under PLC control. The materials and devices used in building the system of the elevator model are as follows:

Vacuum compressor, PLC, solenoid valves, relays, power supply, connector and tray, wires, call switches and cabin switches, regulator, load cell, indicator for load cell, guide to support the movement of the cabin in ascend and descend, and brakes. All the equipment specifications are listed in Tables (1 & 2).

Table (1) Electrical & Pneumatic Components

Electrical components			Pneumatic components		
	Company	Specifications		Company	Specification
Relays	KOINO, RELEQUICK, RELECO	DC 24V (2A) & DC 24V (10A)	Vacuum Compressor	Shownic	1200 W, 220V AC
PLC	LS \ GLOFA-G7M-DR30U	16 inputs, 12 outputs	Solenoid valves	Maxtor	Model PU220-02AR/ DC 24V
Power supply	VAXUN	ps-305D 24V DC 50/60 HZ DC (5A)			
Electrical brake	TFS-A22	Electric Cabinet Door Lock, 24V DC, 0.8A			
Sensors	Ifm electronic Germany	Model TPM0212 DC 24V			
Load cell	SEWHA	Model SS300 Capacity 50K			
PM DC motors	TGP02S	Geared 3-6V DC, 20-230rpm			

Table (2) Mechanical specification of the elevator System

Elevator Cabin		**Elevator Frame**		**Elevators Door**	
Height	37 cm	Height	146 cm	Height	30 cm
External Diameter	19 cm	External Diameter	20cm	Width	16 cm
Cabin Material	acrylic	Frame Material	acrylic	Door Material	acrylic
Acrylic Density	1 GPa	Acrylic Density	1 GPa	Acrylic Density	1 GPa
Cabin Weight	2 Kg	Travel Distance	110 cm		
Max. Load Wight	6 Kg	Maximum Velocity	0.1375 m/s		

2.1. Mechanical Part

The mechanical part of the system is mainly composed of external cylinder, elevator doors, and elevator cabin.

2.1.1. External Cylinder

The external cylinder of the elevator model is structured of a transparent acrylic material sheet. The acrylic sheet has been chosen since; it is low cost, available, light weight, more flexible than the glass sheet, as well as the transparent of the acrylic enables one to see elevator operation inside clearly.

To investigate the mechanical properties of the acrylic sheet, a tensile test was carried on the specimens according to the Standard Test Method (ASTM D638) to find the tensile yield stress σy. The results of the tensile test showed that $\sigma y = 52.8$ MPa. Depending on the results, it was found that both of the radial stress and circumferential stress are less than σy, by using the Lame's equation, therefore, an acrylic sheet of a (5mm) thickness can be safely used for building the elevator. The external cylinder can be constructed with different lengths according to the required design dimensions of the model. This cylinder is constructed with the following dimensions (146cm height × 20cm outer diameter × 5mm thickness) and has two opening ends; one at the top and the other at bottom.

Three apertures were made in the external cylinder to fix three cabin doors on them as shown in Figure (1). The elevator model has three cabin doors fixed on the external cylinder (door for each floor).

Each door is built with dimensions of (15cm × 8cm). Opening and closing process of the elevator doors are very important to evaluate the elevator performance because the door motion is in continuous and direct contact with comfort of passengers. If the elevator doors are moved more smoothly and quickly, this firstly will gives passengers a good impression. Installing the cabin door is somewhat difficult, due to the inaccuracy of placing the door in the cabin, arising from lack of space which may cause some air leakage, so, more efficient design for elevator doors must be taken into consideration. Therefore, most of researchers in the field are initially focusing on the design of the pneumatic elevator cabin doors. Each door is constructed from the acrylic and has a frame of silicone sealant precisely fixed on one of three external cylinder apertures to prevent any possible leakage during the period of closing the doors. The doors as well as their frames have dimensions of (15cm × 30cm × 5 mm). The doors are assembling with its frames. Each door is opened and closed by a DC motor controlled through a PLC as shown in Figure (1-a).

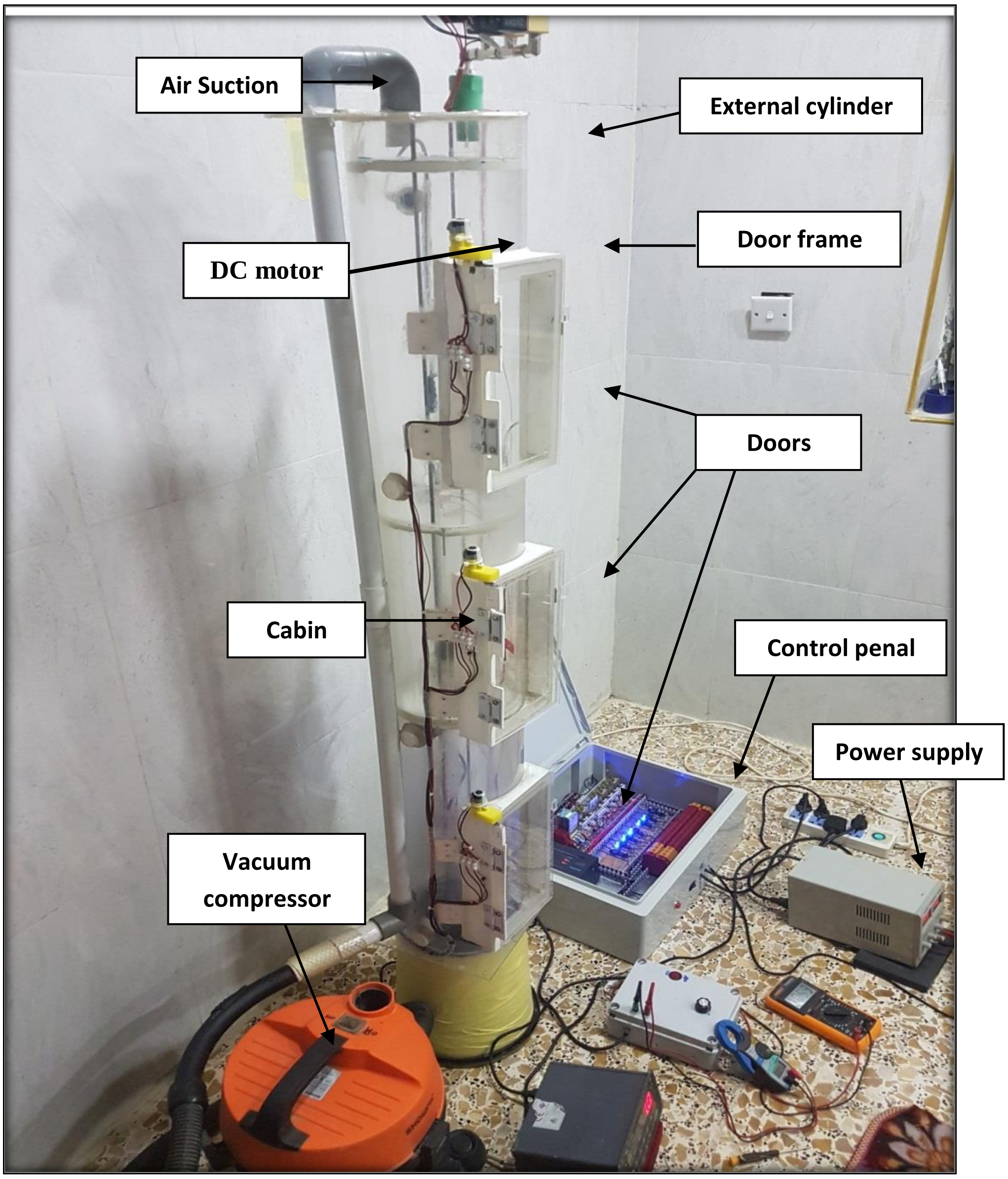


Fig. (1-a) the electro-pneumatic vacuum elevator system (side view)

2.1.2. Elevator Cabin

The elevator cabin (internal cylinder) moves up and down inside the external cylinder to transport the loads through the floors. An acrylic sheet of 5mm thick also was chosen to build the cabin since it is lighter than the hard metals like iron and it is transparent. It has higher resistance to pressure and lower breakage possibility compared to conventional glass, which makes the proposed elevator model very suitable to be used for the educational purposes. The cabin had been designed with dimensions (37cm height × 19cm outer diameter × 5mm thickness). The elevator cabin has a weight of 2kg. The elevator cabin has to move with a maximum velocity of 13.8 cm/s. The cabin cylinder has an aperture with dimensions of (15cm × 30cm) equal to the door dimensions, to permit entering and exiting passengers easily through it when the door is open.

3. Electrical Part

The electrical part of the elevator prototype includes the following devices:

3.1. PLC

All elevator system operations are fully controlled via a PLC. The PLC could be connected to a personal computer (PC) and reprogrammed to be suitable to the work requirements. (LS\GLOFA-G7M-DR30U) PLC shown in Fig. (1-b) is programmed with (GM WIN 4.18) ladder language. The input signals from different sensors are given to the PLC to produce output signals to actuate various loads like: DC motors for cabin doors, air valves, floor lamps, door open or close lamps, etc.

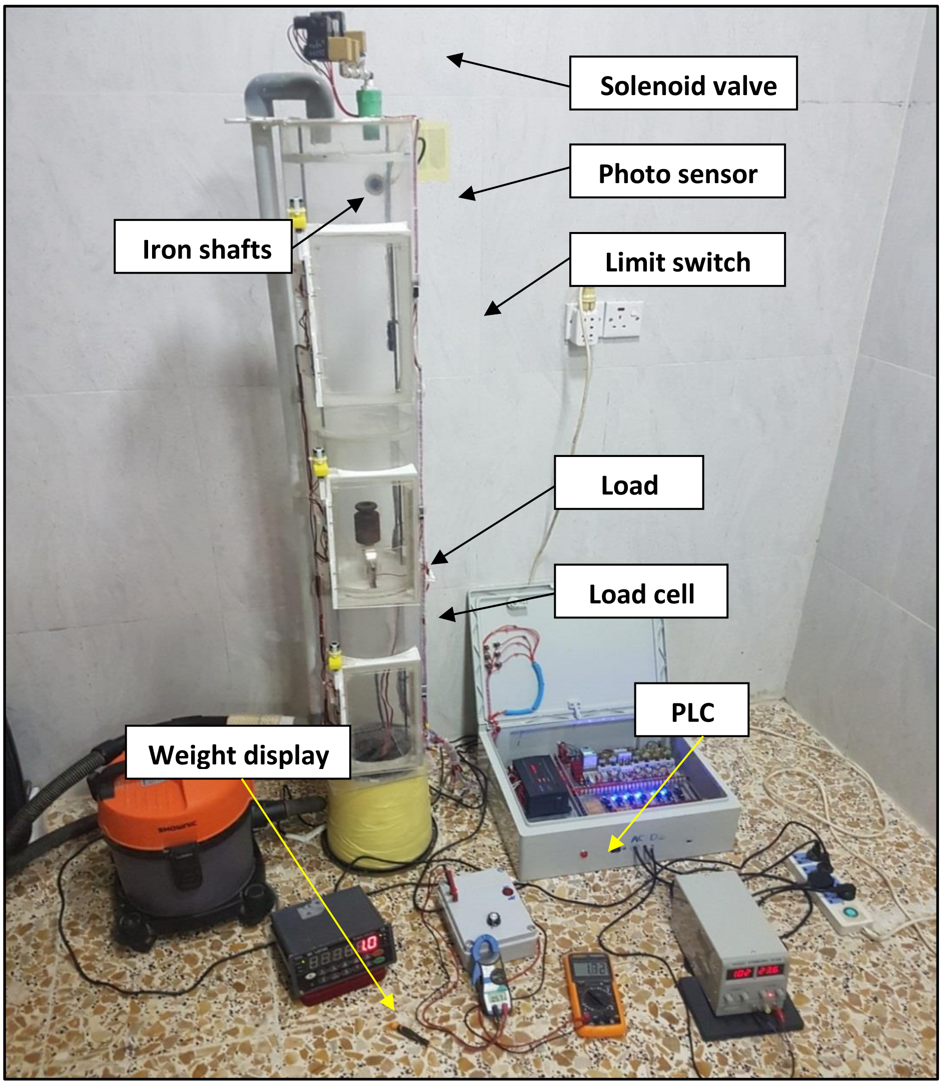
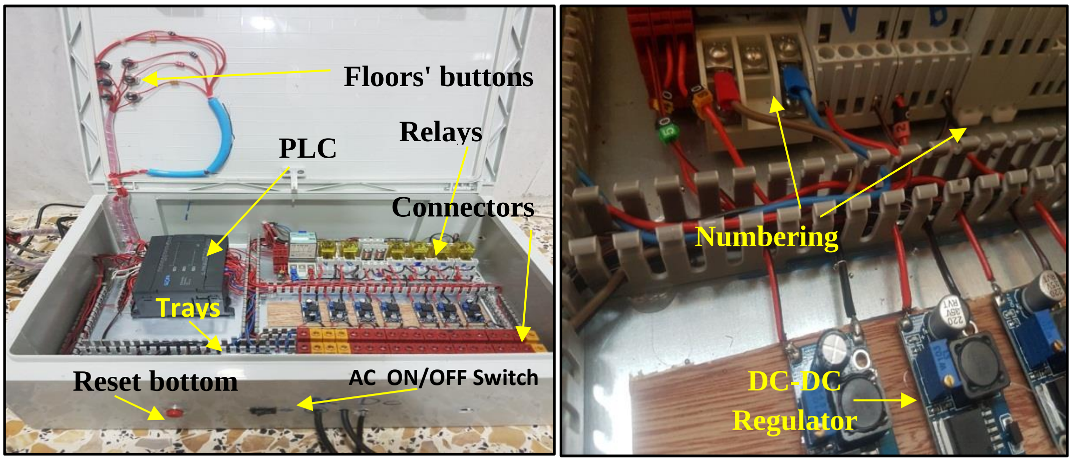


Fig. (1-b) the electro-pneumatic vacuum elevator system (front view)

3.2. Relays and Sensors

Nine relays are used in the elevator model and distributed as follows: six relays of them are used for opening and closing the doors; two for each door, one for opening the door and the other for shutting, named as (R1, R2, R3 for opening the doors and R11, R22, R33 for shutting them). The three remainder relays are: one relay (Relay down) for venting valve, one relay (Relay up) for running the vacuum compressor and the third (Relays brake) for braking the elevator car as shown in Fig. (2). The coil of each relay operates on 24V DC.

A SS300 load cell combined with its support frame is mounted inside the cabin as shown in Fig. (1-b). The load cell measures the value of load weight inside the cabin and gives a signal according to the weight value to operate the system at a certain power with variable loads at constant speed. The load cell capacity is 50 kg. It is connected to an indicator to display the weight value and acts as an input signal to the PLC as shown in Fig. (1-b). To know the status of the doors (open or closed), limited switches are fixed behind the doors as shown in Fig. (1-b). The cabin also contains a buzzer, alarms when the weight is exceeded the allowable maximum value. Three 24V PNP photoelectric sensors (sensor for each floor) are used to detect the location of the cabin as shown in Fig (1-b).



(a) **(b)**

Fig. (2): Control circuit panel (a), and wire numbering (b)

3.3. Vacuum Compressor

Vacuum compressor is the main component in the elevator system; it is used for sending and descending the cabin. It descends through the venting and this is one of the advantages of the proposed system (energy conservation). The vacuum compressor is characterized by its low cost and availability. A 1200W (220V, 5V) vacuum cleaner is used as a vacuum compressor, runs with an electric power limited according to weight sensed by the load cell. The compressor should be supplied with power enough to lift the cabin under maximum load. Specification of the vacuum compressor is shown as Table (1).

3.4. DC Motors

Three permanent magnet DC motors shown in Fig. (1-a) are used to control the motion of the cabin doors, they work with 5V DC, so a (24V/5V) LM2596 DC-DC Step-Down voltage regulators, able to drive loads with 3A as shown in Fig. (2) are used to convert 24V coming from a DC power supply into 5V to fed the DC motors.

3.5. Brake and Cabin Guide

During the elevator work, many emergencies might be happened like: 1- Power cut, 2- Occurrence of hole (or cut) in the connected hoses or in the external cylinder, 3- Fault happening in the PLC and 4- Conflict in instructions and repetition in orders, etc.

The system has absolute safety. At worst, if any interruption occurs, the cabin will not fall and for more safety, a pair of brakes as shown in Fig. (4) is used, they fixed facing to each other (on both sides) under the cabin to maintain its position and avoid sliding it. Another problem might face the elevator operation is how to stop the cabin at specific point because the air suction and the venting make it difficult to stop the piston (cabin) at a certain point. To solve this problem, three air solenoids mounted on top surface of the elevator are used for this propose as shown in Fig. (1-b). To prevent the cabin cylinder from rotating during its transfer through floors, two iron shafts, penetrating the upper and lower cabin faces, are used as shown in Fig. (1-b).

Fig. (4) Brake

3.6. Pneumatic Valves

Three model Maxtor PU220-02A/ DC 24V pneumatic solenoid valves shown in Fig. (1-b) are used to vent the cabin during its descending. The valves are adjusted to be opened or closed according the load value inside the cabin to maintain the cabin moving at constant speed. All the valves are opened, as the cabin is empty while they are closed when the cabin is maximally loaded.

3.7. Power Supply

A linear DC power supply PS-305DM (30V/5A) shown in Fig. (1-a) is used to supply all the electrical equipments with DC power. Some components are working on an AC power like, the PLC, the red switch, the relays' contacts. Other components work on DC power like, the relays' coils, the PLC's inputs, the photo sensors and the outside and the inside call buttons.

3.8. Connectors and Trays

Connectors are used for delivering the power from the 220V voltage source to several terminals. The connectors deliver the AC power to the relays and the power supply. All the electric system equipments are connected by common point N.

In spite of assembling the all components with numbering method, the tangle of wires remains as big problem, because of the huge number of wires. Therefore, it is desirable to use trays. The tray is a plastic moldable route. It has an opening in its side used to pass wires and has a plastic cover as shown in Fig. (2-a).

4. Implementation Procedure

4.1 Hardware Implementation

After selecting an external cylinder with thickness of 5mm and length of 146cm, the cylinder is divided into three equal parts (three floors). The height of each floor is 36cm, leaving some distance at the top of external cylinder for air suction and venting pipes as shown in Fig. (1-a). The three openings used for entering and exiting passengers are made. The three constructed doors and their frames are fixed on those openings. The three photoelectric sensors (sensor for each floor) are mounted to detect the location of the cabin as shown in Fig (1-b).

Next step, is putting the cabin (internal cylinder) inside the external cylinder, noticing that the cabin does not attached to the internal walls of the external cylinder (air- suspended). The external cylinder has small holes in its sides to mount the brakes used to get more safe lifting. Any air outlet could be covered with plastic pieces with a sealant to prevent the air leakage.

Different kinds of buttons are used for the elevator model. Each floor has a one button to give an order for calling the cabin to a certain floor according the passenger's request; the buttons are similar to the buttons used for a real elevator. Finally, a main black switch is used to turn off/on the whole system. The red bottom is used to reset the PLC as shown in Fig. (2-a). After that, the assembling steps of the system components and how connecting those to the PLC controller would be accomplished. The PLC controller is connected to all the previously mentioned inputs and outputs. Numbering method shown in Fig. (2-b) is executed for arranging wires and preventing the interlacement between them and makes one easily dealing with electrical connection in the system.

4.2. Software Implementation

The elevator system software had been programmed according to the actual algorithm of the elevator traffic management. The integration of the hardware and software executes the simulated function of a primary elevator system. All the functions of the elevator control systems are carried out using the PLC programs. These functions are including registration, displaying the messages about the floors, monitoring the door opening and closing, monitoring the safety system, prioritizing the hall-call, and car-calls. PLC unit receives the input signals from the various sensors and the corresponding outputs such as floor lamps, hall call lamps, opening and closing door opens, etc are generated.

The PLC software is written in Ladder GMWIN 4.18 diagram. The PLC software firstly checks the floors status (scanning), the up and down elevator movement, the door opening and closing by using servo DC motors. After that, the Ladder program is executed in the system for controlling all the programmed movements in time. The detailed procedure of the elevator control system can be clarified with the help of the process flowchart demonstrated in Fig. (5).

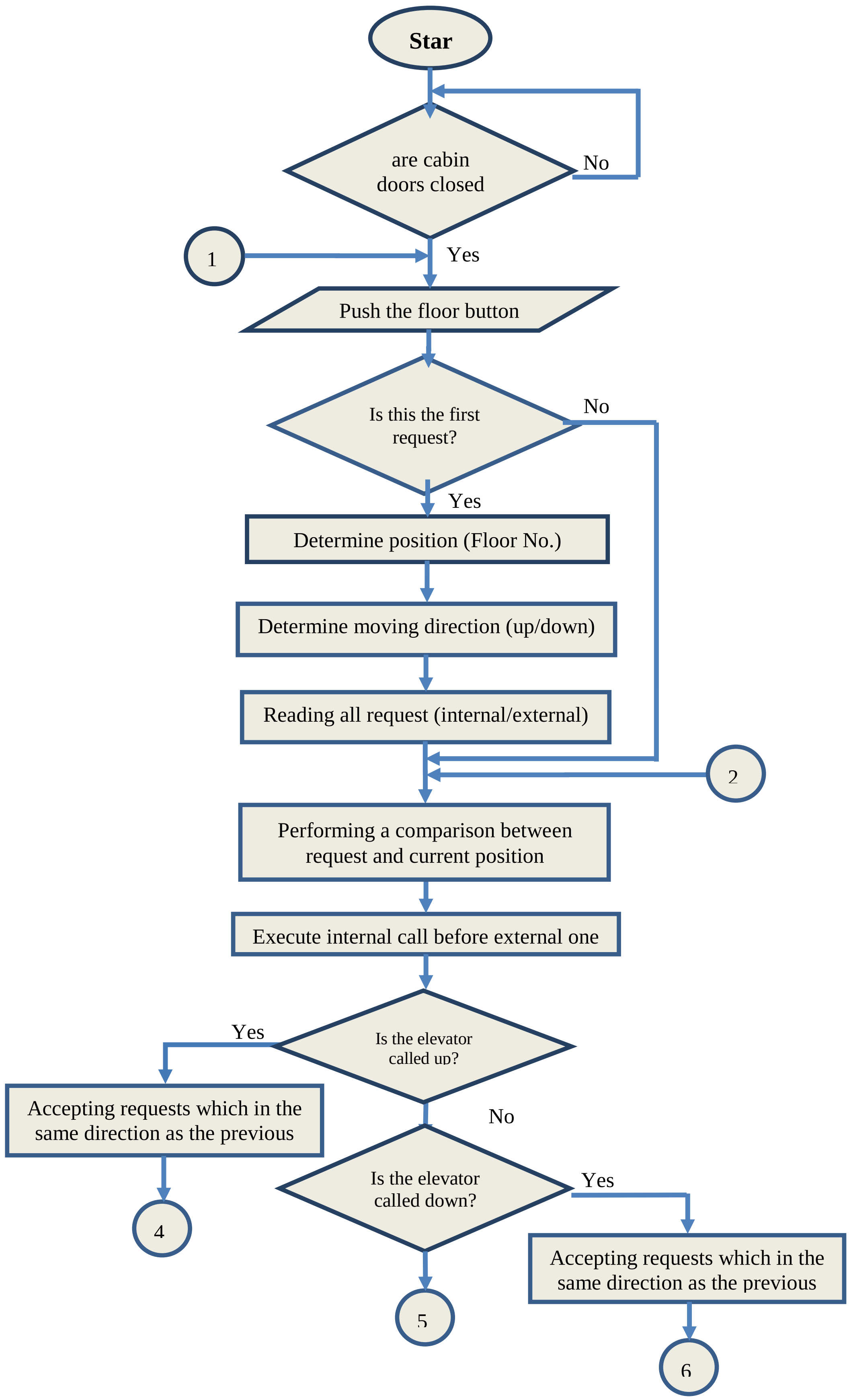


Fig. (5) Flow chart of Elevator system

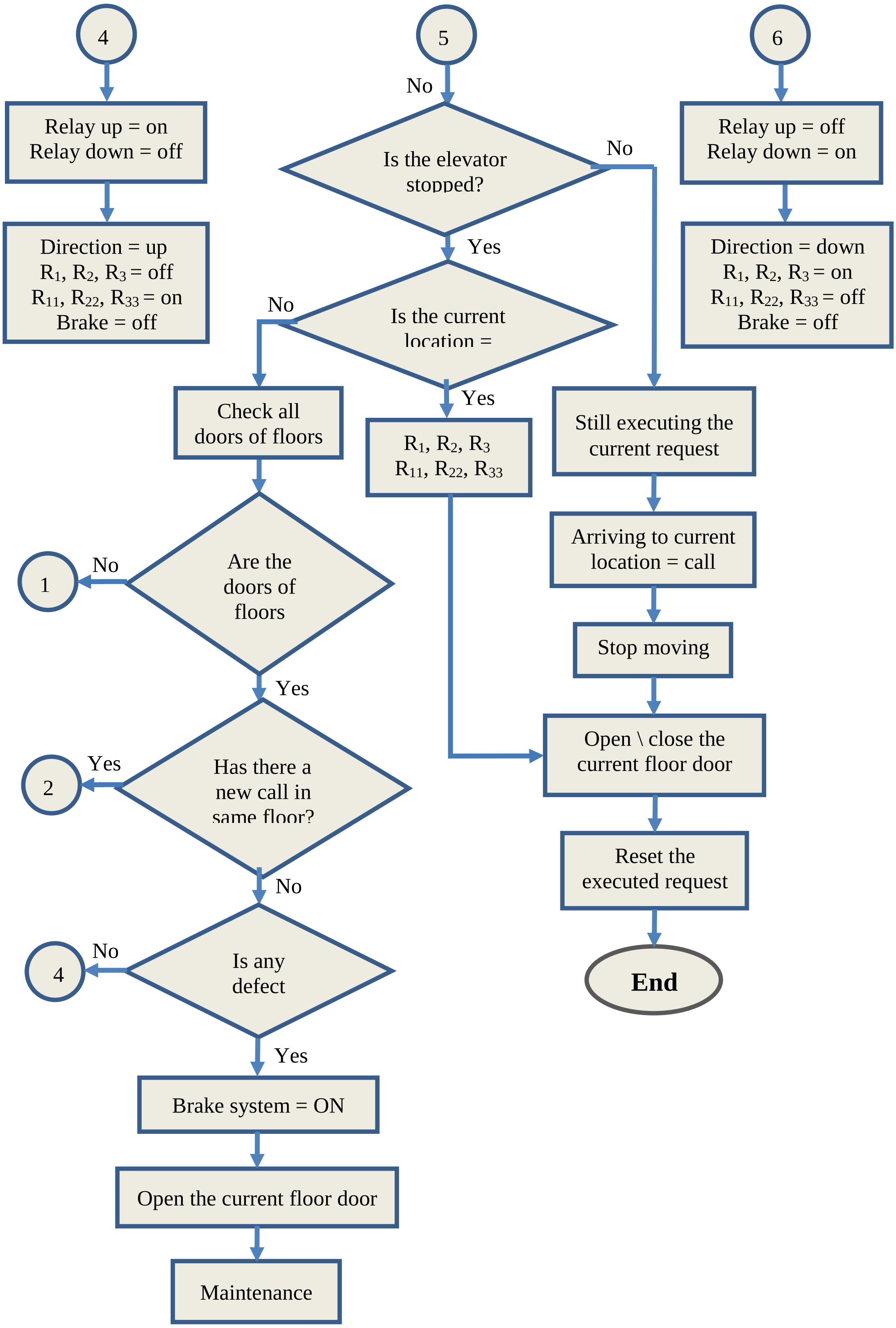


Fig. (5) Continues

5. Results and Discussions

Depending upon basic concepts and definitions concerning the electro-pneumatic vacuum elevator, as well as, the implementing procedures previously explained, the experimental results are obtained and discussed in this Section.

5.1 Calculating the power required

The electrical power required to move the cabin in elevator prototype with constant speed of (13.75 cm/s) during a time of about (8 sec) along the whole elevator path of (110 cm) might be calculated by measuring the corresponding values of voltage and current required for the vacuum compressor for each value of load weight in the cabin elevator as demonstrated in Table (1):

Table (1): Compressor ratings versus load weight

Weight (kg)	Voltage (V)	Current (A)	Power (W)
0	46	1.19	54.74
1	54	1.36	73.44
2	60	1.53	91.8
3	68	1..65	112.2
4	79	1.87	147.73
5	82	2.11	173.02
6	96	2.34	224.64

5.2 Elevator simulator

It is required to design and implement an elevator control system. An elevator simulator by software (using LabVIEW) is pre-built and equipped with a car that travels through three floors, a car hoist system that uses a vacuum compressor, floor sensors to detect the position of the car, and an elevator call pushbutton on each floor.

A data acquisition system with analog I/O and digital I/O capability is used. The LabVIEW software and hardware interfacing electronics for the simulated elevator control system was designed such that it mimics the operation of a typical elevator.

Both hardware and software design are required for interfacing the elevator to a PC-based DAQ system for a measurement application. Floor sensors on the elevator are used for controlling the position of the car.

The experimental results were carried out in the laboratory of Fluid in Machinery and Equipment Engineering in the University of Technology/Baghdad.

These results were obtained from the Labview software connected with Arduino board in the test rig shown in Fig. (6), by means of a load sensor and pressure sensors for monitoring different cases results.

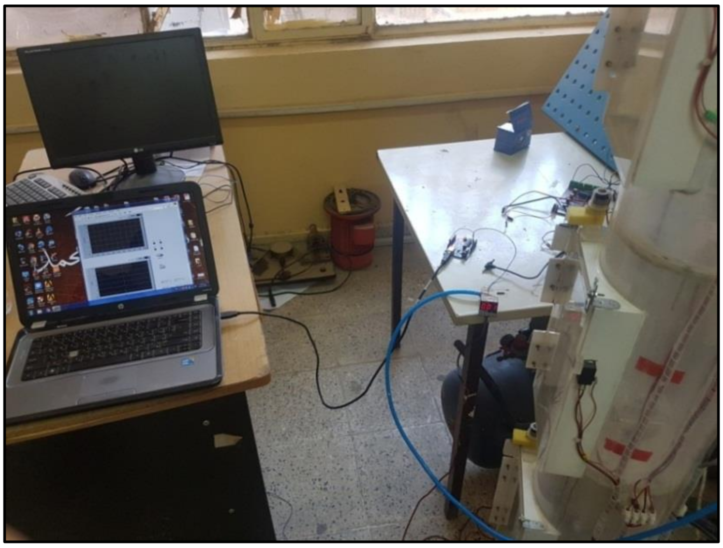


Fig. (6) Experimental setup interfacing to a PC-based DAQ system

An order pattern of floor levels (floor 1 → floor 2 → floor3 → floor 2 → floor 1) is proposed to obtain the pressure curves with time for different cases of loading as shown in Figs. (7 & 8). The proposed load cases are: no-load and 6 kg (max. allowable load weight).

A. No-load case

In this case, the whole weight of the cabin including the brake weight is found almost equal to (2kg).

Applying the proposed sequence order, the instantaneous pressure curve is shown in Fig. (7).

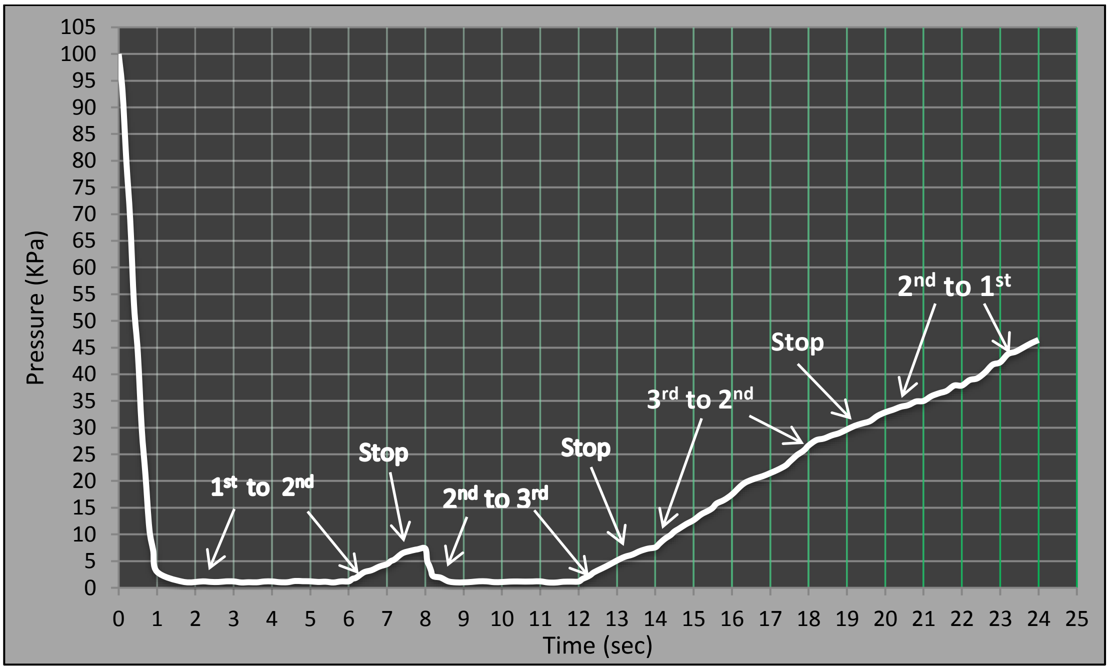


Fig. (7) The instantaneous pressure curve at no-load

In this figure, the pressure curve could be divided into 7-intervals as follows:

In the interval (0 ~ 2 sec), the elevator is at the rest in the first floor until reducing the pressure from 100 kPa to ~ 1.2 kPa to start the cabin movement. In the interval (2 ~ 6 sec), the cabin is in the rising mode from the first floor to the second floor with a constant pressure of about 1.2 kpa (or 0.012 bar) and constant speed of a 13.75 cm/sec. In the interval (6 ~ 8 sec), the cabin is stopping in the second floor and the door opens for 2sec and then closes causing some air leakage through the door edges, causing the pressure to rise until finally reaches 7.5 kPa (or 0.075 bar). This value is larger than the designed pressure because of the lost happening in pressure due to the air leakage. In the interval (8 ~ 12 sec), the pressure begins to reduce maintaining the pressure on 1.2 kpa rising the cabin to the third floor with speed of 13.75 cm/sec, and then finally the brake is closed when cabin stops at the third floor, and its door open for (2 sec) with some air leakage, causing the pressure to rise until finally reaches 7.5 kPa. In the interval (12 ~ 14 sec), the cabin stops at the third floor. In the interval (14 ~ 18 sec), the compressor is switch off, all the valves are opening to raise the pressure above the cabin to make it moves down to the second floor. In the interval (18 ~ 20 sec), the cabin stops in the second floor and its door open for (2 sec) with some air leakage. In the last step, the interval with (20 ~ 24 sec), the cabin goes back to the first floor.

B- Payload of (6 kg)

Same procedures above could be followed for all cases of load weight and floor level patterns.

Increasing the payload to (6 kg) with the floor levels of (1→2→3→2→1) pattern creates a pressure curve shown in Fig. (8).

In the interval from (0 ~ 2 sec), the elevator is at the rest at the first-floor until reducing the pressure from 100 kpa to ~ 3.36kpa (or 0.0336 bar) during 0.9sec to start the cabin movement. In the interval (2 ~ 6 sec), the cabin is in the rising mode from the first floor to the second floor with about 3.36kpa pressure with constant speed of 13.75 cm/sec, and then stops in the second floor at a time equal 6sec and the brake is closed. In the interval (6 ~ 8 sec), the cabin is stopping in the second floor and the door opens for 2sec and then closed with some air leakage causing the pressure to increase to ~ 10.1 kpa. In the interval (8 ~ 12 sec), the cabin again will be in running mode causing the pressure to reduce to 3.36 kpa with speed of 13.75 cm/sec and finally the brake is closed at the third floor. In the interval (12 ~ 14 sec), the cabin stops in the third floor and its door opens for (2 sec) with air leaking causing pressure increase to value of ~ 10.21 kpa. In the interval (14 ~ 18 sec), the compressor is turn off, the brakes are opening and the cabin moves down to the second floor. In the interval (18 ~ 20 sec), the cabin stops in the second floor and its door opens for (2 sec) with air leakage and pressure rise to ~ 21 kpa. In the last step, the interval with (20 ~ 24 sec), the cabin goes back to the first floor, all valves are closed and the compressor is turned off, the cabin again come down to the first floor.

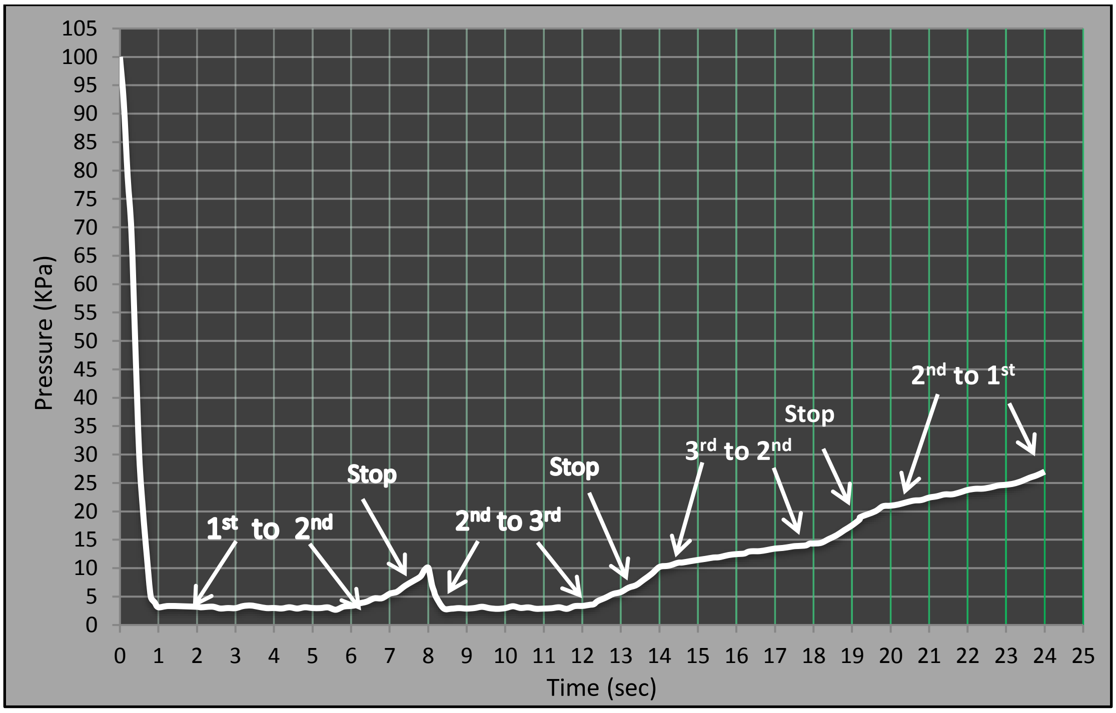


Fig. (8) Instantaneous pressure curve at (6 Kg)

6. Conclusions

The Electro-pneumatic vacuum elevator is revolutionary technology firstly established as a concept modified for vacuum elevator when the compressed pressure air idea is replaced by vacuum air. This paper aims to implement a prototype model of three level electro-pneumatic vacuum elevator system controlled by a PLC. The current elevator is implemented to demonstrate and simulate the operations of the real elevator. Some conclusions may be drawn:

1- This elevator is easier to install, operate and maintain than the other types of elevators.

2- Its construction does not need the costly and heavy machinery. This considerably reduces its construction cost.

3- It has zero energy consumption during its descent. While, ascending it requires the use of a 220V vacuum engine. This makes it one of the most energy efficient devices of the modern times. So, this technology agrees with the energy saving and minimization of energy consumption.

4- The pneumatic elevator does not simply fall, thereby making it the safest elevator. Even during a power failure, the elevator automatically descends to the ground floor, as it requires no power for descent.

5- Starting and stopping operations are extremely smooth.

6- Electric circuits within the cabin are 24 volts, eliminating the risk of shock.

7- The proposed prototype elevator system can be invested for educational purposes.

CONFLICT OF INTERESTS.

- There are no conflicts of interest.

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تنفيذ نظام مصعد أوتوماتيكي مفرغ

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الخلاصة

في السنوات الأخيرة أصبح مَصعَد الفراغ الهوائي هو خياراً شائعاً في بيوتِنا والبنايات المنخفضة. يمثّل مَصعَد الفراغ الهوائي مَفهوم جَديد مُطوّر عن فِكرة استبدال الهواء المضغوط بالهواء المُفرّغ. إنّ مَصعَد الفراغ الهوائي قادر على نقل الأشخاص بين طوابق بناية بدون إستعمال لأيّ أحبال، أو أوزان، أو بكرات. في البحث الحالي تَمّ تركيب وتنفيذ نموذج لمنظومة مَصعَد فراغي كهرو هوائي بسيط ومُنخفض الكُلفة. نموذج نظام المصعَد يتألف من ثلاثة طوابق ويَرفع حُمولة 6 كيلوغرام. تَمّ تَوظيف المُسيطر المنطِقي القابل للبرمجة (PLC)، من سلسلة (LS\GLOFA-G7M-DR30U) ذو (16) مَدخل و(12) مَخرج ومُبرمج ببرامج المُخطط السُلمّي (Ladder)، للسيطرة المُؤتّمَتة الكامِلة على مَنظُومة المَصعَد. مِن المتوقع أن تَنتَشر فِكرة نِظام المَصعَد المُقترح على نحو واسع في البنايات السَكّنية الواطِئة.

الكلمات الداله: الكهروهوائي، مصعد الفراغ، PLC.