Special construction solutions for secure senior and disability living

Specialkonstruktionslösningar för Tryggare Senior och Handikappsboende

Authors


Dr. Sharon Kao-Walter, Department of Mechanical Engineering,


Mr Per-Olof Svensson, Department of Mechanical Engineering,


Md. Shafiqul Islam, Department of Mechanical Engineering,


Mr Abdullah Khan, Department of Mechanical Engineering,

Department of Mechanical Engineering, School of Engineering

Blekinge Institute of Technology, Karlskrona

Executive Summary

Population development

In Sweden there are approximately 1.7 million persons aged 65 or older. The group represents 18 percent of the population, compared with 12-13 percent in the 1960s and almost 5 percent in the 1850s (Ref. Statistics Sweden (SCB) (2010), Statistical Database (Population)). During the period between 1950 and 1990, the number of people aged 65 or older doubled (Ref. SCB, Statistical Yearbook 2010). More than 490000 people are 80 or older (Ref. SCB (2009), Demodraphic report 2009:1). According to population forecasts for the Nordic countries as a whole, the proportion is that persons over 80 years will amount to about 8 percent of the population in 2040, compared to the current 5 percent (Ref. Statistics Denmark, Ulla Agerskov (2007), Nordic Statistical Yearbook 2007, Vol. 45th).
The group aged 65 and older will in the approximate values increase from the current 1.7 million to nearly 2.1 million in 2020, to more than 2.3 million in 2030, to over 2.5 million in 2040, to nearly 2.6 million in 2050 and just over 2.7 million in 2060. The group's share of the total population is projected to increase from the current 18 percent to 25 percent in 2060 (Ref. SCB (2010), Statistical Database, SCB (2010), future population of Sweden 2010-2060).
Even the people who are 80 and older are increasing in number, according to SCB forecasts. Over the next 10 years, the population aged 80 and older only increases marginally. However, a dramatic increase is inspected to start around 2020. It is the baby boom of the 1940s that will be affecting the development. It is primarily the development of the number of people aged 80 and older that affect the cost of health care.
The number of persons aged 80 and older has risen since the 1960s. In 1960, there were 141 000 individuals aged 80 and over, and in 2008 the number was 493 000. Until about 2020, the number will be relatively constant but it will after a few years increase rapidly when the large litters born in the 1940s reach these ages. At the end of the forecast period, the number of individuals aged 80 and older will reach almost one million.

The Faculty of Mechanical Engineering at Blekinge Institute of Technology (BTH) has contributed significantly to the Strategic Sustainable Development (SSD) and offer productive engineering solution for human disability issues. For the past 10 years, BTH in collaboration with different organizations has produced quality research projects covering different areas of healthcare and senior housing to make healthy living style for people with disabilities.

In collaboration with the insurance company Länsförsäkringar, the Faculty of Mechanical Engineering has conducted the present project during 2011 and 2012. This project has involved the expertise of five faculty members (Docent Sharon Kao-Walter, senior project coordinator Per-Olof Svensson, PhD, Armando Leon, Professor Bo Helgeson and PhD Mats Walter), four assistants (Xin Chen, Hongyu Deng, Abdullah Khan and Md. Shafiqul Islam) and 15 students. Some persons from

the County Council of Blekinge have been involved in discussions. The involved members have visited different companies (Boverket, Länsförsäkringar Blekinge, Ronnebyhus, Hjälpmedelscentralen Blekinge etc) and cooperated in order to survey and collect information about requirements, needs, existing solutions and research possibilities. This research team has visited and interviewed healthcare staffs at Valjeviken rehabilitation center, the Vidablick sheltered housing, and staff and patients at the sheltered housing and care homes of Fregatten.

One of the authors of this document, Per-Olof Svensson, is the CEO of Innovage, a company in housing that provides a sound foundation for the planning of senior housing for a secure and pleasant future. For a long time, Per-Olof Svensson has contributed in international projects about senior housing, health, e-health and a number of projects in the area of health care at Faculties of Mechanical Engineering and Health and Communication at Blekinge Institute of Technology. Some of the projects that Per-Olof Svensson has been a member of are described in the following sections.

Two of the earlier projects have been the basic for "***Senior Living - a whole concept***". The first project is "**Senior Living 2000",** a national project carried out at BTH with the focus on how to organize the senior living with senior housing, service center and an association composed of the inhabitants in the housing and those who live in the nearby area. The second project is "**WelHops"** which is an EU-project with the document "***Recommendation how to build senior housing",*** a handbook about the design and planning of senior housing.

The concept of senior housing carried out in the above mentioned projects has been awarded has been awarded as ***Best Practice 2010 in Europe*** by the network *Silverlife,* and was a **finalist in *World Habitat Award 2010***, a *United Nation award* that started 27 years ago. Only four candidates from Sweden have been finalists since the award was first given.

From 2010 to 2011 BTH was formed part of the EU project **"IMMODI".** The aims for the project were to capitalize results and good practices developed by the partners in the field of e-government and e-health, which strongly contribute to the development of mountain and rural territories. Since January 2012 is BTH member of the project "**Innovage-project**". The aims for this project are: Firstly, increasing the effectiveness of regional development policies for eco-independent living for the elderly who can firstly be achieved through regional and inter-regional networking, Mentoring activities and clustering activities. Secondly, the project partners can increase the efficiency of these development policies by adopting an approach that enables regional decision-makers to implement new policies for eco-independent living, as well as developing new tools that help assess the effectiveness of these policies.

Together with this and other projects and a great network in the area of senior housing, we have together built up a strong competence in how to plan, build and organize services, housing and care for the seniors to ensure a living that is secure and characterized by wellness. The research project described in the following is mostly theoretical and few prototypes are done. Hopefully, in the new project we can do prototypes together with the industry. There are a lot of possibilities when it comes to conducting new research in the area of health and housing. Adjusting the homes for persons with disabilities signify higher costs for the municipalities. We hope to go further with new projects in this area.

Some of the research projects which have been conducted in the healthcare area at BTH are listed as

- Shower easy access for the elderly or people with physical disabilities.
- Electric wheelchair for easy access to toilet with lifting device adapted for the elderly or people with physical disabilities.
- Easy Functions Cupboard Design for Elderly People.
- Single view metrology applied for dynamic control of sink height for children.

During the project and after discussions with users, businesses and organizations, the need of a number of ideas for safer senior living has been chosed, which has resulted in some solutions related to this project, including:

- An optimized design of a new stair climbing wheelchair.
- Locking mechanism in a manual wheelchair

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1. Introduction:

Population development

In Sweden there are approximately 1.7 million persons aged 65 or older. The group represents 18 percent of the population, compared with 12-13 percent in the 1960s and almost 5 percent in the 1850s (Ref. Statistics Sweden (SCB) (2010), Statistical Database (Population)). During the period between 1950 and 1990, the number of people aged 65 or older doubled (Ref. SCB, Statistical Yearbook 2010). The number of people aged 80 or older are more than 490 000 people (Ref. SCB (2009), Demographic report 2009:1).According to population forecasts for the Nordic countries as a whole, the proportion is that persons over 80 years will amount to about 8 percent of the population in 2040, compared to the current 5 percent (Ref. Statistics Denmark, Ulla Agerskov (2007), Nordic Statistical Yearbook 2007, Vol. 45th).
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The number of persons aged 80 and older has risen since the 1960s. In 1960, there were 141 000 individuals aged 80 and over, and in 2008 the number was 493 000. Until about 2020, the number will be relatively constant but it will after a few years increase rapidly when the large litters born in the 1940s reach these ages. At the end of the forecast period, the number of individuals aged 80 and older will reach almost one million.

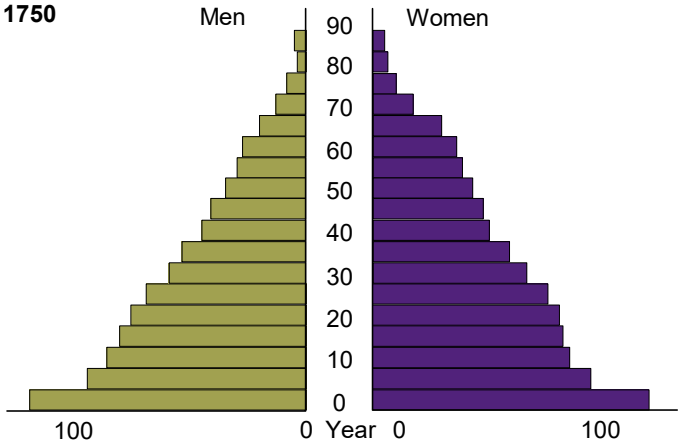
Reduced mobility and physical disability (Ref. SCB (2002/03, 2004, 2005, 2006, 2008), Surveys of Living Conditions (ULF).).

Reduced mobility occurred in 2006 in approximately 25 percent of the men and about 33 percent of the women in the group 65-69 years. In the age groups 70-74 years and 75-79 years, less than half to nearly 60 percent of the women presented reduced mobility, for men, the incidence was15-20 percentage points lower (31 percent, 43 percent) than among women. In the group of 80-84 years, approximately 60 percent of men and 80 percent of female are impairment.
Impairments occurred in 2008 in the group 65-74 years in approximately 7 percent of the men and about 17 percent of the women. In the age group 75-84 years, this

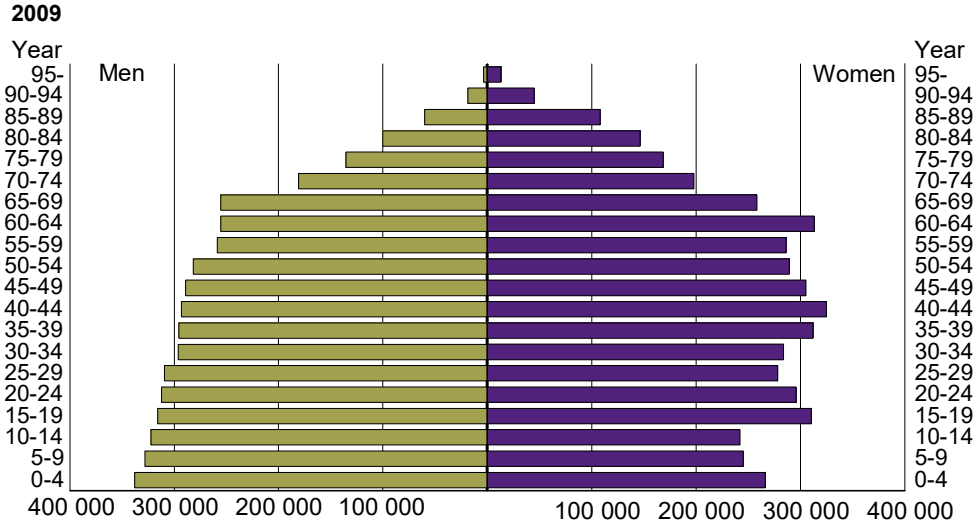
proportion increased to 20 per cent among the men and about 27 per- cent among the women. Among the oldest old (85 +), about 48 percent of the women presented a physical disability. No corresponding data are available for men.

Severely disabled individuals, i.e. people who need help or facilities to move, were in 2008 about 5 percent of the men and about 8 percent of the women in the group 65 to74 years. Corresponding for the group 75-84 years was about 14 percent of the men and about 19 percent of the women. Among the oldest old (85 +), 44 percent of the women were severely disabled. No corresponding data are at hand for the men.

The population dispersion has changed a lot during the last 260 years and will change more during the next 25 years.



Ref: Statistical Yearbook 2010, SCB



Ref: Population statistics, SCB

2. Research in Health Care at Blekinge Institute of Technology (BTH) at the Faculty of Mechanical Engineering

The research work can be divided into two major categories,

- Modification for smart housing (indoor) 2.1
- Redesign and improvement of wheel chairs 2.2

A short summary of these projects can be found in the next chapter. A detailed description of each project can be found in Appendix A.

2.1. Modification for smart housing:

2.1.1. Single view metrology applied for dynamic control of sink height for children

In our modern society, the design and implementation of intelligent equipments for autonomous physical services become more and more important. In line with this, the proposed Intelligent Vision Agent System, IVAS, is able to automatically detect and identify a target for a specific task by surveying human activities space.

One of IVAS' applications can be the adjustment of sink height for people of different heights. Usually, the sink is fixed in one place, however, the sink could be too high to use for children. This could become a real problem and may bring much inconvenience and insecurity for little boys and girls.

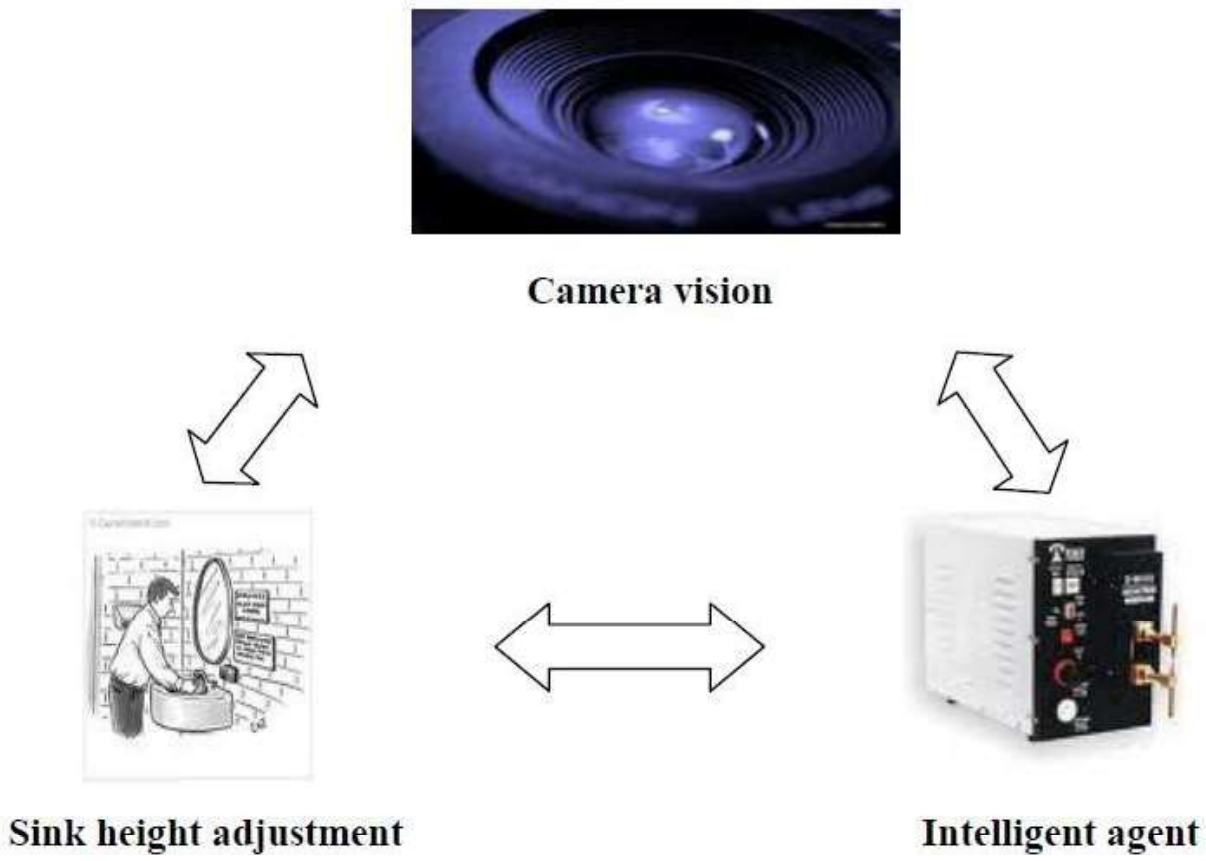
The equipment for dynamical adjustment of sink height is rare in today's society. The most common sink height adjustments are of two types. The first alternative is to use two sinks, one for adults and one for children. The second way is to use a spring device to adjust the height of the sink. But both solutions have some limitations.

Example of double height sink for children

Example of adjustable sink height for children

The disadvantage of the first method is that it takes too much space, and not all bathrooms can

accommodate two sinks at the same time. The weakness of the second method is the need to manual adjusting the height of the sink.
In order to achieve an optimal design of an adjustable sink height, the author of this project author uses a camera fixed on the wall that is connected to an intelligent agent controlling suitable actuator. The camera takes a photo of the person who comes to the sink. The height of the person can be estimated from the image. Then, this height value is used to find the suitable sink height for the user. Finally, the sink descends or ascends by the lifting columns to adjust it to the different heights of people.



An overview of an intelligent vision agent system in the sink height adjustment application

In this thesis, the author has implemented a method, which estimates the height of a person from a single image. This technique is based on the single view metrology.

2.1.2 Easy functions cupboard design for elderly people

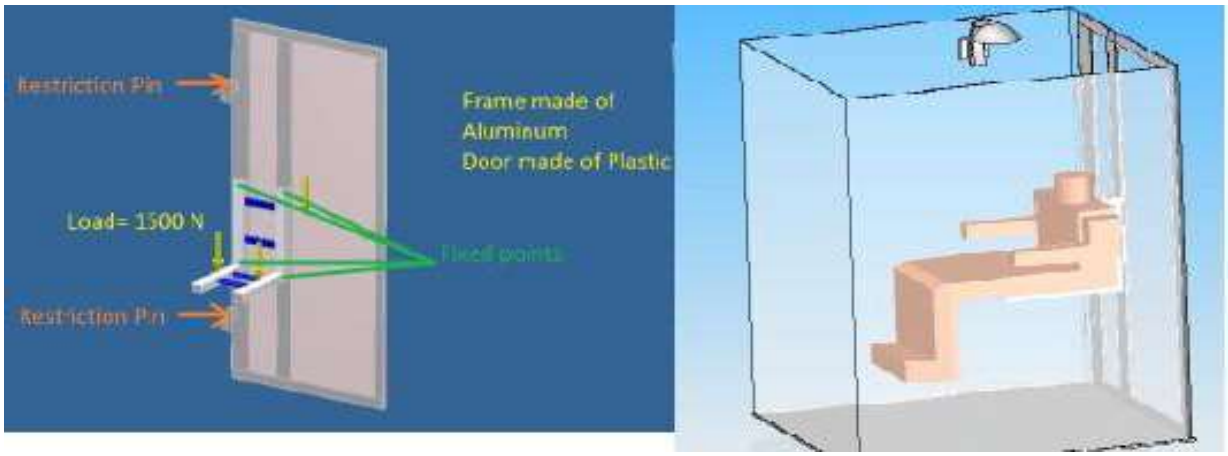
In this research, the focus was on designing a kitchen's cupboard for elderly people. Some common problems, such as unsuitable height of cupboards, were addressed. First, the upper cupboard was designed so that it can easily be pulled down allowing, in a better way, elderly people to have access to the stored goods or tools. Secondly, a lifting lower cupboard was designed in a way so that elderly people do not need to unnecessarily bend their backs to reach what is stored in it.

Physical difficulty that can be prevented by redesign

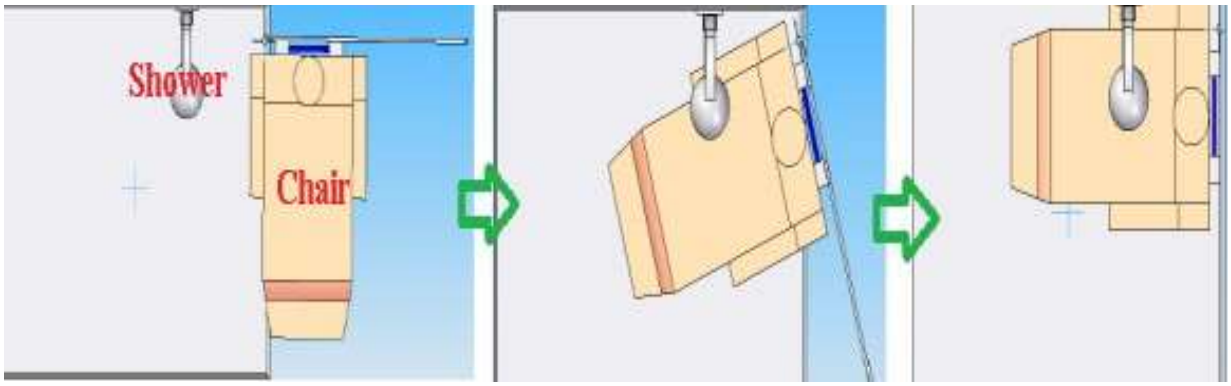
Computer Aided Design (CAD) software, INVENTOR, was used to model our suggested cupboard, as well as its Finite Element Method module to develop stress analysis to make the design more accurate and truthful.

2.1.3. Shower easy access for elder or people with physical disabilities

This project has been created to help the elderly or people with physical disabilities. The help consists of getting easier access to the shower. To reach our purpose, we realized a really innovative idea. The idea is based on a door which rotates 90° with respect to a lateral axis. A chair is attached to that door to easier get to the shower. When the user is in front of the opened door, it will be easier for him or her to reach the chair which is added to the door. After that, when the door is closed, the user will be in the perfect position for a shower. A CAD model was developed to make this design and also to evaluate its resistance and safety.



Chair attached to the shower door



Movement of the shower door

2.2. Redesign of wheel chair:

2.2.1 Electric wheelchair for easy access to toilet with a lifting device adapted for older or people with physical disabilities

This project has been created to help the older or people with physical disabilities. The help consists of getting easier access to the WC. To reach our purpose, we realized a really innovative idea. The idea is based on an electric wheelchair with a lifting device which helps to stand up/sit. This lifting device consist of a pneumatic piston that acts only when the person wants to sit down on the toilet, pushing the chair down, or when the user wants to get up from the toilet, pushing the chair up, always keeping the back upright. Another secondary use is that of an indoor wheelchair. A CAD model was developed to make this design and also to evaluate its resistance and safety.

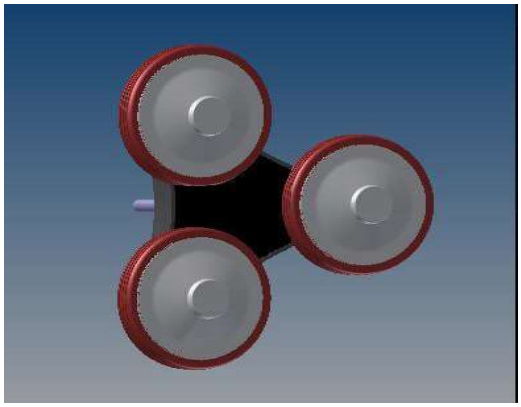
Final CAD Design of wheelchair coupling with the toilet.

To facilitate for elderly people, with the purpose of enabling a healthy life style, this thesis project is focused on the design of an electrical slim-home wheelchair with an application for easy access to toilets. This wheelchair is like a conventional electric wheelchair, but is characterized by a lifting device in the back that helps disabled/elder people to stand or sit up from the toilet bowl.

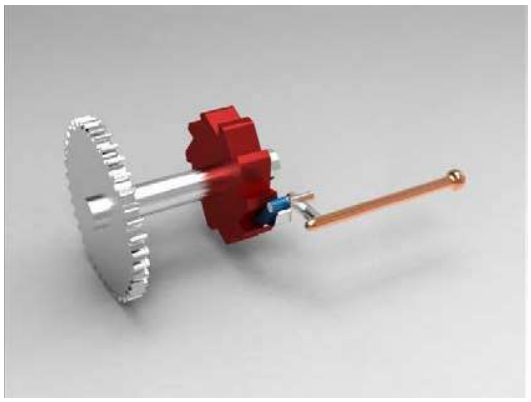
2.2.2. Newly Designed Stair-Climbing Wheelchair

A new stair-climbing wheelchair was designed during this thesis project, which can work in three modes: a stair-climbing mode, a powered wheelchair mode and a manual mode. It offers help in the cases of physical disabilities and also for elderly people to move more flexibly and comfortably. In this project, a walking mechanism and the transmission system are first designed, followed by the theoretical design and calculation to decide the structure of the wheelchair. Further structure analysis and modeling was done by using the design software Auto Desk Inventor and Rhino.

New and improved design of stair-climbing wheelchair



Planetary wheel mechanism

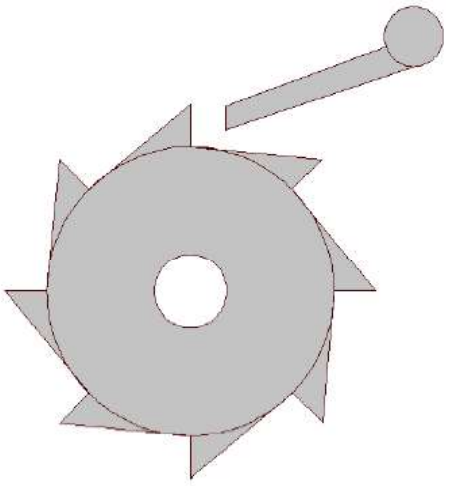


Wheel Lock mechanism

In the optimization design, a planetary wheels mechanism is optimized, and the seat backrest adjustment system and locking system are introduced. All the improvements in the wheelchair are designed based on ergonomics. Finally simulations and analysis are performed to evaluate the design and validate the physical results with numerical calculation.

2.2.3. Locking System of a Wheelchair Wheel

Current wheelchairs do not have a brake system when going backwards, therefore the individual's hands are the ones responsible for stopping the chair. This can lead to several risks concerning the users' security. For example, climbing up a hill could be a great challenge for people sitting in a wheelchair. The user needs to grab the wheels all the time to avoid going backwards and have an accident. Consequently, this is very tiring and dangerous, and something that needs to be solved. In order to solve this problem, the idea of designing a braking system that operates every time the wheelchair is climbing a slope was presented. This system would be activated by the user, as in the ordinary life when backward movements are necessary. When the brake system is activated, the wheels will never go back, they will only go forwards. So, if the user happens to be on a slope and stops grabbing the wheels, the chair would stop, before starting to come down. The brake system works with a separate and removable mechanism. This mechanism has a small one-way wheel, which can only move in one direction. When the blocking system is activated, the small wheel gets in contact with the wheel of the wheelchair, never allowing the wheel to go backwards. The removable braking system, consisting of a one-way wheel and a normal brake, has three positions: braking, normal moving and backwards blocking



First idea

One-way wheel

3. Research in progress at the Department of Mechanical Engineering:

- Ongoing Research Projects
- Prototype Development of existing projects
- Research Publication

Ongoing Research Projects

One of the main goals at Blekinge Institute of Technology is to do projects and thesis in close cooperation with companies, organizations and end users. One examples of this is the following thesis, done by a Spanish student at Department of Mechanical Engineering and in cooperation with the company Jobaccomodation and end users in Spain. The student have supervisors from both BTH and the company.

HEALTH CARE PROJECT – A COMPLEMENT FOR A CHAIR AND DESK FOR CHILDREN WITH DISABILITIES

1. Description

There are a percentage of people with disabilities who are children. Most of the schools are not equipped with furniture that is adapted for them. This project will, thus, be based on designing accessories for chairs and desks.
The accessories should be simple and easy for use and change.

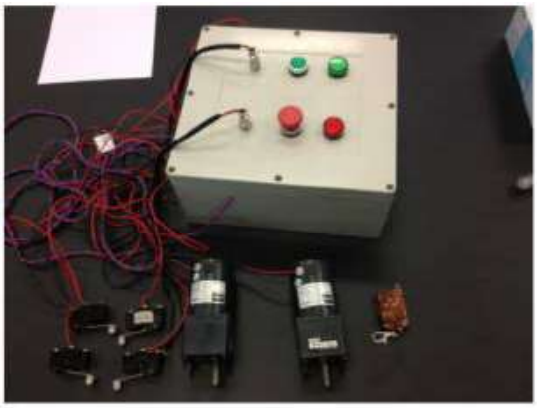
2. The company, *Jobaccommodation,* and their products.

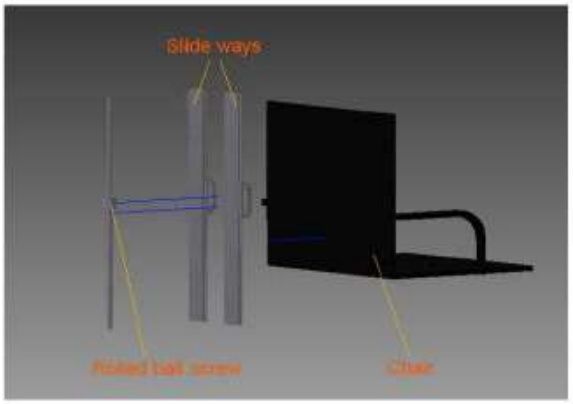
The small company was created in 2009. It is growing steadily and the company goal is to develop products for an international market launch. In 2013, the first three products will be launched to the market.
Jobaccomodation is a technology - based company that works towards the development of products and consulting services that can generate opportunities for people with disabilities and the elderly, in both professional and leisure ambits.
The mission of the company is to serve as a facilitator agent for people with disabilities, improving their personal autonomy and their opportunities in the work environment as well as in their social life, through innovation, engineering and technology.

Website: http://www.jobaccommodation.es/

In the current research, they are planning to make a table as in the picture above with some modification. This kind of table has a hollow in the front side which accommodates extra space by the wheel chair and the child can sit close to the table surface and its top surface can be inclined when required. The table has book shelves attached. For this work in progress we planned to put wheels to the table legs. These wheels can be mounted or dethatched from the table as required. This will allow easy movement of the table in every corner of the house as well as outside.

Another research project in cooperation with end users focuses on an adjustable easy access shower door and its control system. This new design will allow disabled people of different heights to use this facility and its horizontal movement can allow user to access soap, shower gel etc. much more easily.





Prototype development of existing projects at the Department of Mechanical Engineering

The students are making the prototype of an adjustable easy access shower door and the control system in the research facility.

Another prototype is in progress on an adjustable back rest of wheel chairs.

Research Publication

Preparation of an academic article about the "Länsförsäkringar" project has started and will be published rather soon.

The result is and will be presented in different seminars and also constitutes occupied one contribution as best practice in the EU project "Innovage-project". The result has been presented for a Chinese delegation from YCDC, one of the leading real estate development companies in the areas of residential quarters, office and hotel properties. In the last few years, YCDC has focused on development and operation of elderly care and service facilities as well as housing for elderly populations.

The Department of Mechanical Engineering future plan is to attend the 4th international Conference on Manufacturing Science.

4. References:

[1] Shangdong Shi, Wen Shi, Ruicheng Guo: Easy functions cupboard design for elderly people, Thesis, ISRN: BTH-AMT-EX—2011, Blekinge Institute of Technology, Karlskrona, Sweden.

[2] IRAITZ MUGICA CATALINA, ASIER URKIZU INSAUSTI: Easy shower access for the elderly or people with physical disabilities, Thesis, ISRN: BTH-AMT-EX—2011, Blekinge Institute of Technology, Karlskrona, Sweden.

[3] Lin Zhang, Xi Feihong: New Stair-Climbing Wheelchair, Thesis, ISRN: BTH-AMT-EX—2012, Blekinge Institute of Technology, Karlskrona, Sweden.

[4] ALEJANDRO GARCÍA MAYORAL IVÁN GARCÍA GARCÍA: Electric wheelchair for easy access to toilet with a lifting device adapted for older or people with physical disabilities, Thesis, ISRN: BTH-AMT-EX—2011, Blekinge Institute of Technology, Karlskrona, Sweden.

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[6] Single view metrology applied for dynamic control of sink height for children. Not published yet.

Appendix:

Appendix A:

"Easy functions cupboard design for elderly people"

Author: Shangdong Shi, Wen Shi and Ruicheng Guo
Department of Mechanical Engineering School of Engineering
Blekinge Institute of Technology Karlskrona, Sweden

Abstract:

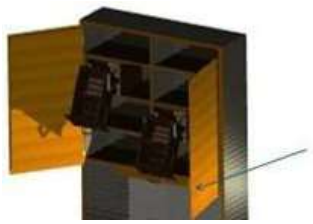
In Sweden it is estimated that nearly 16% (1.5 million) of its population is over 65 years old. In most of the cases, the elder people would like to live by their own. This means that comfortable and safe environments are in need to match the expectations of this important sector of the society. In this thesis, we focused on designing a kitchen cupboard for elderly people. We want to solve some common problems such as the unsuitable height for the target group.
First, we designed an upper cupboard that can easily be pulled down allowing, in a better way, the elderly to have access to stored goods or tools. Secondly, we designed a lifting lower cupboard in a way so that elder people do not need to unnecessarily bend their backs 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.

New Design

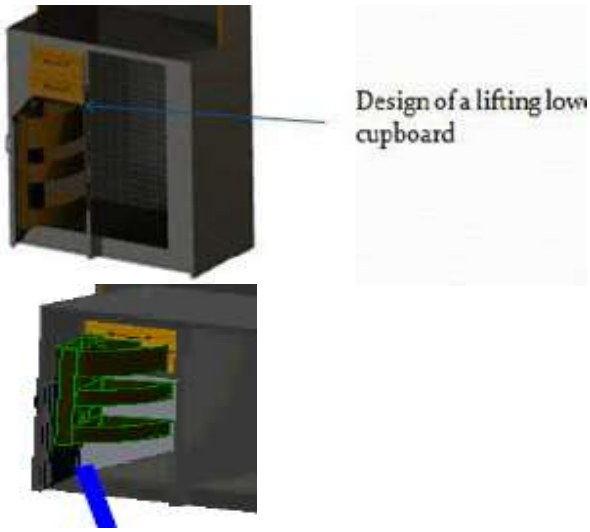
A standard kitchen was studied.

In the upper part of the cabinet an additional basket can be attached that can slide outwards and then rotate 60 degree downwards to the user to reduce the height. This will offer more usable place of the cupboard as the upper part of the cupboard is usable without stretching for it



Design of sliding a rotating upper cupboard

Improvement of the upper part



For the lower part a lifting shaft is provided which on its pulling up pulls up all the boxes (baskets) and locks it at a certain height with the help of a spring-loaded lock. This lock automatically locks the baskets as two spring loaded solid edges fit the slots (Imagine the lock of a door).
When a button is pressed that releases the lock, the shaft along with the baskets go down again due to their weight.

Suggestion was given on choice of material.

The whole concept was drawn in Inventor with details which can be used for the actual manufacturing of a special cupboard.

A stress analysis was done to validate the design safety and usability.

Conclusion

For the world society it is essential that the living conditions of its inhabitants become progressively better, more comfortable and safer. Designing a cupboard which would be better especially for elderly people represented an interesting task that can be seen as a way to contribute to the improving of the living conditions of this important sector of our society. During the three-month design, we had a lot of problems, from the initial conception to the 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 goods or kitchen tools from the upper or lower cupboard.
Through the software called INVENTOR, we expressed our ideas as a computer model. We also use this software for a stress analysis to evaluate our design. We considered unusual materials such as rattan-wood composite materials, -6061, PVC-U. Rattan- wood composite materials are lighter and stronger than standard woods

“Shower easy access for elder or people with physical disabilities”

Author: IRAITZ MUGICA CATALINA, ASIER URKIZU INSAUSTI
Department of Mechanical Engineering School of Engineering
Blekinge Institute of Technology Karlskrona, Sweden

Abstract:

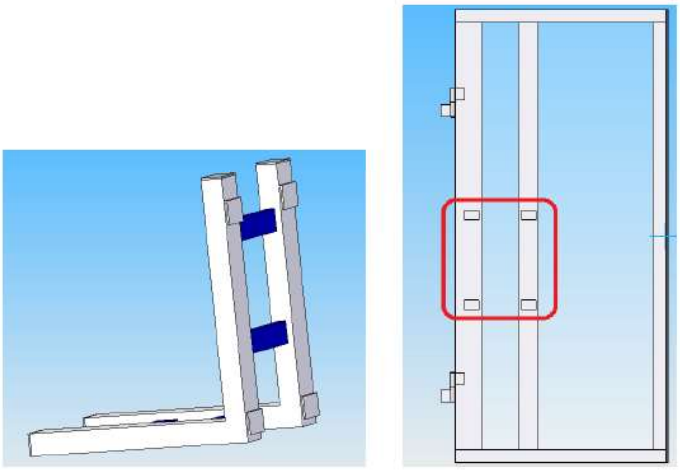
This project has been created to help the elderly or people with physical disabilities. The help consists of getting easier access to the shower. To reach our purpose, we realized a really innovative idea. Our idea is based on a door which rotates 90° with respect to a lateral axis. In that door a chair is attached to get easier to the shower.
When the user is in front of the opened door it will be easier for him or her to reach the chair which is added on the door, and after that, when the door is closed, the user would be in the perfect position for a shower. A CAD model was developed to make this design and also to evaluate its resistance and safety.

The Idea

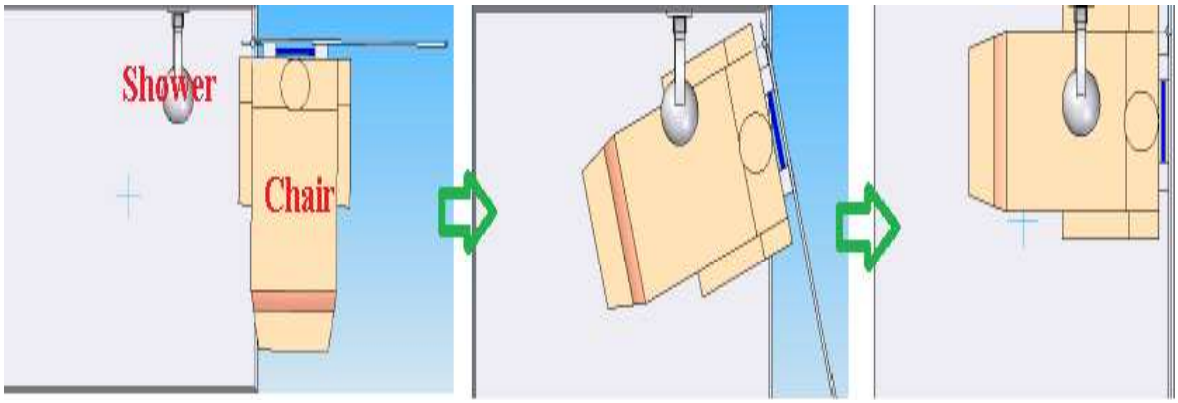
Our idea was to use the machinery to move the disabled person inside the conventional bathroom, by putting a chair on a bathrooms door. But this novelty was not the only one, because for comfort and ease of the user, the door rotates 90º on a central axis. We believed that this new idea would simply than the previous one, it would be to make an easy access for the user and be more important, and could now be economically available to all customers. The operation of this prototype would be simply being that when the chair is out of the bathroom (the door would be closed) the user would sit on the chair. When the user is seated, the door would rotate 90º (the door would continue closed) and then the user would be located inside for the bath or shower. In the same way, after the bath or shower, the user would repeat the same action to get out of the bath.

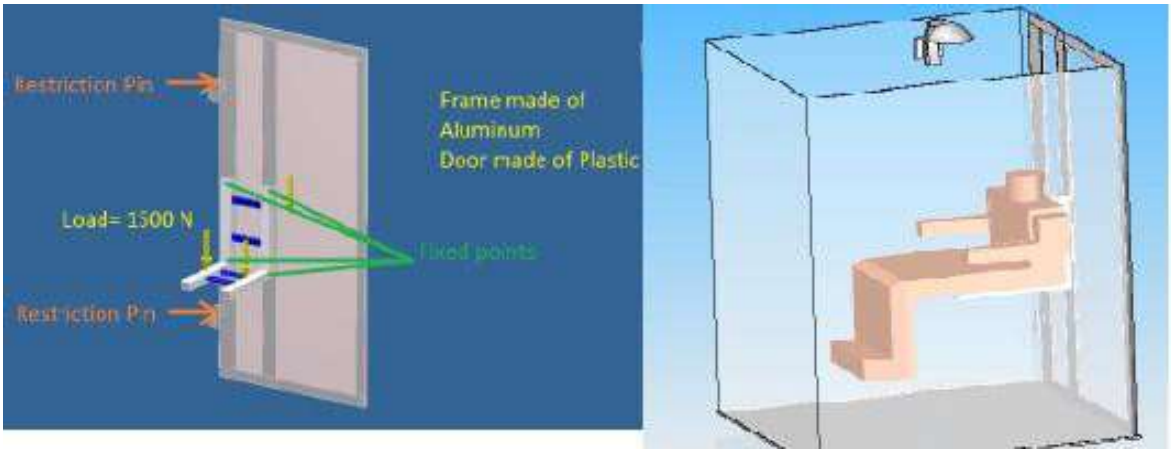
New Design

We designed some profiles with regular forms in the manufacture of aluminium windows. All the profiles are made from aluminium.
The two pieces that divide the screen door and at the same time are the pieces that support the chassis of the chair are of this type of profile and we call it the central bar. Following this, we designed some reinforcement, that we use to change the chassis and to combine two L-s.



Next we designed a rectangular lid, to avoid getting water inside and into the chassis. To finish with the chassis, we designed the tabs with which we combined the chassis and the door.





Having done all the design and simulation of the shower, we wanted to give another point and introduced the shower into the conventional bathroom. A standard bathroom was used and we

designed a toilet, a sink, a washing machine apart from the shower designed above. This would be the design of our complete bathroom. A stress analysis of the chair and shower room door was done for validation of safe usability.

Conclusion

After finishing this thesis work, we arrived to the following conclusions:

- An Easy Shower Access solution was designed.
- The design is applicable to normal or standard bathrooms. We wanted to make it possible for our design to be placed in any home and to be used by any user.
- Our design is safe according to our manual calculations and stress analysis in INVENTOR.
- It is made of commercial materials, which means it is feasible to construct at relatively low prices.
- It is a practical solution, because it uses commercial materials, it can be shaped for the majority of bathrooms, and it is safe. We thus feel that the project could be concretized and help a lot of people

“New Stair-Climbing Wheelchair”

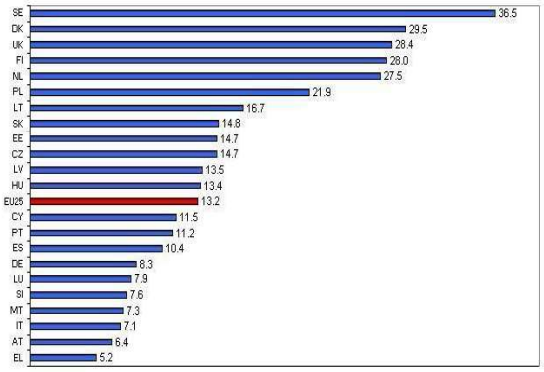
Author: Lin Zhang & Xi Feihong
Department of Mechanical Engineering School of Engineering
Blekinge Institute of Technology Karlskrona, Sweden

Abstract

A new stair-climbing wheelchair was designed during the research of thesis project, which can work in three modes: a stair-climbing mode, a powered wheelchair mode and a manual mode. It can help people with physical disabilities and elderly people to move more flexibly and comfortably. In this project, a walking mechanism and the transmission system are first designed, followed by the theoretical design and calculation to decide the structure of the wheelchair. Then the structure analysis and modeling was done by using the design software Auto Desk Inventor and Rhino. In the optimization design, a planetary wheels mechanism is optimized, and a seat backrest adjustment system and locking system are introduced. All the improvements in the wheelchair are designed based on ergonomics. Finally the simulations and analysis are performed to evaluate the design and to validate the physical results with numerical calculation.

Introduction

According to the WHO 2011 “Global Disabled Person Report", the number of patients with disabilities is on the rise. There were 650 million disabled people, which is about 10% of the global population, in the 1970s, and now the number has increased to 15%. The percent age of people suffering from illness or disability among the working ages in EU is 13.2% while Sweden has the highest ratio with 36.5% of sick or disabled persons.



Inactivity due to illness or disability among working age population in percent.

Common wheelchairs provide easy access in developed countries but during stair climbing, it might be difficult for a person to climb the stair himself or even with help of assistance. This circumstance will not only restrict the individual outdoor activities but will also have a great impact psychologically. This project provides a viable solution for the improvement in the existing wheel chair and also proposes improvements in the design to make life more easy and comfortable.

Design and Modeling

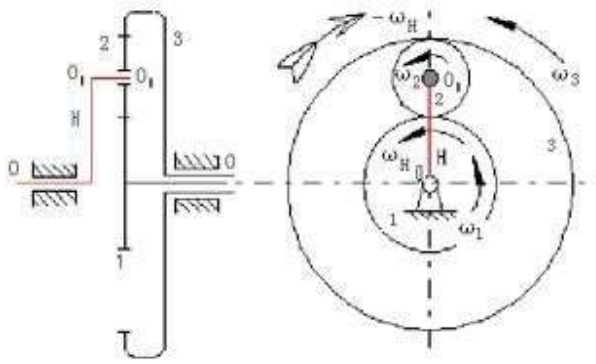
The walking mechanism and transmission system for the stair-climbing wheelchair were designed first. Then the structure of the wheelchair was determined by theoretical design and calculation, and later the optimization design was carried out which included the planetary wheel system optimization, the seat and backrest adjustment system design, the lock system and some other useful design based on the ergonomics. The figure below is our design which offers a compact structure, light weight, an aesthetic design, and comfortable and durable use.

New and improved design of stair-climbing wheelchair

The Autodesk Inventor Software was used during design, modeling and simulation. Rbino software was also used to build our 3D model and rendering, the software offering a powerful advanced modeling function, created by Robert McNeel Company of America in 1998.

Walking Mechanism Design

A walking mechanism is a very important part of the stair-climbing wheelchair, as it has a direct impact on the stability, security and comfort of the wheelchair. We must, thus, overall consider all kinds of factors to choose our walking mechanism.

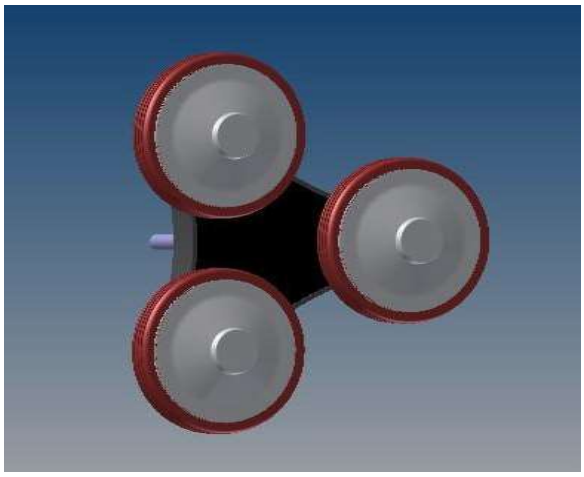


2K-H Epicyclical wheels system

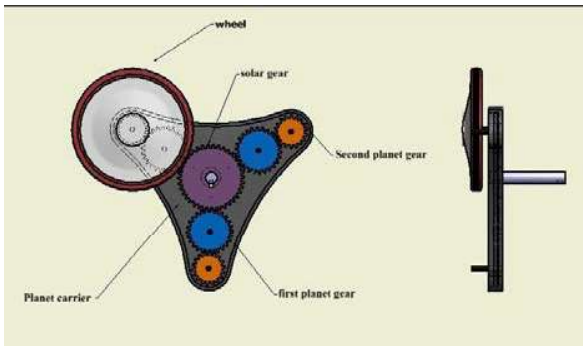
The planetary wheel mechanism has a great advantage among the stair-climbing wheelchairs, as it is not only made of a simple and compact structure, providing flexible movement, but also offers good stability, a small fluctuation range of gravity centre, thus combining the advantages of walking on the ground and climbing stairs. Therefore, the planetary wheel mechanism is chosen as the walking mechanism in our design.

Transmission system design

There are two kinds of motion mode: a walking mode and a stair-climbing mode. An epicyclical gearing was chosen as the transmission system for each locomotion unit, where the two degrees of freedom are wheels and planet carrier rotations. If we want the wheelchair to have determined locomotion, we must give two determined inputs to the locomotion unit. The inputs differ between the walking mode and the stair- climbing mode.



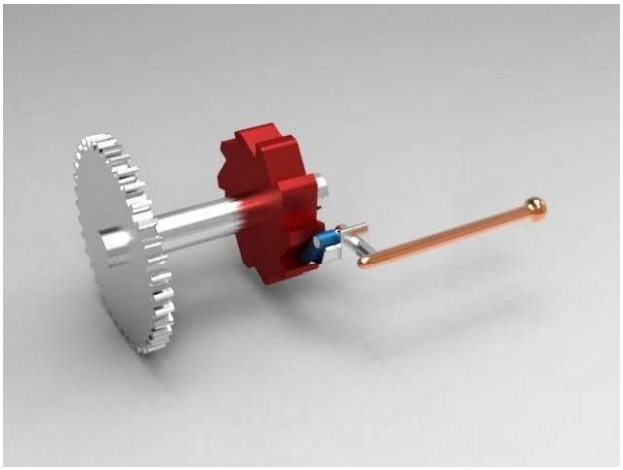
3D models of planetary wheels



Structure of wheels cluster

Locking system design

When the stair-climbing wheelchair climbs stairs, a danger of falling down the stairs exists. In order to protect the user and avoid this to happen, we install a ratchet mechanism locking system on the central axis. When the wheelchair goes up and down stairs, the handle can be screwed to lock the wheelchair and thus prevent the wheelchair from slipping down the stairs.



Ratchet locking device

Simulations and Analysis

In addressing the complex task of stair ascent or descent, the most important requirement is the user´s security and stability. In order to take these requirements into account and to know if our optimization designs improve the property of the wheelchair or not, the following simulations and analysis are needed:

1) If the wheelchair had a sufficiently large support base which can resist the expected loads under static conditions;
2) If the desk had enough strength when people use it;

3) If the lock device is strong enough for locking the wheelchair when climbing up and down stairs;

4) Simulations are assembled for the wheelchair, to see if the structure of the wheelchair is reasonable, and to see if any interference exists between any parts of the wheelchair.

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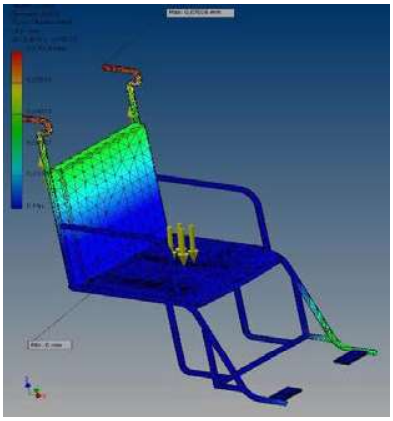


Stress Analysis of wheelchair

Conclusion:

In this project we designed a new kind of wheelchair, which has a compact structure, can cope with flat inclined or undulating ground, uneven terrain, stairs and obstacles. With the help of the software of Autodesk inventor and Rhino, we modeled all parts of the wheelchair, and used simulation analysis to make sure that the strength of the framework and gear shaft provides security for the users, and the result is:

1) Design the walking mechanism and transmission system for our stair-climbing wheelchair, and according to the calculation decide the structure of the wheelchair, and model all parts of the wheelchair.

2) The optimization for the planetary wheel system changes the torsion acting on the box of the gear train instead of acting on the gear, which provides the security and service life of the gear.

3) The backrest adjusting mechanism adopts manual operation, which is not only energy-saving, offering environmental protection, but also reduces the weight for installing the motor.

4) Users can adjust the seat backrest system to make sure that the chair of the wheelchair is parallel to the level ground.

5) The optimization of ergonomics has been added in our design for more convenience and comfort.

6) Add locking system to avoid the wheelchair from slipping down when it goes up and down stairs.

7) Choose two different kinds of material to analyses the mechanical property in Inventor in order to choose suitable material.

8) Strength checking on the locking system and the desk in inventor to ensure the security of the wheelchair.

“Electric wheelchair for easy access to toilet with a lifting device adapted for the elderly or people with physical disabilities”

Author: ALEJANDRO GARCÍA MAYORAL IVÁN GARCÍA GARCÍA, 2011
Department of Mechanical Engineering School of Engineering
Blekinge Institute of Technology Karlskrona, Sweden

Abstract

This project has been created to help the elderly or people with physical disabilities. The help consists of getting easier access to the WC. To reach our purpose, we realized a really innovative idea. Our idea is based on an electric wheelchair with a lifting device which helps to stand up and to sit. This lifting device consists of a pneumatic piston that acts only when the person wants to sit down on the toilet, pushing the chair down, or when the user wants to get up from the toilet, pushing the chair up, always keeping the back upright. Another secondary use is that of an indoor wheelchair. A CAD model was developed to make this design and also to evaluate its resistance and safety.

Introduction

Disability is defined as a difficulty in carrying out activities necessary to maintain an independent living, including self-care tasks staff (core activities) and others to live independently at home (instrumental activities). Problems to carry out the activities of daily living can be considered as synonymous to disability. The difficulty in carrying out activities of daily living is often a good predictor of a future functional decline of people, with the consequent needs for attention and care, and demand for health services and institutionalization.

Rank of countries ordered by quality of life

In order to make a healthy life style available to elderly people this thesis project is focused on the design of an electrical slim-home wheelchair with an application for easy access to toilets. This wheelchair is like a conventional electric wheelchair, but it is characterized by a lifting device in the back that helps disabled/elderly people to stand or sit up from the toilet bowl.

Like any wheelchair it can be used both at home and on the street.

Final simulation of wheelchair coupling with the toilet.

Conclusion:

1. This design is applicable to normal or standard bathrooms. The design could be placed in any home and it could be used for any user.

2. The design is safe, according to our manual calculations and stress analysis made in AutoDesk Inventor software.

3. The wheelchair is made of commercial materials, which means it is feasible to construct at relatively low prices.

Author: Iñigo Moraza, Jon Morgado, 2012
Department of Mechanical Engineering School of Engineering
Blekinge Institute of Technology Karlskrona, Sweden

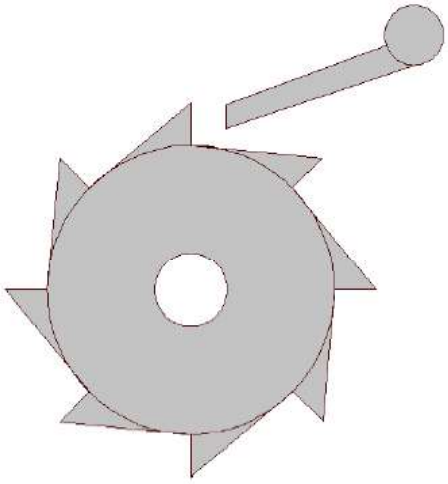
Abstract:

Current wheelchairs do not have a brake system when going backwards, therefore the individual's hands are the ones responsible for stopping the chair. This can lead to several risks concerning the users' security. For example, climbing up a hill could be a great challenge for people sitting in a wheelchair. The user needs to grab the wheels all the time to avoid going backwards and have an accident. Consequently, this is very tiring and dangerous, and something that needs to be solved. In order to solve this problem, the idea of designing a braking system that operates every time the wheelchair is climbing a slope was presented. This system would be activated by the user, as in the ordinary life when backward movements are necessary. When the brake system is activated, the wheels will never go back, they will only go forwards. So, if the user happens to be on a slope and stops grabbing the wheels, the chair would stop, before starting to come down. The brake system works with a separate and removable mechanism. This mechanism has a small one-way wheel, which can only move in one direction. When the blocking system is activated, the small wheel gets in contact with the wheel of the wheelchair, never allowing the wheel to go backwards. The removable braking system, consisting of a one-way wheel and a normal brake, has three positions: braking, normal moving and backwards blocking

The wheel chair and locking handle

Contribution to the design:

The main purpose of the thesis is to design a removable backwards blocking system for wheelchairs. The way to block the chair is a small one-way wheel in contact with the wheel of the wheelchair. Our goal is to avoid the wheelchair from going backwards when the user climbs up a slope. The main contribution of the thesis is the design of a new product that can be attached to any wheelchair, that is, a separate and removable mechanism. We have applied an existing mechanism, the bearing system that only goes one way, to develop a new functionality. This has been possible thanks to the idea of getting both wheels in contact with each other. All the analysis needed (stress, shear forces, etc.) have been done using the program Inventor.



New Design

Appendix B

Links to the complete research paper:

☐ **Easy functions cupboard design for elderly people**
http://www.bth.se/fou/cuppsats.nsf/all/7d12e5db83d3f25ec125793f0018d5ca/$file/BTH2011S hi.pdf

☐ **Easy Shower Access for the elderly or people with physical disabilities**
http://www.bth.se/fou/cuppsats.nsf/all/f9cbb4b1ca63cedfc125794a005c7909/$file/BTH2011ca talina.pdf

☐ **Single view metrology applied for dynamic control of sink height for children**
http://www.bth.se/fou/cuppsats.nsf/all/f671244f6abd4c5fc12578700011504f/$file/BTH2011.HUILUI.pdf

☐ **Electric wheelchair for easy access to toilet with a lifting device adapted for the elderly or people with physical disabilities**
http://www.bth.se/fou/cuppsats.nsf/all/c0d8069e9c186118c12579a7004872a3/$file/BTH2011Garcia.pdf

☐ **New Stair-Climbing Wheelchair** Web not published yet

☐ **Locking System of a Wheelchair Wheel** Web not published yet

For more information contact: Mats Walter, +46 455 38 55 08 or mwl@bth.se