Automatic Pump Down Air Conditioning System for Refrigerant R22 Split Unit

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Abstract
Pump down is a process of pumping and storing refrigerant from the air conditioning system into an outdoor unit using a solenoid valve in the liquid line. The conventional method would be to pump down the refrigerant manually before conducting maintenance to the air conditioning system. Industrial refrigeration units use massive amounts of refrigerants. Without a pump down process, the liquid refrigerant would be sucked out from the evaporator and enter the compressor. Compressors do not pump liquid therefore the compressor would be destroyed if a large amount of liquid is found in the compressorhe result shows that 99.98% refrigerant were able to recovered. Hence, this project focused on developing an automatic pump down system. For the purpose of this study, an air conditioning system with 1 horse power (hp) capacity was mounted with two sets of pressure switch and solenoid valve. Once the desired temperature is reached, the thermostat will open and the valve will close. The compressor will then continue to run and evacuate any refrigerant from the solenoid valve's outlet, including the compressor. The system will continue to pump the remaining refrigerant into the outdoor unit. The whole system will completely shut off after all refrigerants were safely kept inside the outdoor unit. Based on the findings, the process of reducing and controlling refrigerants leakage from the air conditioning system is more efficient and effective when applying pressure of 110 psi.

Keywords: pump down, efrigerant leakage, ozone depletion

1.0 Introduction

Air conditioning or more often referred as "air-cond or AC" are often used in domestic as well as commercial sectors. Air conditionings help to achieve a more comfortable and conducive environment, typically for living beings. In industrial sectors, air conditioners are used to cool and dehumidify rooms contained heat-producing machineries and electronic devices, such as computer servers. Depending on the purpose of the air conditioner, some air conditioners may require frequent maintenance. It is imperative that the air conditioning system must be in a leakage free condition. Air conditioners contains refrigerant, which act as a heat transfer agent. Hence, a close cycle system is needed to control the pressure and to prevent the system from operating abnormally. Under certain circumstances, a leakage may occur and refrigerant will be loss. This reduces the operating efficiency of the system, and eventually attracts negative impacts to the environment as well as operation productivity.

Hence, this study aims to build a system that triggers any refrigerant leakage and automatically pump down the refrigerant into the system.

Refrigerant leakages sometimes occur between the air conditioning pipes and the connection components. This is due to poor workmanship during installation process or it could be from wear and tear process. When refrigerant leaks from the air conditioner, it reduces the efficiency of the air condition system, which leads to increase in power consumption and greenhouse gas emissions. This triggers high maintenance costs and eventually will lead to system failure (Grace, Datta, & Tassou, 2005). Compressor is an important component in an air-conditioning system. When there is an insufficient amount of gas, the compressor would have to exert more power which then caused the compressor to malfunction and the ampere will increase. This is because the compressor does not have any refrigerant to compress. When the compressor operates on low pressure refrigerant, the compressor will be damaged as it impacts on compressor motor winding. According to (Rodriguez, 1995) refrigerant undercharging creates a higher than normal superheat as well as lower sub cooling and decreases the system's capacity. Refrigerant loss in the compressor will cause the compressor to operate with high vibration and noise, leading to further damages. Furthermore, the high expenditure will be incurred in order to replace the damaged compressor together with the labor cost. Apart from that, very limited study is done on refrigerant, hence limited knowledge regarding the air conditioning maintenance.

Refrigerant leakage contributes to ozone depletion and global warming. Chlorofluorocarbons (CFCs) and Hydro chlorofluorocarbons (HCFCs) are refrigerants used in air-conditioning split unit that may cause depletion of ozone layer (Kaur & College,2015) states that 'Chemical reactions on the surfaces of ice crystals in the clouds release active forms of CFCs. Ozone depletion begins, and the ozone "hole" appears'. Individuals involved in refrigeration and air-conditioning industry must be aware that there is a chemical reaction contributing to ozone depleting refrigerant and global warming.

2.0 Research objectives

This study aims to build a system that triggers any refrigerant leakage and would automatically pump down the refrigerant into the outdoor system. In order to achieve this aim, three objectives were set. There are:

i. To design and fabricate an automatic pump down system
ii. To install the automatic pump down system; and
iii. To analyze the capability of the system when set at various conditions.

3.0 Methodology

The overall methodology used in this project was divided into three stages: design selection, fabrication, and analysis as shown in Figure 1. The first stage would be the design selection stage. At this stage, the system has to be selected, the purpose of the design was established, a bill of material was created, and the material selection was made. The second stage would be the fabrication stage. At this stage, the outdoor unit was assembled, wiring connections were done, programming and installations of softwares, vacuum, charging the refrigerant, and leakage test was performed. The final stage would be analysis stage, where the experiment was set up, run, and the results were obtained and analysed.

These three section are interchangable where the process could take one step back if an error was encountered.

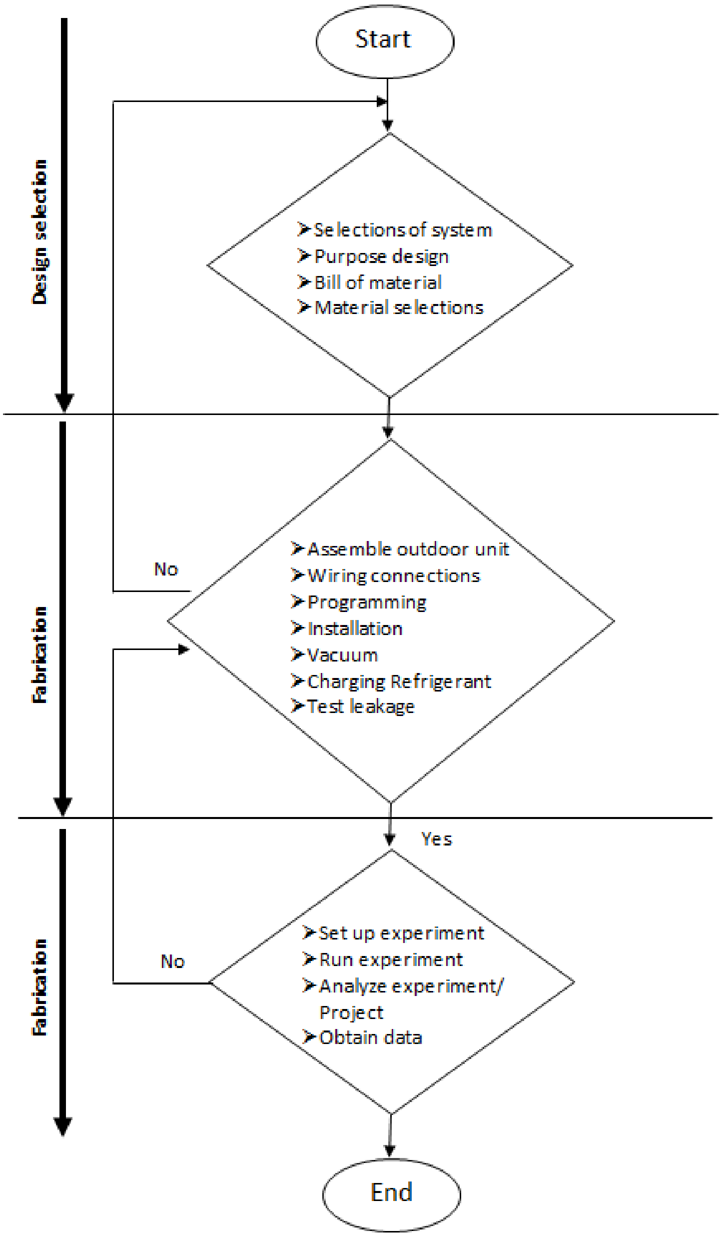

Figure 1: Methodology flowchart

3.1 System components

The construction of the automatic pump down design was consisted of four major components which are the air conditioning unit, the low pressure switch, the solenoid control valve, and the refrigerant. Light indicator was utilized to indicate the ongoing operation of the system. Table 1 summarizes and describes each component used in this design.

Table 1: System components

Item	Quantity	Specifications	
AC (outdoor unit)	1	Brand	Acson
		Model	ALC 10N-AMHOH
		Series Number	20534002-66767
		Rated current (A) Maximum	4.21A
		Type Refrigerant	R22
		Weigh refrigerant	0.60kg
		Rated power supply	220-240 V 1 Phase 50Hz
		High side pressure	29.9 Bar/433.60 Psi
		Low side pressure	15.5 Bar/244.80 Psi
Solenoid valve	2	Brand	Castel
		Maximum pressure	45 Bar/625 Psi
		Type Refrigerant	HCFC and HFC
		Rated power supply	220-240 voltage
		Temperature range	-35 °C to 110°C
Pressure switch	2	Maximum pressure	Castel
		Type Refrigerant	45 Bar/625 Psi
		Rated power supply	HCFC and HFC
		Temperature range	220-240 voltage
		Maximum pressure	-35 °C to 110°C
Refrigerant	1	Refrigerant R22: 13 kg, Boiling point -40.81°c, critical pressure 4990 kPa. Tank colour green.	

3.2 Proposed design

The single split Acson air conditioning (1.0 Hp) was modified as shown in Figure 2. The modification process was done in which a solenoid control valve and a low pressure switch were installed after the indoor unit between the 3-way control valve and compressor, as well as before the indoor unit between the 3-way control valve and the capillary tube.

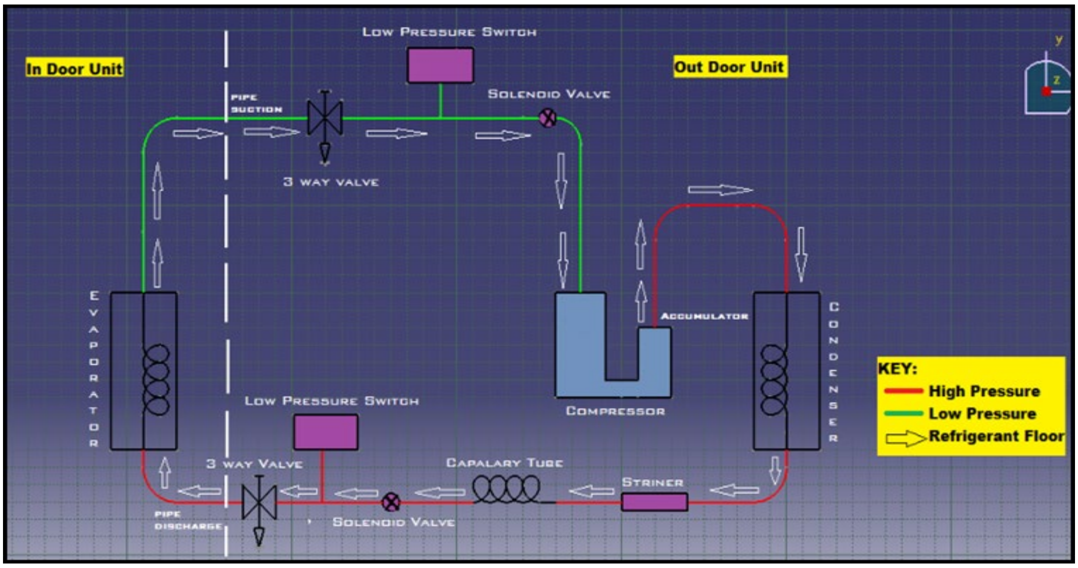

Figure 2: Schematic drawing of modified outdoor unit

When cooling is needed, the 3-way valve will open and the refrigerant soon enters the evaporator. The pressure will continue to increase until the low pressure control closes. When low pressure is set, the switch will detect any changes in the refrigerant pressure. This is when the condensing process starts until the desired temperature is reached. Once the desired temperature is reached, the thermostat would then open while the solenoid valve will block the refrigerant. Concurrently, the compressor will start to operate and pump out all the refrigerant from the evaporator into the outdoor unit. When the low pressure control opens up, the compressor will stop. Concurrently, indicator light (red) will light up to signal that the pump down process is complete. Figure 3 shows modification wiring for outdoor unit.

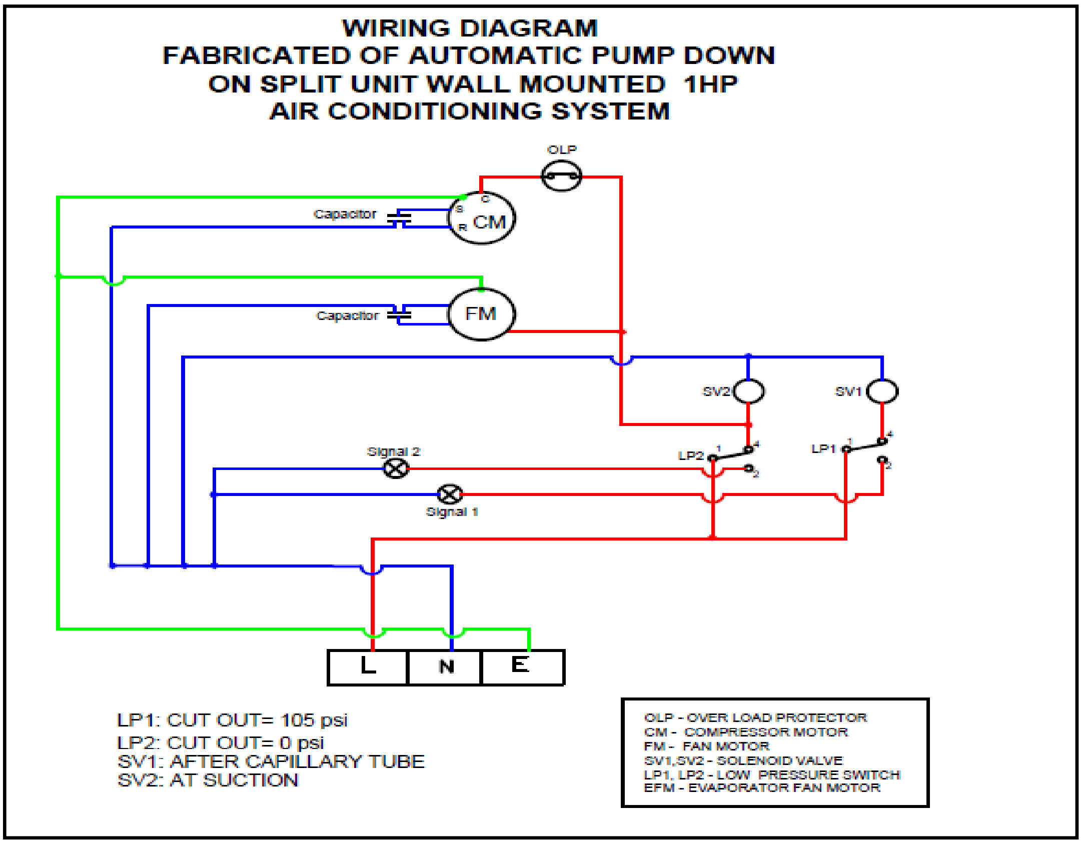

Figure 3: Wiring diagram fabricated of automatic pump down on split unit wall mounted 1hp air conditioning system

3.3 Experiments for system capability

An experiment was conducted to show the relation between current, time, and the refrigerant amount against the pressure switch setting. In this experiment, the pressure switch will be a manipulative variable. The pressure switch setting was set depending on the refrigerant capacity in the system. When less pressure is applied, the pressure switch will automatically detect the lack of refrigerant and the solenoid valve at the discharge pipe will automatically turn off and overall refrigerant will be stored in the outdoor unit. If the pressure switch at the suctions pipe was set at zero, the pressure will also be zero and the solenoid valve at the suction will turn off as well. The pressure switch at the suction will cut off the current supply to the outdoor unit. During this process, the indicator may display green light if the pump down process is still ongoing. After the process is complete, the indicator may display red light instead.

The experiment set up followed a series of steps and procedures which include initial set up for variables as well as keeping records and observation for the desired parameters. The set up started by firstly setting up a low pressure to the suction pipe at 0 psi. Secondly, set the pressure switch in the discharge pipe at 110 psi. Thirdly, run the system. Next, observe the readings of the electric current and the pressure refrigerant using a clamp meter and manifold gauge attached to the outdoor unit. Next, release refrigerants to the service tank. At the same time, observe the low pressure switch as the switch is able to detect low pressure. Next, observe the solenoid valve operation to see whether or not it achieves 0 psi. Difference in pressure will cause the operation of solenoid valve to open and close. Next, observe operations outdoor unit shut off or not after completing the pump down process. If the pump down process is still ongoing, the indicator will be in light green. Once the operation is completed, the indicator will be in red. Lastly, record the time taken for the pump down process, total refrigerant balance saved in the outdoor unit and current electric. The total amount of refrigerant balance that was able to save in the system can be identified by observing the reading of the weight of the refrigerant inside the service tank used in the weighing scale. Repeat the experiment by setting the low pressure switch at 105 psi, 100 psi, 95 psi, 90 psi, 85 psi and 80 psi respectively.

4.0 Result and discussion

For the purpose of this study, the initial weight of the refrigerant R22 used is 600 grams. This analysis was based on the setting of the pressure switch during the experiment was conducted. The data were obtained from the amount of refrigerant balance stored in the outdoor unit, the time taken to process pump down system and the amount of current as shown in Table 4.

Table 4: Summary data from experiment 1-7

Experiment	Pressure switch setting (Psi)	Amount refrigerant balance (Gram)	Time(Sec)	Current (Amp)
1	110	600	13.62	3.8
2	105	599.97	13.00	3.7
3	100	599.88	12.20	3.6
4	95	599.74	10.75	3.5
5	90	599.57	10.29	3.4
6	85	599.35	10.23	3.3
7	80	599.15	8.96	3.2

Figure 4 represents the relation between current, time, and the refrigerant amount against the pressure switch setting. It shows that when the pressure switch is set at 110 psi and there is 600g of refrigerant stored in the outdoor unit, it would take 13.62 seconds to pump down the refrigerant with 3.8 amps of current. Next, the pressure switch is set at 95 psi and the electric current was reduced to 3.5 amps, the graph shows that it would take 10.75 seconds to pump down the refrigerant and the weight of the refrigerant stored decrease by 599.74g. When the pressure switch is reduced to 80 psi and the current is at 3.2 amps, the result shows it took 8.96 seconds to pump down and the amount of refrigerant left is 599.15g.

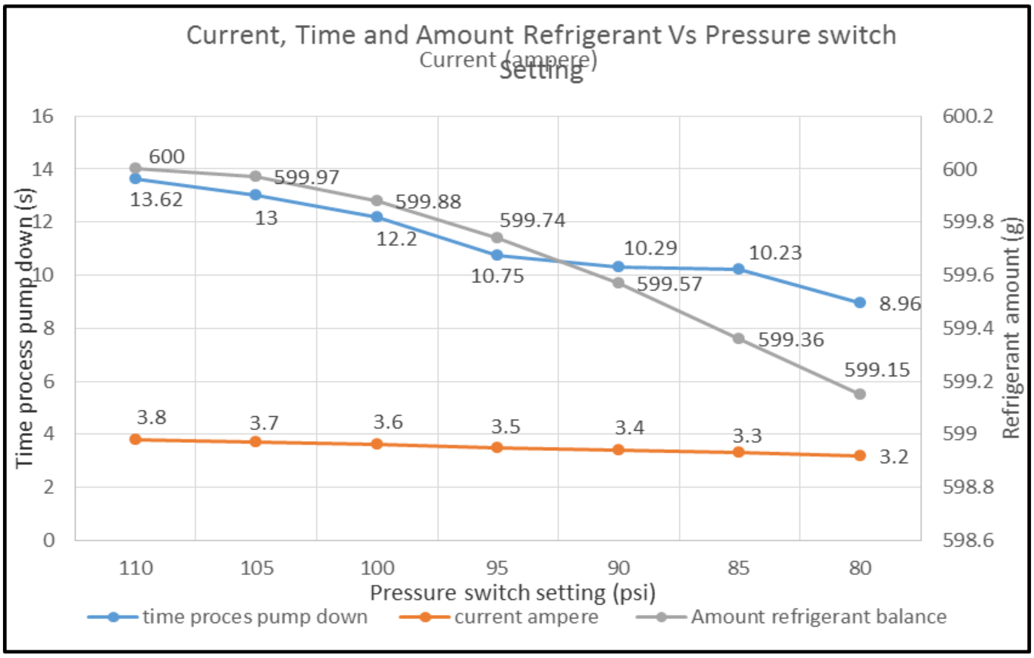

Figure 4: Current, time, and amount of refrigerant against the pressure switch setting

Hence, it can be observed that the content of the refrigerant is directly proportional to the pressure of the refrigerant. Another observation that can be made is that current is directly proportional to the pressure refrigerant. Based on Figure 4, it can be observed that between 10.75 sec to 10.23 sec, the graph only shows a minimal change. This is due to the refrigerant that was stored in the service tank could be almost full. Had the refrigerant was released to its surrounding, the graph would most likely to drop drastically.

Based on Table 5, it can be concluded that 110 psi is best to apply when reducing and controlling refrigerant leakage from the air condition. This is because of the massive amount of refrigerant that can be saved despite a slightly longer time was needed to pump down the refrigerant. It can protect and reduce the risk of damage to the compressor as compared to when the pressure switch setting is set at 95 psi and 80 psi. Life span of a compressor is very vital for the efficiency of the system. Compressor is the heart of the air conditioning system. If a fault occurs, the system may not be as efficient as it is designed to be.

Table 5: Results of various pressures switch setting

Pressure switch setting (psi)	Amount refrigerant balance (g)	Time (Sec)	Current (Amp)
110	600	13.62	3.8
95	599.74	10.75	3.5
80	599.15	8.96	3.2

However, this project also has its own limitations and constraints. For the purpose of this experiment, 1hp of air conditioning split unit constant type of Acson brand was used. Although there is a difference of hardware used, the simulation, nonetheless, remains the same. Cost wise, the experiment is limited to air conditioning of one brand and type only, as well as its capacity due to budget constraints.

5.0 Conclusion

Based on the problem statement identified, it can be concluded that fabricating an automatic pump down system could be a solution. Due to various factors, leakages often occur between the pipes connection and its components. Hence, preventive measures have to be taken to prevent refrigerant leakages as it may contribute to other environmental problem, which indirectly affects human health. It is highly significant for the users to reduce the damage of the air conditioning system at the same time, reducing ozone depletion and global warming. This project had achieved the objectives of the study where it aims to reduce and control refrigerant leakage from the system. If damage system is reduced, it would be beneficial in terms of cost and environment.

References

ASHRAE. (2014). *ASHRAE position document on refrigerants and their responsible use.*

Grace, I., Datta, D., & Tassou, S. (2005). Sensitivity of refrigeration system performance to charge levels and parameters for on-line leak detection. *Applied thermal engineering, 25*(4), 557-566.

Guechi, A., Chegaar, M., & Aillerie, M. (2012). Environmental effects on the performance of nanocrystalline silicon solar cells. *Energy Procedia, 18*, 1611-1623.

Kaur, R. & College, R.S.D.,(2015). *Ozone Depletion : Its causes, effects & protective measures. , 4*(8), pp.12–16

Rodriguez, A. G. (1995). Effect Of Refrigerant Charge, Duct Leakage, And Evaporator Am Flow On The High Temperature Performance Of Air Conditioners And Heat Pumps. *Energy Systems Laboratory report for EPRI,* Texas A&M University.

Technologies, E. C. (2007). *Solenoid valves and their importance in refrigeration systems.*

Walker, R. (2015). *Basic operation of automatic pump down medium temperature walk-in coolers.* Retrieved from

https://www.hvactrainingsolutions.net/basic-operation-of automatic-pump-down-medium-temperature-walk-in-coolers/