



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**DEVELOPMENT OF PORTABLE LIFTER TO LIFT OUTDOOR
UNIT FOR SPLIT TYPE AIR-CONDITIONING**

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Mechanical Engineering Technology (Refrigeration and air-conditioning system) with Honours.

by

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Refrigeration and air-conditioning system) with Honours. The member of the supervisory is as follow:

.....

(Amir Abdullah bin Muhamad Damanhuri)

ABSTRAK

Aktiviti ergonomik berhubungkait dengan kemalangan di tempat kerja. Selain itu, ergonomik dan keselamatan juga berkait rapat antara satu sama lain untuk memastikan keselamatan masyarakat. Kajian terdahulu mengatakan bahawa sebanyak 90% daripada 112 rumah telah memasang penghawa dingin bilik di rumah rakyat Malaysia. Pemasangan pemeluwap untuk penghawa dingin menjurus kepada beberapa masalah iaitu tidak ergonomik dan kurang faktor keselamatan. Permintaan pelanggan terhadap penghawa dingin mini tidak berpaip di Malaysia bermula pada 2013 sehingga 2015 adalah sebanyak 2,407 pemasangan. 30 set borang soalan tinjaun telah diedarkan untuk membina kaedah "House of Quality". Kemudian, perisian SolidWork telah digunakan untuk mereka bentuk produk pengangkat mudah alih untuk pemeluwap ini. Produk ini direka untuk mengangkat pemeluwap sehingga ketinggian 8 kaki. Penggunaan nisbah gear untuk "hand-winch" dalam produk ini adalah 3.40. Tambahan pula, penggunaan nisbah gear yang sesuai untuk mengangkat 2HP adalah 5.33 dimana berat pemeluwap tersebut adalah sekitar 40kg. Jadi, produk ini mampu mengangkat pemeluwap sehingga 70kg. Selain itu, produk ini juga direka untuk mengurangkan tenaga dan meningkatkan faktor keselamatan kepada pekerja.

ABSTRACT

Ergonomic activity significantly reliant with accidents at workplaces. Besides, ergonomic and safety are related with each other to keep society safe. Earlier study stated that 90% of 112 houses install Room Air-Conditioning in Malaysian home. Installing air-conditioning outdoor unit led into several problems which is un-ergonomic and less safety factor. Ductless Mini-Split Air-Conditioner demand in Malaysia from 2013 until 2015 was 2,407 thousand installation. 30 sets of questionnaires have been distributed to develop the House of Quality. Then, SolidWorks software has been used in designing portable outdoor unit lifter. This portable outdoor unit lifter could lift outdoor unit until 8feets. The used of hand-winch gear ratio was 3.4 in this product. In addition, the appropriate gear ratio was 5.33 for 2HP outdoor unit which weight around 40kg. Thus, this product also can handle up to 70kg of outdoor unit. Hence, this project developed to reduce energy and increase safety factor to workers.

DEDICATION

I dedicate this project to Allah Almighty my creator, my strong pillar, my source of inspiration, wisdom, knowledge and understanding. He has been the source of my strength throughout this program and on His wings only have I soared. I also dedicate this project to my family who has encouraged me all the way and whose encouragement has made sure that I give it all it takes to finish that which I have started. This project also is especially dedicated to my supervisor, for his willingness to guide me to the success of project for my degree.

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LIST ABBREVIATIONS, SYMBOLS AND NOMENCLATURES

ft	- Feet
GR	- Gear Ratio
HOQ	- House of Quality
HP	- Horse power
HSS	- High strength steel
kg	- Kilograms
mm	- Millimetres
Mpa	- Megapascals
MSDs	- Musculoskeletal disorders
OSHA	- Occupational Safety and Health Administration
RAC	- Room air-conditioning

CHAPTER 1

INTRODUCTION

1.0 Briefing

Ergonomic activity significantly related with accidents at workplaces (Picchio & van Ours, 2017). Majority of the workers done the task activities by neglecting the ergonomic features. Another one factor need to be considers in doing the task job is safety. Ergonomic and safety are related with each other to keep this society safe.

1.1 Project Background

Dangerous can be defined as any unsafe condition that can lead to workplace accidents. The dangerous cannot be eliminate perfectly, but can be reduces into almost zero percent. Therefore, safety factors are important to keep human stay health and does not involves in accident among the working activities. The safety implementation intends to keep the working activities avoided from any high possibility of risks. The task lead to problem if there are no safety implementation. Split type air-conditioning installation got highest demand until now. But, un-ergonomic task existed while the installation of outdoor unit. This ergonomic take an interest about the capabilities and limitations of the people in daily life. The aims of ergonomic is to ensure the tasks, equipment, information and environment fit each worker in charged. There is several individual characteristics involved in ergonomic factor which is body shape, strength, posture and experiences. In common, small body shape of human cannot afford to carry and lifting the heavy stuff by their

strength. Only the suitable and correct equipment could help them to do the tasks. By applying the ergonomic factors to the workplaces, it can reduce the percentage of danger and improve the working performance and productivity (Health and Safety Executive, 2013).

1.2 Problem Statement

Nowadays, air-conditioning expert workers pursue to fulfil air-conditioning demands by customers. Earlier study also stated that 90% of 112 houses install Room Air-Conditioning in Malaysian homes (Jaafar & Croxford, 2010). Majority of Ductless Mini-Split Air-Conditioner installed in bedrooms and used during sleeping hours. Due to statistics mentioned before, it is confirmed that there are many outdoor unit installation has been done to ensure the system work well. Implications from split type air-conditioning installation lead to un-ergonomic and dangerous activity to lifting outdoor unit into appropriate position. Hence, installing air-conditioning outdoor unit facing several problems which is un-ergonomic and less safety factor. It could cause dangerous during the activity. This lead the activity is not ergonomic and less safety features. Figure 1.1 illustrated the situation. Before the fabrication of portable outdoor unit lifter, the dimension of outdoor unit need to be familiarized. The design was an actual prototype, means the product truly can lift the outdoor unit. By implement this innovation, the workers no longer need to lift the outdoor unit of split air conditioner by their strength while install the outdoor unit.



Figure 1.1 Man power to lifting outdoor unit

1.3 Proposed Solution

Information above lead to the purposes of this project. This project focused to fabricate the portable outdoor unit lifter that could ease the worker to install the outdoor unit. Man power to lift the outdoor unit may be reduces through this project. Therefore, the criteria of this project have been set which could reduce the man power.

1.4 Objective

There are a few targets to be achieve in this project. These objectives should be achieved in the end of the project. Therefore, the following below are the objectives that has been considered:

1. To design the portable outdoor unit lifter by using SolidWorks software.
2. To fabricate portable lifter for lifting split outdoor unit for up to 70kg.

1.5 Scope

This project focused on designing and fabricate the portable lifter for lifting the outdoor unit in reducing the man power to installing the outdoor unit. Several limitations have been determined through this project. 8ft has been set as limitation for length of the lifter can reach in height from the floor. The product design requires the base as stable as possible to avoid the outdoor unit fall during the lifting activity. Besides, this product designed to lifting the outdoor unit of Ductless Mini-Split Air-Conditioner type only. Person are not allowed to be lift by this product in considering the safety factors. According to the Panasonic installation manual, the weight of common 2HP outdoor unit are in the range 64kg. Hence, the limitation weight of the outdoor unit has been set until 70kg only. The weight above the limitation that has been set are not allowed to be lift by this product.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

According to previous research, circulation shape of workplace injuries and risk has been identified. Vulnerable workers was a term labelled for group at higher risk of work-related injury (Lay et al., 2017). This kind of society also suitable to refer the workers that installing outdoor unit of Ductless Mini-Split Air-Conditioner. In common, strength of workers needed to lift outdoor unit. This kind of case caused many company should provide any procedure and safety factors to prevent the accident occurs. Previous studies also shown that many company take proactive department to ensure workplace risk prevention follows the minimum legal requirements (Pouliakas & Theodossiou, 2013). Company license could be declared uncertified since the safety benchmarks are not been maximized. Uncertified license could conduct into dangerous happened by careless. Next, design concept considered as important to fabricate portable outdoor unit lifter. Design concept must relate with all safety factor and criteria. By fulling the requirement needed, it can reduce danger percentages in workplace. This chapter lead the research about linked topic to fabricate the portable outdoor unit lifter.

2.0.1 Statistic of air-conditioning installation

Nowadays, air-conditioning became important thing in daily life to gain thermal comfort due to rising number of air-conditioning used (Yu, Li, Yao, Wang, & Li, 2017). This thermal comfort related to individual

perception toward the environment to did their jobs (Wang, 2000). Most common type of air-conditioner used in residential area was Room Air-Conditioning (RAC). This type of air-conditioner does not use ducting as air distribution medium into the zone area. RAC divided into two which is window type and split type. Split type of air-conditioning also referred as Ductless Mini-Split Air-Conditioning.

Table 2.1 RAC demand by Asian countries in thousand (JRAIA, 2016)

RAC demand		2013年		2014年		2015年	
		Window-Type	Split-Type	Window-Type	Split-Type	Window-Type	Split-Type
World total		14,193	69,563	14,384	68,781	13,879	65,510
Japan			9,013		8,500		8,104
Overseas:		14,193	60,550	14,384	60,281	13,879	57,406
China		348	33,124	325	32,461	303	29,945
Asian countries		1,897	10,482	1,846	11,350	1,840	11,884
	India	747	2,698	703	2,971	705	3,142
	Indonesia	14	2,139	9	2,189	9	2,100
	Vietnam	3	953	2	1,176	2	1,544
	Thailand	5	1,067	3	1,200	3	1,265
	South Korea	12	656	12	656	11	656
	Taiwan	215	886	216	744	205	754
	Malaysia	4	817	5	806	5	784
	Philippines	405	203	418	210	425	226
	Pakistan	50	533	40	600	38	606
	Hong Kong and Macao	318	188	312	193	312	187
	Bangladesh	29	113	31	121	30	134
	Myanmar	4	113	4	170	4	170
	Singapore	5	135	5	130	5	125
	Cambodia	1	77	1	80	1	84
	Sri Lanka	25	48	25	49	25	52
	Others	60	55	60	55	60	55

RAC demand in Asian countries from 2013 until 2015 has been shown in Table 2.1. There is no window type installed in Japan from 2013 until 2015. Majority of Asian countries demands to install Ductless Mini-Split Air-Conditioner of RAC which is 11,884 thousand on 2015 rather than window unit type that shown only 1,840 thousand. In another point, overall Ductless Mini-Split Air-Conditioner demand in Malaysia from 2013 until 2015 are in number five which is 2,407 thousand installation behind Thailand that installed 3,532 thousand split type air-conditioning. Number one was India with 8,812 thousand installations and Indonesia was in second place with 6,428 thousand installations. Vietnam was in number three by installing 3,673 thousand split type air-conditioning in their country. This trend also

shown all of five these countries lead in demanding list of Ductless Mini-Split Air-Conditioner among Asian countries exclude Japan and China.

2.0.1.1 Outdoor unit installation guideline

Outdoor unit is a part that reject heat from air-conditioning system. This part also referred as condensing unit. Since hot air blown by condensing unit, it is needed to place the unit in proper location. It was intended to ensure hot air are not recirculate through the system. Split type of air-conditioning cannot be functioning as well as usual when the hot air recirculated. There is space required by condensing unit to completely run.

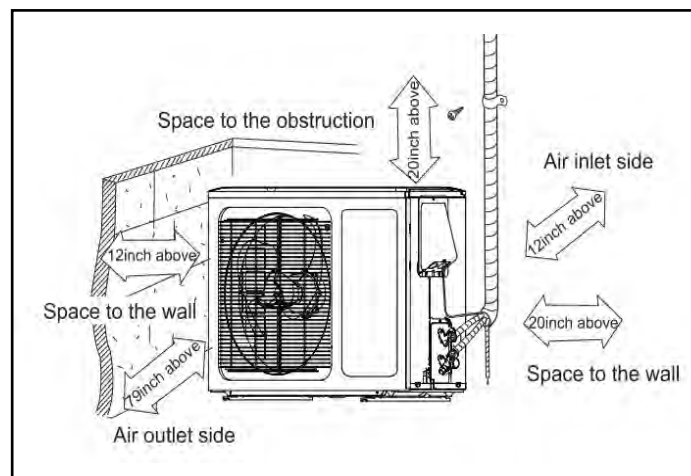


Figure 2.1 Minimum space required to be left in mm

According to Gree Split Air-Conditioner installation manual (2008), Figure 2.1 shows the minimum space required to be left when installing outdoor unit. 12 inch was minimum space between condensing unit and wall. It is because condensing unit need to suck static air behind the fan and blow hot air to surrounding. 79 inch minimum spaces required for hot air to be blown by condensing unit.

At the top, 20 inch minimum spaces needed to be left. In addition, 12 inch and 20 inch minimum spaces need to be left at left side and right side to ease installation procedure and service maintenances.

Based on Gree Split Air-Conditioner installation manual (2008), height of outdoor unit placement should be less than 5 metres from the indoor unit. Since the refrigerant lose their cool effect through length of copper tube, it was better planning to minimizes length of copper pipe. Maximum length of copper pipe installed recommended was 15 metres. In common, outdoor unit placed behind indoor unit to shorten the length of copper pipe. Rate of cooling effect should be shortened since length of copper pipe minimized as short as possible. This information lead the placement of outdoor unit in higher position below 5 metres from indoor unit.

2.1 Occupational Safety and Health Administration (OSHA)

Occupational Safety and Health Administration (OSHA) was one of organisation involved due to safety and health of workers. OSHA had been organized in 1970 when President Nixon implement Occupational Safety and Health Act of 1970 into law (U.S. Department of Labor, 2016). OSHA already publish many type of safety standard to be follow. Besides, all employers were recommended by OSHA to provide safety environment at workplaces based on OSHA standards. It is quite clear that all the purpose of OSHA was to ensure vulnerable workers survive in high-risk job that could give them injuries. The injuries could be effected by un-ergonomic activity. One study from OSHA 3125 stated that muscle injuries commonly happened due to un-ergonomics activity. OSHA also initiated the inspections without notice to find out unsuccessful employers who failed to afford responsibilities.

2.1.1 OSHA Standard: 29 CFR Part 1910

New ergonomic program standard provide by OSHA has been released on 2000. This standard also could be known as 29 FCR Part 1910. This safety standard published intend to reduce the percentage of injuries in workplaces by accentuating ergonomic criteria (Heacock et al., 2004). This safety standard concerned about ergonomic and safety factor in workplaces. It was stated in OSHA 3125, meaning of ergonomic is a science concerned about relationship between people and their work to demonstrate percentage level of comfort. In another word, job should fit the worker rather than worker fit the job by physically forcing. Majority of workers have been protected by this standard from any danger and serious hazards (U.S. Department of Labor, 2016). However, this standard covers certain industries and jobs only. Jobs covered by this standard was truck driving, maintenance of equipment or structures, boat building and utility line operations including maintenance, installation, construction and improvement operations (US Department of Labor, 2000). This safety standard also a guideline for companies to be follow and provide better and comfortable job environment. Companies should be taking serious about the implementation of ergonomic and safety factor. Implementation of ergonomic and safety factor can be defining in wide-general topic. Ergonomic could be control through the equipment design, work practices and personal protective equipment (US Department of Labor, 2000). This could lead the statistic of muscle injuries reduces in percentage.

2.1.1.1 Statistic of musculoskeletal disorders

Musculoskeletal disorders also known as MSDs. MSDs referred as strain injuries of muscles, ligaments, tendons and cumulative trauma disorders (Rahman. A, Mumin. A, & Naing, 2017). This injury affected the long-term performance of productivity. There is certain condition caused MSDs problem

toward workers. One of them was unsupported positions. It means the human physical limits stretched by awkward postures and caused tendon irritated. Besides, muscles damaged along periods of time for workers held the stuff in static postures and position. Both condition represent un-ergonomic problem occurred at workplaces (US Department of Labor, 2000).

Table 2.2 Example of musculoskeletal disorders (US Department of Labor, 2000)

Body Parts Affected	Symptoms	Possible Causes	Workers Affected	Disease Name
thumbs	pain at the base of the thumbs	twisting and gripping	butchers, house-keepers, packers, seamstresses, cutters	De Quervain's disease
fingers	difficulty moving finger; snapping and jerking movements	repeatedly using the index fingers	meatpackers, poultry workers, carpenters, electronic assemblers	trigger finger
shoulders	pain, stiffness	working with the hands above the head	power press operators, welders, painters, assembly line workers	rotator cuff tendinitis
hands, wrists	pain, swelling	repetitive or forceful hand and wrist motions	core making, poultry processing, meatpacking	tenosynovitis
fingers, hands	numbness, tingling; ashen skin; loss of feeling and control	exposure to vibration	chain saw, pneumatic hammer, and gasoline-powered tool operators	Raynaud's syndrome (white finger)

The example of musculoskeletal disorders happened has been shown in Table 2.2. Thumbs, fingers, shoulders and wrists was a part of body affected by MSDs. Symptoms came first as a prediction to analysed which part of body was affected. Based on table above, majority of MSDs happened when installing outdoor unit was shoulder and back injuries. Lifting outdoor unit by shoulder caused the certain body soft tissues and tendon related became