Eastern Mediterranean University

Department of Mechanical Engineering

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Name of Project: **Circular Automated Storage and Retrieval System**

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EVALUATION

ABSTRACT

Nowadays, small and medium size companies have limited places to store their products due to increasing variety of products and storing the products separately in specified places. Lands are getting expensive day by day due to increasing population. To use limited land with maximum efficiency new systems are required to prevent land wastage. The aim of this project is, designed and developed middle plate which handles up to 99 objects to be stored on shelfs and the propored C- ASRS is reconfigurable so that it can be adopted various enterprices. Basically, in this project will be using new systems which will be utilizing amount system for product storage. Product will fit in the specified location for that kind of product itself. A cylindrical automated storage and retrieval system (C-ASRS) is considered which consist of 10 different floors with 10 stations in each floor. Sliding mechanism with gripper is placed in the center of storage system and will be picking the materials from the certain area which is connected through to conveyor belt system. RFID system will be used to identify object. Additionally, the proposed C-ASRS enables the handling of variety of objects. Object is to be stored in determined area by rotational plate. This system can be used for small and medium size companies for material storing with transportation system. There will be 8.5 cm height in first 4 floors and other 6 floors has got 5 cm height. Also the C-ASRS is fully automated which has minimum human rist factor.

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CHAPTER 1 - INTRODUCTION

1.1 Summary of the ASRS

Autometed storage and retrieval systems C-ASRS include the different computer control systems that it is used to store the parts automatically**.** Autometed storage and retrieval systems C-ASRS are typically used in techniques where there are various materials with having different sizes, colors, types and required to store them in shelfs with the condition of calling them back in a easiest way, people want to use this technology because it helps to save land space and preents big mess in the production area. Actually, land price is so expensive in big city, because of this reason people need to C-ASRS system. People have to give lots of money to take the warehouse. If the people take the warehouse in this time transportation of the parts will be difficult and also price will be so much. However if people use the C-ASRS systems they do not have to take warehouse and also they do not have to give money for the transportation. It shown in FIGURE 1.

FIGURE 1: C-ASRS **[1]**

Also the time that the campanies are spent for product transportation to the warehouses, can be save. In other words, less speding time for transportation causes high production. C-ASRS system also has advantage in terms of emloyee. Rather than having lots of employes in company, C-ASRS reduces the number of employee also their salary will be kept in company. Aim of this Project is to reduce the production time and reduces the money that company spends for employee salary according the decrease the number of employee in company.

1.2 Advantages of the AS/RS

Automated storage and retrieval system provide the lots of benefits to us. First of all, people don not have to give lots of land price to storage the parts. Because of the Automated Storage and Retrieval System, people use the empty area in their factory consequently, they don not waste their money. Automated storage and retrieval system reduce the labor cost while increasing safety. It shown in FIGURE 2. Because, worker only control the C-ASRS, they don't touch the anythink everything is made by the robot automatially. Worker don't have any risk. Other advantage of the C-ASRS is that, People save the time. To find the some material in the factory people can call easly from the computer and the people can find the part easly. Especially, medicine factories use this C-ASRS systems. Because they produce the lots of drug and separete the drug is so difficult but we can separete the all of the drug easly with the autometed storage and retrieval system. People win the time and they can find the drug easly. People can analysis the part where they put the parts or they can seperate the parts easly. For example, if workers have different parts and they want to storage the parts diffrent place they can do this with the C-ASRS. Because they will see the all of the parts where they put before.

FIGURE 2: Vertical ASRS [2]

1.3 Components and Operating Features of an ASRS

Typically, C-ASRS consist of a series of a storage aisles each of which is served by a storage and retrieval (SR) machine or Crane. Each aisle is supported by a pickup and delivery (PD) station typically located at the end of the aisle and accessed by the srorage and retrieval machine and the external handling sytems.There will be RFID sensor sytsems shown as in FIGURE 3.There will be controler system to use the C-ASRS system.We are thinking to use ARDUINO. Also there will be one conveyor system. When the parts continue on the conveyor systems RFID will stop the conveyor and robot arm will put the parts on the C-ASRS system.

Type of Tag	EPC Class	Memory Type	Radio Frequencies Used	Word Length, Bits	Power Source	Reading Distance, Meters
RFID passive	0	ROM	138 KHz 13.85 MHz	64	Reader EMF	0.04 – 3
RFID active	4	ROM	13.85 MHz	64	Battery	3 – 10
RFID passive programmable	1	EEPROM	138 KHz 13.85MHz	96, 128	Reader EMF	0.04 – 3
RFID active programmable	2, 3, 4	EEPROM	138 KHz 13.85 MHz	>128	Battery	3 – 10
Data tag	2, 3, 4	CMOS RAM Flash RAM	13.85 MHz 985 MHz (UHF)	>128	Battery	3 – 10
RF location	-	EEPROM or CMOS RAM	303 MHz, 2.4/5.8 GHz, UWB	64	Battery	1 – 100

TABLE 1: Types of RF tags[30]

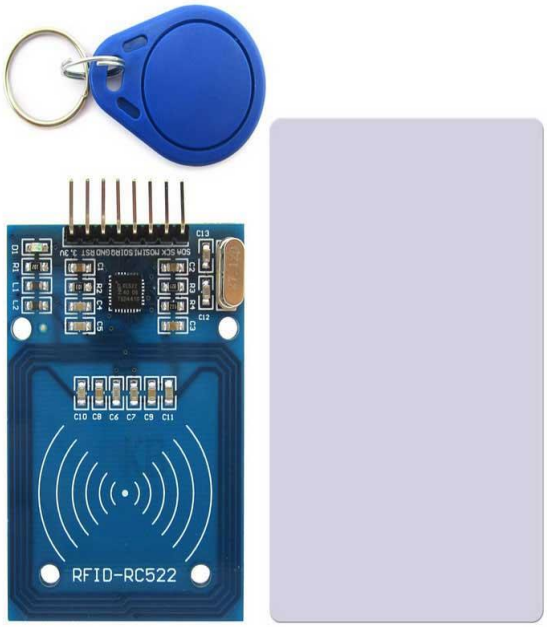


FIGURE 3: RFID [3]

1.3.1 Storage Structure

Normally, the storage structure was made by steel, because steel is vey strong, resistant and it can be handled easly. However ın our Project plexiglass will be used. Because in Cyprus conditions plexiglass can find easly also finding to steel is very difficult. Steel is expensive then plexiglass. we will produce the shelf from the plexiglass.

1.3.2 Storage Modules

The storage modules will be circular and it will became 10 floor. Each floor will have 10 stations.The storage modules are the unit load containers of the stored material.There will be pallet to take the parts and put it again.

1.3.3 Control Systems

We will use the some control systems equipment. For example, we have to use ARDUINO mega where the ASRS system put the part in the system shown at the below in FIGURE 4.Also we will use some sensor to stop the conveyor system and put the parts in the ASRS system.We will define the parts which part is big or small because in the system there will be two catagories.Some floor will be higher than the other floor.

FIGURE 4: Arduino Mega[31]

1.3.4 Step Motors

A stepper motor system consists of three basic elements, often combined with some type of user interface (host computer, PLC or dumb terminal):

- Indexers - The indexer (or controller) is a microprocessor capable of generating step pulses and direction signals for the driver. In addition, the indexer is typically required to perform many other sophisticated command functions.[5]

• Drivers - The driver (or amplifier) converts the indexer command signals into the power necessary to energize the motor windings. There are numerous types of drivers, with different voltage and current ratings and construction technology. Not all drivers are suitable to run all motors, so when designing a motion control system the driver selection process is critical.[5]

• Stepper motors - The stepper motor is an electromagnetic device that converts digital pulses into mechanical shaft rotation. Advantages of step motors are low cost, high reliability, high torque at low speeds and a simple, rugged construction that operates in almost any environment. The main disadvantages in using a stepper motor is the Resonance effect often exhibited at low speeds and decreasing torque with increasing speed.[5]. Shown in FIGURE 5 and FIGURE 7.

Shaft	: 55 mm diameter
Current Per Phase	: 0.3A
Holding Torque	: 3.17Kg.cm
Rated Voltage	: 24V
Step Angle	: 1.8°
Resistance Per Phase	: 3.3Ω
Inductance Per Phase	: 2.8mH

TABLE 2: Step Motor Properties

FIGURE 5: Step Motor for Middle Part

Shaft	: 60 mm diameter
Current Per Phase	: 4A
Rotation Speed	:65±5 rpm
Holding Torque	: 36Nm
Rated Voltage	: 12 V
Reduction Ratio	: 1/67 or 1/63

TABLE 3: DC Motor Properties

FIGURE 6: DC Motor [32]

Shaft	: 35 mm diameter
Current Per Phase	: 0.3A
Holding Torque	: 7.5N.m
Rated Voltage	: 12V
Step Angle	: 7.5°

TABLE 4: DC motor for mils

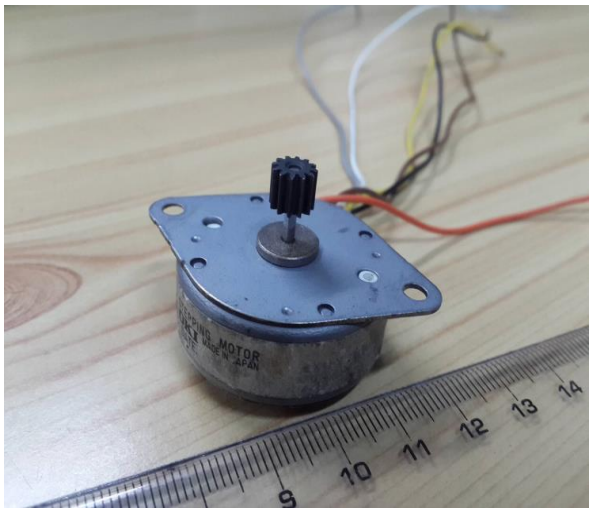


FIGURE 7: Stepper Motor for Sliding

1.3.5 L298N H-Bridge Motor Driver

L298N motor driver can control 2 different dc motor at the same time and also can control a stepper motor shown in FIGURE 8. The L298N H-bridge module can be used with motors that have a voltage of between 5 and 35V DC and current up to 2A. There is also an onboard 5V regulator, thus if applied voltage is up to 12V you can also source 5V from the board. In project 24 volt is applied as input to drive stepper motor for middle rotational motion. And second L298N motor driver is used to control second stepper motor for sliding motion.

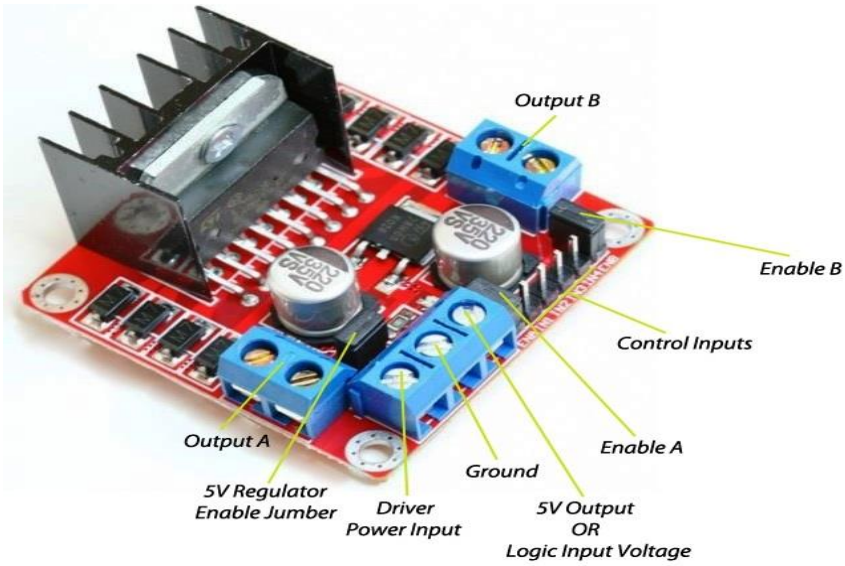


FIGURE 8: Step Motor for Middle Part[33]

1.3.6 Infrared Sensor

. IR Sensors work by using a specific light sensor to detect a select light wavelength in the Infra-Red (IR) spectrum. By using a LED which produces light at the same wavelength as what the sensor is looking for, the intensity of the received light can be input to control floor detection C-ASRS. When an object is close to the sensor, the light from the LED bounces off the object and into the light sensor. By this way floor detection will be accomplished. Sensor is shown in FIGURE 9. [42]

FIGURE 9: Step Motor for Middle Part [42]

1.3.7 Relay

A relay is electrically operated switch and relays are used to control a circuit with a low power signal. In other words, it is used for several circuits to be controlled by one signal. In C-ASRS there will be 2 relays which used to control DC motor that provides vertical motion. One relay is controlled by IR sensor and then the sensor is activated, DC motor starts since second command is received.it is shown in FIGURE 10. [43]

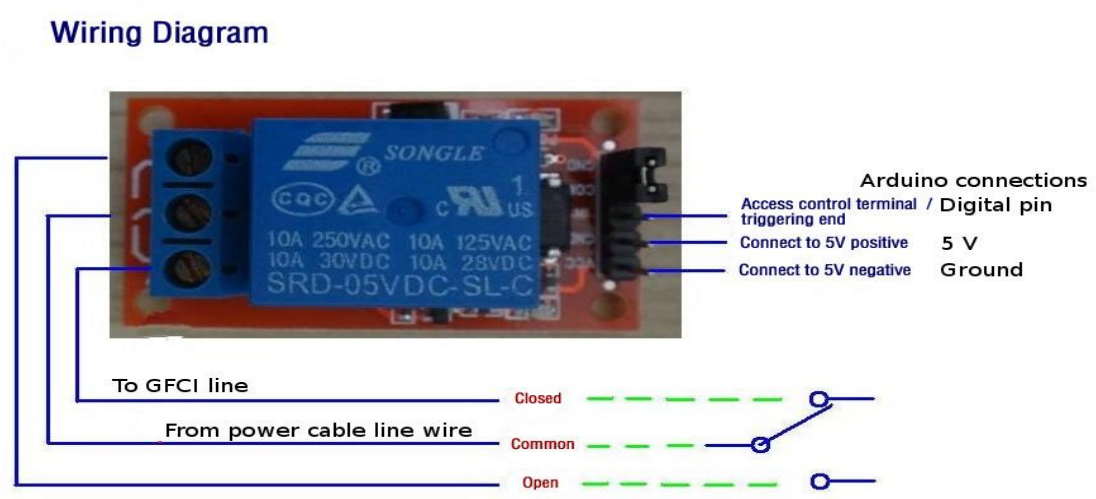


FIGURE 10: Step Motor for Middle Part [43]

CHAPTER 2 - BACKGROUND INFORMATION

2.1 What Has Been Published or Done on a Chosen Project

There are many projects that has been done and has been published on our chosen project. The C-ASRS is used to have easy life standarts and to adapt the faster life that the developed countries have. ASRS is mostly used on auto parking to save the land. Especially under ground fully automated parking systems doesnt accupy a land above the ground so, saved land by C-ASRS can be used for another purposes. Also Some C-ASRS is used to store medicines with the purpose of getting desired kind of medicine in a shortest time, auto bodies, small devices before and after machining. Basically anything that needs to be stored or needs to be in order.

On the other hand, there are some features can be added on storage system by using sensors. For example nowaways wireless controlled C-ASRS is produced. In that system, the communication is controlled by wireless technology so that the design is more clever and easy to understand. “The communication between PIC controller and computer is made by a wireless technology. The motion of the system is based on three DC motors, one for each direction of motion X, Y and Z, controlled through PIC microcontroller.” [7]

Other feature is reached by using RFID sensor. Before RFID sensor, Barcode reader has been used detect and read the barcode which has the informations of tag sticked on material. As a new technology RFID is provided and is used to get better and faster problem solutions. RFID sensor detects the material itself by reading the tag. RFID doesnt need human assist so it is definitely useful for C-ASRS.

2.1.1 Fully Automated Car Parking System

Car parking system is fully automated and produced by Volkswagen in Germany. Main purpose of the Car Parking system is to save the land that the cars accupied and also to get better costumer satisfuction by exhibiting the Volkswagen cars by calling the desired model. How it works? Car comes to front of the costumer by using a robotic arm in the center of ASRS and depend on the desired model robotic arm picks the model that the costomer would like to see and brings to the costomer. Shown in FIGURE 11.

FIGURE 11: Volkswagen ASRS Parking [16]

2.1.2 Underground Car parking system

This system has almost same storage with the Volkswagen ASRS. The only difference is robotic arm that is used for car hanling. Here robotic arm is fixed by to column and arm goes along this 2 column. Storage system is isolated specially to prevent hazardous can be accur under the ground. There are also some Car parking systems, they also wash the car while moving the car to fit in the seperated gap. So that costomers have more satisfaction due to having clean car before leave the parking system.System is shown in FIGURE 12.

FIGURE 12: Under ground car parking[35]

2.2 Different Models and New Ideas

Appereance is important and it affect the usage of system so that different shapes are developed on ASRS. Especially circular shape storage is implemented to car parking systems, square and rectangular shapes are used and sometimes rectangles are added each other to improve new design to have ASRS more efficiently. Chosen ASRS will be serving for a company who has flexible manufacturing system and that system has a conveyor. With the assist of conveyor belt material will be moved by the Circular ASRS system to store it by picking from the conveyor. For this purpose, material can be grapped by the extensile grapper. And then after material is pulled to the middle of shelfs, it will find the correct shelf to fit in. Here are thousands of different robotic arms that is used for similar purposes and also different storages. Several type of ASRS are listed below. Shown in FIGURE 13.

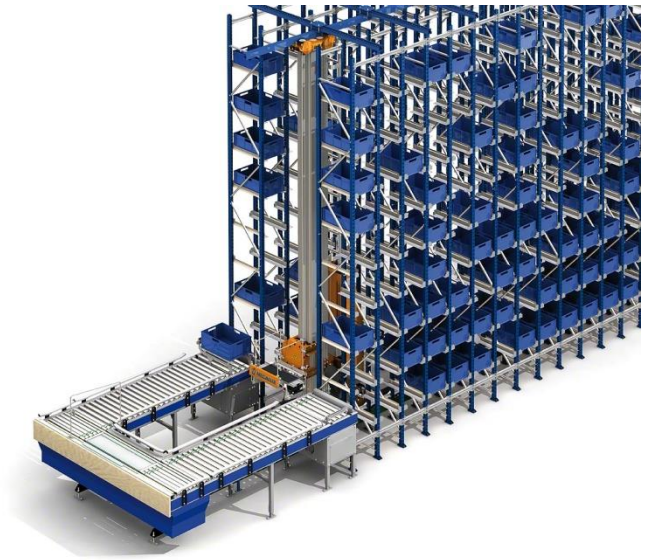


FIGURE 13: Huge Storage for big size companies[36]

2.2.1 Robot Book Fetcher

In this system, ASRS is integrated to the libraries. The library contains thousands of different kind of books in storage seperately for example, it stores math books and physics books in different rooms in ASRS. First time this system is provided at Californian State University. However the picture belongs to library in University of Utah. As seen it has huge storage system for storing the books and easy to grab the books with a arm located in the middle of shelfs. This system is used in libraries allowing for greater safety when consulting and retrieving books.Shown in FIGURE 14.

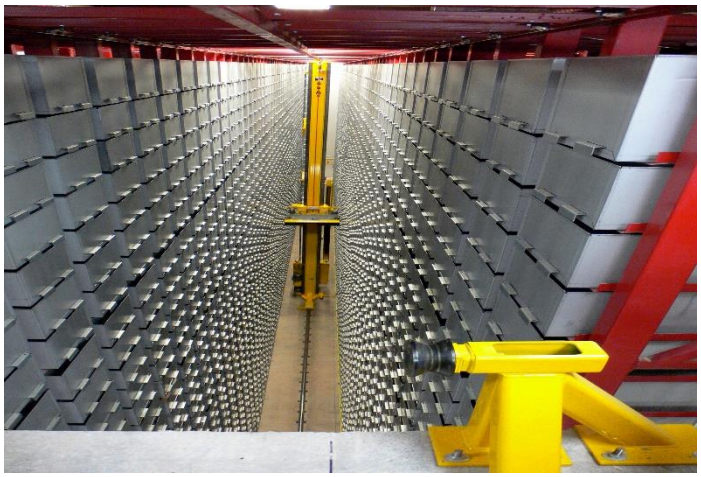


FIGURE 14: Library ASRS[37]

2.2.2 Educational Traning System

In the system a stepper motor is used to grap the materials from the shelfs, the system in the middle can move along x and y axises as shown in FIGURE 15. Also that sistem can be controlled by a touch pedal. Aim pf the system is to show up the materials in a easy way and teaching the students how to control this kind of ASRS.

FIGURE 15: Training System[38]

2.2.3 JA Aichi Minami - a New Distribution Center Exclusively for Flowers

There is an overview from a flower company including a huge storage system in the middle. Flowers are required to move between storage systems and then fit in the tracks to export. The center storage system handles 400 different type of grown flowers. In the storage system they have lighting technology that provides the flowers necessary light for photosynthesis. Fully automated flexible manufacturing system is provides approximately 1.1 million cases are shipped in a year to more than 85 markets from Hokkaido to Himeji in FIGURE 16.

How it works? Before the flower station open, distribution centers transport to conveyors. Flowers are controlled and sticked a tag on them in order to quality of flower and then flowers are moved on the conveyor to store them in the huge ASRS storage temporarily. Mini load ASRS system is used to store the flowers and it is at the temperature of 15 degree Celsius which is enough to keep the flowers alive temporarily.

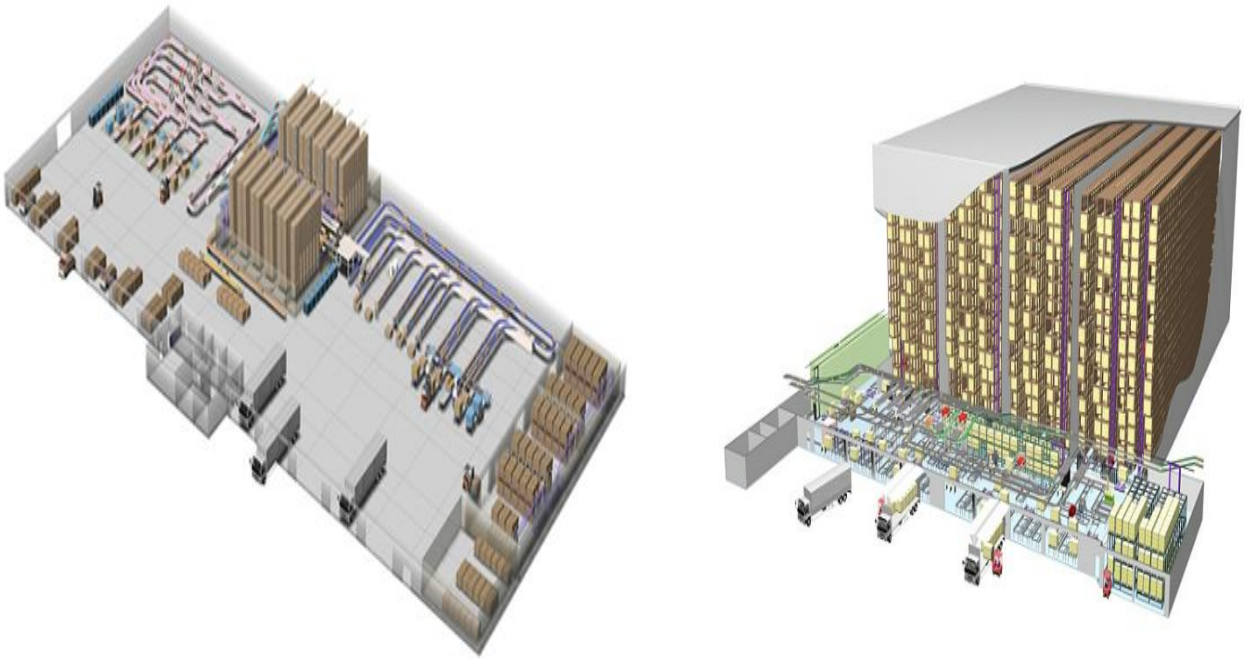


FIGURE 16: JA Aichi Minami ASRS[39]

2.2.4 California State University Library ASRS

The Oviatt library at the California State University is produced the World's first library with ASRS in FIGURE 17. The project was born by a pilot at California State University in 1991 and $2.000.000 is spent to produce this system and expected maintance cost is about $35,000. ASRS system is implemented to library due to provide best book submission and deliver.

FIGURE 17: California State University library[40]

2.3) Developments in Chosen Topic Based on Needs

ASRS is produced to make the life easier and also it provides some human needs. In 1990, especially in libraries there were simple systems that were using to recod the book informations and also when the book consulting and retrieving, availability of the book was known. But only problem was the book consumers. When the book is taken or is retrieved from the sheft, book was getting damaged. Other serious problem was the book delivery. Due to having book in wrong shefts, ASRS or other systems are required. After all, the world's first library ASRS is produced in1991 at California State University.

However there are some ASRS available in market which provides many features due to needs. Some ASRS can read what kind of book is it and then can put in the correct sheft itself. Also some ASRS can clean their own storage itself.

FIGURE 18: Car washing ASRS [41]

In car parking systems, robotic arm can detect the car in terms of size, dept and wide. So that robotic arm can move the car to the corresponding gap while car travels, the system inside the ASRS can wash the car shown as FIGURE 18.

ASRS can be integrated to conveyor systems same as chosen topic. With the help of conveyor belt system, ASRS can get the material after or before machining and it can be stored in storage to protect material before shipping. Nowadays storage systems have light system for flowers to keep them alive and also they are painted with laser technology to protect the materials from oxidations and other hazardous in environment due to climate system.

Conveyor belt system actually helps the ASRS shipping the material to export and also pick the heavy materials to fit in the gaps in storage. The coolest robotic arm is used in auto parking system and in chosen topic, similar system is developed and is used for material handling and storing. The robotic arm is fed with a rotational platform in the center of supported arm.

The advantage of this robotic arm is strong enough to handle heavy materials with having 2 supported edge. Also heavy material will be tied in the center of suported edges and with a rotational motion the way of material is determined and is fixed by extending the middle platform to the gap. After extention, platform is reduced the lever to leave the part on the shelfs shown in FIGURE 19.

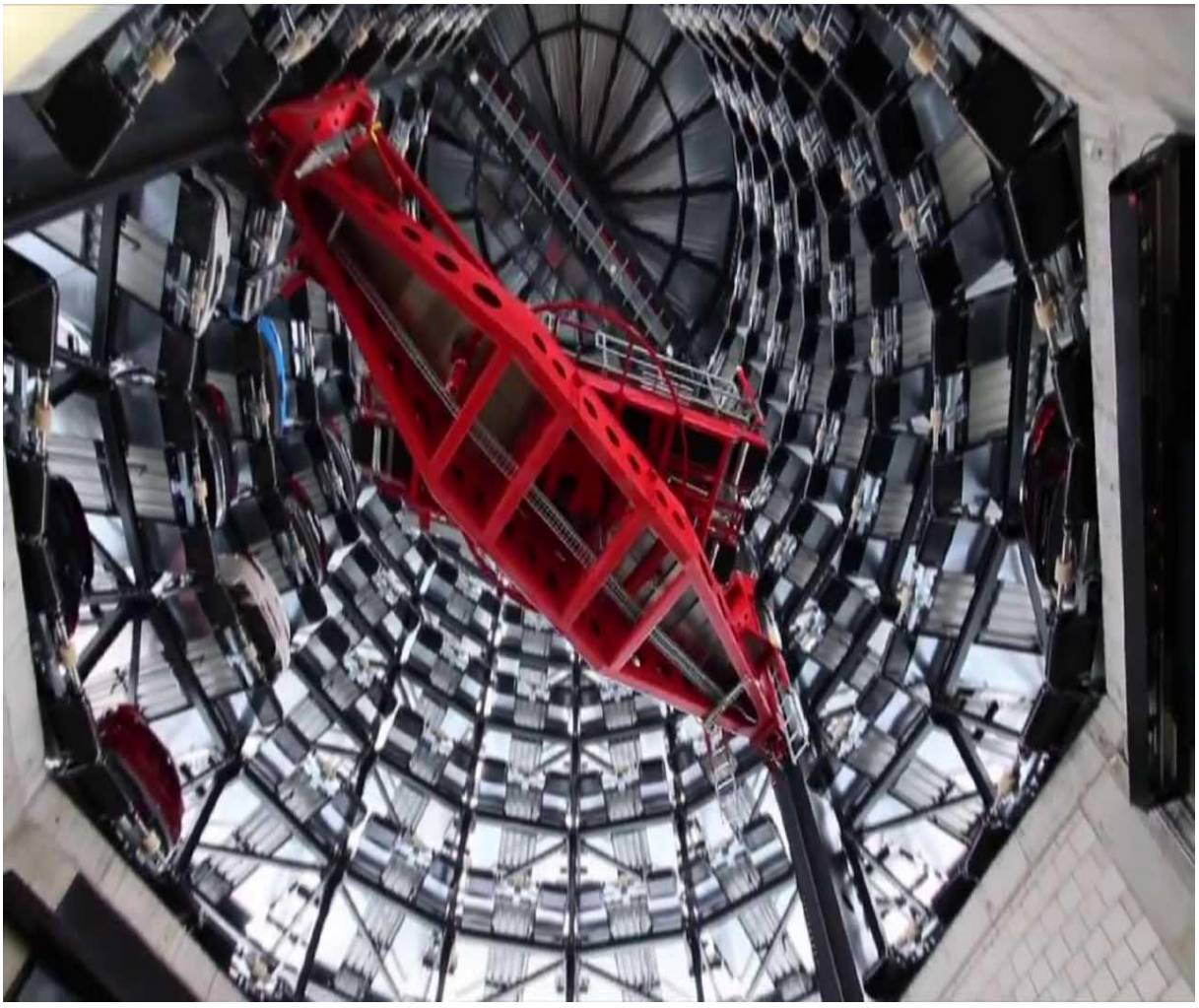


FIGURE 19: Robotic System for Automated Parkıng System[42]

CHAPTER 3-DESIGN AND MANUFACTURING

3.1 Aplied Knowledge of Mechanical Principles for Design Calculations

In sliding mechanism, stepper motor is supported with gearwheels to increase torque of motor in orter to work the sliding mechanism. Also for horizontally linear motion, linear mil is fixed to the side of the mechanism in FIGURE 20. As a result 7.5Nm holding torque for stepper motor is adjusted to the mechanism. Shown in FIGURE 21.

FIGURE 20: Sliding System

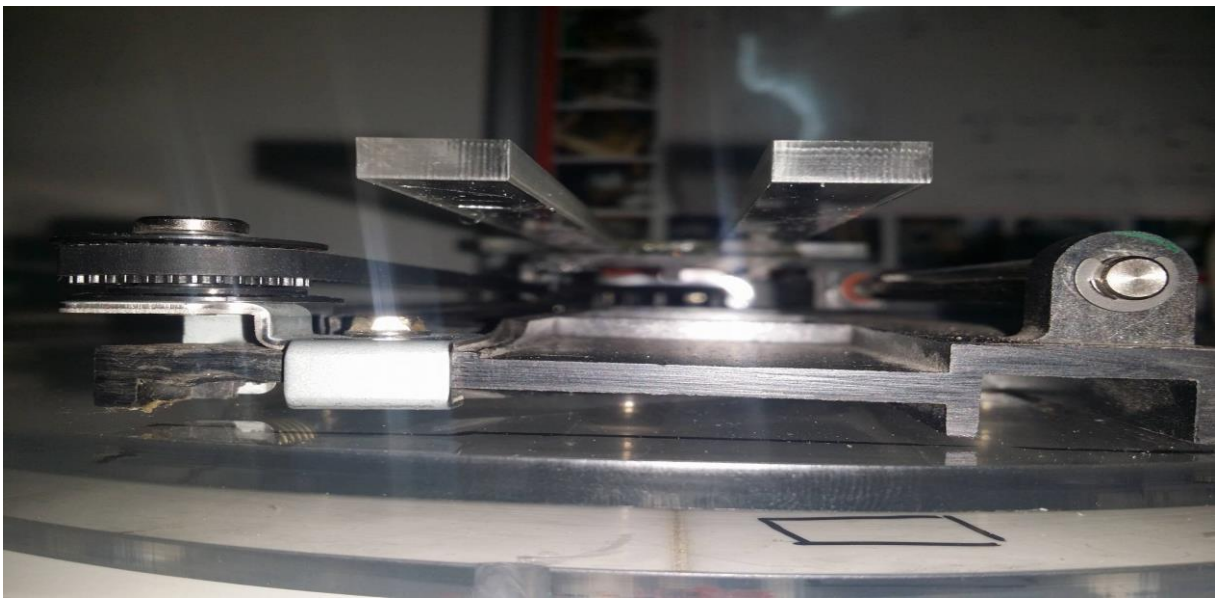


FIGURE 21: Gearwheels of Sliding System

Smooth rotation is required for middle mechanism to match with 36 degree in each floor in order to store the materials. So that balls are put in between to plate and formed 2mm inside both Plexiglas to prevent the system from centrifugal force. Shown in FIGURE 22 and FIGURE 23.

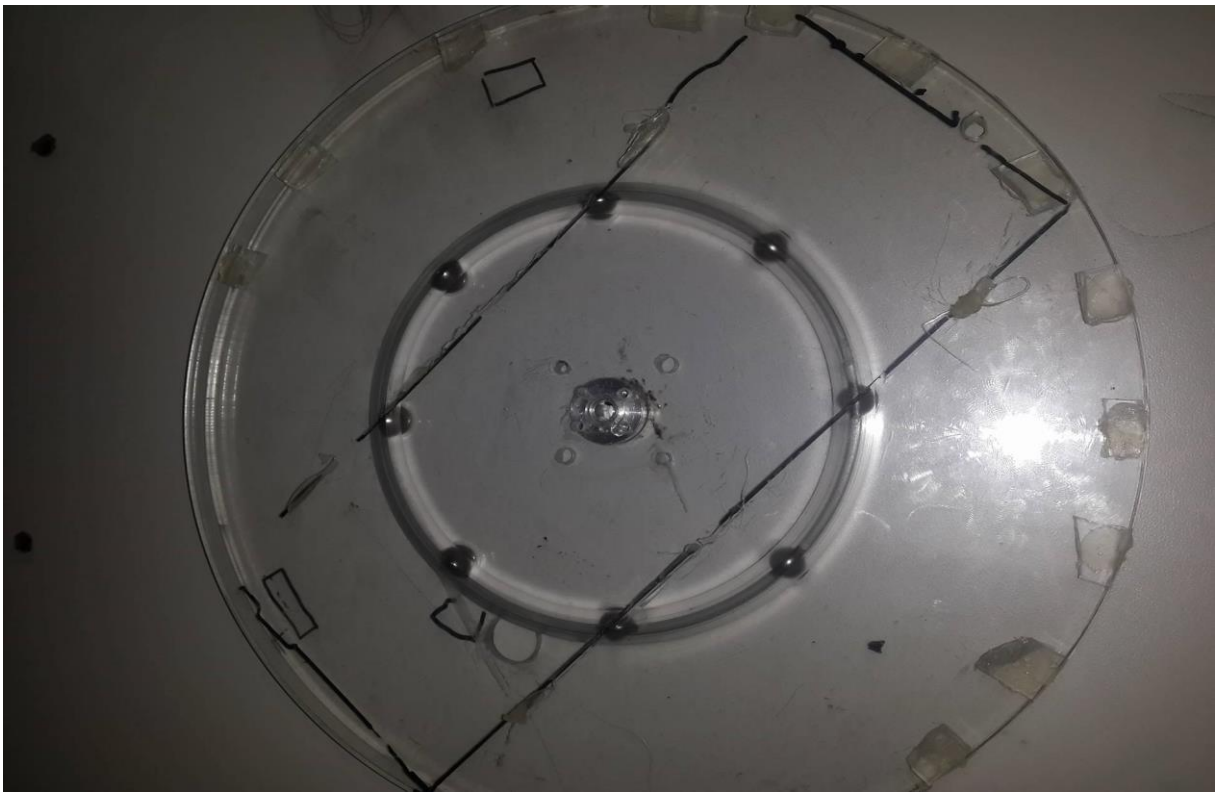


FIGURE 22: Ball Canals

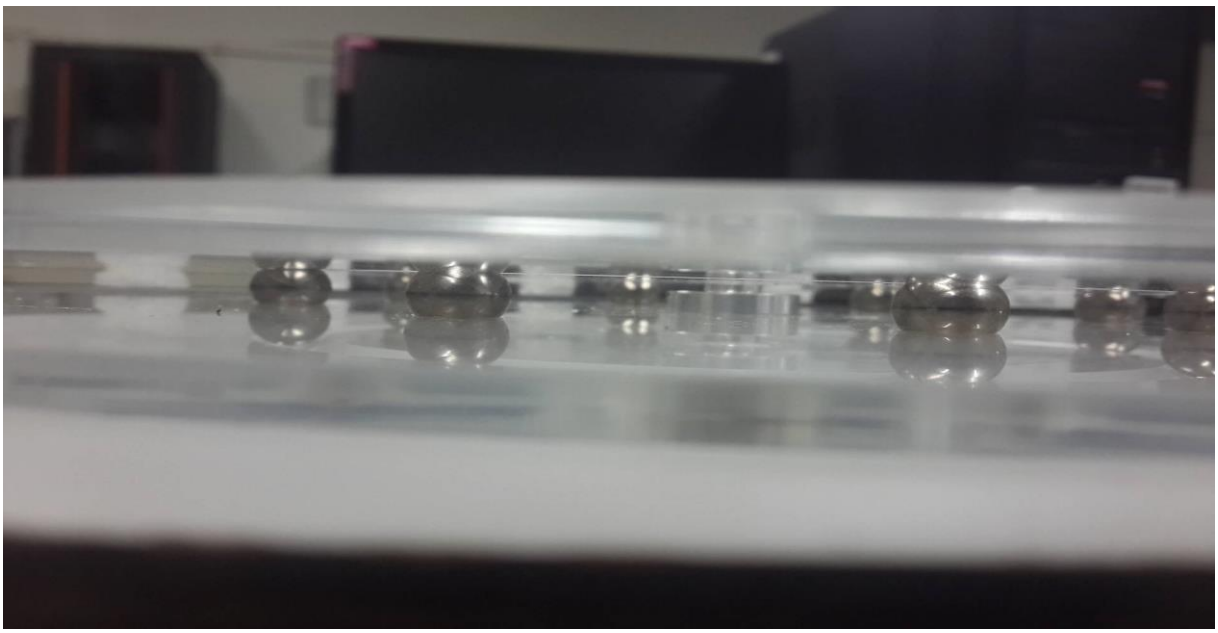


FIGURE 23: Balls

After all design knowledge is transferred to the mechanism. System looked like as shown in FIGURE 24,

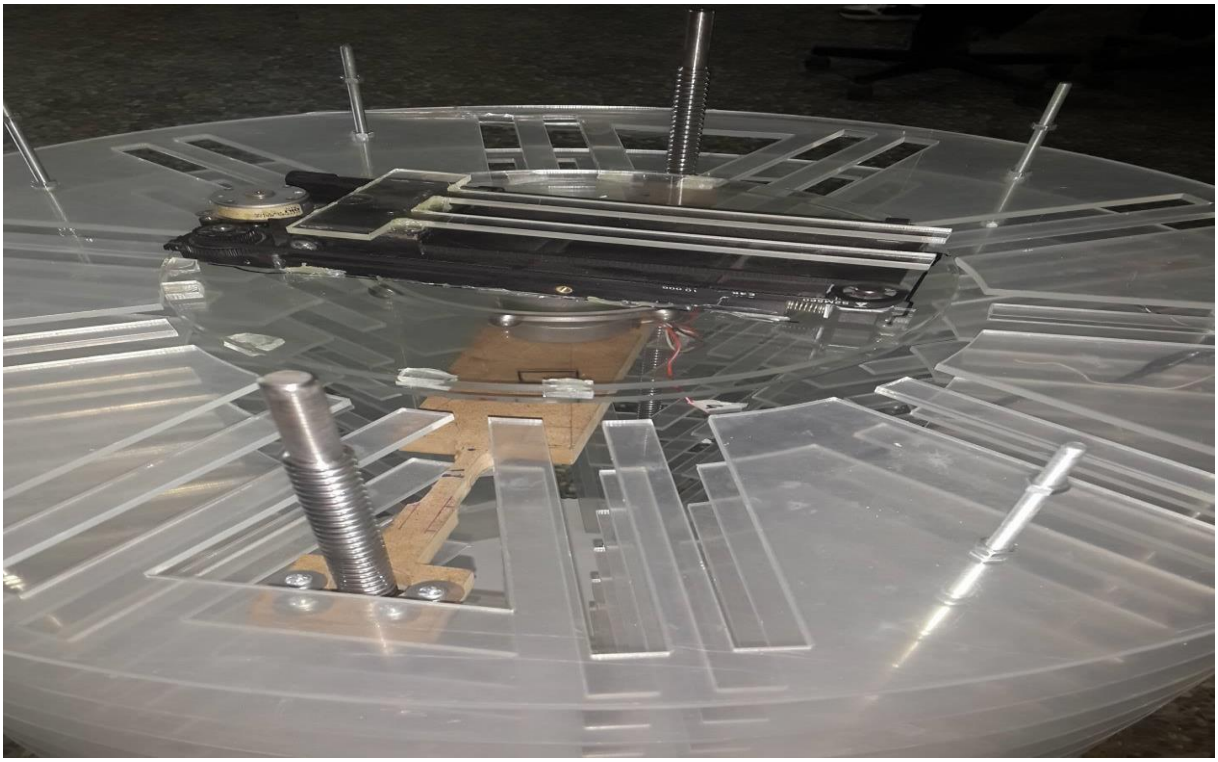


FIGURE 24: Middle Platform with Sliding System

DC motor's mil needed to be fixed to gearwheel because in design motor is given rotation movement to the linear mils at the sime time by helf of gearwheels. Each mill has got own gearwheel and also added one gearwheel to motor's mil. Hence design is completed by connection of chain between 3 gearwheels as shown in FIGURE 25 and FIGURE 26. After that motor is fixed to the basement with 3 bolts, washers and nuts.

FIGURE 25: DC motor with Chain

FIGURE 26: DC motor with Mils

3.2 Solution of Related Equations

3.2.1 Stress

Is a measure of how much force is taken by an object of particular size. It show the amount of strain inside the material. If stress vector is vertical to cross-sectional surface this is **normal stres(σ)**, If stres vector is horizontal to cross-sectional surface this is **share stres(τ).** Basically, stress is include this two type stress as shown in FIGURE 27. This stresses can be different shapes under different loads.

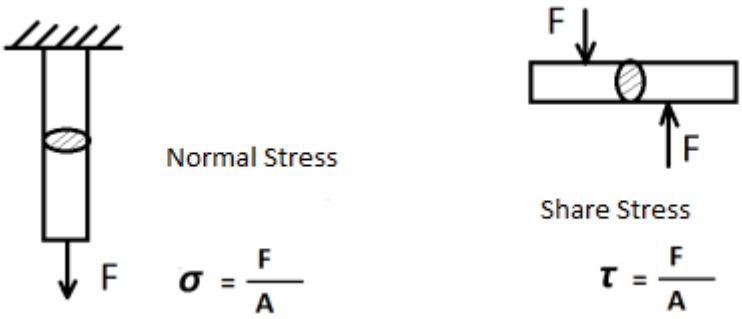


FIGURE 27: Stresses

3.2.1.1 Type of stresses;

- Tensile stress
- Compressive stress
- Bending stress
- Torsional stress
- Share stress
- Buckling stress
- Surface tension
- Special stress

3.2.2 Failor theories:

Physical properties of materials are founding with some simple load are apply to materials.

In engineering practise, some aplication stress can be complicated and exposed to normal and share stress in one point. So the material exposed to not just one direction stress, it couse to two or three dimensional stress condition. This kind of loads are couse to difficult solutions. Some methods have been develop for solve this kind of complicated variations. Main purpose of this methods', the aim of the theories are the values from the pull and push tests to be used to find startig distortion for the materials.

3.2.2.1 Von Mises:

Tytus Maksymilian Huber (1904) The Von mises used isotropic and ductile metal yield while subjected to complex loading condition. Von mises yield criterationis compare the von mises stres and material yield stres. This method useful for calculating to 3-D loading conditions, all kind of complex of share and normal stres. Von mises theorem is based on specification of distortion energy. When the deformation energy is exceed to certain energy,body start to demage. So this theory;

Von mises yield can formulated as equivalent tensile stress or von mises stress

$$\mathbf{2\sigma\gamma^2 = (\sigma x - \sigma y)^2 + (\sigma y - \sigma z)^2 + (\sigma z - \sigma x)^2}$$

'$\sigma\gamma$' is the Von Misses stress formed inside of the material. Stress will be two dimensional and 'σz ' will be "0".

$$\mathbf{\sigma\gamma^2 = \sigma x^2 - \sigma x \sigma y + \sigma y^2}$$

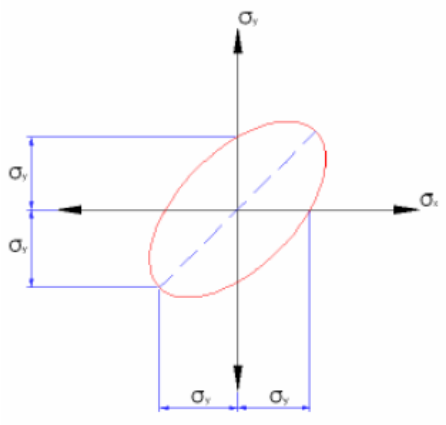


FIGURE 28: Intersection of the Von Mises Yield Criterion[17]

3.2.2.2 Tresca

Henri Edouar Tresca(1814). In a simple tension test, maximum share stress τ(max) while yielding start, equal to maximum share stress τ(em) at yielding shown in FIGURE 29. Deformation start when the maximum share stress and shift allowable stres are equal , under combine loading. In triaxial stress system loading, first stress is possitive, second is negative and third one is zero, maximum share stres;

$$\tau(max) = (\sigma 1 - \sigma 3) / 2$$

This theory is generally use for ductile materials. For single axis $\tau(em) = \sigma(em) / 2$

$$\tau(max) = (\sigma 1 - \sigma 3) / 2 = \sigma(em) / 2 \text{ veya } (\sigma 1 - \sigma 3) = \sigma(em)$$

If principle stress is positive for two axis and, third axis is zero;

$$\tau(max) = (\sigma 1 - 0) / 2 = \sigma 1 / 2 \text{ ve akma } \sigma 1 / 2 = \sigma y / 2 \text{ ve buradan } \sigma 1 = \sigma y$$

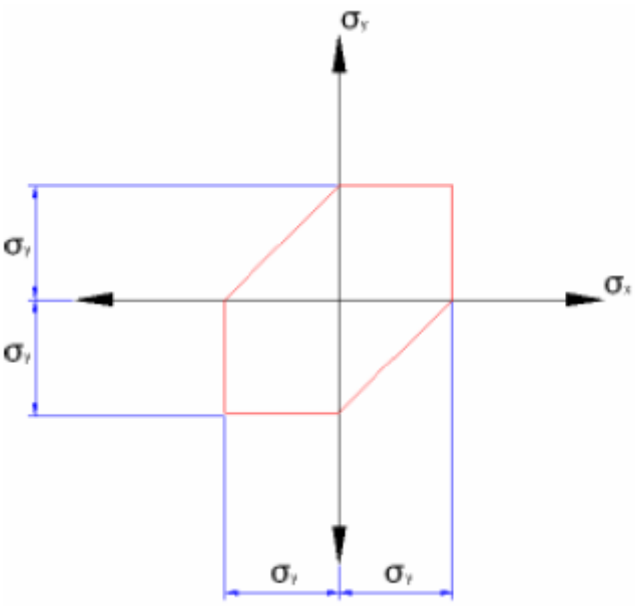


FIGURE 29: Intersection of the Tresca Yield Criterion[17]

3.2.2.3 Rankine

William John Macquorn Rankine(1820) shown in FIGURE 30. Rankine theori is too called Maximum Stress Theory.rankine theory is available for brittle material but not useless for ductile material. Principle stres is under the combine loading principle stres $\sigma 1 > \sigma 2 > \sigma 3$. Deformation start, if any σ value is exceed to limit when applying to force direction push or pull σ(em) .

$\sigma(max) = \sigma 1 \leq \sigma(em)$

This application is not give inteded value

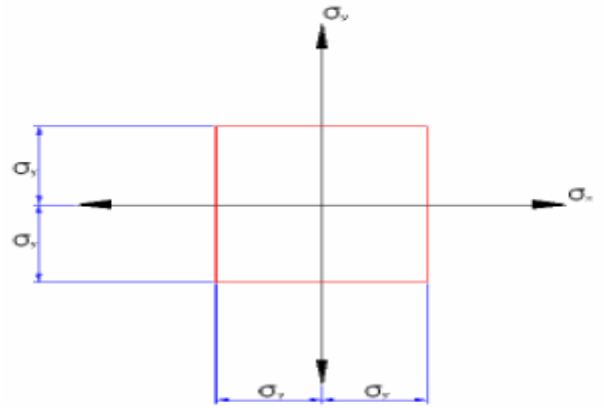


FIGURE 30: Intersection of the Rankine Yield Criterion[17]

3.2.2.4 Comparison of the Fracture Theory for ASRS

Von misses and Tresca is similar to eachother. Von misses is the best theorem for ductice material to use in experiment. Many engineering operation is done with Von Misses Theorem. And this application is pervading day by day. On the ather hands Rankine theorem is using for brittle materals and its not useful for experimental operations.

3.2.3 Static Nodal Analysis and Displacement Analysis of the ASRS

200g force is applied on the specific places on the floor which will be filled with the materials. Therefore each floor has 10 materials. So totally there will be 2kg force is applied. The force and tesile stress is shown at the below FIGURE 31.

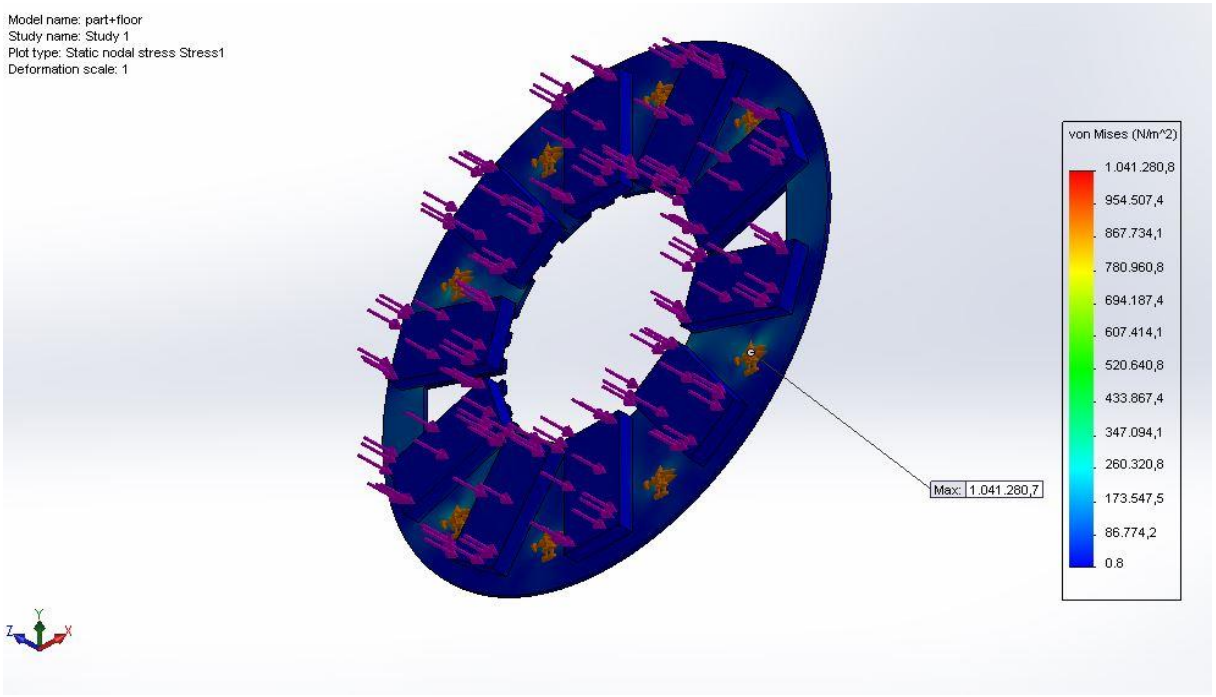


FIGURE 31: Static Nodal Analysis for Floor.

Afterwards the stress is examined by focusing the fixed points. In the graph one fixed point is shown and the colors are explained regarding to the table in figure. Red color shows that von mises values which are shown with the unit of Nm^2. Also shown in FIGURE 32.

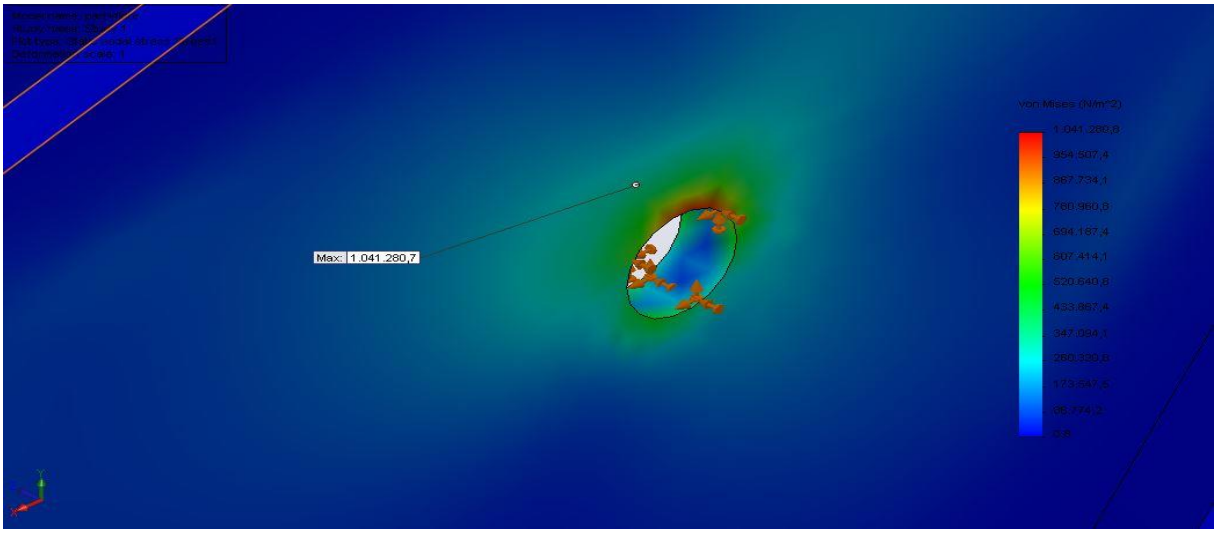


FIGURE 32: Static Nodal Analysis for Fixed Point.

Static displacement on the floor is tested on the SolidWorks similator. The points which has angle change is observed at the below in figure. Stretches are obtained around the lift system and also little stratches are appeared at internal circle. Shown in FIGURE 33.

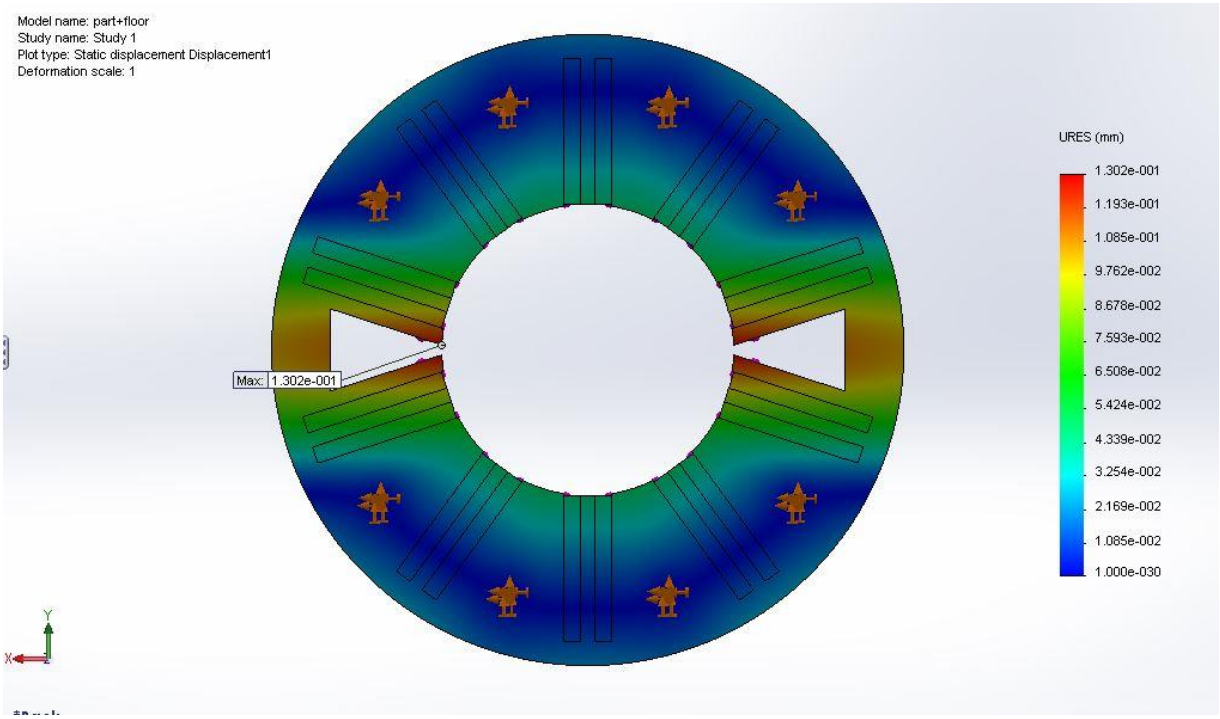


FIGURE 33: Displacements on the Floors Under Pressure.

Static nodal stress analysis of carrier column is tested under pressure. Force has been applied on each nut which handles the floors seperatelly. So for each nut is tested under 4 kg pressure.

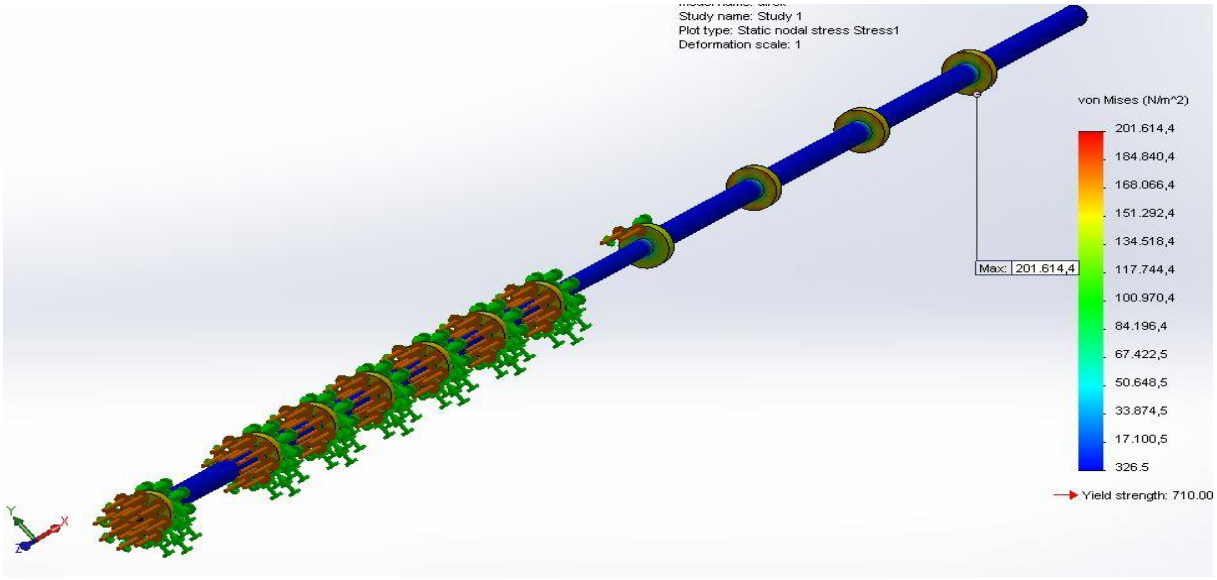


FIGURE 34: Static Nodal Stress Analysis of Carrier Column.

The single nut is zoomed in FIGURE 35 to take a look on it to watch the static nodal stress analysis. Observation has proved that red colours are appeared outside of the nuts which are not hazardous for the system.

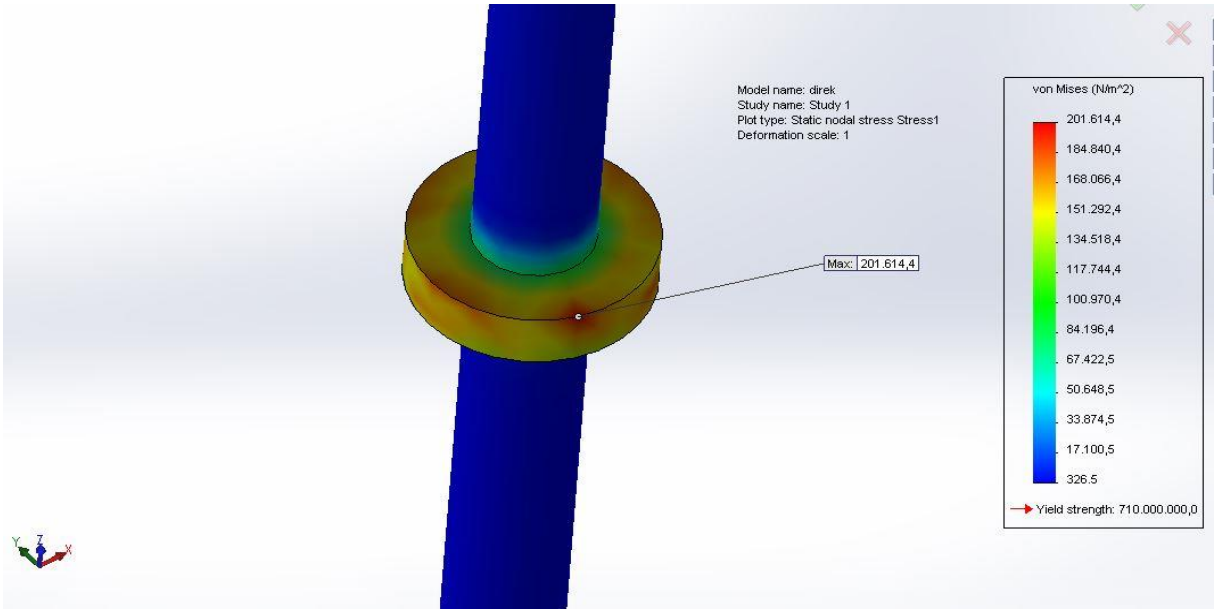


FIGURE 35: Static Nodal Stress Analysis for Single Nut on Carrier Column.

Static nodal stress analysis of the lift system in the middle of the C-ASRS which helps to fit in the shifts the material. 200g material part is applied to the surface of the slide axis in the middle. Stress is gathered arround the intersection of the slide in the middle as shown in FIGURE 36 and FIGURE 37.

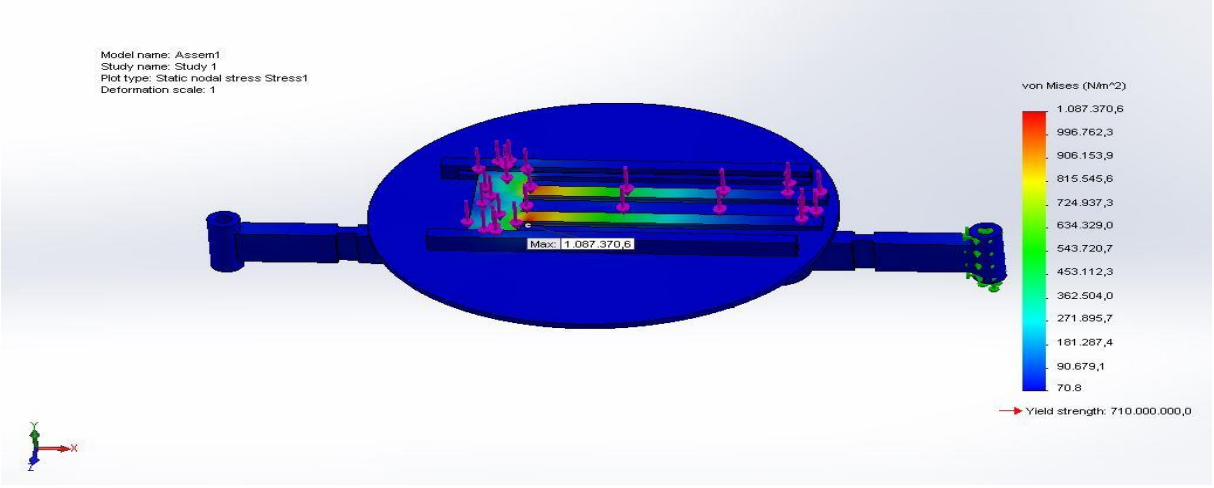


FIGURE 36: Static Nodal Stress Analysis for Lift System.

Also same system is analysed in terms of displacement with having same conditions. And maximin displacement difference is appeared at the end of portions of the slide system.

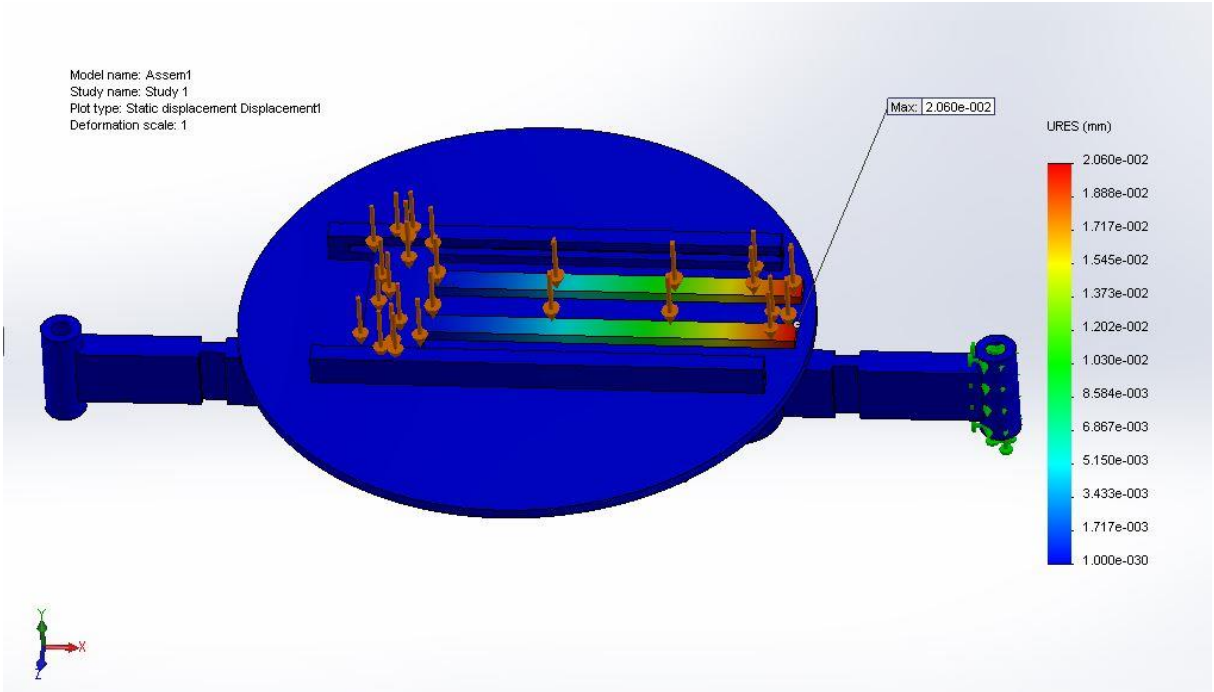


FIGURE 37: Displacement of the Slide System.

3.3 Apply Engineering and Science to Select Suitable Materials

3.3.1 Material Selection for Material Design

In engineering project, material selection can be accomplished with many ways. There are many impressive factor to select the material like cost, weight and machinability but most important part of design is mechanichal performance. Many methods present for optimise parameter rates in mechanical design permit activities like decrease the weight design, design for minimisation for thermal impairment and less cost design. Nowadays material selection is done by effect of environment. The machines which help the provider should be produce for environment friendly material production.

When the designer select to material they have to consider many ways. These factors are mechanical and electrical charachteristic to surface finish and corrosion resistance. Some material properties can be devided 7 parts;

- Density
- Strength
- Elasticity
- Creep
- Ductility
- Hardness
- Thoughness

These properties are classified in order to specific mechanical features. Density is the use for find materials which are light and stiff. Metals has high stiffness but they can show strength and ductility characteristic. Polymers has low density cause of this they shown lower strength and stiffness characteristic. Many material groups has different specific properties, and for this properties there are exceptions in the material groups. Composite and alloys materials every time give real value that is different from pure counterparts.

3.3.2 Material criteria and goals:

The combination of parameters which best depict it or wants to be optimised while engineers have decided on the important design criteria. Other combinations of charachteristic properties use for optimise material selection like criteria as; vibration limitation, strength limitation and cost limitation. Design is principles by many factors, but they can be classified very simply into two categories:

- Objectives
- Constrains

Objectives are aim obtain by the engineer like reducing energy content, mass or size. Restrictions can be about mechanical function and cost. Restrictions can be about mechanical function and cost. ıf restrictions about mechanical stiffnes and strength became important.

3.3.3 Some Factors for Material Selection

Formability of the material is not independent from manufacturing method.cost is other important factor in manufacturing. Nice design is not enough for sell, shape, tissue,colour, esthetic and decoration is everytime important for user.if the producer is not be careful in this subject they can lose their marketing share.

Design problems haven't got unique and exact solution.designer must be open mind and see the all likelihood.

Engineers use this methods for material selection selection:

- Analysis of the essential properties of materials
- The selection of cadidatematerial selection
- Developments of candidates
- Selecting the material that best fits the required properties

3.3.4 Main factors for material selection

- **Strength:** Materials withstand the stres applied during operation.

- **Ductility:** it can change depend on the strength. Ductility usualy, obtained by sacrified of resistance.

- **Design:** In manucafturing main part of the error come up labaratory tests, litle part of error isgrow up manufacturing faul tor material selection fault.

- **Stability:** Operating temprature depends on temprature changes and how long to stay in that temprature.Tempratures not only cause the creepresistance by affecting strength also cause a change in microstructure of material. In sometimes applications radiation can be effective.

- **Availability:** Easy to find material will cause to cheap price

- **Production Conformity:** Each material can not be produced by any method. Producers select to which material don't need a special applications like forming, joining etc.
- **Corrosion Resistance:** Material musnt effected from corrosion in the operating conditions cause of this high corrosion resistance material are prefered.selecting material must be clean and durable to corrosion resistant and musnt affect strength and other environmental impact.

- **Cost:** The price and life of material should be considered together. The Price is not enough for material selection. Bending, driling, milling, etc. cause to different cost in factorial applications.

3.4 Apply Engineering and Science to Select Apportriate Mechanical Components

3.4.1 Shelves

3.4.1.1 Plexiglas (Polymethyl Methacrylate)

Plexiglas is an easily proccessed and it is anathomy is useful for drilling and machining. It can have various colors as well as it can be colorless. It can be transperent or semitransperent. Transparent type of Plexiglas is shown in FIGURE 38.

It has an easily processed, very light and penetrable structure. It is generally sold as 1.5-2 mm flat sheets on the market. It can be softened at 90°C or in a 90°C – 115°C stove. With this, it can be moulded into any shape desired. The only disadvantage is it has low resistance to heat because of it is thermodynamic structure. Plexiglas is very easy to apply on every shape.

Their most important feature is they are cast sheet. Expansion factor, density, softening point and hardiness are well adopted to standarts and has a high polymer count.

Plexiglas comes in various dimensions. It has high luminous transmittance and shatter resistant. It doesn't have sharp edges and it doesn't cause injuries when broken.

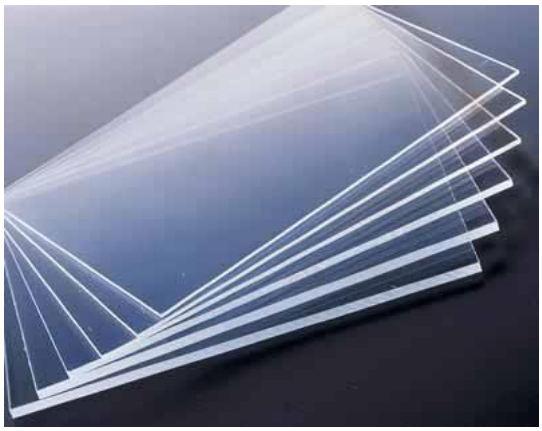


FIGURE 38: Plexiglas [24]

3.4.1.2 Metal Plate

Sheet metal is plated metal (especially ferrous materials) showns in FIGURE 39. They have no luminous transmittance.

It is which highly resistant to heat. It is suitable for metal constructions are exposed to variable and fixed stress.

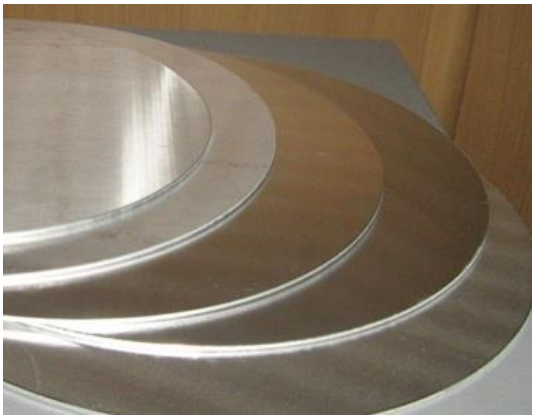


FIGURE 39: Metal Plate [22]

3.4.1.3 Why Plexiglas

Compared to metal plates, plexiglas has more advantages when being used in shelf systems. Since plexiglas has an easily processed, penetrable, light polymer structure, it has great ease during shaping and mounting. It is lightness will greatly reduce the total weight when in used in large numbers. It is transparency will provide a either visual and will make the products on the sheles more attention grabbing and visible, providing a better and easier control for the operator. Other than these, while plexiglas provides and easier mounted and better looking shelf, it will be a lot cheaper per unit than metal plate shelves. Should metal plates would be used, the shelves would be much heavier. It would also have high production cost and more time consuming. Even though metal plate is more durable compared to plexiglas, plexiglas is almost as durable as copper, which makes it more than enought for shelving.

3.4.2 Lift system

A pulley system consists of two pulley wheels each on a shaft, connected by a belt. This transmits rotary motion and force from the input, or driver shaft, to the output, or driven shaft. Friction between the pulley and belt plays an important role in the transmission of the movement. Because it's simplicity it's relatively inexpensive and an easy construct compared to other mechanisms. They can transmit power and motion between two shafts away from each other. They have bending ability and high tensile strength.

With the help of belts and gears system, using a single engine, can be moved to either screw. Thanks to the flexible nature of the belt system, the system will be able to withstand high tensile forces. The screw shaft and which is also used as C-profile, serves to keep the system stable. In assuming the duties of the screw shaft, bearings and takes on the role of c-profile.

Ball screw drive (bearing) is a device that converts rotary motion into linear motion. The circulating ball bearings packed with a device consists of a ball screw and a ball nut. The interface between the ball screw and nut, rotating ball-compatible form is made by ball bearings. The shaft of the screw to be used positioned at the top and bottom end bearings, will be used in immobilized c-beams connected to each other by moving the screw.

C-profile also increases strength, holding steady bearings allows the screw shaft upright. It minimizes friction.

Both screws positioned in the middle of the engine, move the belt system, which transmits the screws.Screw elevators connected with the movement of the teeth of the screw moves the vertical axis. It also increases torque at the wheel by selecting the appropriate structure within the system and facilitate the operation of the system.

3.4.3 Horizontal Platform

In a vertical position movement and handling of the products it is accomplished by lift mechanism. This mechanism takes the moving force of the screw shaft. Motor and the mechanical power from the belt pays to the circular motion screw, the screw port of the elevator moves in a vertical axis. The range of this movement is the length between the bottom shelf of the top shelf. Carrier on the floor of the elevator mechanism is capable of rotating 360 degrees in the parallel axis with the product placement to the desired benefits of the desired shelf.

A horizontal platform will be used from metal pallets left over from the lift mechanism. Transfer product between the carrier and the rack will also be performed by a servomotor and the rail system. Servo motors on a carrier that will allow two-way movement with the help of metal pallets gear. Whereby the products placed externally on the carrier pallet will be moved in the vertical axis. Then it will continue on the horizontal axis then will be rotated 360 degress and placed on desired shelf compartment.

3.5 Explained the Manufacturing and Assembly Technique

3.5.1 Screw system

Screws can be defined briefly as a connection point. A screw, or bolt, is a type of fastener characterized by a helical ridge, wrapped around a cylinder.

It's used in many branches of industry and all branches of engineering.

3.5.2 What is bolt's material

Bolts are usually made of steel. Nuts are made of steel such as bolts. All types of steel used in production

Also bolts, not only the bonding material is sometimes used in the transmission of movement.

3.5.3 Nut:

Nut, bolt is part of a machine element that makes the task of tightening the connection. Nuts are made according to bolt measurements.We will be using flanged nut in this project The reason for choosing flanged nut is it doesn't untightened easily thanks to rubber. Nuts are shown specifically in FIGURE 40.

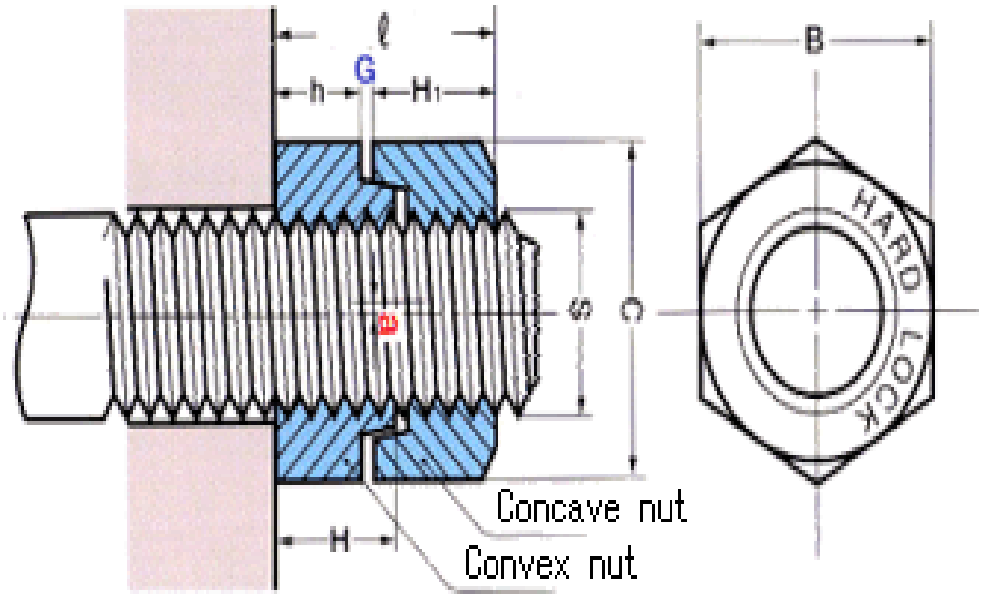


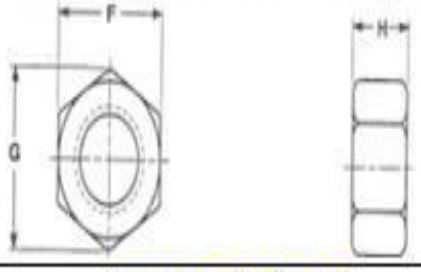
FIGURE 40: Nut and Bolt [25]

3.5.4 Screw and Nut System Use Places :

The 8 colums that will carry the mezzazine. One plexiglas shelf will clamped between the two nuts placed on the screws.

The aim of using the screw system is that it provides us the ease of changing the distance between floors.

Dimensions of Metric Hex Nuts



Metric Hex Nuts
ISO 4032

Nominal Size	Thread Pitch	F		G	H	
		Width Across Flats (Wrench Size)		Width Across Corners	Thickness	
		Max	Min	Min	Max	Min
M1.6	0.35	3.2	3.02	3.41	1.3	1.05
M2	0.4	4	3.82	4.32	1.6	1.35
M2.5	0.45	5	4.82	5.45	2	1.75
M3	0.5	5.5	5.32	6.01	2.4	2.15
M4	0.7	7	6.78	7.66	3.2	2.9
M5	0.8	8	7.78	8.79	4.7	4.4
M6	1	10	9.78	11.05	5.2	4.9
M8	1.25	13	12.73	14.38	6.8	6.44
M10	1.5	16	15.73	17.77	8.4	8.04
M12	1.75	18	17.73	20.03	10.8	10.37
M14	2	21	20.67	23.35	12.8	12.1
M16	2	24	23.67	26.75	14.8	14.1
M20	2.5	30	29.16	32.95	18	16.9
M24	3	36	35	39.55	21.5	20.2
M30	3.5	46	45	50.85	25.6	24.3
M36	4	55	53.8	60.78	31	29.4
M42	4.5	65	63.1	71.3	34	32.4
M48	5	75	73.1	82.6	38	36.4
M56	5.5	85	82.8	93.56	45	43.4
M64	6	95	92.8	104.86	51	49.1

TABLE 5 : Dimentions of Metric Hex Nuts[26]

3.5.5 Linear Mils:

Linear mils are produced to handle heavy industrial work mostly in serial production. In production where either linear movement are required or minimum wobble are required, linear mils can be used. In C-ASRS project, wobble is required to detect the specific stores. Vibration of the system and wobble affect the system efficiency directly so that linear mils are chosen in project.

3.5.6 Assembly Techniques

There are various assembly techniques that is used in C-ASRS's mechanical structure and also Plexiglas is cut and assemble in a way that is explained at the below.

3.5.6.1 Chemical Method:

Chemical methods consist of three paramaters that is used attach awkwardly shaped or fragle plexiglasses. Parameters are adhesives, adhesive tape or cements. Adhesives are commonly used for dissimilar materials and the bond in between them is limited by tensile strength due to having angle difference at the connection surfaces. The disadvantage of the chemical methods that they require longer time than the other methods. Shown in FIGURE 41.

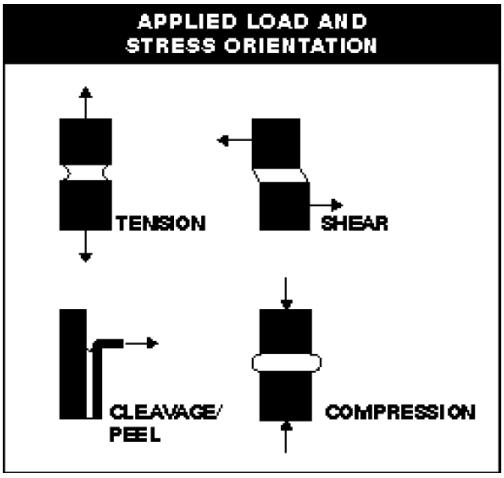


FIGURE 41: Applied Load and Stress Orientation [28]

Plexiglasses are compatible with adhesives providing versatility by using with other polymers to have desired design. However the strength of the chemical assembly is depent on the material and the operator who accomplish the assembly. Joint design can be accomplished with different ways which are Butt, Lab, Scarf and Tapered Lab. Their strength is mentioned in following FIGURE 42.

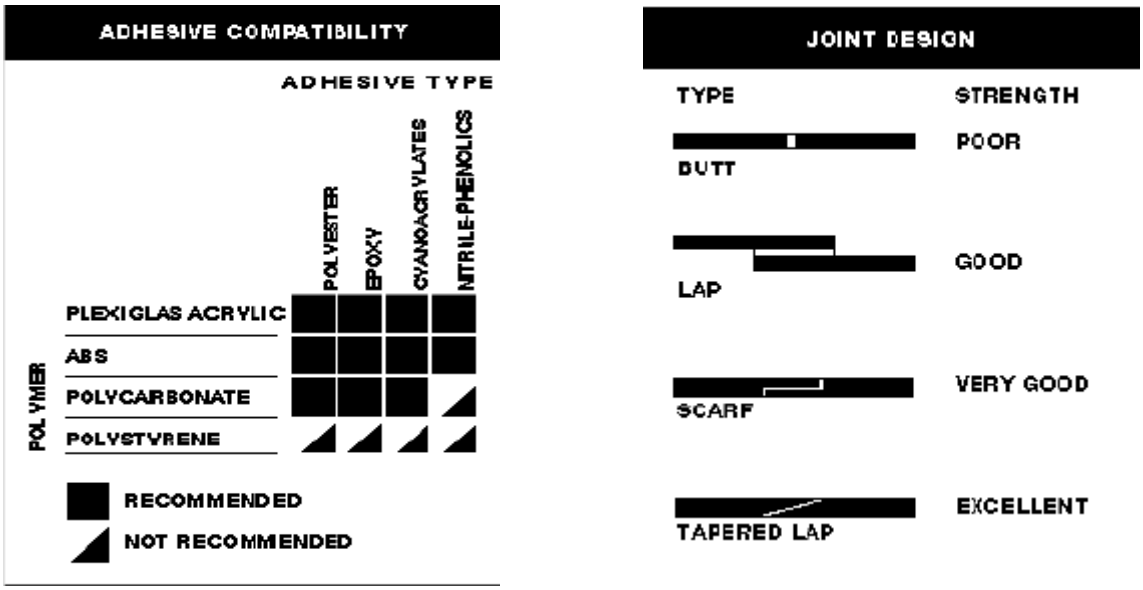


FIGURE 42: Adhesive Compatibility [28]

3.5.6.2 Welding Method:

Welding assembilies can be applied to the plexigrasses and as a result a melt bond accures the place where the welding prosses is accomplished and also welding processes include hot plate, vibration, ultrasonic effects. Welding processes are nicely suited for the leak proof, permanent and free high strength bonds are required as shown in FIGURE 43.

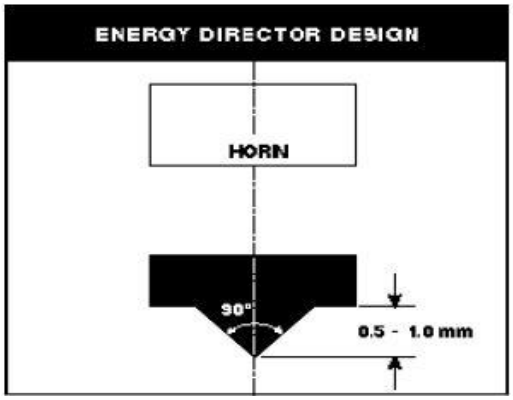


FIGURE 43: Energy director design [28]

3.5.6.3 Mechanical Methods:

Mechanical methods include some techniques for example fastening, snap fits and riveting which are used for applications where fast assembly and non destructive disassembly is required. Plexiglass can be usef for all applications that is mentioned below in TABLE 6.

Thermal Method Guidelines

	Plexiglas V-Series			Plexiglas MI7			Plexiglas DR		
	Ultrasonic	Vibration	Hot Plate	Ultrasonic	Vibration	Hot Plate	Ultrasonic	Vibration	Hot Plate
PMMA	G	E	E	G	E	E	G	E	E
ABS	G	E	E	G	E	E	G	E	E
ABS/ PC	G	VG	VG	G	VG	VG	G	VG	VG
PC	G	VG	VG	G	VG	VG	G	VG	VG

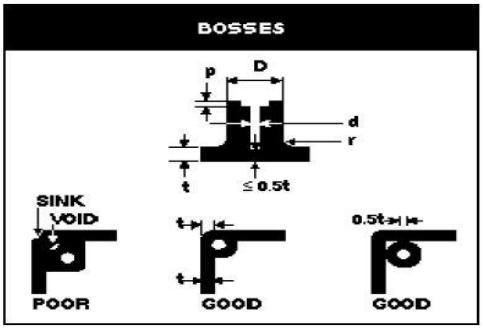


TABLE 6: Thermal Method Guidelines [28]

3.5.7 Annealing Procedure for Plexiglas:

Annealing is a process of heating a melt part over a period of time that used to insure optimum quality with maximum lifetime from the assembled plexiglas. Annealing parts are increased resistance for external stresses (ex: mechanical, chemical etc.) and their advantage is to have high dimentional stability at high temperatures. In order to increasing temperature, melt part is became soft and it causes stress relaxation without distortion of the shape of design. So that the temperature is a critical factor to protect distortion from design shape.

3.5.8 Selection Importance to Choose Best Annealing Cycles:

There are three steps to achieve best benefits from annealing which are as follows;

1) Place the measured melt parts into the oven at high temperature with specific temperatures from the table.

2) Heat the part with the required period of time which can be read from the table due to the thickness of part.

3) Remove the part from the oven and keep the part at room temperature for a couple of hours after this application the part becomes ready to re-measure the dimentions.

4) If the new measurement change should be less than 1%. So in this case the part can be annealed successfully.If the new measurement change exceeds 1%, the application need to repeatted at lower temperature and time from the table. If the result provides unacceptable dimentions in the next applications, the part is poorly molted and requires improvement of melting processes.

Maximum Thickness (inches)	Plexiglas V825, V826		Plexiglas V052, V045, V044, V920, DR, MI7, HFI10, HFI7, SG10, SG7		Plexiglas VM, VS, VH		Maximum Cooling Rate (°C/Hour)
	95°C	90°C	85°C	80°C	75°C	70°C	
0.060 to 0.150	2.5	7.5	2.5	7.5	1.5	7.5	40
0.151 to 0.375	3	8	3	8	2	8	20
0.376 to 0.750	4	9	4	9	3	9	10
0.751 to 1.125	5	10	5	10	4	10	8
1.126 to 1.500	8	13	8	13	7	13	5

TABLE 7: Plexiglas Temerature Table w.r.t. Tickness [28]

Plexiglases has got different sizes with different resistance of temperature. So that in C-ASRS project 5mm (1.127 inches) plexilas is used and it has resistance of 80 degree celcius and more temperature standarts are shown in TABLE 7.

3.6 Final Cost Analysis :

The expected cost for all of the materialsused in the study is given in Table 8.

Pleksiglass Structure	1200
Linear Mils	170
Flange Nuts	40
Linear Rollers *2	60
Step Motor 12V	50
Step Motor 24V	120
DC Motor 12V	40
RFID Reader	40
Arduino Mega 2560 + Breadboard	142
Rollers * 4	60
Stepper Motor Driver *2	120
Power Supply 12V/10A	45
Power Supply 24V/10A	55
Infrared Sensor	20
Balls * 8	20
Total Cost	2182

TABLE 8: Cost Analysis.

CHAPTER 4 –ASSEMBLY DESIGN AND MECHANISM

C-ASRS has got 2 linear mil opposite each other. Mils are located and fixed by roller from headstock and tailstock with help of wooden circle platform. Rollers's case are prepared in turning machine in EMU workshop and wooden platforms are prepared in EMU. connection between two mils which need to handle the middle platform are cut by CNC machine in Mechatronics Lab. Middle platform consist of 8 little balls in 2 plates for rotation, a stepper motor which rotates the middle platform is fixed lower plate. Cables are put inside 2 plate and fixed by adding small pieces surrounding the fixed plate.

Motors are selected in order to decrease the number of sensors in system. Sliding system is prepared by adding two gearwheels and also supported with mil along the sliding. The system is designed to move 14cm forward direction. The platform on the sliding car is to store the material. So that 14 cm is measured to extend that material to the shelf. Belt is used to provide gearwheel connections with motor. Motor is selected as stepper motor although dc motor is appropriate for the mechanism. Because DC motor is needed to be supported with two limit switches. Instade of switches stepper motor is preferred to be used in system to be controlled by stepping in Arduino program.

DC motor is selected due to the structure weight. In the beginning middle mechanism is assumed to be approximently 1.5 kg. Shafts are fixed to the bottom platform to decrease the weight which formed on motor. So that motor is selected with regarding the approximate calculations that the system structure's weight.

First attempt or trial for middle mechanism is done with 1.8 degree stepper motor working voltage is 12V. Although the mechanism has got 1.5 kg weight motor could not handle the middle mechanism rotation because of friction that the wires caused.Second time stepper motor with high voltage and high amper is chosen to succeed high efficiency from the mechanism. Floor stations are located in each 36 degree and 10 stations available in a single floor. So stepper motor's rotation is controlled on Arduino program to match with specific degrees.

FIGURE 44: Stepper motor fixed lower plate

Sliding system is designed with a belt which rolles between two gearwheels. One side of the gearwheel is connected to the stepper motor. To increase the motor strength and to control the system more sufficient one more gearwheel is added to the motor's mil. In this way, sliding process is accomplished. Mill is added along the way to provide linear movement onto the upper plate and fork type of plexiglass is glued on it to reach to the shelfs on the structure. For rotational movement is provided by 12V stepper motor with a 1.8 ^{0} angle. For sliding system 12V stepper motor is used. DC motor could control easier than stepper motor.

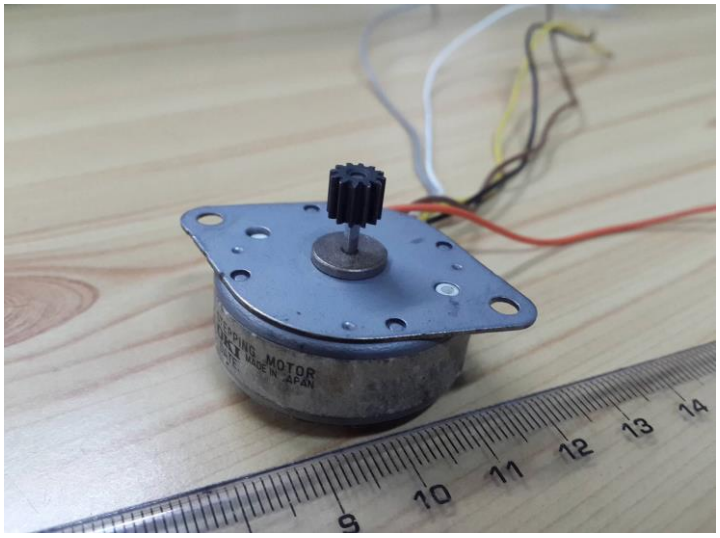


FIGURE 45: Stepper Motor

However no sensor usage is preferred so that stepper motor controlled at an angle to control distance. Motor has got 200 steps per revolution and 14cm length is reached by giving 1000 steps to the motor in Arduino program. The calculation of distance is done by one revolution of steper motor which is 200 steps. In one revolution motor went 2.8 cm so that if one revolution takes 2.8 cm, 14cm can be taken with 5 revolution and each revolution has got 200 steps. 200 steps is multiplayed with 5 revolution and result 1000 steps. In Arduino program its written 1000 steps regarding to this calculation. Mechanism shown in FIGURE 46.

FIGURE 46: Middle mechanism

CHAPTER 5 – RESULTS AND DISCUSSION

Although there are 2 linear mils in system, balance problem is occued at the bottom of C-ASRS. The length was fixed and same between bottom side and top side of mils. In order to solve this problem, motor mil and gearwheels are disassembled and checked by vernier caliper. Skewed gearwheels and the piece of mil which is added on the DC motor mil is corrected in turning machine and then welded to the motor mil. After all, DC motor and gearwheels is assembled to the mils and basement to see how the system work. The result was positive and the group with the MACHINE HUMANS is succeed on this problem.

Main structure consist of 10 different floors and 2 top and bottom plates are fixed to prevent shake. All these supports haven't been enough to have fixed structure. Because DC motor's vibration is affected and transferred to the main structure. In order to finding solution, mil that is welded to the motor mil is disassembled. Gearwheel is fixed with less distance to motor to prevent vibrations and also shake of motor. The result is succeeded after assembly.

Middle sliding mechanism is prepared earlier times with a different design. However the first design was well done, belt assembly and gearwheel positions became a problem in this case. Although all possibilities are tried on mechanism, ended up with negative result. Therefore, new system for the middle part is designed. However new designed system's weight is high, stepper motor that is used to control middle mechanism handeled that amount of weight. Early designed middle sliding system is shown in FIGURE 47.

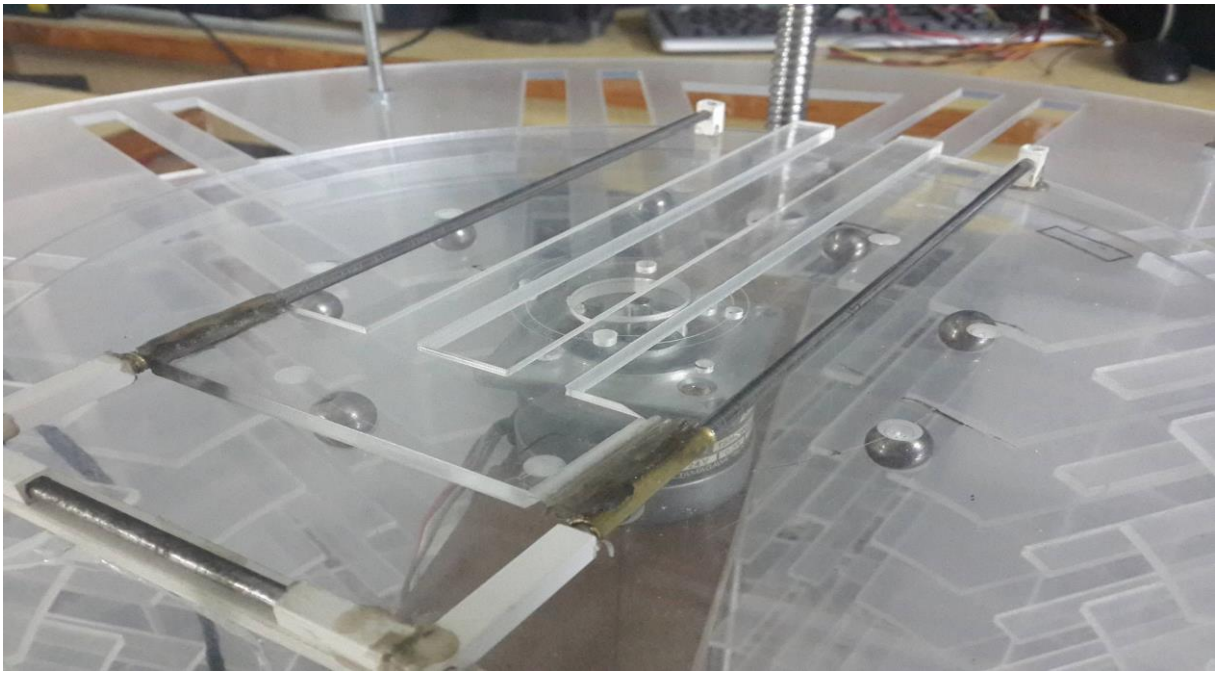


FIGURE 47: Early Designed Sliding System

CONCLUSION

First of all, the topic of the CAPSTONE Project have been discussed between the members of Capstone Project Team and then C-ASRS has been chosen with help of advisor teacher. After that, discustion brought up new idea which is the C-ASRS with conveyor belt sistem.The materials were choosen for the Project. There will be used plexiglas for the main part. Because, plexiglas is useful, cheap, and light. Plexiglass can be machined easly and also can be found easier than other materials in Cyprus conditions. Some sensors will be used in this Project. For example, RFID.RFID system is supported with two stepper motors by linear module are used in the Project to control the part to fit in the shelves. Lift system will be used in the Project, it will take the part and put the parts from Conveyor to shelfs. Conveyor system will be used in the Project, conveyor only transports the part to lıft system. Nowadays, land price is very expensive in the city so people need to empty area so much. The aim of the Project is to store maximum amaunt of material with use of minimum land size. This Project can be used in some industries like medicine industry. Because in the medicine industry there are various medicines which required to be in different shelf. C-ASRS is designed to use with a conveyor system to grab the material from the conveyor belt system. After the material is grabed, due to type of material it will be stored in specific shelves. There will be 10 different colour of materials with 2 various size matierials will be used in our C-ASRS.

FUTURE WORK

C-ASRS is compound of machanial structure and also interface between arduino and labtop. Interface is designed by use of phyton programing. No sensor usage is preferred for rotation in middle plate therefore system informations and station availability is stored in laptop. As known as 10 floors are available and each floor has got 10 stations so that there can be 10 different color material and 2 different sizes in circular C-ASRS project. In future, colors can be adjusted by changing color with the operation in production. For example red color is to be drilled, yellow color is to be welded etc. By help of robotic arm materials can be moved to the conveyor connected to the storage and whenever needed to take material from the C-ASRS in order to specific operation. In addition, middle platform can be worked with wireless communication. One of the major problem is rotational movement with wired systems. As long as rotation continues, wires need to move with mechanism. First problem is wire fracture and second one is to have stops in rotation. Each stops in rotation deflection occurs that causes wrong storage addresses in structure. In order to reach the addresses on shelfs, middle motor has to stop each 3.6 degree. By utilization of wireless communication in the system, there would not be any wire and deflection problem that causes many hours to be lost while finding the solution of that problem in the system.

Furthermore, there can be added image processing sensor to recognize the user to work system. Also lock, keypad, finger scan feature can be added to increase the function of the C-ASRS. To sum up, main structure and the idea of the project is done in EMU.

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APPENDICES

APPENDIX A

LOGBOOKS

Zeki's Logbook

09.03.2015	First of all , we search the some Project and we discuss together with our friends.
16.03.2015	This week we decided to ASRS Project with our friends and our advisor Prof. Dr. Majid Hashemipour.
23.03.2015	I start to prepare the gantt chart.
30.03.2015	We start to research of our project that Autometed Storage and Retrieval System we collect the general information
06.04.2015	I continue the collect the information abaut the ASRS and I try to learn ASRS system.Also we visit the our advisor and we give the information what we are doing.

13.04.2015	We visited our advisor to get information abaut the Project and we distrubute the duty in our group.
20.04.2015	We search the information abaut the Project what we use in this Project like sensors,design,robot etc.
27.04.2015	I learn lots of thinks abaut theASRS system like working principle
04.05.2015	I prepared appendix, ganttchart and my logbooks for the final report.
11.05.2015	I draw the design of ASRS system with my Project member from SolidWorks.
18.05.2015	I did some calculation abaut the Project.I discuss with my friend How we can fix the part.Also I collect the information fort he final report.
25.05.2015	I continue the collect the information and I prepare the proposal with my friends.Also I start to write Chapter 1.
01.06.2015	I finished the proposal with my friends and I continue the write the Chapter 1.

08.06.2015	I finished the Chapter 1 and also we finished the writing formula and calculation.
15.06.2015	. I prepared appendix, ganttchart and my logbooks for the final report.
22.06.2015	Working on assemblying and resulting the final report for the submission,

23.10.2015	Plexiglas design and measurments are disgussed with POORYA GHAFOORPOOR YAZDI.
27.10.2015	Assembly is done with the help of POORYA GHAFOORPOOR YAZDI.
11.11.2015	DC motor problem and couple of design fails are discussed and solved with POORYA GHAFOORPOOR YAZDI.
30.11.2015	Stepper motor drivers and Stepper motors are selected and mils are taken to workshop to reduce the diameter.

06.12.2015	RFID sensor and how to use is learned by POORYA GHAFOORPOOR YAZDI.
20.12.2015	Middle platform is failed and redesigned.
30.12.2015	Solidwork drawings and design is talked with POORYA GHAFOORPOOR YAZDI.

Cihat's Logbook

09.03.2015	First of all , we search the some Project and we discuss together with our friends.
16.03.2015	This week we decided to ASRS Project with our friends and our advisor Prof. Dr. Majid Hashemipour.
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15.06.2015	. I prepared appendix, ganttchart and my logbooks for the final report.
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23.10.2015	Plexiglas design and measurments are disgussed with POORYA GHAFOORPOOR YAZDI.
27.10.2015	Assembly is done with the help of POORYA GHAFOORPOOR YAZDI.
11.11.2015	DC motor problem and couple of design fails are discussed and solved with POORYA GHAFOORPOOR YAZDI.
30.11.2015	Stepper motor drivers and Stepper motors are selected and mils are taken to workshop to reduce the diameter.
06.12.2015	RFID sensor and how to use is learned by POORYA GHAFOORPOOR YAZDI.

20.12.2015	Middle platform is failed and redesigned.
30.12.2015	Solidwork drawings and design is talked with POORYA GHAFOORPOOR YAZDI.

Emre's Logbook

09.03.2015	First of all , we search the some Project and we discuss together with our friends.
16.03.2015	This week we decided to ASRS Project with our friends and our advisor Prof. Dr. Majid Hashemipour.
23.03.2015	I start to prepare the gantt chart.
30.03.2015	We start to research of our project that Autometed Storage and Retrieval System we collect the general information
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15.06.2015	. I prepared appendix, ganttchart and my logbooks for the final report.
22.06.2015	Working on assemblying and resulting the final report for the submission,

23.10.2015	Plexiglas design and measurments are disgussed with POORYA GHAFOORPOOR YAZDI.
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11.11.2015	DC motor problem and couple of design fails are discussed and solved with POORYA GHAFOORPOOR YAZDI.
30.11.2015	Stepper motor drivers and Stepper motors are selected and mils are taken to workshop to reduce the diameter.
06.12.2015	RFID sensor and how to use is learned by POORYA GHAFOORPOOR YAZDI.

20.12.2015	Middle platform is failed and redesigned.
30.12.2015	Solidwork drawings and design is talked with POORYA GHAFOORPOOR YAZDI.

Servan's Log Book

09.03.2015	First of all , we search the some Project and we discuss together with our friends.
16.03.2015	This week we decided to ASRS Project with our friends and our advisor Prof. Dr. Majid Hashemipour.
23.03.2015	I start to prepare the gantt chart.
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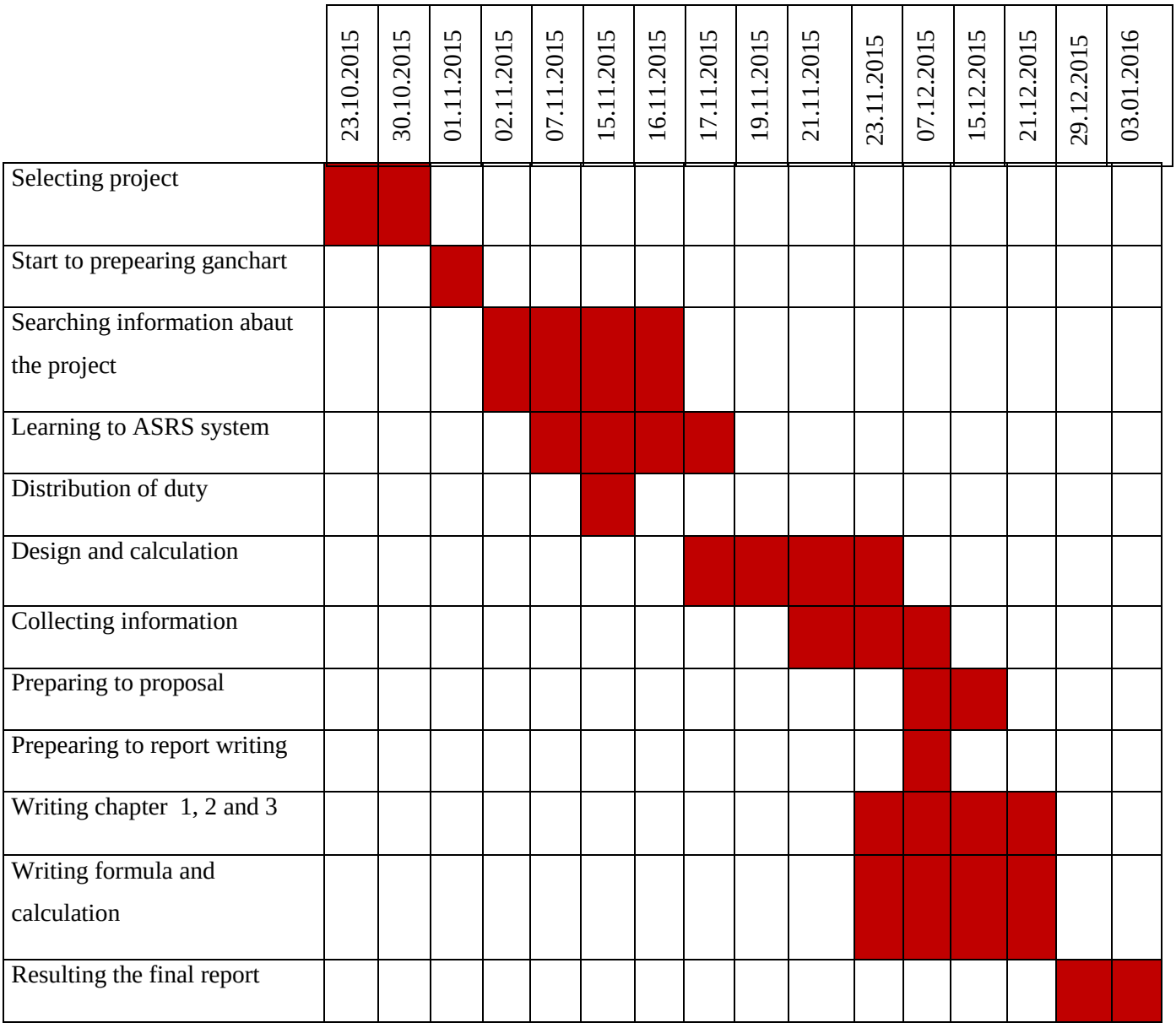
20.12.2015	Middle platform is failed and redesigned.
30.12.2015	Solidwork drawings and design is talked with POORYA GHAFOORPOOR YAZDI.

APPENDIX B

GANTT CHART



	9.03.2015	16.03.2015	23.03.2015	30.03.2015	06.04.2015	13.04.2015	20.04.2015	27.04.2015	04.05.2015	11.05.2015	18.05.2015	25.05.2015	01.06.2015	08.06.2015	15.06.2015	22.06.2015
Ordering Plexiglas and cutting																
Started to assemble Plexiglas																
Searching information about the mechanical support																
Searching Arduino and learning how to control arduino																
Motor selection																
Motor driver and sensor delivery																
Designing main structure																
Adding DC motor and fixing mils																
Searching information about RFID																
Designing middle part and phyton programming																
Program writing in Arduino																
Preparing control box and last touches to structure																

APPENDIX C

TECHNICAL DRAWINGS

No : 1	FLOORS
No : 2	TOP AND BOTTOM PLATFORM
No : 3	COLUMN MILS
No : 4	LINEAR MILS
No : 5	ROLLER CASE
No : 6	ROLLER
No : 7	LINEAR MIL ROLLER
No : 8	WOODEN PLATFORM
No : 9	BOTTOM PLATE FOR MIDDLE MECHANISM
No : 10	TOP PLATE FOR MIDDLE MECHANISM
No : 11	SLIDING SYSTEM ASSEMBLY
No : 12	CAR FOR SLIDING SYSTEM
No : 13	FORK GRIPPER
No : 14	DC MOTOR
No : 15	STEPPER MOTOR FOR MIDDLE MECHANISM
No : 16	STEPPER MOTOR FOR SLIDING SYSTEM

	NAME	DATE	SIGN	
DRW.BY	Machine Humans	04.01.2016		E.M.U
CHK.BY				
SCALE	DRAWING LIST			DRW NO:

SOLIDWORKS DRAWING AND WORK PERFORMED

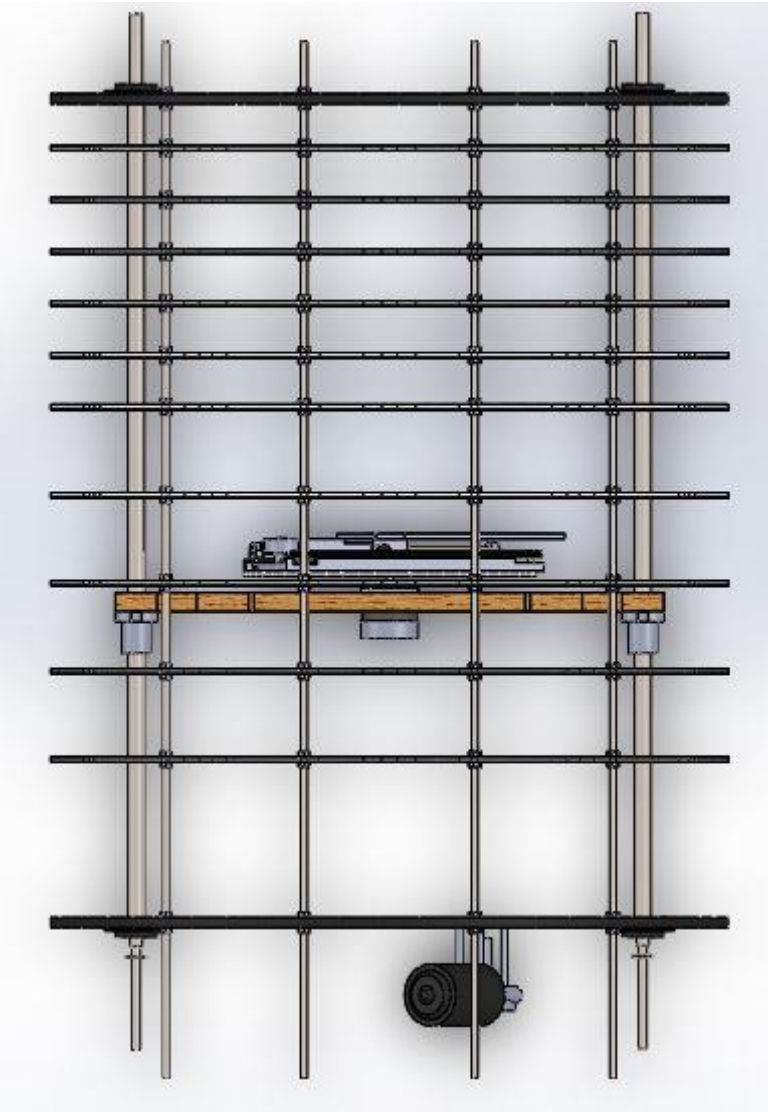


FIGURE 48: Front View

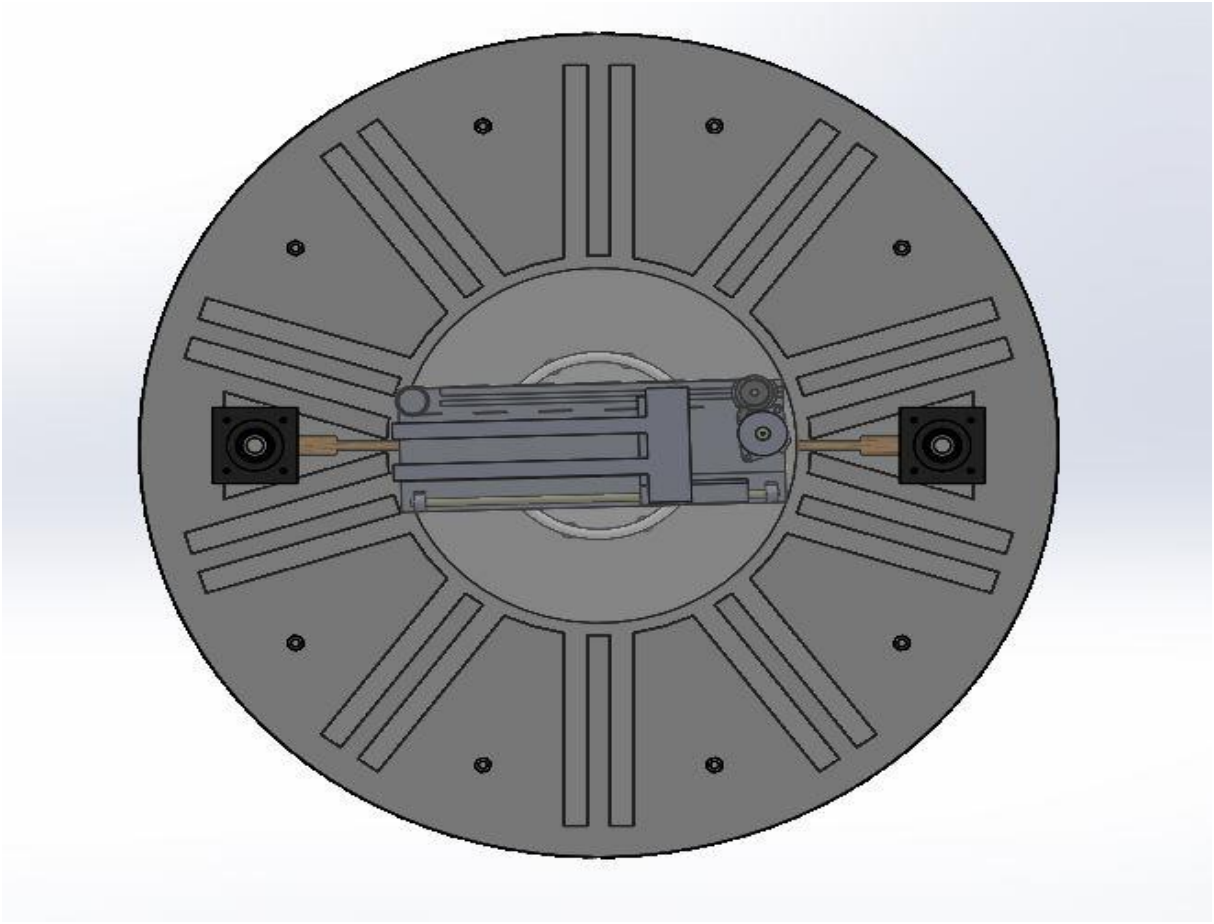


FIGURE 49: Top View

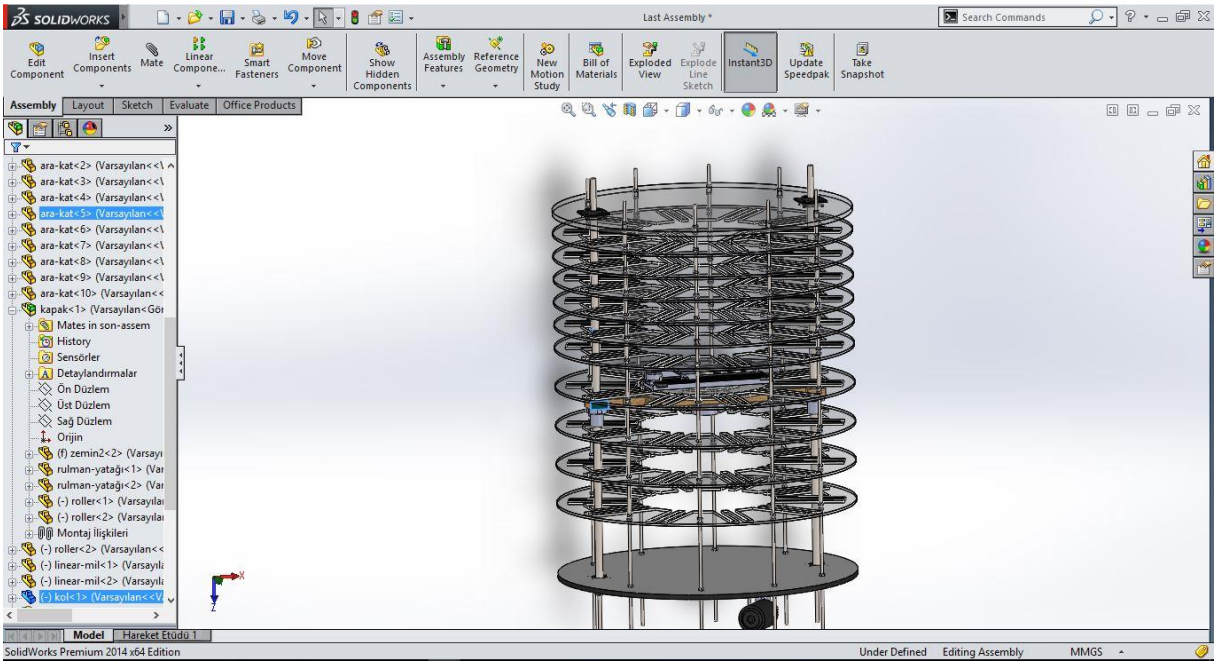


FIGURE 50: A view from SOLIDWORK

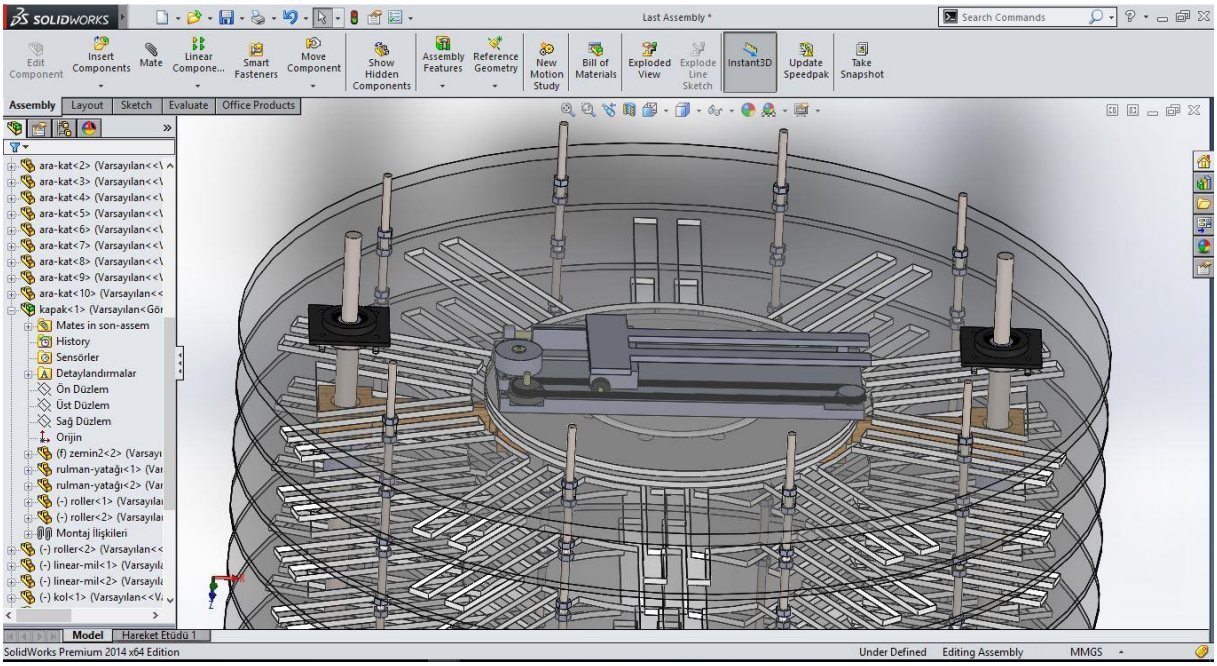


FIGURE 51: Lift System Front View

FIGURE 52: Lift System in AS/RS View

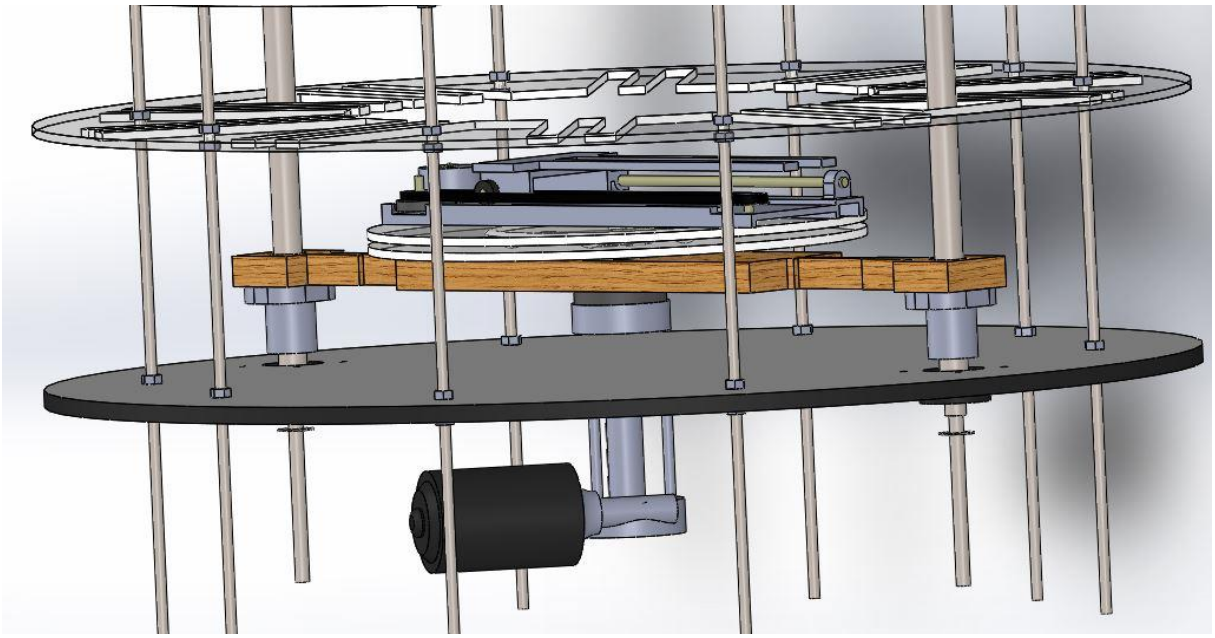
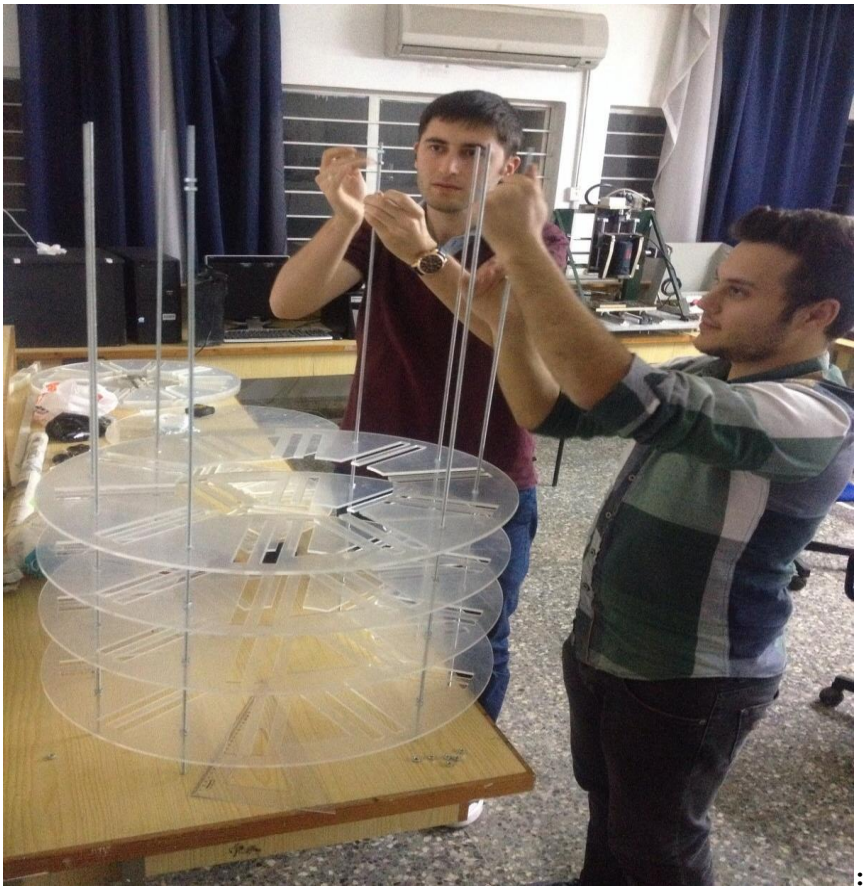


FIGURE 53: A View of Handling The Material

F**IGURE 54**: Plexiglas delivery after laser cut

 :

F**IGURE 55**: assembly of plexiglas

F**IGURE 56**: wire connections

F**IGURE 57**: CNC cut in EMU

F**IGURE 58**: wooden platform fixed to the mils

F**IGURE 59**: Last seen of complete project.

APPENDIX D

ENGINEERING STANDARDS

Thickness Tolerance of Plexiglas:

The thickness tolerance for all colorless Plexiglass MC sheet is -5% / +10%. However there is excepsion for colorless 0.118” and 0.220” which have a thickness tolerance of -10% / +10%. For all Plexiglas MC colors have a thickness tolerance of -10% / +10%.

Length and Width Tolerance of Plexiglas:

For Plexiglas MC sheets which less than 108” in length and cut tolerances are +0.25” and -0” Although for Plexiglas MC sheets which greater than 108” in length, cut tolerances are +0.375 and -0”. Although the width tolerance for all Plexiglas MC sheets is +0.25” and -0”.

Flatness Tolerance:

For dimensions <= 48” the maximum allowable bow is 0.125”.

For dimentions > 48” but =96” the maximum allowable bow is 0.25”.

For dimentions > 96” but <= 168” the maximum allowable bow is 0.375”.[18]

Weatherability of Plexiglas Sheet:

Plexiglas G, Plexiglas MC and Plexiglas Impact sheet products have proven ability to resist the effect of sun. weather and temperature changes in outdoor use. For clear samples after more than 10 years in outdoor use, accur an average of more than 90% light transmission which represents a loss of only 2%. Due to having inspection tests a few samples have obvious damages.

For colourless Plexiglas G sheet exposed outdoor for 20 years that show no obvious discoloration, loss of light transmission, crazing. Also Plexiglas MC sheets behave in similar behave with Plexiglas G sheets with similar conditions. [17]

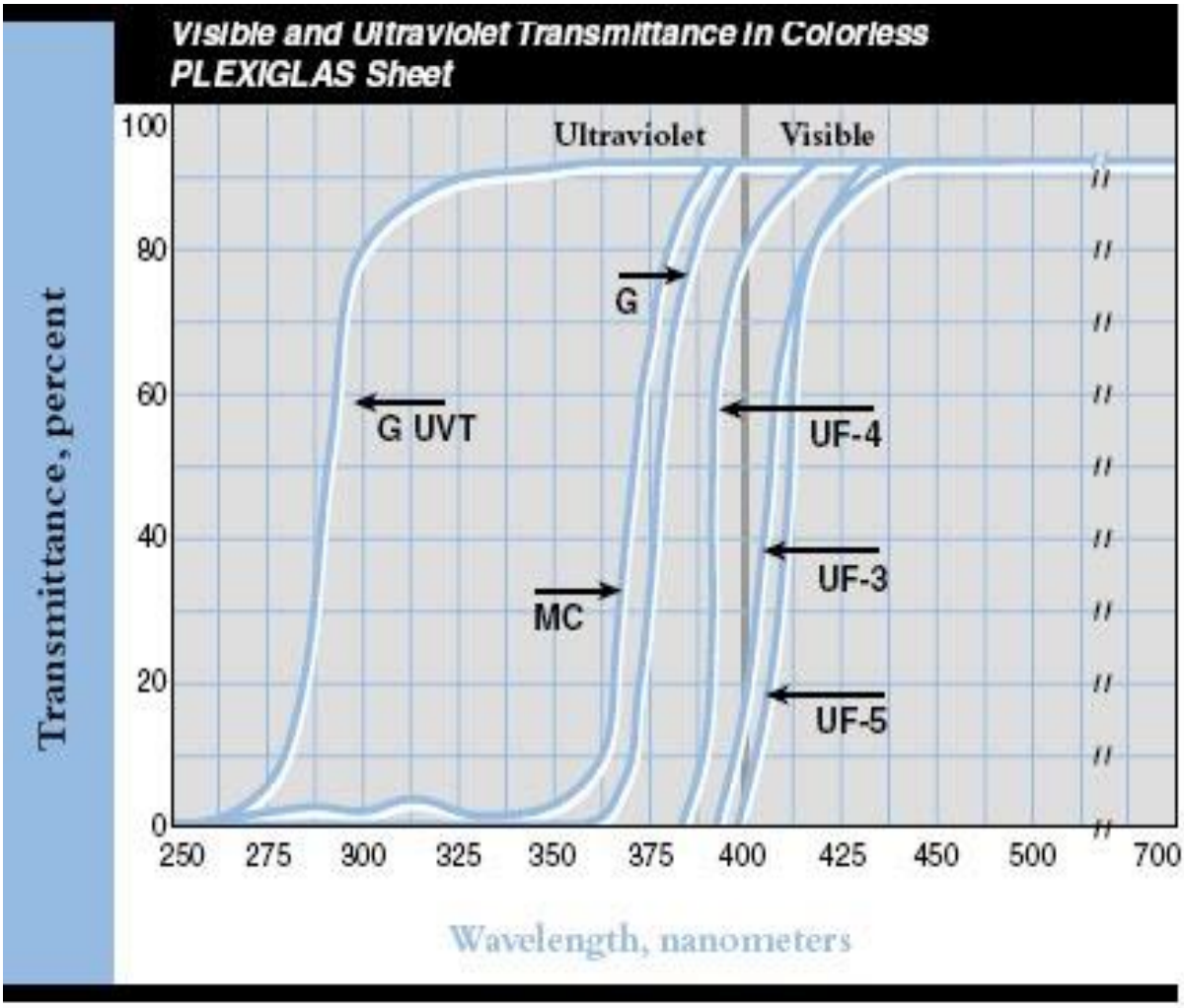


TABLE 9: Plexiglas light transmission [27]

APPENDIX E

Website of the Project: http://students.emu.edu.tr/111515/

LIST OF FIGURES

LIST OF TABLES