Bachelor's Degree Thesis

Easy functions cupboard Design for elderly people

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Design for movable cupboard

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Abstract

In Sweden is estimated that near 16% (1.5 million) of its population is over 65 years old. In most of the cases, the elder people would like to live by their own. This means that comfortable and safe environments are a need to match the expectations of this important sector of the society. In this thesis, we focused on designing a kitchen's cupboard for elderly people. We want to solve some common problems such as their unsuitable height for them.

First, we designed an upper cupboard that can easily be pulled down allowing, in a better way, elder people to have access to some stored goods or tools. Secondly, we designed a lifting-lower cupboard in a way that elder people do not need to unnecessarily bend their back to reach what is stored in it.

We use Computer Aided Design (CAD) software, INVENTOR, to model our suggested cupboard, as well as its Finite Element Method module to develop stress analysis to make our design more accurate and truthful.

Keywords:

Elderly-specific cupboard, CAD, Design,

Stress - make our design more accurate and trustful.

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Contents

1. Introduction

In every kitchen, the cupboard plays an extremely important role since we can arrange and organize our dishes, cups, etc and also store some food by using them. Commonly, the furniture designers make cupboards more youthful. They tend to design personalized furniture which may meet the young peoples' needs but it will bring problems to the aged people. Is the cupboard comfortable to use for the aged people? These kinds of questions may appear. Actually, in most of the cases, today's cupboards are too high and too low for elder people. It may cause some safety problem and other inconveniences.

We are looking for the safe, convenient and humanized kitchen. So this thesis focuses on these problems and proposed solution. Therefore, in the present thesis work two cupboard functions were considered in a proposed design in order to make it more suitable for elderly people. First, one upper cupboard was proposed to allow people reaching some goods by an easy pulling up-down drawer. Then, a lower cupboard was designed allowing people lift food easily without bending back.

1.1 Global aging

In 2009, U.S. Census Bureau announced the forecast shows that by 2050, global population over the age of 65 will be increased to 1.53 billion. It is 16% of the mankind population.

According to U.S. researchers predicted that by 2050, Europe will remain as the continent with largest old population with 29% followed by Latin America and sub-Saharan Africa with 18% and 5%, respectively.

United States Census Bureau believes that China and India, two most populous countries, the proportion of older population, although currently is not very obviously, the aging population trend is increasing.

So the aging problem is our main subject in this century. It is the fact that we will all be old someday. So, design the elderly-specific furniture is very essential.

From this fact, we think that design a specific cupboard is very meaningful. It can avoid a lot of accident when old people want to get stuff from the high or low place.

1.2 The aged people's needs

When getting older, we are in many cases, gradually reduce some of our physical capabilities and also our memory. Taking goods or kitchen's staff from standard cupboards can become a hard job when being older. Standard cupboards use to be too high and/or too low and as a consequence people has to stretch their backs, step on chairs, etc, which can be dangerous and put in risk their health. Therefore, we need to improve the cupboard's function for old people.

Considering the particularity of the aged people, the design of the cupboard should offer the following:

- Easy access to get things.
- Easy visualization to remember what staff in the cupboard.
- No need for the user to bend down to get the things from the cupboard..
- More safety for aged people, reducing risk of back pressure.

From this we can know that old people need more requirements to care. Old people have done a lot to our society. We should do something for them to make their lives happier and comfortable.

Think about this, we find that there is a lot of loophole of cupboard that we buy from the market. Such like not very safety, so heavy for the old people to open.

So we think about the requirements of the elderly-specific cupboard.

1.3 Requirement of kitchen

To meet the aged people's needs, the kitchen should have these characteristics:

- Safety
- Reasonable cost
- Good looking
- Room saving – it should arrange space reasonably.
- The cupboard should be easy to use.

2. Some methods and goals on design

The goal is to design a new cupboard, which suit aged people. We want them not having any need to bend their back to take some stuff out of the cupboard. So we want to design a cupboard that old people can easily use without any need to tiptoe to get things from the high cupboard.

We use CAD software and run stress analysis to solve the problem we have met.

3. Describe our kitchen and how to improve it

3.1 The kitchen of situation

We should do thing that is make old people take something convenient in our thesis. Then, we start improving cupboard from the kitchen of my flat. In the first place, we need to know about our kitchen of details that have which defects. After that we though the needs of old people, we will design a cupboard that fit them. The picture below 3.1 to 3.3 show that is our cupboard style and where should be improved.

Figure 3.1 Original kitchen

Show in figure 1, we can see that is a typical small cupboard, its high of about 2400mm and long 1200mm. It makes use of wood material in whole body. Next we look at its internal structure. We can see figure 3.2

Figure 3.2 upper part of the cupboard

This is an upper part of cupboard that is a very normally place where put something in figure 3.2. There are four floors which floors have the same height. However, if old people take or put something who feel that very uneasy to get the thing of high place. Because the height is 1700mm to 1860mm from layer second to layer third. That means take something from high place that is so dangerous for old people. Hence, we should improve these defects, and make old people to have a nice environment where take and put things easily.

Figure 3.3 under part of the cupboard

However, not only upper part of the cupboard has problem of safety, but also under part of the cupboard has convenience issue. As figure 3 shown, we can know about if someone takes thing who need bent down or squatted. But these motions are extremely inconvenient for old people. They could be injured in these motions. As we all know that their bones will be crisp in the old age, while the elderly the most vulnerable place is their waist. Therefore, in order to easily pick up stuff below, we will design a new under cupboard, which the old people can easily pick up the following things without having to bent down and squat.

The information above is what we look like the original kitchen cabinets, and where is the summary of the result we need improvement.

3.2 Improving a cupboard.

To improve a kitchen's cupboard we began considering how we should innovate from the old people needs (see Section 1.3).Therefore, we can look around these aspects to start our design.

3.2.1 Improving the upper cupboard

Firstly, the upper part of the cupboard must allow the elderly to take things easily. Then, we consider that the upper cupboard can drop down. There are two aspects that can be improved in our cupboard. The first aspect is making the whole upper cupboard that can be move down including the frame of cupboard. The second aspect is only moving ambry of the grid inside the cupboard.

The following table is a comparison which method is better:

	Advantage	Disadvantage	Use
Whole upper cupboard	1) It can be dropped very lower.	1) Inconvenient when old people only take one thing. 2) It can't install other device such as rang hood.	No
Partial space in cupboard	1) That is convenient to take things from each partial space. 2) It can be install other device.	1) Old people may not remember which partial space has which staff.	Yes

To better understand the second aspect, let's look at the figure 1.5.

Figure 3.4

The basket for spices can be used instead of having the different spicy jars in an inside box at the cupboard. This design is very good and convenient, and can easily allow old people or disable people to get something. However, this way is not suitable for our cupboard, because the upper cupboard is too high to pull down the basket. This basket represents an important reference for us. In our case, we would like to have it as an internal box of the cupboard that can easily be pulling down from the upper cupboard. This idea could bring easy access to some goods and also save space in the kitchen.

3.2.2 Improving lower cupboard

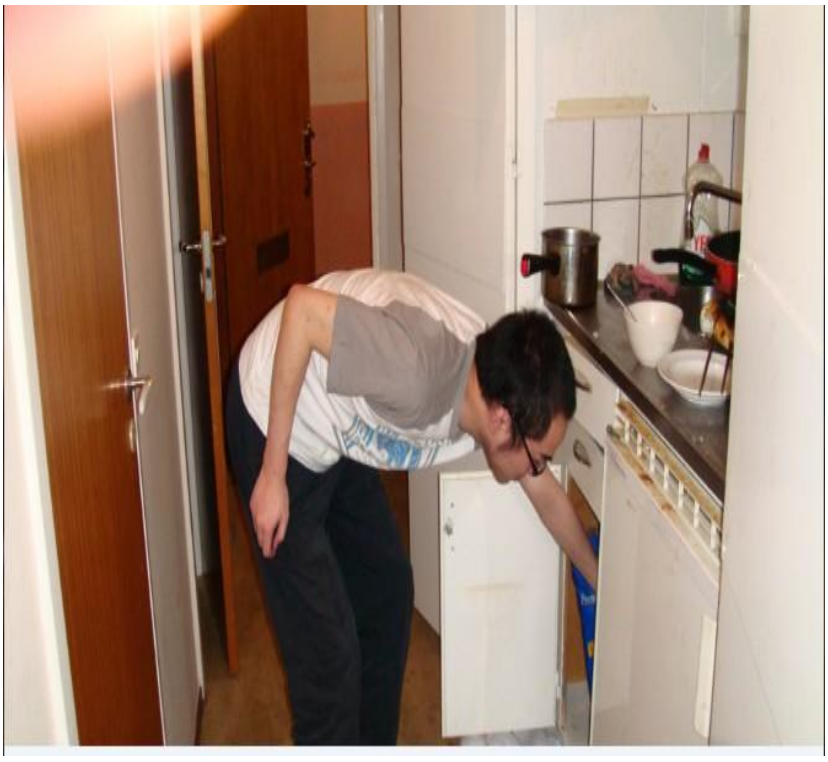


Figure 3.5

Commonly, old people need to bend their back when they get something from the lower cupboard. This is a very harmful action and we should avoid this problem. So, we have a new idea for the under cupboard. In this case, we would like to have a lifting inner box or shelves in the cupboard that can reduce significantly this problem.

4. Cupboard design and innovation for upper cupboard.

4.1.1 Upper cupboard

We use AutoCAD-Inventor to design our cupboard. We have designed three models and these models can be shown as real furniture in our kitchen. Figure 4.11 a shows the original cupboard model (from a standard kitchen) and figure 4.11, b shows the cupboard after we introduce our suggested improvements.

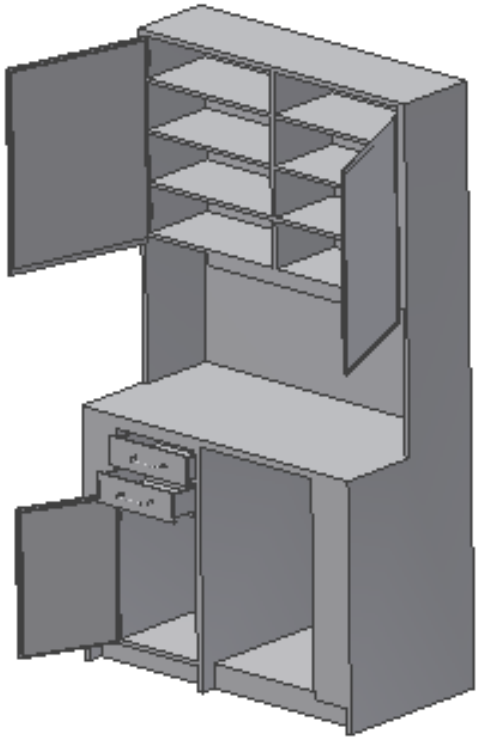


Figure 4.11 Original cupboard

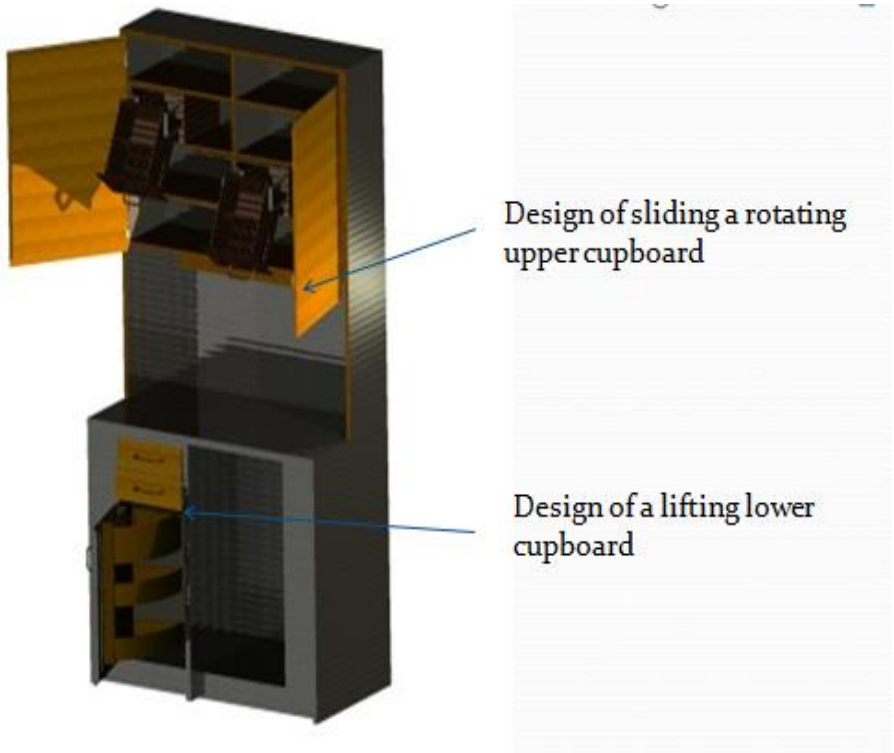


Figure 4.12 improved cupboard

From figure 4.11 and 4.12, we can see the difference between two cupboards. We observed that the upper cupboard can rotate and drop down, and after it moves, old people can get something easily. This result we want to get. Next we will show the function of the upper cupboard.

Figure 4.13 Show the upper cupboard when it works.

From figure 4.13 that is upper cupboard design. We made a pull-out style in the upper cupboard. Then, we reduce the height by rotating way in order to the old people to get things easy.

4.1.2 Main parts

We have known that upper cupboard works detail. Then, we will introduce the main parts.

First one is frame part, we can see figure 4.14:

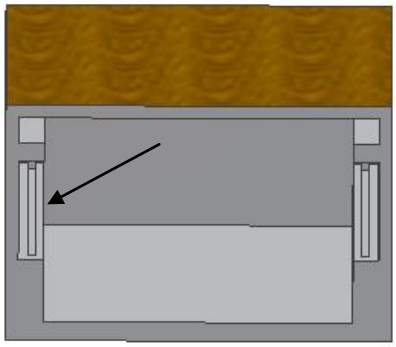


Figure 4.14 Frame part

According to this figure, we can see two tracks in the frame. The two tracks are slide rail that we can reduce friction by two slide rail when we pull the inside box. Old people pull the box that can be save labor if that box is heave.

Second is rotating part that is very important in our design.

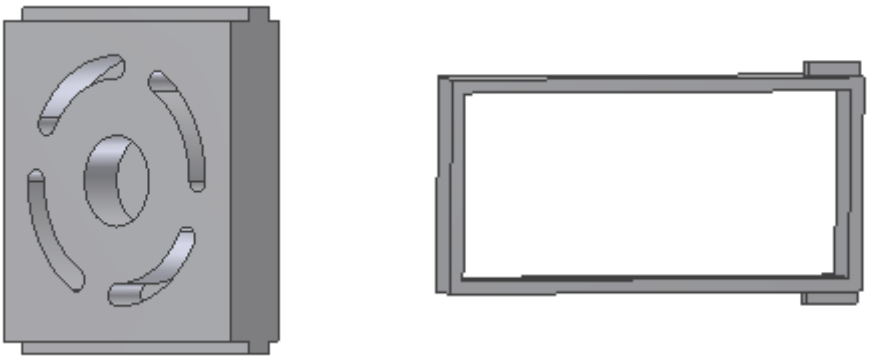


Figure 4.15 rotating part and support part

Figure 4.15 shows two parts that the rotating part should be slide in the extend part track. The support part joint frame part and the rotating part joint the main box. Therefore, these parts fulfill rotating without crash between box and frame. There is

60 degree path groove in the rotating part, so we can pull box down 60 degree and reduce the height so that old people can easy to get thing.

Third is main box part, which we can see in Figure 4.16.

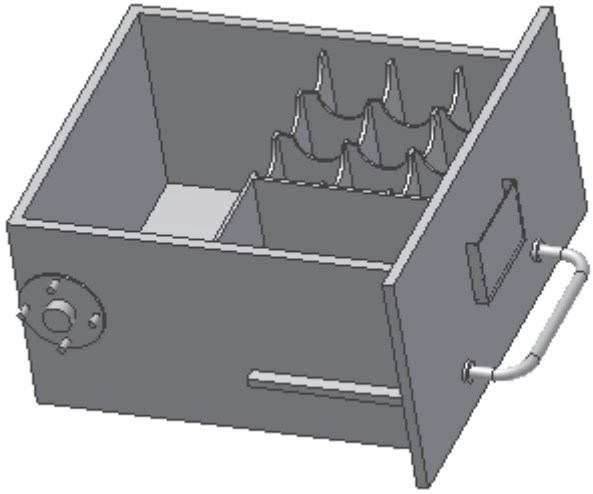


Figure 4.16 box part

The main box part has a little design in there. One is a card groove who can write information in card and insert it that can be easy to remember what things in this box for old people. This special pattern can protect staff that is not crashed when the box move. In the box, the right side can put some condiment bottles. The left side and top side can put some large things.

4.2.1 Upper cupboard stress analysis

Stress analysis for support part can be divided into two aspects. One is use Inventor simulation. The other is calculated by hand.

4.2.2 Inventor simulation

Firstly, we need assemble these parts when we create stress simulation. Then, we should choose material, find fix point, and add gravity and forces on the model. Finally, we get the result that we see the following the figure 4.21

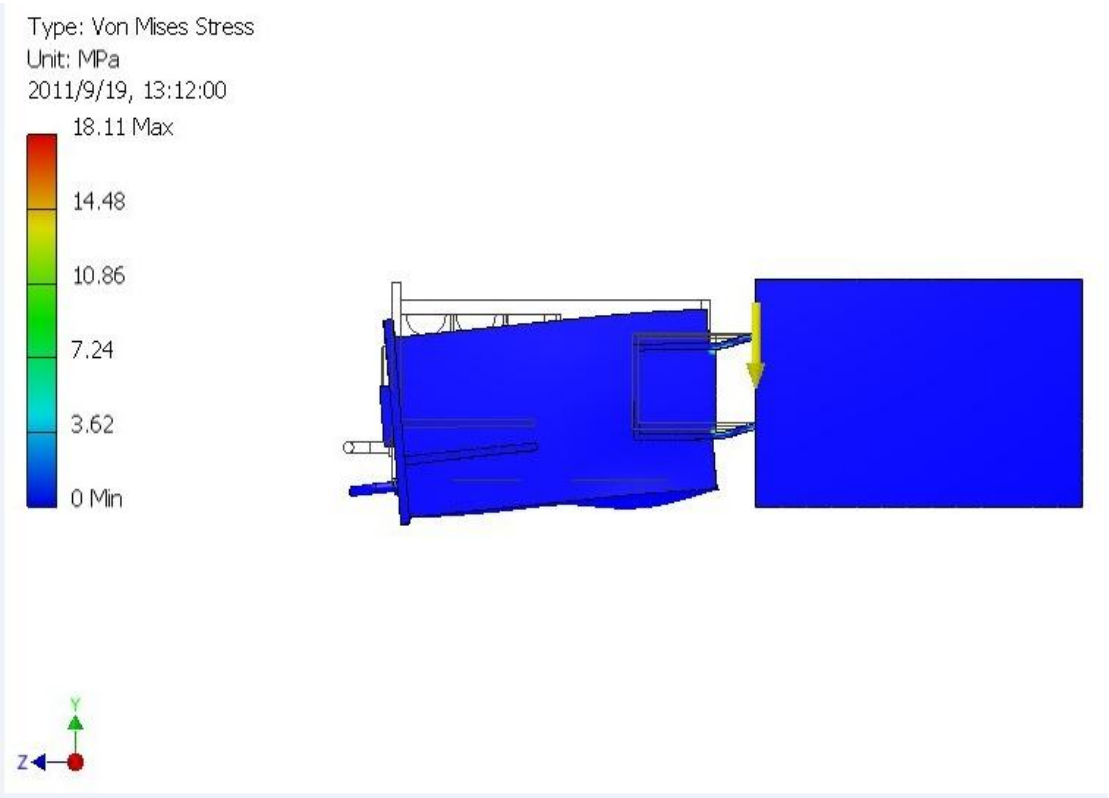


Figure 4.21 stress analysis

In the figure 4.21 we can find the largest stress on the support part is 18.1Mpa. We add 75N on each support part and put a pressure 0.003Mpa in the box. The material of support part is aluminum 6061. A more detailed information of the material in found in table 3.1.

Table 4.22 Aluminum 6061 properties

Name	Aluminum-6061	
General	Mass Density	2.71 g/cm^3
	Yield Strength	275 MPa
	Ultimate Tensile Strength	310 MPa
Stress	Young's Modulus	68.9 GPa
	Poisson's Ratio	0.33 ul
	Shear Modulus	0 GPa
Stress Thermal	Expansion Coefficient	0.000000000236 ul/c
	Thermal Conductivity	167 W/(m K)
	Specific Heat	1256.1 J/(kg c)

We know the maximum stress in figure 4.21 and the yield strength in figure 4.22

So we calculate safe factor:

$$\Psi = \frac{[\sigma_{all}]}{\sigma_{max}} = \frac{275}{18.1} = 15.2$$

Safety factor is 15.2 that meaning the product is very safe when it works, but maybe safety factor is so large it led to waste material in the product. We can improve that problem in the future.

4.2.3 Stress analysis to the beam by hand.

We choose Aluminum 6061 for two support frames. The size is 140mm × 18mm × 5mm. Because the support part has two beams, we calculate one beam is enough. If one support part has 75N, so the one beam has 37.5N, and we use inventor tool to measure that stress force distance is 52.31mm. The middle centre of section y is 2.5mm

Calculate the moment of inertia (I) and the section modulus (W) with the mechanical formula:

(A small groove in the section, the groove is too small to we ignore it. So, we assume the section as rectangular)

$$I = \frac{1}{12} bh^3$$

$$I = 187.5\ mm^4$$

$$M = FL$$

$$M = 37.5 \times 52.31 = 1961.625\ N \cdot mm$$

$$\sigma = \frac{M \times y}{I}$$

$$\sigma = 26.155\ Mpa$$

So we can calculate the safety factor:

$$\Psi = 10.5$$

The value said it's safe enough.

4.2.4 Discuss the result between analysis stresses by inventor and calculate by hand

One thing we get know that the two result between by inventor and by hand are proved the structure is safe. But, there are some differences in the result. Obviously, we can find one difference that is 18.1Mpa is by inventor and 26.155Mpa is by hand. The difference is due to the approximations in geometry.

4.3.1 Dynamic simulation

Dynamic simulation in INVENTOR was also carried out to evaluate the necessary force to pull the drawer we design at the upper cupboard (See Figure 4.31 and 4.32). For running this simulation we consider the following:

Load: 200N in the box (about 20 kg as a Design load)

Friction coefficient: 0.1 (very low friction)

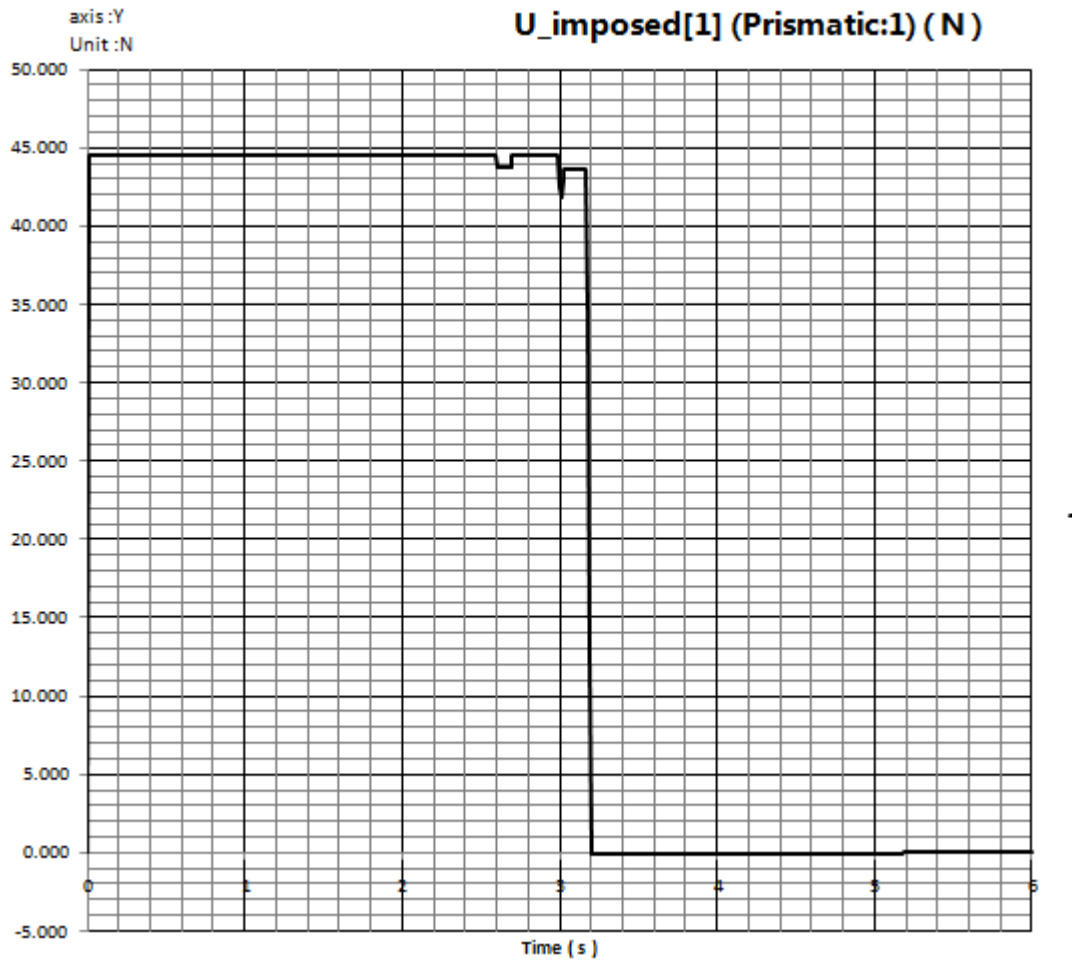


Figure 4.31 Dynamic simulation

We assume as simulation time 3 seconds.

The results show that a force of 45 N is need to pull the drawer out, when there is a weight of 20 Kg, which is only our design load, to make safer the cupboard. In reality, the load could be about 10 Kg as maximum, which means that the necessary pulling force will be much lower. Then, the elderly people will be able to easily open it.

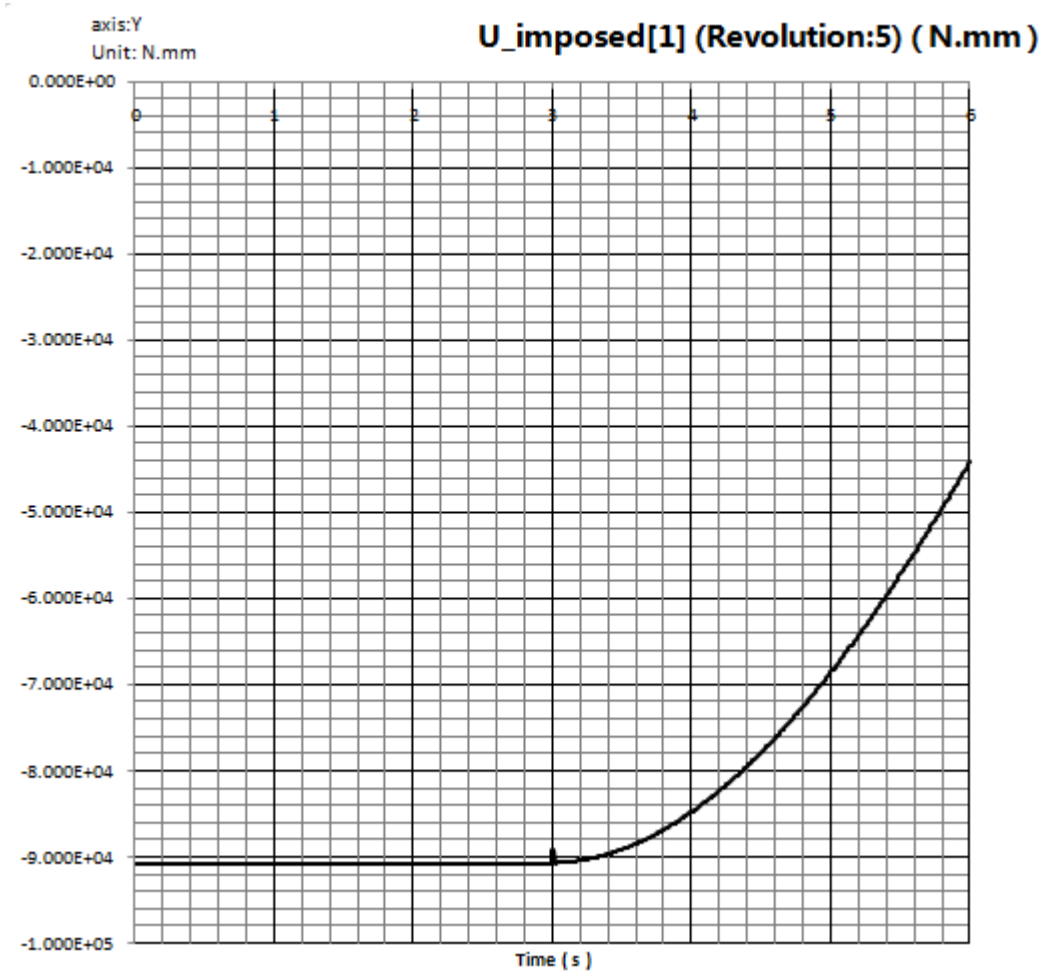


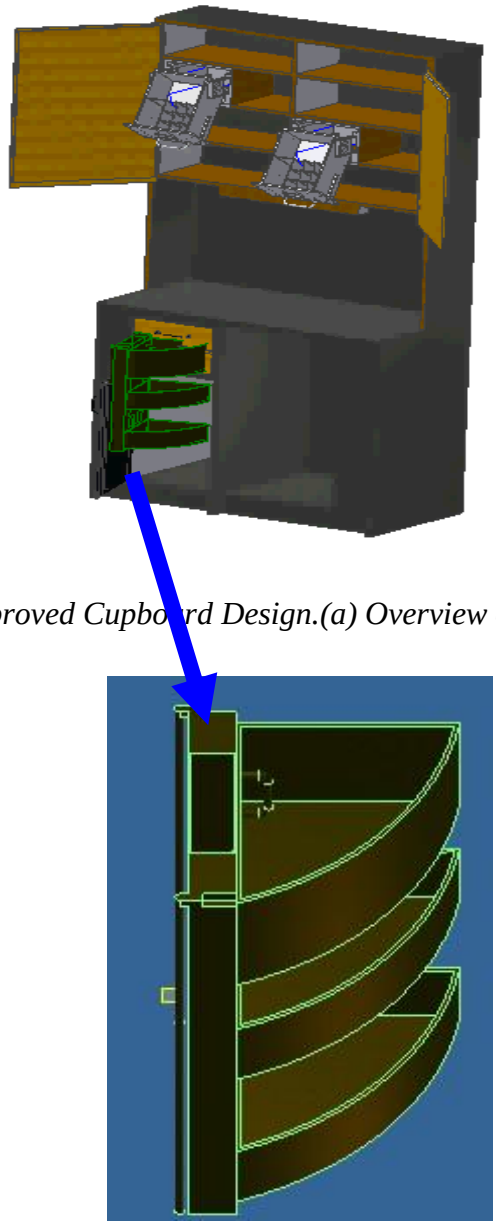
Figure 4.32 Dynamic simulate for rotation

Figure 4.32 shows the rotation angle of the drawer when pulling it down.

5. Cupboard design and innovation for lifting cupboard

5.1.1 Lifting cupboard

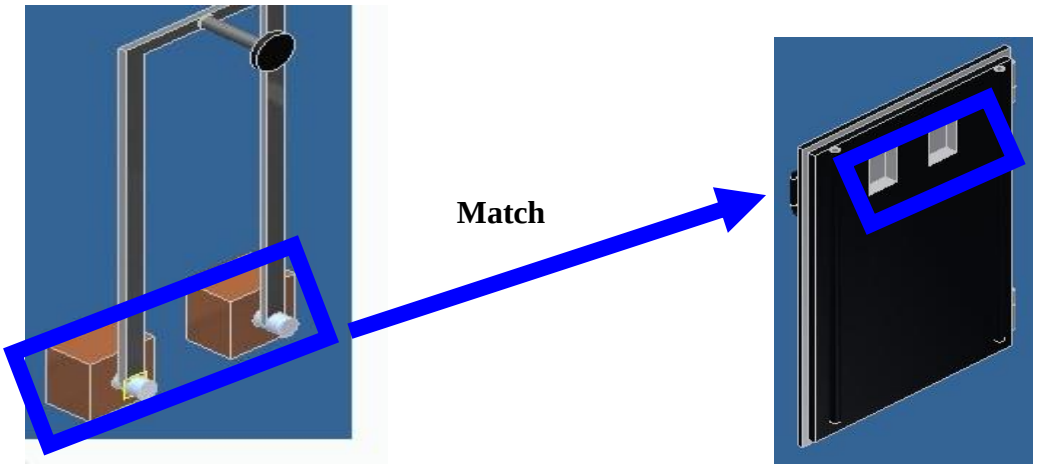
We also use AutoCAD-Inventor to design our lifting cupboard. From the picture 5.11.a and picture 5.11b, we can clearly see the lifting cupboard's structure.



5.11 Improved Cupboard Design.(a) Overview of the cupboard.

5.11(b) Lifting Cupboard

5.1.2 Principle of the lifting cupboard's operation



5.12 rectangular solid *5.13 concave*

We install a protruding rectangular solid (Figure 5.12) on the bottom of shelf which is inside the lifting cupboard. And there is a spring in the protruding rectangular solid. And then we make a same size concave rectangular solid (Figure 5.13) on the top of the door of the lifting cupboard. Let's think about it. If we pull up the lifting cupboard, the protruding rectangular solid is perfectly matched with the concave rectangular solid. So the shelf is fixed. The 2 part can be perfectly together. and the spring on the cupboard is compressed with the door and it could be together.

However, when we take up the cupboard, the spring (Figure 5.14) in the rectangular solid is protruding. So we can image that when we take up the cabinet high enough, the bottom of the cabinet‘s protruding rectangular solid is just insert in the concave rectangular solid on the top of the door of the cabinet. So the cabinet is fixed and will

not drop by the gravity.

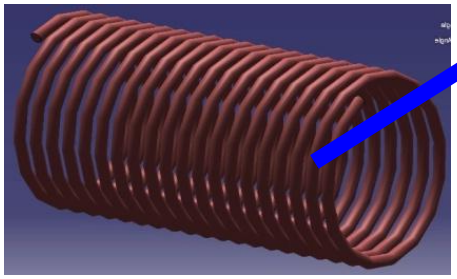


Figure 5.14 Spring

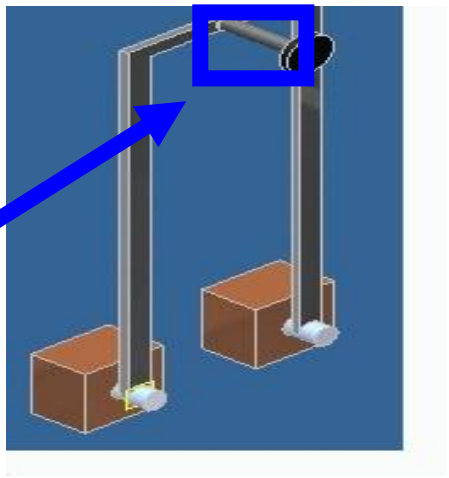


Figure 5.15 the place to install the spring

How to make the raised cupboard down? We make a press-button on the cabinet. The press-button can control the spring. If we pressed the button, the spring could back immediately. So to make the raised cupboard down, we just need to press the button. It is very convenient.

The material of the lifting cupboard is PVC-U and Aluminum-6061. The function is 1) store food and seasoning; 2) cupboard could be upgraded. The max load capacity is 30kg.

5.2.1 Stress analysis for lifting cupboard

Here is the simulation result for the lower cupboard.

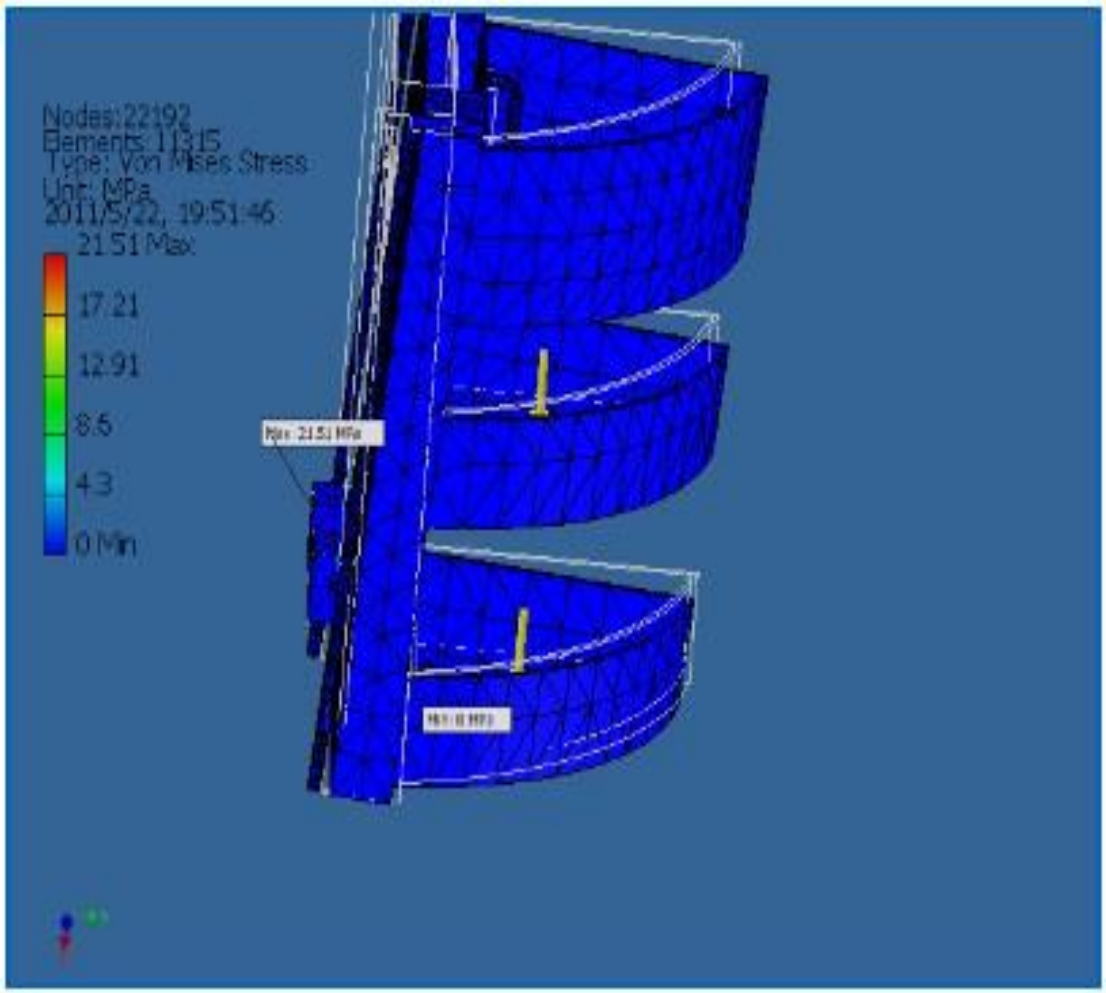


Figure 5.21 Stress Analysis of the lifting cupboard

From this picture we can find the largest stress is 21.51Mpa.The load at cupboard is 30 Kg. Yield strength is 46.53Mpa. Ultimate Tensile Strength is 50Mpa. Young's Modulus is 2.5Gpa.

$$\varphi = \frac{\sigma_{all}}{\sigma_{max}} = \frac{46.53}{21.51} \approx 2.16$$

6. Material Choose for Our Cupboard

People want their own living environment healthy and comfortable.Especially for sensitive old people, healthy environment is important.So, when selecting advanced materials we must meet the following factors:sustainability,weight,strength and economical efficiency.

First of all, sustainability is a concept which must be advocated in 21st century.As the earth's resources constantly mining,human has more and more survival pressure.Use green, recyclable materials is a good choice.For humans, sustainability is the potential for long-term maintenance of well being, which has environmental, economic, and social dimensions.

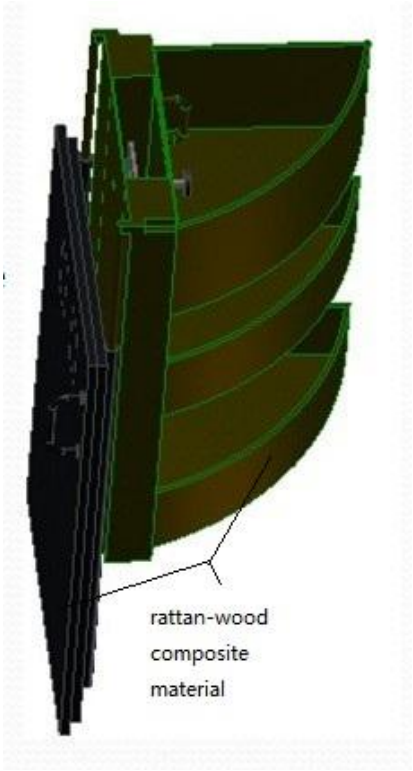
The second requirement is weight.The hand strength of old people is limited, cupboard material must be light.Even if there's an accident, it also can take the damage to a minimum.

At the availability of weight, these also need strength.Mechanical property has a direct influence on the using life.

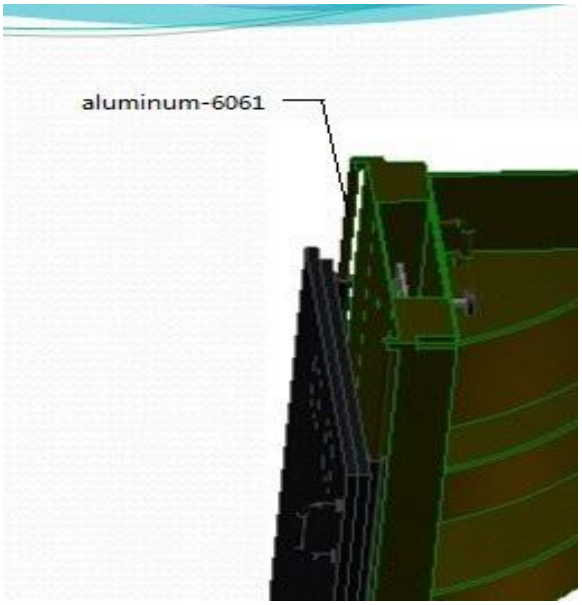
Finally,the economical efficiency of material is also very important, it relates to whether a design that can popularize.

Combining with the above four characteristics,we decided to choose the following major materials : rattan-wood composite materials,aluminum-6061 and PVC-U.

Rattan-wood composite materials are characterized by light weight, high strength, sustainable and low price. It is usually three-layer structure , the two surface use of poplar wood, middle with rattan materials .Experiments show that this material is more lighter and stronger than the same thickness of pure wood . We use rattan-wood composite material as the main material for the rotating upper cupboard and lifting cupboard.



In the slide, we used aluminum-6061 as the main material. It is based on magnesium and silicon as alloying elements. Overall have good mechanical properties, heat treatment and welding can be. It is the most commonly used aluminum. The tensile strength is 290 MPa and the yield strength is 241 MPa.



7. Conclusion

For the world society is essential that the living conditions of their inhabitants become progressively better, comfortable and safe. Designing a better for cupboard which especially for elderly people who represented an interesting task that can be seen as a way to contribute improving the living conditions of this important sector of our society. We feel that it has been a great help for us to develop a design of this cupboard. During the three-month design, we had a lot of problems, from initial conception to final result. Finally, we completed the initial conception with the guidance of our supervisor.

Our final design consisted of a cupboard that can offer two useful functions: a Rotating Upper Cupboard and a Lifting Cupboard. We think that both functions will be helpful for elderly people to reduce the risks of hurting themselves when taking some goods or kitchen tools from the upper or lower cupboard.

Through the software called INVENTOR, we put our ideas expressed as a computer model. We also use this software for stress analysis to evaluate our design. We consider unusual materials such as rattan-wood composite materials, -6061, PVC-U. Rattan-wood composite materials are more lighter and stronger than standard wood.

Aluminum- 6061 was also consider for some components of the cupboard since it has great mechanical performance and PVC-U light，and cheap. In addition, our design can reduce the range of motion for elderly people when they want to take something.

8. Further Work

We are still considering some details of our cupboard design that can be done as a further work, such as use electrical automation technology to make the cupboard more simple and safe. In addition, with the continuous development of biotechnology, we can use some material which can keep food fresh in the future.

9. Reference

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