

DESIGN AND FABRICATE SMART LAUNDRY CART

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DESIGN AND FABRICATE SMART LAUNDRY CART

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A report submitted in partial fulfillment of the requirements for the award of the

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SUPERVISOR'S DECLARATION

I hereby declare that I had read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the purpose of the granting of Diploma of Mechanical Engineering.

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STUDENT'S DECLARATION

I declare that this thesis entitled "*Design and Fabricate Smart Laundry Cart*" is the result of my own research except as cited in references. The thesis has not been accepted for any diploma and is not concurrently submitted in candidature of any other diploma.

Signature :

Name : ANETH ATHEA BINTI MAT SOM

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This book is dedicated to all conscious life.

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ABSTRACT

Musculoskeletal injury risk factors associated with pushing and pulling of loads. The most common cause of musculoskeletal injury is a combination of physical overloads created by overtraining or by the repetitive use of a joint or a particular muscle group. The field of invention relates to a cart structure, and more particularly pertains to a new and improved multipurpose laundry cart which is arranged for the support and transport of various laundry stations. Many laundry cart apparatus of various types have been utilized in the prior art. However, they fail to provide the necessary multiple laundry work stations, ease of assembly, storage and mobility with appropriate ergonomic factors that can reduce MSI or musculoskeletal injury. It is an object of the present invention to provide a multipurpose laundry cart which fulfills these needs especially in reducing the factors of any injury causes. A light weight easily constructed multipurpose laundry cart which is constructed of aluminum sheets and horizontal tubular aluminum provides supports hanging or clothes therein and further provides stacking and sorted shelves compartment. The horizontal bars are for hanging such clothes and the top of the cart can be used as a platform for ironing process. Wheels are attached for mobility purpose and a special compartment is featured to keep iron in fixed position. The height of the laundry cart was constructed to avoid the MSI from occurring. Suitable height was constructed for various users play a major role in the factors of MSI and determination of suitable height was based on the common height of Malaysians citizens. In future advance of engineering, development of physical properties of tools should be better and more advance and focusing in health aspects.

ABSTRAK

Kecederaan otot berlaku adalah disebabkan faktor berkaitan dengan menolak atau menarik beban. Punca paling umum dari kecederaan otot merupakan kombinasi dari fizikal berlebihan yang dilakukan oleh penggunaan berulang kali sesama atau antara kumpulan otot tertentu. Bidang rekacipta dan penemuan berkaitan dengan *cart* atau gerabak, khususnya berkaitan gerabak yang serbaguna yang disusun untuk dijadikan sokongan dan pengangkutan bagi proses dobi. Sejak berzaman dahulu, stesen dobi atau perkakasan dobi telah digunakan tetapi gagal untuk menyediakan keperluan mendobi serbaguna, kemudahan pemasangan, tempat penyimpanan, kemudahan bergerak dengan faktor ergonomik yang tepat yang boleh mengurangkan MSI atau kecederaan otot. Projek ini serba sedikit memenuhi keperluan tersebut terutama dalam mengurangkan faktor dari setiap penyebab kecederaan. Projek ini yang ringan dan mudah untuk dibina diperbuat daripada kepingan aluminium dan batang tubular aluminium yang menyediakan sokongan untuk menggantung pakaian dan menyediakan rak penyimpanan. Batang tubular aluminium digunakan untuk menggantung dan bahagian atas gerabak dobi boleh digunakan sebagai tempat pemprosesan menyeterika (*ironing process*). Roda dipasang bagi kemudahan bergerak dan tempat penyimpanan seterika disertakan bagi kemudahan untuk menyimpan seterika. Ketinggian yang bersesuaian ditetapkan bagi mengurangkan risiko MSI dan pemilihan ketinggian ini berdasarkan purata ketinggian rakyat Malaysia. Pada masa hadapan dalam bidang kejuruteraan haruslah berfokuskan kepada pembangunan sifat fizikal alat yang lebih baik dan lebih maju dan berfokuskan ke dalam aspek kesihatan.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Laundry carts make transporting clothing to and from the laundry area a lot easier. People living in apartments may also find using a laundry cart convenient, as most household laundry carts fit in elevators. Large institutions that require a constant flow of clean linen, working-clothing or uniform, will often employ the services of an industrial laundry. Hospitals, prisons and hotels, for instance, will usually have their own laundry departments. The organized collection, laundering and timely delivery of textile service ware is essential to the operation of the institution.

1.2 OBJECTIVE

To design and fabricate smart laundry cart that reduces the factor of Musculoskeletal Injury or in short form MSI with developing basic technical skills.

1.3 PROBLEM STATEMENT

Existing laundry carts causes Musculoskeletal Injury (MSI) and do not have wide range of purposes. Therefore, the smart laundry cart reduces the risk of MSI and has additional functions.

1.4 SCOPE

The scopes of the project are:

- 1.4.1 A scale of 1:3 prototype is fabricated.
- 1.4.2 Maximum withstand weight is 10 KGs (prototype).
- 1.4.3 Fabricated for domestic usage only.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Laundry carts are widely use for hospitality in hospitals, prisons, and hotels and also known as one of the household appliances. Laundry carts are famous in places stated as above because users are dealing with a big load of laundry and the process should be within organized ways and timely effective. In days to come, laundry carts are being develops to meet the needs of worldwide.

2.2 FRONT LOAD LAUNDRY CART



Figure 2.1: Front Load Laundry Cart

Source: <http://store.kelcolaudry.com/>

This laundry cart was designed especially for front loader washers. The heavy duty basket plat in chrome and welded to 4 tires and round tubular base for better stability.

2.2.1 Advantages

Other than its special feature of light weight, this particular cart takes less space when storing.

2.2.2 Disadvantages

The unsuitable low height increase the risk of MSI to the user and it didn't not feature many purpose those the usage is limited and so does spacing for loading loads.

2.3 BUSHEL VINYL ALL SWIVEL LAUNDRY CART



Figure 2.2: Bushel Vinyl All Swivel Laundry Cart

Source: <http://store.kelcolaundry.com/>

This cart is being use in the laundry room, mail room and material handling. This cart usually used for big size load such as bed sheets. It is made mostly from plastic.

2.3.1 Advantages

This particular cart can be fold when not in use. The space consumed when storing is lesser than a normal laundry cart that usually takes up a big space. The vinyls laminate liner is detachable for replacement and cleaning and it is easy to assemble.

2.3.2 Disadvantages

Despite the lustful of advantages, this laundry cart, however have few disadvantages. It is expensive and difficult to maneuver when load is in as the wheel is small to support the heavy load. When unloading loads such as clothes, it is very difficult to reach to the bottom of the cart.

2.4 MOBILE LAUNDRY CENTER



Figure 2.3: Mobile Laundry Center

Source: <http://www.stacksandstacks.com/>

This mobile laundry center is a unique, high quality space-saving laundry center on wheels. This laundry organizer includes full size ironing board, also includes a slide-out laundry hamper, iron rest, adjustable clothes rack and a zippered cover.

2.4.1 Advantages

This cart allows easy access to find specific clothing when clothes are folded. The ironing place is provided on top of the cart and there is a detachable laundry bag dirty clothes or unfolded clothes.

2.4.2 Disadvantages

In order to iron clothes on the space provided, the cart must be place near the power source and the small wheels are easily break when heavy loads are on the cart.

2.5 TRIPLE LAUNDRY SORTER



Figure 2.4: Triple Laundry Sorter

Source: <http://www.stacksandstacks.com/>

This triple sorter makes chores easier. To avoid the cart to move around when is not needed, it comes with caster with step on locks. The material and design of stylish chrome frame and canvas bag are simple and eco-friendly. It includes cover on top to hide dirty clothes.

2.5.1 ADVANTAGES

This kind of laundry sorter is lightweight as it built from light materials and mostly came from sewed cloths for the sorter. Due to small compartments, small wheels are attached to the sorter and make it easy to maneuver.

2.5.2 DISADVANTAGES

Due to its small size, it has very limited usage as a laundry cart and cannot withstand heavy loads. The height of the cart is not suitable for daily usage and it increases the risk of users in getting Musculoskeletal Injury.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

The process of production of this product was started by making the design by the concept that I highlight as the base of generation of this new design. It covers on how it being fabricated and what would be the material of it. Note that the cheapest production way is the main point. This product is fabricated as prototype on the scale of 1:3. The design process would be focused on the scope to ensure the successes point of the product. This particular design of smart laundry cart will be for indoor use and the essential of management of laundry will be much more organized with this smart laundry.

3.2 CONCEPT GENERATION

The process produced four concepts including the one that is finalized.

3.2.1 1st Concept

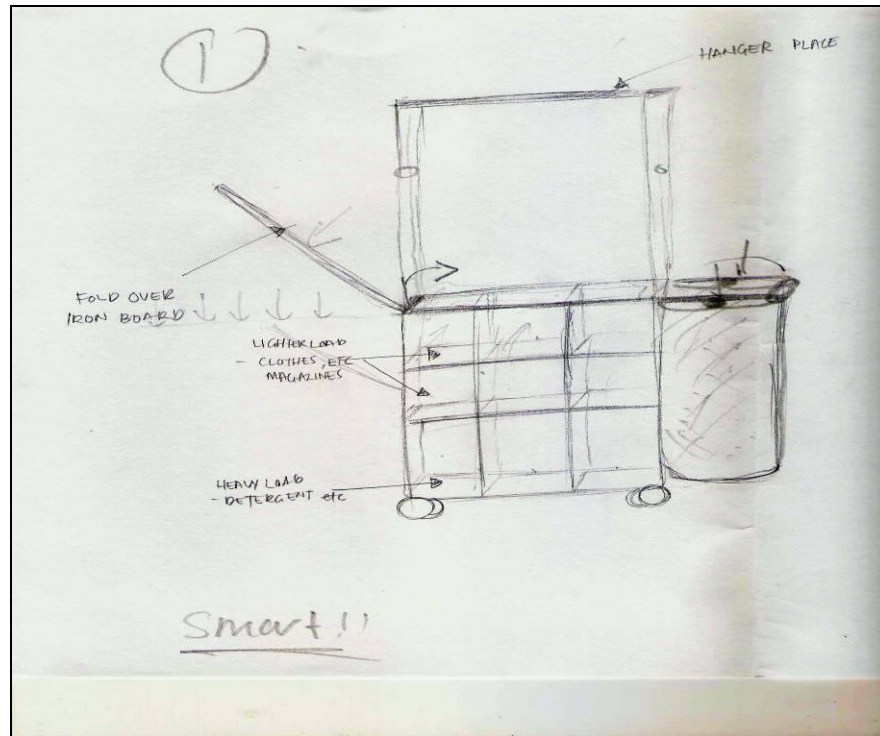


Figure 3.1: Sketching of 1st Concept

This concept has plenty of partition that can fit various sizes and weight of objects. The laundry bag is detachable and environmental friendly.

3.2.2 2nd CONCEPT

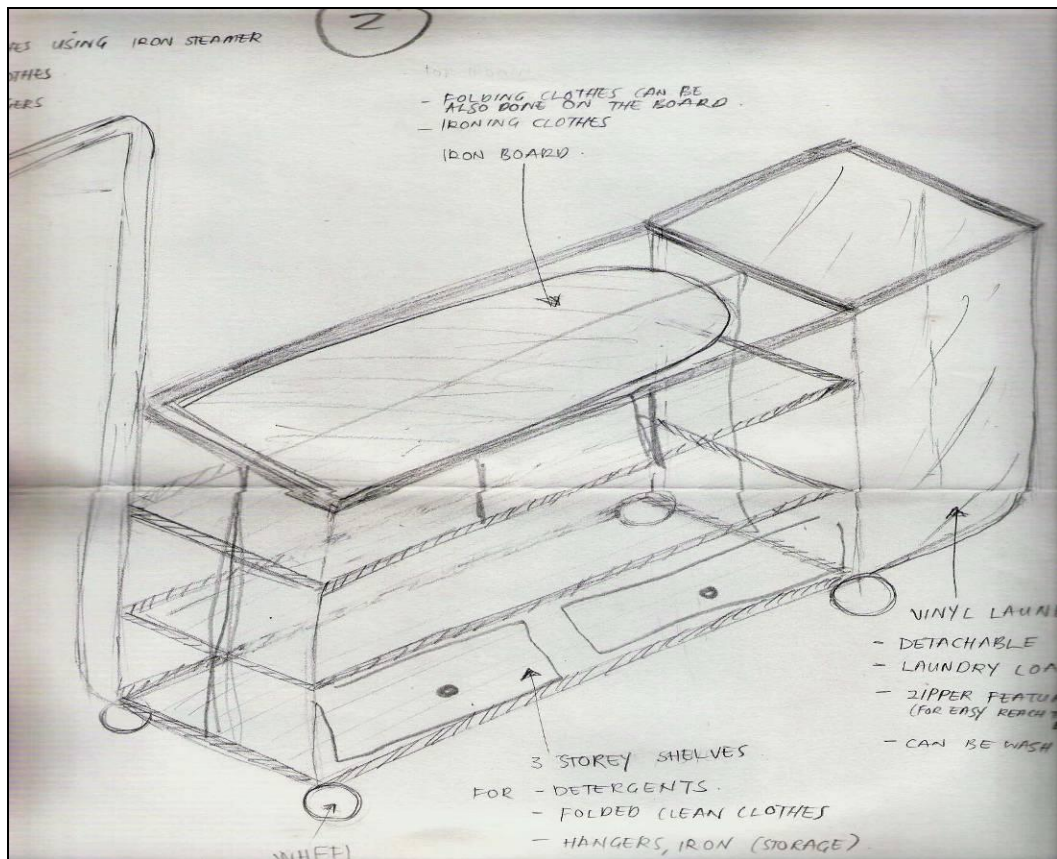


Figure 3.2: Sketching of 2nd concept

This concept feature ironing board on it with side hanger for steam ironing and at one side there is detachable laundry bag. The bottom shelf has 3 parted sliding drawers

3.2.3 3rd CONCEPT

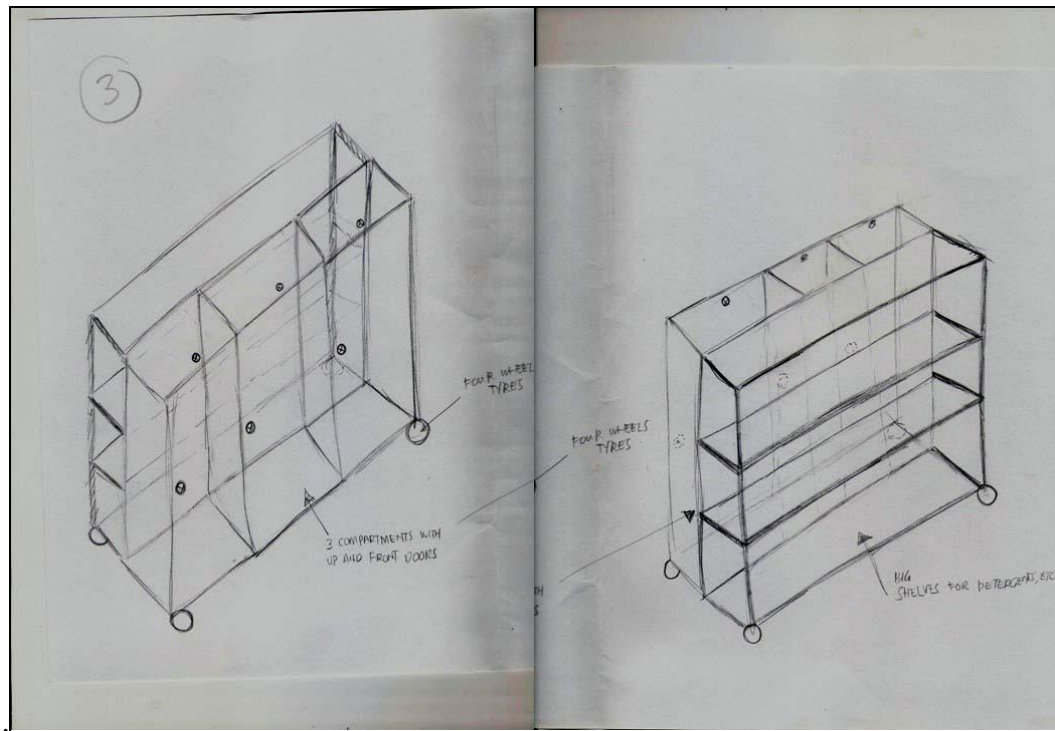


Figure 3.3: Sketching of 3rd concept

This concept has limited usage. It has 3 parted doors for sorting clothes and the shelves are bigger so that bigger objects such as detergents can be place. This cart takes small storage area.

3.2.4 FINALIZED CONCEPT

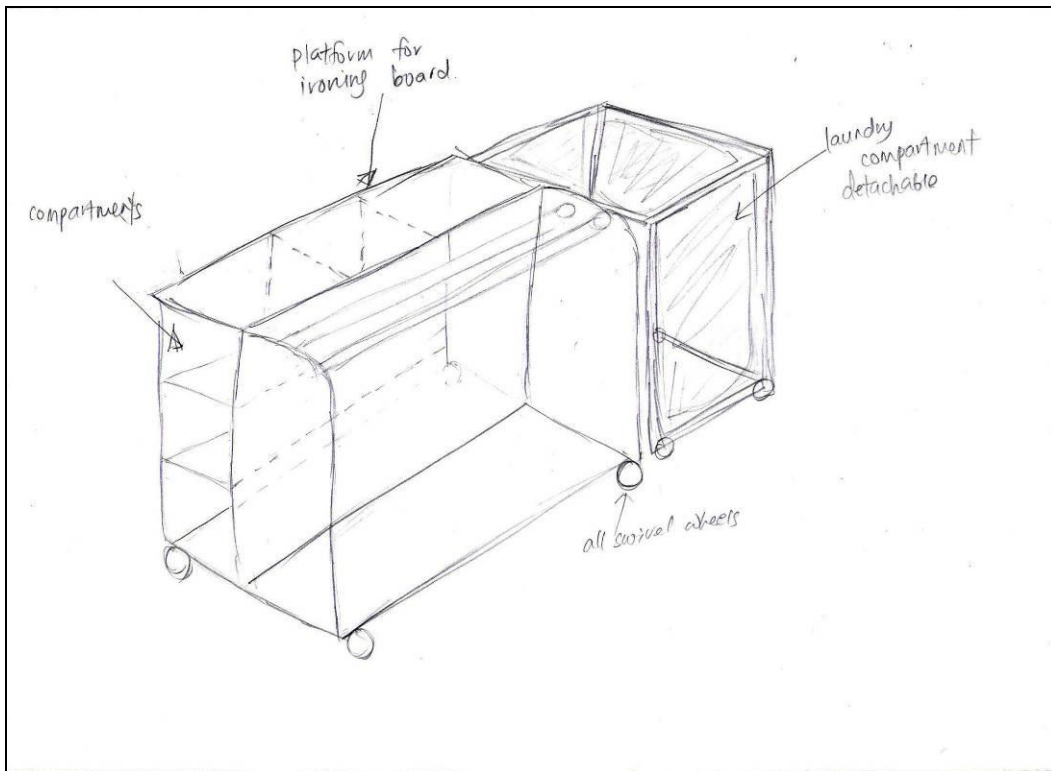


Figure 3.4: Sketching of Finalized concept

The finalized concept is the combination of all concepts. This chosen concept has achieved the solution for problems stated earlier. Thus fabrication process will be based on this concept.

3.3 CONCEPT SELECTION

In order to choose the most appropriate and the best choice among the concepts, screening method was performed. Here, all the four concepts are being compared with each other and also the datum (the existing product).

Table 1.0: Concept screening

Concept Variants					
Selection Criteria	1st Concept	2nd Concept	3rd Concept	4th Concept	Datum
Ease of handling	+	+	+	+	0
Mobile	0	0	+	+	0
Multipurpose	+	+	+	+	0
Easy to fabricate	-	-	-	0	0
Big load handling	+	+	+	+	0
Detachable	0	0	0	+	0
PLUSES	3	2	4	5	
SAMES	2	2	1	1	
MINUSES	1	1	1	0	
NET	2	1	3	5	
RANK	3	4	2	1	
CONTINUE?	NO	NO	NO	YES	

3.4 FINALIZED CONCEPT

3.4.1 AutoCAD drawing

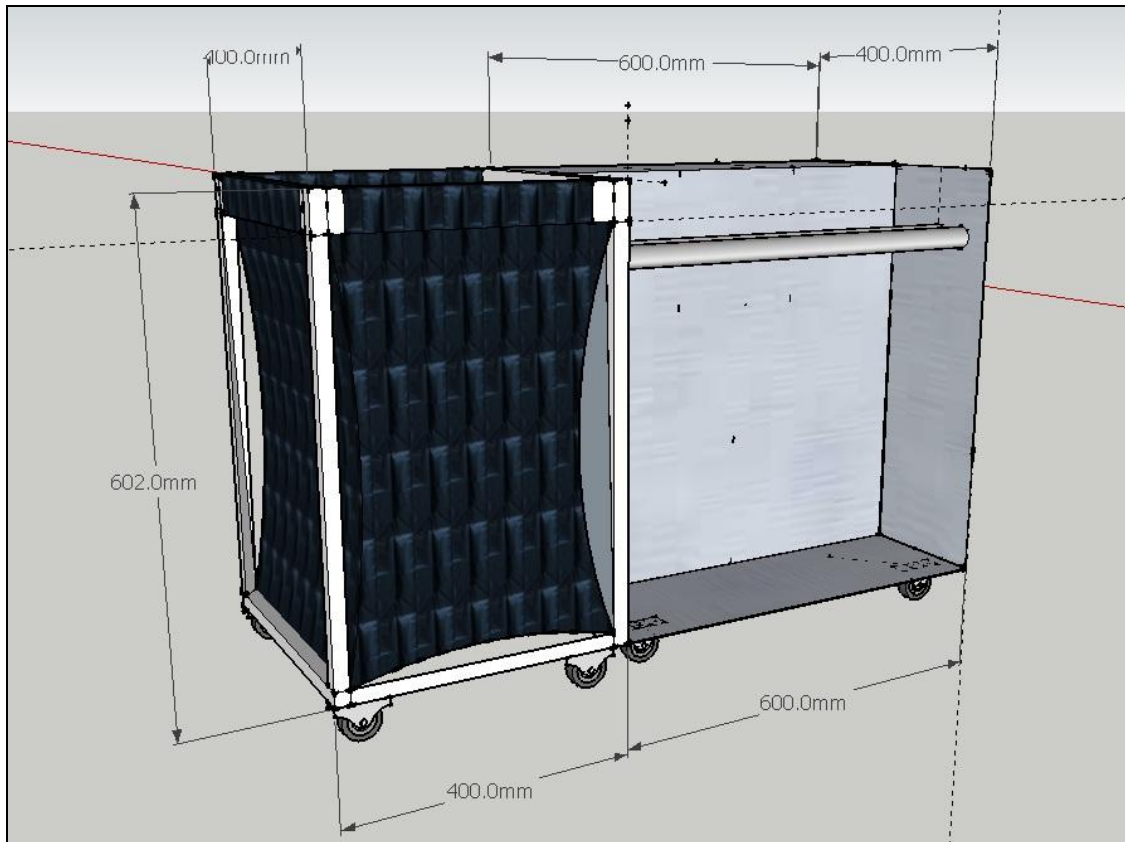


Figure 3.5: AutoCAD drawing laundry cart

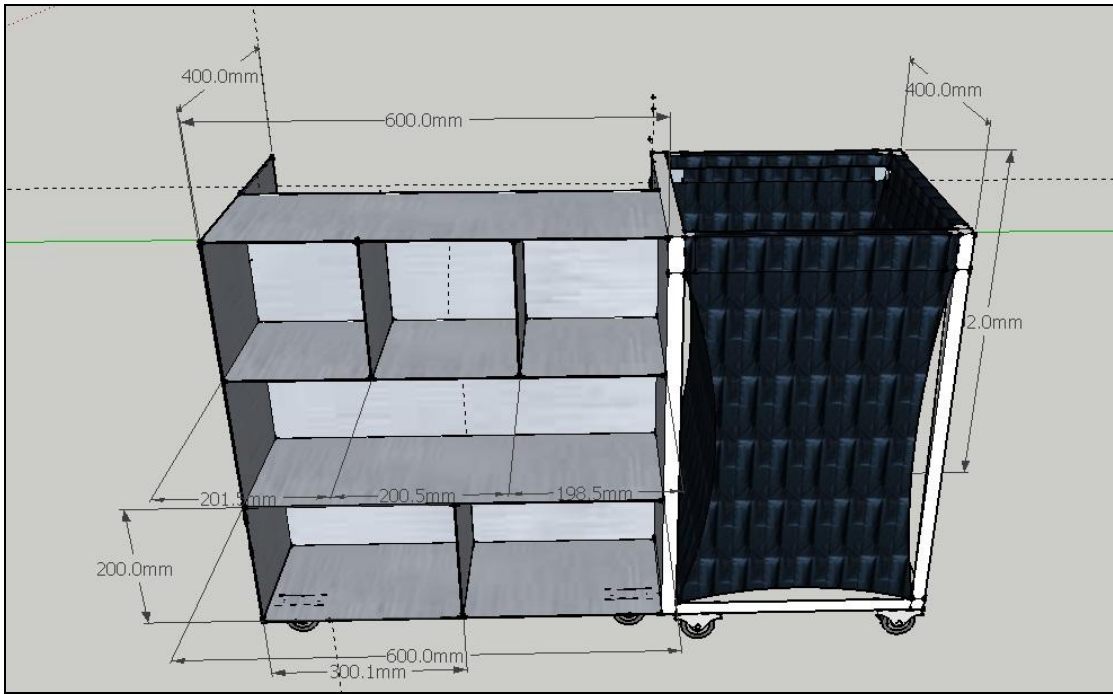


Figure 3.6: Compartment view of laundry cart

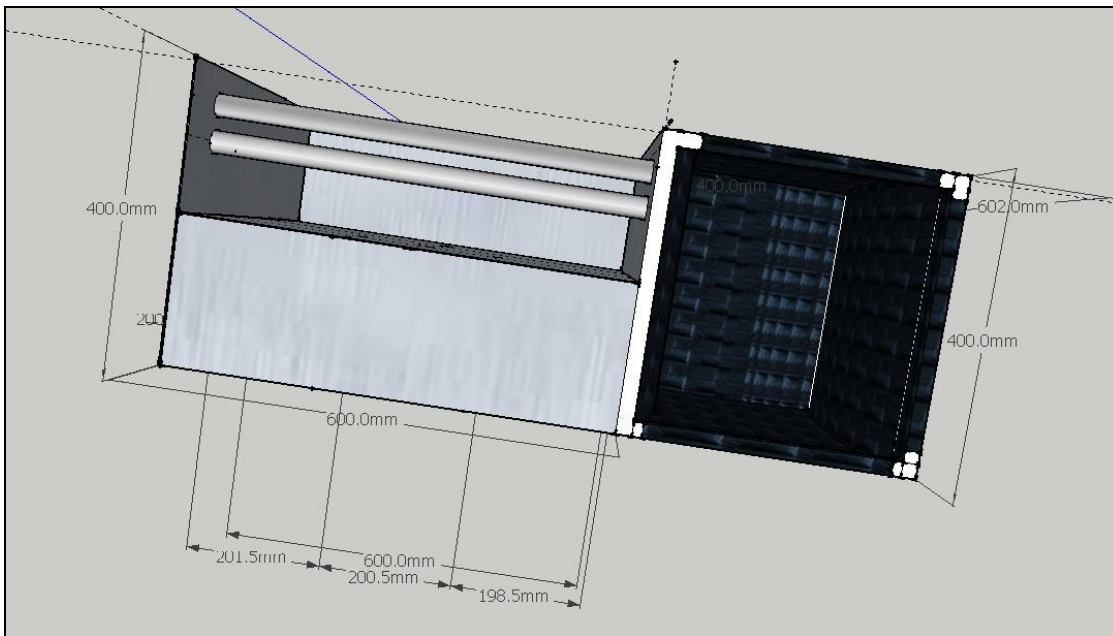


Figure 3.7: Top view of the laundry cart

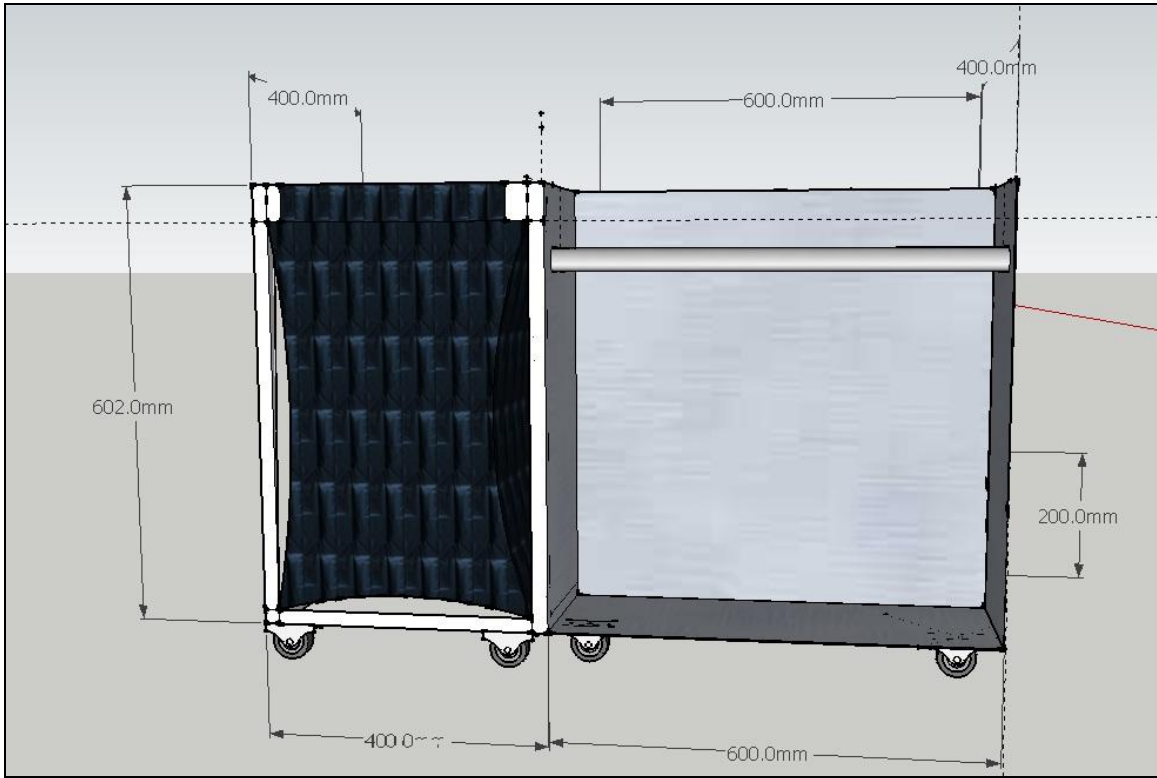


Figure 3.8: Another view of laundry cart

3.5 MATERIAL SELECTION

Selecting material is a very important process the process of fabrication. Reliable properties featured on the material play a major role in effectiveness and reliability of the laundry cart.

3.5.1 Aluminium Rod

This material is used as the long rod for hangers. Aluminum rod was chose because the toughness of the material itself. It can withstand heavy load acting on it and it is lightweight, as what needed most while fabricating this product.

3.5.2 Aluminium Sheet Metal

Fabrication process will be a lot much easier with this material. Aluminum was chose because it's lightweight and resistant to corrosion. The tough features of the aluminum enable the product have a longer life span in usage and maintenance.

3.6 FABRICATION

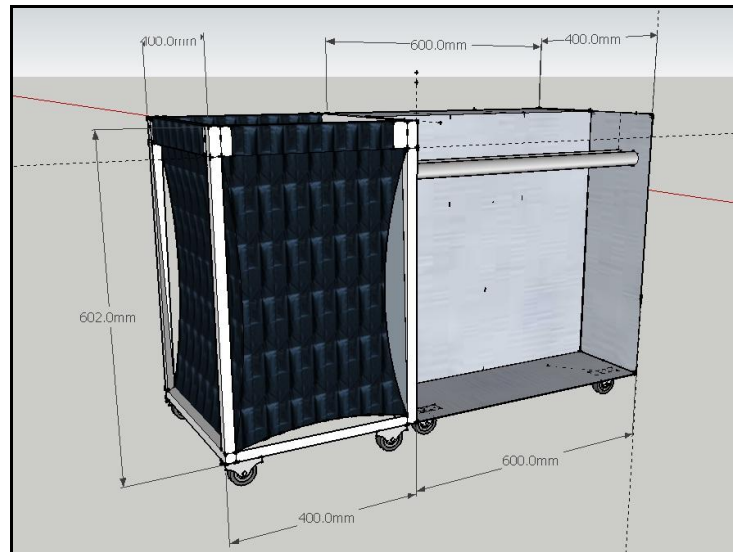


Figure 3.9: Expected End Result

The fabrication process started from marking every material to desired dimensions. To ensure the effectiveness of time management, this fabrication process was carried out according to task distribution dates so that all fabrication process will be done on time.

3.6.1 Marking

The marking process was based on dimensioning. Tools involved were center punch, vernier caliper, 90° elbow and wheeled mechanical measuring device.



Figure 3.10: Marking Process



Figure 3.11: Wheeled Mechanical Measuring Device

3.6.2 Cutting

This method was involved for all materials as the materials were originally in bigger size. All materials were cut in desired measurement so that everything comes together perfectly by the end of the fabrication process. The materials were cut using hand metal cutter for aluminum rod and shear cutting machine for aluminum sheet metal.



Figure 3.12: Vertical Band Saw



22 February, 2010

Figure 3.13: Hand Metal Cutter



22 February, 2010

Figure 3.14: Shear Cutting Machine

3.6.3 Drilling

Drilling process was carried out in order to have holes for rivet. Most of the joining process will be riveting and holes were made on materials by using portable hand drilling machine.



Figure 3.15: Press Drill Machine



Figure 3.16: Portable Hand Drilling Machine

3.6.4 Riveting and Adhesive Glue

Joining most of the part of the product will be riveting. Adhesive glue was also involved in joining process of metal-on-metal. All joining will be based on the drawing.



Figure 3.17: Adhesive Glue



Figure 3.18: Riveting Process

3.6.5 Bending

Most of the part that require bending, pneumatic bending machine was used.



Figure 3.19: Pneumatic Bending Machine

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

The product was predicted to have a mobility feature and multipurpose. This product also predicted to reduce MSI by fulfilling ergonomic values that are absent on existed design on market. Each and one of existed laundry cart have its own portability, effectively handling and multipurpose usage. Therefore this project chooses to make some improvement especially in contact of reducing MSI factors and few additional in the usage of the laundry cart. I encouraged in defining the material, design of the body and how the user match the local civilians in ergonomic features mainly referring to Malaysians as the product will be sold in Malaysia's markets.

4.2 EXPECTED RESULT

The smart laundry cart has been fabricated successfully as plan based on the concept design earlier. The laundry cart can carry out few tasks at a time such as loading laundry, compartments for folded clothes, ironing process, placing iron statically and it is mobile for easier transportation. Though, the result would achieve the best when all tests are carried out on the real size of the laundry cart. Below are few pictures of the product itself.



Figure 4.1: Laundry Cart from Compartment View



Figure 4.2: Laundry Cart from Bars View



Figure 4.3: Detachable Laundry Bag



Figure 4.4: Side View of the Laundry Cart



Figure 4.5: Iron Storage Compartment

4.3 ADVANTAGES

This product features few advantages than the existing laundry cart in the market.

4.3.1 Iron can be kept neatly and secured

At the side of the laundry cart, a special combination of metal with the size of one iron and this particular compartment for iron can make the process of keeping iron and its wire in the easiest way on the cart with good safety approach. When iron is being stored after ironing process is done, the hot metal plate of the iron will be facing the cart. Thus, avoiding from any contact with the user that can cause injuries such as burn. The wire can be neatly put under the iron as there is a special compartment for the purpose of wire storage.



Figure 4.6: Iron Storage Compartment

4.3.2 Detachable Laundry bag

The main purpose of its detachability is to ensure that the bag can be clean in case it's gone too dirty. The laundry bag and the laundry cart can be completely detached as it will give a smaller and lighter cart.



Figure 4.7: Detachable Laundry Bag

4.3.3 Platform for ironing process

In existing market, there are several sizes from the smallest to the biggest size of ironing board. On this cart, I decided to put a small platform that can fit a small size of ironing board. Though this cart should be near to a power supply in order for ironing process to be done, this can be considered as one of the advantages of the laundry cart.



Figure 4.8: Ironing Process Platform

4.3.4 Rod for hanging clothes

This may come in both as advantage and disadvantage. This particular aluminium rod featured on the laundry cart was meant for hanging small clothes or normal size bathing towels.



Figure 4.9: Hanging Area

4.4 DISADVANTAGES

Though the product listed few numbers of advantages, this product still has its own disadvantage. Below are the list of the disadvantage and its brief explanation.

4.4.1 There is no place to hang clothes.

Ironed clothes cannot be hanged on this laundry cart as it has no high rise rod featured on it. This is due to the shortage of raw material and possible problem might occur if there is such place on top of the laundry cart as it will disturb the ironing process.

4.4.2 Absence of lock on wheels

The absence of the lock on the wheel will cause the cart to move on incline or decline surface.

4.4.3 There is no handle to push or pull the cart

User has to hold on to any part of the laundry cart in order to maintain the direction of the cart.

4.5 PROBLEMS ENCOUNTERED

Problems can occur from both aspects: environmental and individual aspect. Environmental problems occur mostly come from the surrounding of the workplace, while individual aspect comes in time management mostly. Due to some constraints and difficulties faced before and during the fabrication process, I had to make a few adjustments onto the design, material used and some changes on the fabrication process.

Below are the difficulties I faced:

4.5.1 The limited usage of some machine in the mechanical lab

Due to lack of skills of MIG or Metal Inert Gas, I have to convert every joining part that involved MIG with riveting. As a result, the whole product's joining process was done by riveting. As towards the end of the duration of fabricating, some of the drills were broken and as alternative, I used strong adhesive metal-on-metal to join some parts on the cart.

4.5.2 The lack of desired raw material

The original size of the prototype was 1:2 to scale. But due to limited material of aluminium sheet metal, the product has to be scale to 1:3. Some rods was planned be featured on top of the cart, but due to shortage of supply, the rod for hanging clothes have to be removed.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

The main objective is to design and fabricate smart laundry cart that is multipurpose and reduces the factor of Musculoskeletal Injury (MSI). The issue of MSI rises when the common users of laundry cart suffer from muscular or joint pain. At the early beginning of starting of this project, the stage of designing should comprises multipurpose usage, by means the end product should be able to carry out several tasks at a time. The product concept was mainly playing role in being a multipurpose product. At the very early stage of designing, it is decided that the product should be able to carry out several tasks at one time. After succeeded with the fabrication process, the product should be in complete assemble as according to design chosen. Various experiments were carried out on this scale of 1:3 prototypes to predict results of its usage, as size play major roles on identifying the effectiveness, actual experiments should be carried out on actual scale product to achieve a precise and accurate result.

5.2 RECOMMENDATIONS

Every day the needs of users on particular product in market are constantly changing. New products in lines are trying to fulfill every positive needs needed in many aspects including in ergonomic values, environmentally friendly and easy to use product. Other than that, the ease of manufacturing and assemble are also play a major role by the manufacturers. On this particular result of fabricating the smart laundry cart, after a brief survey and observation, these recommendations are not impossible to apply.

5.2.1 Closed compartment at one of the shelves

Plenty of shelves are being offered on this laundry cart. These shelves can store various kinds of things at any size that fits. An improvised version on the shelf would be a close compartment or drawers.

5.2.2 Better joining method to withstand heavy load

Aluminium rod on the cart will be appropriately constructed with gas metal arc welding as it is for aluminium joining purpose. The construction will be much stronger with the usage of that particular welding and help to improve its ability to withstand heavy loads acting on the aluminium rod.

5.2.3 Appropriate handle for handling

Handles should be added to reduce awkward postures while pushing the carts from behind or from the side.

5.2.4 Locking mechanism on the swivel wheel

Front directional locking and rear swivel castors were added. Directional locking prevents the castors from swiveling and keeps the cart moving in a straight forward direction, which in turn requires less effort from the user. If this cart are about to build in bigger size, pushing and maneuvering will become easier by increasing the size of the wheels and changing the castor arrangements.

REFERENCES

This guide is prepared based on the following references:

1. Commercial & Industrial Laundry Equipment
<http://www.kelcolaundry.com/>
2. Ikea Antonius Laundry
<http://www.ikea.com.my/>
3. Health and Safety Executive on MSI
<http://www.hse.gov.uk/msd/>
4. Universiti Malaysia Pahang on Thesis Writing Guide
<http://www.ump.edu.my/>
5. Investigating the properties of aluminium sheet metal
<http://www.metalweb.co.uk/>

APPENDIX A2

FLOW CHART

