UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF LOW COST PORTABLE LIFTER FOR SPLIT UNIT INSTALLATION

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 Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor in Mechanical Engineering Technology (Refrigeration and Air-Conditioning Systems) with Honours. The member of the supervisory is as follow:

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ABSTRACT

In hot & dry climate conditions, air conditioning plays important role to achieve thermal comfort. Malaysia shows a significant increase in demand of split unit installation in this past 3 years. However, the installation of split unit typically is using manpower and manual lifting process. Therefore, the ergonomics emphasized to the blue-collar worker will have significant impact to their health. Besides, ergonomic and safety are related with each other to keep society safe. This study aims to develop a low-cost portable lifter to lift split unit air conditioning system. Earlier study stated that 90% of 112 houses install Room Air-Conditioning in home. Installing air-conditioning outdoor unit led into several problems which is not ergonomic and less safety factor. From 2014 until 2016, the number of demands for window-type air conditioning in Malaysia are very low which is only 14 rather than split-type which has demand in about 2429. Before the designing process, 30 sets of questionnaires have been distributed to see what the criteria that will ease the installer or worker task. It also been done to develop house of quality based on the survey. Then, SolidWorks software has been used in designing portable outdoor unit lifter. After the designing process finished, the fabrication process has been done. 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. Other than determining the appropriate gear ratio, the force needed to lift the outdoor unit are also been determined. Thus, this product also can handle up to 70kg of outdoor unit. Hence, this project is developed to reduce energy and increase safety factor to workers.

ABSTRAK

Dalam keadaan cuaca panas & kering, penghawa dingin memainkan peranan penting untuk mencapai keselesaan terma. Malaysia menunjukkan peningkatan yang ketara dalam permintaan pemasangan unit berpecah dalam tempoh 3 tahun yang lepas. Walau bagaimanapun, pemasangan unit berpecah biasanya menggunakan proses tenaga manusia dan manual. Oleh itu, ergonomik yang ditekankan kepada pekerja kolar biru akan mempunyai kesan yang ketara kepada kesihatan mereka. Selain itu, ergonomik dan keselamatan berkaitan dengan satu sama lain untuk menjaga keselamatan masyarakat. Kajian ini bertujuan untuk membangunkan alat pengangkat mudah alih murah untuk mengangkat sistem penyaman udara unit luar. Kajian terdahulu menyatakan bahawa 90% daripada 112 rumah memasang penyaman udara di dalam bilik-bilik rumah. Memasang unit luar penghawa dingin membawa kepada beberapa masalah yang tidak ergonomik dan kurang faktor keselamatan. Dari tahun 2014 hingga 2016, jumlah permintaan untuk penghawa dingin jenis tingkap di Malaysia adalah sangat rendah iaitu hanya 14 berbanding jenis pecahan yang mempunyai permintaan sekitar 2429. Sebelum proses reka bentuk, 30 set soal selidik telah diedarkan untuk melihat apakah kriteria yang akan memudahkan tugas pemasang atau pekerja. Ia juga telah dilakukan untuk membangunkan rumah kualiti berdasarkan tinjauan. Kemudian, perisian SolidWorks telah digunakan dalam merekabentuk pengangkat unit luaran mudah alih. Selepas proses perancangan selesai, proses fabrikasi telah dilakukan. Pengangkat unit luaran mudah alih ini boleh mengangkat unit luaran sehingga 8 kaki. Penggunaan gear gear winch adalah 3.4 dalam produk ini. Di samping itu, nisbah gear yang sesuai adalah 5.33 untuk unit luaran 2 horsepower (HP) yang beratnya sekitar 40kg. Selain daripada menentukan nisbah gear yang sesuai, daya yang diperlukan untuk mengangkat unit luaran juga telah ditentukan. Oleh itu, produk ini juga boleh mengendalikan sehingga 70kg unit luaran. Oleh itu, projek ini dibangunkan untuk mengurangkan tenaga dan meningkatkan faktor keselamatan kepada pekerja.

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 this project which I have started. This project also is especially dedicated to my supervisor, for his willingness to guide me to the success of this project for my degree.

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ft	-	Feet
GR	-	Gear Ration
HP	-	Horse Power
HSS	-	High Strength Steel
kg	-	Kilogram
mm	-	Millimetre
MPa	-	Megapascals
MSDs	-	Musculoskeletal Disorders
OSHA	-	Occupational Safety and Health Administration
RAC	-	Room Air-Conditioning

CHAPTER 1

INTRODUCTION

1.0 Briefing

The task activities done by majority of workers has neglecting the ergonomic features. Safety is another factor that need to be considered in doing the task job. Both ergonomic and safety factor cannot be neglected to keep this society safe.

1.1 Background

Any unsafe condition can be defined as dangerous that can lead to workplace accidents. Elimination of dangerous cannot be done perfectly, but it can be reduced into almost zero percent. Workplace accidents span the full range of severity from minor injuries such as cuts or scrapes to fatalities. For sure, minor incidents occur much more frequently than major ones (J.C. Mauro et al, 2018). Accident at workplaces are significantly reliant with ergonomic activity (Picchio & Van Ours, 2017). Therefore, safety factors are important to keep human stay healthy and avoiding any accident among the working activities. When there is no safety implementation, the task can lead to many problems. Un-ergonomic task existed while the installation of outdoor unit. These ergonomic factors 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 such as body shape, strength, training and experiences. For example, 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. It can reduce the percentage of danger, improve the working performance and productivity by applying the ergonomic factors to the workplaces (HSE, 2013).

1.2 Problem Statement

In this fast-changing world, air-conditioning expert workers pursue to fulfil air-conditioning demands by customers. Earlier study has pick 112 houses for survey purpose and 90 % of them has installed room air-conditioning in Malaysian homes especially in the bedrooms (Jaafar & Croxford, 2010). Due to statistics mentioned before, it is confirmed that installation of split-unit air conditioning is a must for every house. Some implications from split-type air conditioning installation lead to un-ergonomic and dangerous activity while undergoing the installation process especially when lifting the outdoor unit. Furthermore, installing air-conditioning outdoor unit will pose several problems which is not ergonomic and less safety factor. The risk of accident during the activity will increase. Figure 1.1 illustrates the situation. The dimension of outdoor unit needs to be familiarized before the fabrication process of portable outdoor unit lifter. 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 alone while installing the outdoor unit.

Figure 1.1: Manpower 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. Manpower 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.
3. To determine the appropriate gear ratio and force needed to lift the outdoor unit.

1.5 Scope

This project focused on designing and fabricate the portable lifter for lifting the outdoor unit. Furthermore, installing air-conditioning outdoor unit will pose several problems which is not ergonomic and less safety factor or unit in reducing the man power when installing the outdoor unit. Several limitations have been determined through this project. 8ft has been set as limitation for the lifter height to carry the outdoor unit from the floor. Stability is one of the most important factor of product design to avoid the outdoor unit from falling during the lifting activity. Basically, this product is designed to lift the outdoor unit of split unit air-conditioner type only. This portable lifter mainly used mild steel as its main material. The thickness of the mild steel used is 5mm. In consideration of the safety factors, installer or worker are not allowed to be lift by this product. According to the Panasonic installation manual, the weight of common 2HP outdoor unit are in the range 64kg. Hence, the limitation for the weight of the outdoor unit that can be lift 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

A review of literature was performed to identify the studies which relevant to the topic of research. There is a number of a good literature that can be relate to this project. According to previous research, circulation shape of workplace injuries and risk has been identified. Higher risk of work-related injury group was labelled as Vulnerable workers (Lay et al., 2017). This type of group also suitable to be refer as the workers that installing outdoor unit of Split-type air conditioner. Commonly, strong worker is needed to lift outdoor unit. This kind of case caused many companies to provide any procedure and safety factors in order to prevent the accident risk that will occurs. Previous studies also state that many company has taken proactive measure 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 lead into dangerous situation happened because of carelessness. Next, design concept is considered as important factors to fabricate the portable outdoor unit lifter. Design concept must be related with the safety factor and criteria. Complaints, accidents even disasters, occupational diseases, drops in both productivity and quality, increased unit costs and a high number of breakdowns are just some of the consequences of the poor design of any product or system that does not take man and his role as a factor of reliability and safety into account (J.-C. Sagot et al., 2003). By fulfilling the requirement needed, it can reduce danger percentages in workplace. This chapter led the research about linked topic to fabricate the portable outdoor unit lifter.

2.1 Statistics of Air Conditioning Installation

In hot & dry climate conditions, the humidity level of the supplied air to the conditioned space is not sufficient to meet the required human comfort (Dhamneya, Rajput, & Singh, 2018). To achieve the desired thermal comfort, it is not an easy job to be done. Many aspects need to be considered in order to achieve the desired thermal comfort. This thermal comfort related to individual perception toward the environment to do their jobs (Wang, 2000). The 2016 world RAC demand is estimated to reach 88.81 million units with a 2.9% increase compared with the previous year (JRAIA, 2017).

Table 2.1: RAC demand by Asian countries in thousand (JRAIA, 2017)

RAC demand	2014		2015		2016	
	Window-Type	Split-Type	Window-Type	Split-Type	Window-Type	Split-Type
World total	14,384	76,320	13,879	72,365	13,119	75,688
Japan		8,500		8,104		8,352
Overseas	14,384	67,820	13,879	64,261	13,119	67,336
China	325	40,000	303	36,800	309	38,100
Asian countries	1,846	11,350	1,840	11,884	1,730	13,193
India	703	2,971	705	3,142	620	3,662
Indonesia	9	2,189	9	2,100	9	2,200
Vietnam	2	1,176	2	1,544	2	1,910
Thailand	3	1,200	3	1,265	3	1,420
South Korea	12	656	11	656	11	655
Taiwan	216	744	205	754	198	752
Malaysia	5	806	5	784	4	839
Philippines	418	210	425	226	487	244
Pakistan	40	600	38	606	34	645
Hong Kong incl. Mac	312	193	312	187	299	198
Myanmar	4	170	4	170	4	193
Bangladesh	31	121	30	134	30	136
Singapore	5	130	5	125	4	125
Cambodia	1	80	1	84	1	102
Sri Lanka	25	49	25	52	24	57
Others	60	55	60	55		55

RAC demand in Asian countries from 2014 until 2016 are as shown in Table 2.1. From 2014 until 2016, the number of demands for window-type air conditioning in Malaysia are very low which is only 14 unit rather than split-type which has demand in about 2429 unit. Malaysia placed 7th for the demand statistics while the 1st placed were taken by India which has demand for split-type air conditioning in about 9775 unit for 3 years. Indonesia were placed 2nd in the demand statistics.

2.1.1 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.

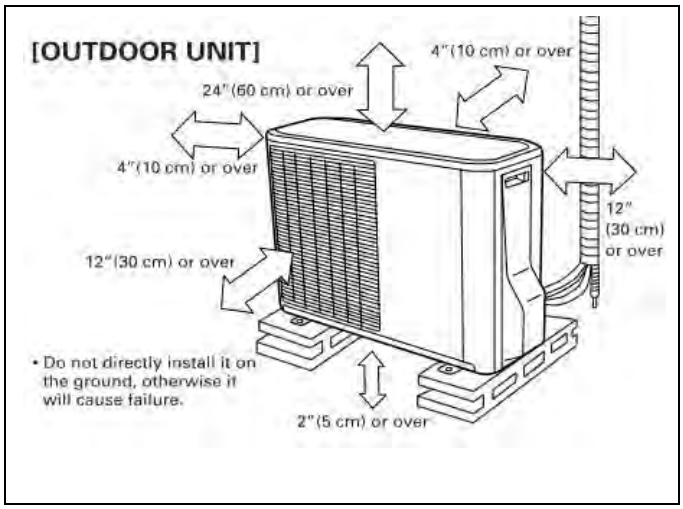

Figure 2.1: Minimum space requirement for outdoor unit installation

According to Sharp split-type air conditioner installation manual (Sharp, 2018), Figure 2.1 shows the minimum space required when installing the outdoor unit. Minimum space required shown in the figure must be followed so that the air flow is not blocked. Also, for efficient operation, leave open three of the four directions front, rear, and both sides. The front side must have about 12-inch clearance to allow better heat rejection.

For quality installation of outdoor unit, a strong foundation is required, away from direct heat. There should be no obstruction to air circulation. The space around the outdoor unit must be more than 150-250 mm (6"– 9.8") in the rear and more than 1500 mm (59") in front of the unit. It should be placed away from any flammable materials. If there is a shade above the outdoor unit, it will improve its performance. Avoid locating the outdoor unit where it would be exposed to salty atmosphere. The tubing should have minimum bends and elbows (Handbook, 2013).

Figure 2.2: Proper location for outdoor unit

2.2 Ergonomics

Ergonomics is the process of designing or arranging workplaces, products and systems so that they fit the people who use them. Ergonomics aims to create safe, comfortable and productive workspaces by bringing human abilities and limitations into the design of a workspace, including the individual's body size, strength, skill, speed, sensory abilities (vision, hearing), and even attitudes. it is necessary to know the workers personal characteristics on one hand and the shape, hardship, time of the job and environmental conditions on the other hand. Work arrangement with the least difficulty in doing work of the same quality is a successful arrangement. This can only be achieved with ergonomic solutions (K. Miura et al., 2018).

2.1.2 Posture

In every daily activity, posture plays a huge role. There is suitable posture for sitting and lifting. Without a correct posture while doing the daily activities, our body may suffer some injuries.

2.1.2.1 Lifting Posture

Lifting posture has been debated extensively with contradictory findings on hip and spine posture and the use of either a squat or stooped lift associated with low back injury risk (Hlavenka et al., 2017). Some air conditioning installer may have been suffered from the low back injury that cause by incorrect lifting posture.

Manual Handling involves the lifting, carrying, pushing and pulling of materials and objects. Training in safe handling techniques is a recommended way to reduce risk factors associated with manual handling within the working environment, particularly the lifting of low-lying objects as this has long been associated with an increased risk of lower back injuries (Vecchio, 2017).

Figure 2.3: Correct Lifting Posture