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Final Report

Team2

Project title: Automated Storage and Retrieval System (ASRS)

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Abstract

Automated Storage and retrieval System is known as ASRS which is controlled by a mechanical system. ASRS can be shown in the complete operation system where the system has been moving in very narrow places and in high quality orders. The system has introduced many advantages in the production, storage, distribution, and customer services. The project has three different directions based on X-axis, Y-axis, and Z-axis. ASRS proved its efficient work in world organizations and in world libraries using the specific mechanical motors. In this project we have designed, built and tested prototype ASRS depending on Servo Motor that has helped in moving different weights and sizes of packages from a place to another. The project has used the three types of axes to save time and to reduce the cost of manpower working in the storage tasks. In addition, in small areas and in libraries people need to transfer items from places to others and this project could have helped them without effort. Furthermore, special needs people have been going to use this project in simple methods with simple mechanical efforts.

Acknowledgments

We would like to thank our colleagues from the different departments who provided us with practical effort and experiences which greatly assisted the team in all areas of the research and in the project design, structure and operation. We thank the advisor Dr. NADER SAWALHI for his assistance and helpful technical and practical experiences. We appreciate all of his comments which increased our knowledge and professionalism while making the stages of this project. All of his support and instructions given during the different periods improved our work till the conclusion of the research.

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Chapter 1

1. Introduction

1.1 Project Definition:

The current technology development and the integration between the functions of mechanical engineering and technology tools show high quality of work performance in industry. The individual manpower focuses on different tasks that operate the machines with specific programs depending on different styles of software programs. During the last two decades robots occupied many positions that help mechanical engineering showed creativity through industrial functions and helpful for developing the industrial services. The nature of dynamic work always needs technology tools and effective cooperation dealing with the importance of quick and quality in serving human beings and their requirements to their other tasks.

Automated Storage and Retrieval System has passed with different steps and processes for the development of using high quality and best performances. The vision for the companies in using the system focuses on quick and creative procedures for serving people in their work by using computerized system in the mechanical movements. ASRS is integrated with different products in the same field with similar tasks such as Flexible manufacturing System and Flexible Manufacturing Automated System. Both of these two systems were built in the beginning of mechanical design and the structure depended only on the quality of mechanical operation. The sensors and the programs that guided robots were not available according to the power of mechanical process and the effectiveness of manpower. By the recent updates to the technical development in robotics, the need for new development was in need. The new system of ASRS used aluminum parts which was fixed by bolts and used bracketing standards that were fixed on the wall and on the ground firmly. In this new development of the system there are rolls and sensors that are programmed with a pneumatic cylinder and two tracks for moving horizontally and vertically for storage requirements. The sizes must be designed with the different uses and with the importance of using accurate measurement. The sensors play very important roles in pointing to the materials with the par code machine system to send the signs and orders to the mechanical system. The bolt pallet rack in ASRS system is fixed with automatic locking system interchangeably. There are also two motors that move mechanically according to the design and the software that are programmed with the robot tasks. There are specific stages in the project till it works effectively for an example of mechanical and electronically integration.

Table (1.1) The five stages

Stage	Description	Objective
Stage (1)	Design and components	Providing materials and building the structure with accurate measurements and components.
Stage (2)	Storage and retrieval machine	It is to provide the process of transferring the loads from storage area to the delivery in another area using this machine with its different components.
Stage (3)	Storage modules	They are provided in one unit that load containers of the stored materials with different parts built for this purpose.
Stage (4)	Testing and calculations	It is necessary to record the tests for successful conclusions and to treat with unexpected troubleshooting. It is important to calculate the time and the different sizes that help in successful operation.
Stage (5)	Data analysis and evaluation	All data collected from tests and after notes recorded will be in analysis and evaluation processes to practice modifications and adjust the required stages in final test for mechanical and electronically evaluation.

1.2 Project Objectives:

There are three objectives in our project:

1. To introduce new design that can be used in libraries and in stores
2. To design new robotic tasks that can introduce more tasks in simple operations
3. To depend on self – operation using high quality of robotic programs in low cost

1.3 Project Specifications:

This apparatus was being designed to be used in small areas with simple programming and in simple mechanical operation. The quality of the system will be helpful for people who need effort to transport items and materials in correct order and also in stores that avoid making mistakes in delivering items.

1.4 Products Architecture and Components:

In the system overview there are available components which include par code reader that can be programmed simple with computer software and provide the computer system with numbers and data required. It also needs Wi-Fi connection to accept computer orders from different distances depending on the high quality sensors and storage machine. Mechanically there are simple motors and rollers for racks and mainly depend on accurate structure with professional design. Transmission machine plays important role with the quality of the system operation.

1.5 Applications:

ASRS is used in many different tasks that serve storage services:

- Transferring materials and items in stores to organize them for delivery services

- Storage and delivery in automated and mechanical systems.

Chapter 2

2. Literature Review

2.1 Project background

Our project has been mechanically designed for specific services in storage and in retrieval materials in different sizes and weights depending on the capacity of the project's servo motor and the three different axes. The importance of this system is to give easy and organized styles in storage for distributing materials. The similar projects had been only designed mechanically and in big machines that load different sizes and weights from a place to another in stores. On the other hand, the automatic system with the same functions to our project increased the tasks of ASRS for the benefits in industry and in big warehouses. The first ASRS in 1990s was very limited to transfer the items in correct orders and to serve the production of manufacturing. The overview of the ASRS has been completely in automation where technology focuses on the quality of new projects with similar services in stores that make the distribution very easy and to control the orders using computer software programs.

Some institutions worked effectively to use different types of ASRS, but not in high technology tools that are used in the current time. Also some complex development used complex system that was concentrated in flexible manufacturing process with different kinds of projects. The system passed with different series of mechanical development in two products that began in 1990s. The mechanical system was the basic development in the system using different types of conveyor system depending on the mechanical control system. It was significant to get an introduction for the second product and the following multiple products without any interference to the automated system or using any robotic system as the current ASRS. Most of the results showed the importance of mechanical systems that created a variety of engineering development especially in flexible manufacturing system and the flexible assembly system.

2.2. Theory of ASRS structure analysis:

Specifications and structures for the idea in manufacturing system in the first type the three axes could be used with the milling machine that have already been fitted in the control system. Engineers for those kinds of projects for ASRS used the network or a mechanical system control to the cell which was built-in to go through the other unit attached. This was called the Holke Milling Machine (HMM). In another type for KEMCO they coordinate the machines with different measurements that can be operated manually with some automation system with some attempts in similar projects proposed the similar results. The main idea of using the mechanical transfer was to focus on load and unload station which consisted of new mechanical products and special motors from BOSCH. In the assembly station type there was concentration on the robot functions to support mechanical systems with high quality integration for more advantages for the next new machines.

There are more concerns with those systems and the types of flexible machines that were used for transporting materials and products in the stores and for the relevant services. Flexible machine cell consists of some kinds of pallets with the conveyor system from mechanical items in BOSCH where mechanical support was required for structure an operation. The materials were connected with another stacking part because the task was to store blanks for some products such as the raw materials. In addition, that part or the stacking system was to store the complete products with numbers and marks according to the data of them in the records of the company. In that system, robots also were in the situation to concern with load and unload situation in the company’s construction for the benefits of the storage system that made missions easier than using manpower in the same tasks.

It is considerable to point to the racking material as it was introduced in the development of ASRS in the introduction as it is shown in figure (2.1). It is specified for new systems with the advantages of using robot and the different software programs. In the design of some system that seemed an L-shaped one can be considered with the cross design section. It was showed in some designs that the shape has already been drilled and it has been painted with steel to show the racking system in clear position. The storage capacity can be defined with different loads in the ASRS such as the multiplication process the number of rows X number of columns in the experiments of the previous ASRS.

Figure (2.1): ASRS racking [Ref. 6]

2.3 Previous work:

In this type of ASRS, it has been considerable how that machine would have a competitive advantage for the company in different tasks because it has ensured the ability to different storage tasks in the new changing markets today and in the future. In different inventory levels in many companies for their products, it is important to get instant system for accessibility to different spaces in stores. There are three different types that are available to work in different circumstances the first is single-deep ASRS and the second is the double-deep ASRS which they work with telescopic fork as new developing technology tools. The third type is high –density, multiple-deep ASRS.

2.4Single-deep ASRS

This system works under the automatic design system to comprise and direct retrieval for the loads from different units as they are available in stores between the sides of any area that needs to transfer products to and from another area. This machine is complete and perfect for lower range items or stock keep units because the client needs instant service to transfer different loads from the store or to send some other items to the storage area. In this machine it is controlled by unique software that allows telescopic fork works easily and move in flexible movements with simple operation to identify and mark programmed items.

2.5Double-deep ASRS

It is specified for the retrieval system to unit loads which can develop the first time instead of transferring from one side to another, it is possible to have double task. This system to retrieve the loads in different sizes as it is programmed from two sides of any storage item in aisle in a double-deep configuration. This type of the machine is completely useful for companies' warehouses with large range of items or stock keep units that take much time in manual or single-deep systems. This has already reflected its importance to work for inventory storage systems that have various tasks relevant to the double-deep configuration. Furthermore, it has utilized a telescopic fork with more efficient service by using internet service in order to use satellite device especially for heavier loads and large units.

Figure(2.2): DD ASRS [Ref.7]

Figure (2.3): DD ASRS [Ref.7]

2.6 High-density, multiple-deep ASRS

This system is more effective and the most environmentally to the warehouses' tasks and suitable to the modern designs to Westfalia. It works with satellite channels and professional software programs and with transport technology which is highly maintained for efficient work. It has been working with rack entry vehicle for the multiple deep configurations that can transfer to store pallets and they reach to 18 deep. This system works in small buildings and it does not make noise especially in the area surrounded by neighbors.

Figure (2.4): HD, MD ASRS [Ref. 7]

2.7Comparing the three projects

*Table 2.1*Comparing the three types of ASRS

Single-deep ASRS	Double-deep ASRS	High-density, multiple-deep ASRS
comprises direct retrieval of all unit loads in storage from either side of any S/RM.	It retrieves loads from either side of any S/RM aisle in a double-deep configuration	Retrieve loads from either side of any S/RM aisle in a high-density storage configuration.
It is ideal for a lower range of items.	It loads from either side of any S/RM aisle in a double-deep configuration.	It is beneficial for businesses handling a low to medium range of SKUs.
Standard single-deep AS/RS operate using a telescopic fork.	It is useful for warehouses with a larger range of items or SKUs	Ability to store pallets 2 to 12 deep without numerous aisles allows planners to use land and space more effectively.
	It utilizes a telescopic fork but could also use a satellite device for heavier loads	It saves energy and money and reduces the carbon footprint of the facility.

Chapter 3

3. System Design

3.1 Design Requirements, Constraints and Specifications

The experience in working with developing ASRS is based on the quality of technology and the components needed to complete the different stage. The beginning of work was done after drawing the structure of the work to get the suitable design after testing the bases of the wall and the surrounding stands. It was necessary to get complete knowledge about the expected modifications according to parameters in each part of each system which made the team works effectively on ASRS control system from the first stage taking the excessive downtime in the operation system in consideration. The components were prepared for the design from the local market depending on the workshops in the industrial areas in the city. In addition it was suitable for providing hardware systems to be fixed appropriately to the first design system. Those facilities helped the team to get the quality of items fixed in each part. The design components were divided into four parts and each part specified with the components according to the final design.

3.2 Storage configuration

According to the mechanical and electrical design the ASRS proposed a unit load in automatic movement in the operation system which handles according to the loads units in the design specific pallets figure (3.1). The options of the storage in the main system was divided into three depth levels which are single, double and multiple for configuring the mechanical components to be used in the store with double and multiple levels. This has been done in the design for some identical units to work with loading and unloading operations. The movement of this part will be in the opposite sides depending on racking which was fixed in the main mechanical part. Those components were fixed accurately as it will be shown in figure (3.1). The mechanical components and electrical parts were shown in table (1.1) in both of the two products. It was decided to get single deep configuration to get access for the other components which will be implemented in testing stage especially in the storage part. In this stage it will be a good chance for making comparison in operation to all of the components that allow accessibility in equal operation with the results in simplified movements with both of the retrieval and storage.

3.3 The crane

This part is a very necessary part in the project which comes in the front to handle the items and carry different sizes according to the main function. There are different movements in the retrieval and storage crane which have been completely required with vertical, horizontal and shuttle such as the forks in the previous works to move forward and to be reversed on racking system. Moreover, the crane has been fixed in order to control the speed on the racking in the cases of loading and unloading units using the quality of Servo Motor. In this part the torque is measured and considerable in the speed regulation. The components of the converters are also used because it is necessary to control the speed in this part considering the two ways of acceleration and deceleration depending on the quality of the motors in the design system.

3.4 Methodology

In figure 3.1 it will be obvious the different mechanical and electrical parts that were needed in the operation system. The design was specifically marked with numbers to identify each part with the components used for the structure and they were fixed according to the numbers in each division. The small and big components were tested before installing each part to ensure the quality of operation in each stage. The top plate, for example was assembled and mounted to show the units in the top using two pairs of metal wheels after testing the mechanical operation in plastic wheels.

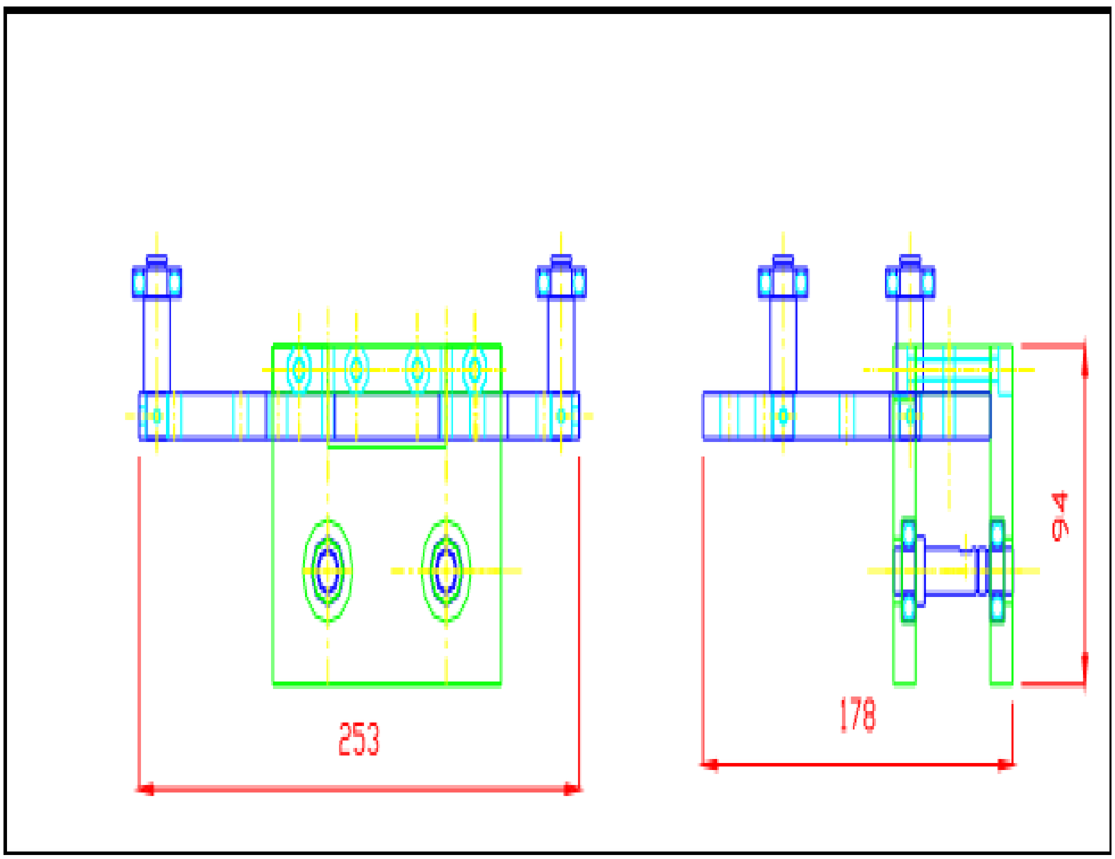


Figure (3.1): Top Plate Design [Ref. 3]

The guide faces and guide wheels were also assembled for the mechanical functions and introduce the required facilities in movements. This will be shown below in figure (3.2). The importance of the design components was to have the quality of operation in simple way and accurate measurements.

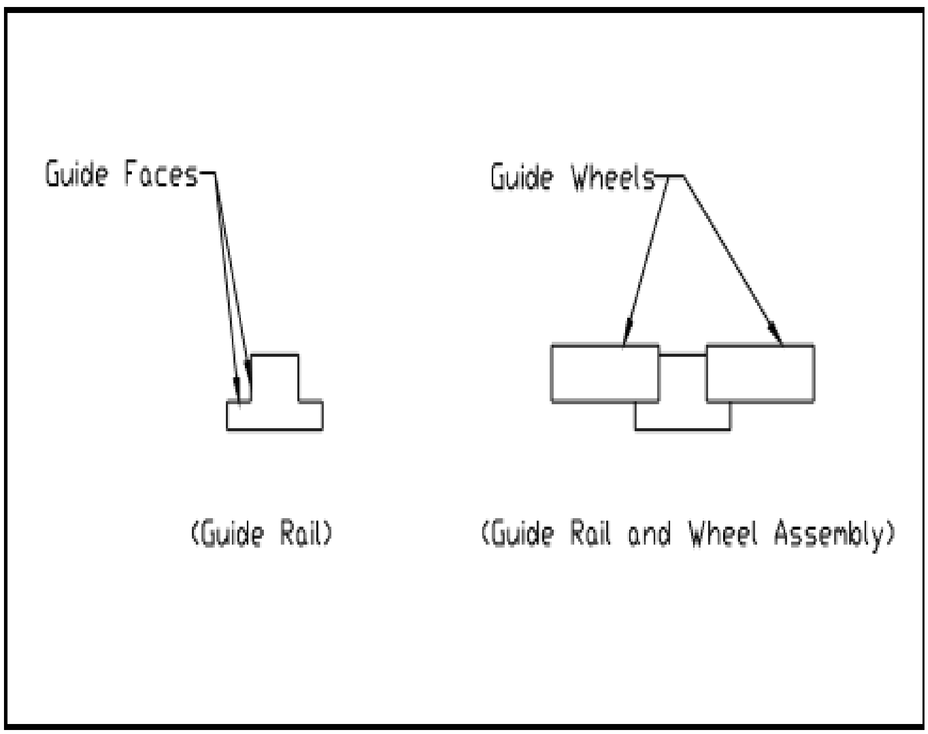


Figure (3.2): Guide rail and wheels [Ref. 3]

All of the requirements in the mechanical and electronic operations use high functional parts including the pattern and to work with the external control keys to allow for more options. In this part the team was very keen on protecting the powerful overload which will be in consideration. There is also a drive drum that collects and releases the cable of steel especially in the vertical movement up and down functions.

3.5 Solid Works

The following components as it is shown below in table (3.1) are used in the design as shown in figure (3.3). The main materials were from wood, steel and plastic which were available to design the main system and introduce effective sample for the ASRS. In our project we have several types about the mechanism, structures and installation to describe our solid works. In the following table these are the components which are used in the automated stored systems as it shown in next diagrams which can be explained in details. In addition, each of these parts helped in building the main structure and the final design. The quality of installation part in the project needs some assistant tools to just fixing the motors and to ensure the operation of the electrical wiring part. After collecting the parts it becomes necessary to give the details with more figures to show the stages of the solid works and how all of the mechanical, electrical and electronic systems are in consideration.

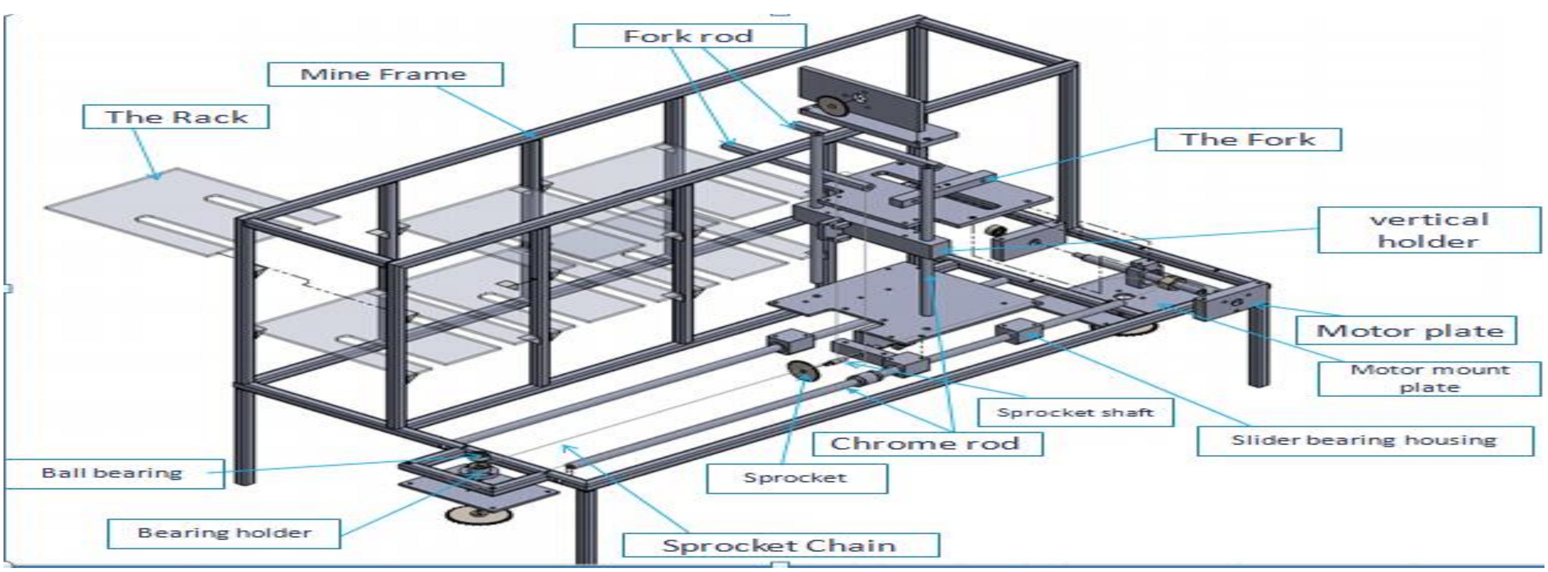


Figure (3.3): The design with components of the project

Table (3.1) The components of the project

Part No.	Part Name	Material	Quantity
1	Main Part	M.S.	1
2	Clamp	M.S.	4
3	Screw	M.S.	1
4	Rectangular Profile	Chain	1
5	Slider Bearings	Std. Part	4
6	Sprockets	Std. Part	2
7	Couplings	M.S.	1
8	Moving Board	Chain	1
9	Vertical Screw nut	M.S.	2
10	Motor Clamp	M.S.	1
11	Vertical Shaft Motor	M.S.	1
12	Supporting Vertical Pipe	Fiber Glass	1
13	Reduction Gear Box	Fiber Glass	1
14	Limit Switches	C.I.	1
15	Chrome Rods	Fiber Glass	1
16	Motor	Std. Part	1
17	Rack System	M.S.	1
18	Rack System Frame	M.S.	1
19	Container	Fiber Glass	1

3.6 Mechanism

In some extend the mechanism of using the main structure depends on the quality of bearings that are considered have specific functions. The bearings have allowed the parts of the machine especially the Servo Motor to move relative to another. It has been obvious to know that the motion can be linear or as it will be required in some operations to be in rotation style. These types will need specific Bearing Holder X-Axis, Y axis and Z axis with the Sprocket as it is shown in figure (3.4) because we needed one piece made of aluminum (6061) the measurements were also taken to the holder to be suitable for the axis area according to the design. In general, the assembly of the project can introduce the various functions that affect the basics of bearings to help the belt and the crane move in the required directions for handling the items. The rolling varieties in the bearings are known as a ball bearing.

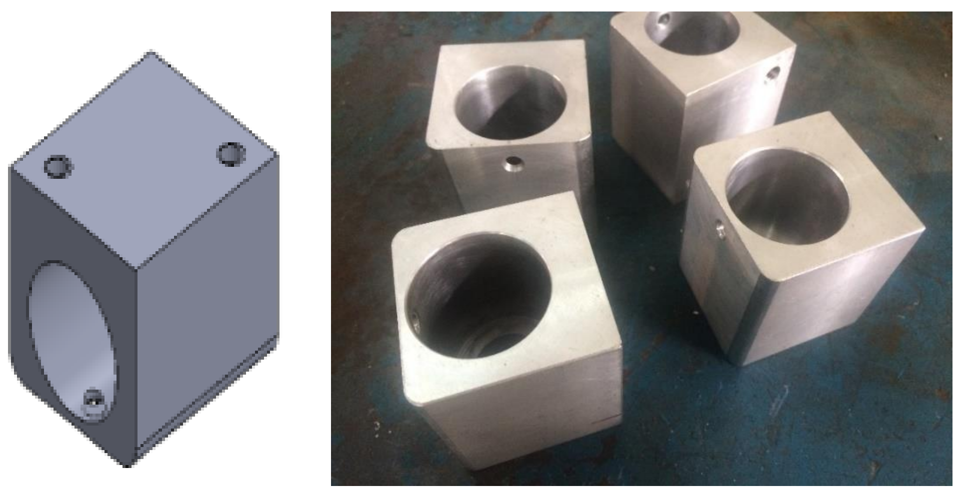


Figure (3.4): Types of bearings

These types are very common bearings as it is shown below in figure (3.5) where the plain bearings and rolling bearings. In the figure ball bearings position can be seen on the left side of the diagram that can be effective used in flexibility without causing any frictions between the parts and the bearing holder for the three axes considering the height and the weight of the loads. This is because the motion freely is required by adding four pieces in the bearing houses to protect the types of bearings used. As it has been shown in the figure below sizes and the calculations have been done accurately to fit the bearing houses and the sizes of the ball bearings in the mechanical system. The design also has showed small bearings that are helpful in different applications because the spaces between the motors and the holders were limited especially in the automotive and electrical parts.

Figure (3.5): Bearing Holder X-Axis Sprocket

While we need the items to be placed on the trays and in different positions which are vertically to hang from the bars, the chains or the drives as it is shown below in figure (3.6) are fixed to move up and down. For the ASRS the chains has helped to rapid storage and they have been used in the retrieval tasks in order to facilitate the movement of the components especially in the horizontal direction by the chain mechanisms which have been fixed to the moving base.

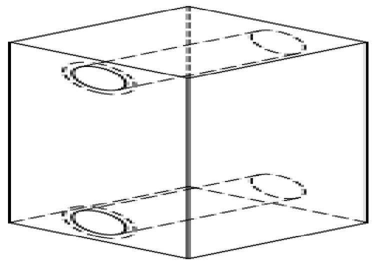


Figure (3.6):Chain Fix P2

A suitable chain in our project as it is shown in figure (3.7) below has been used accurately for other functions to facilitate the required movement in the mechanical part in the ASRS components in the X-axis. It can be seen that the chains connected to two chain gears in the rigid part in the base by carrying them in the solid stainless rod in small sizes. They can be also fixed in the system in support by the small bearings depending on the place of the bearing houses, in addition. One of the chains has been connected with the electrical moor with the chain for the functions of driving gear.

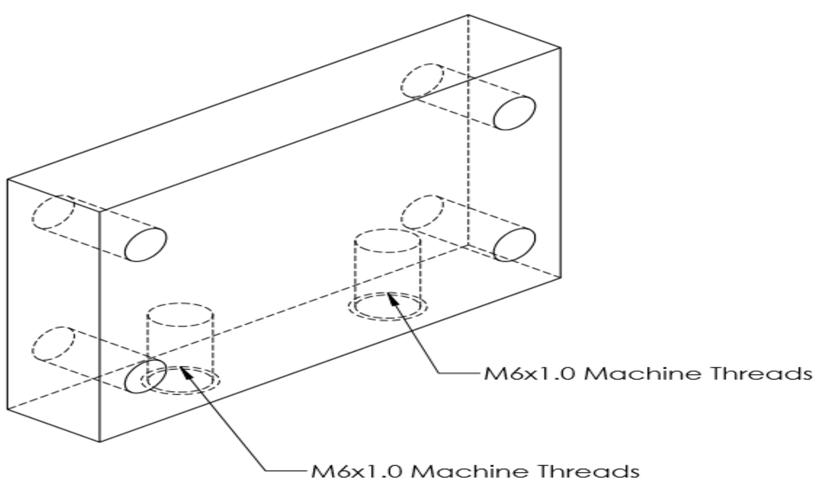


Figure (3.7):Chain FixP3

In the mechanical operation the pulley in the project is fixed in the place near to the bearings fixed especially for the movement freely and the pulley is to carry the belt or the chain that help in moving the holder plate with the loads in the system. The functions of the steel rod in this part was fixed in very small area and the ends of the solid rod work in effectiveness of the bearings in the upper bases as it is shown in figure (3.8) below.

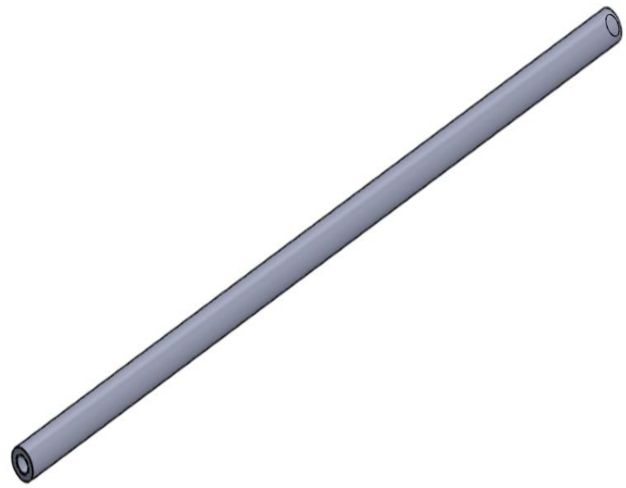


Figure (3.8): Chrome Rod

According to the structure of the project design the holder plate is fixed to different positions and mechanically that plate is fixed vertically in the solid guide rods. The main reason for this part is to enable the movement of the fork plate which is connected with the fork arms in the X-axis. It is necessary to point to the fork plate which can carry the two fork arms and according to the figure (3.9) were fixed with four bolts in different sizes as it is shown in the mechanical part which is connected with the fork plate. In the diagram, the back holder is designed especially for the fork plate in the holder where the fork arms are tested to the loads which are fixed by four screws.

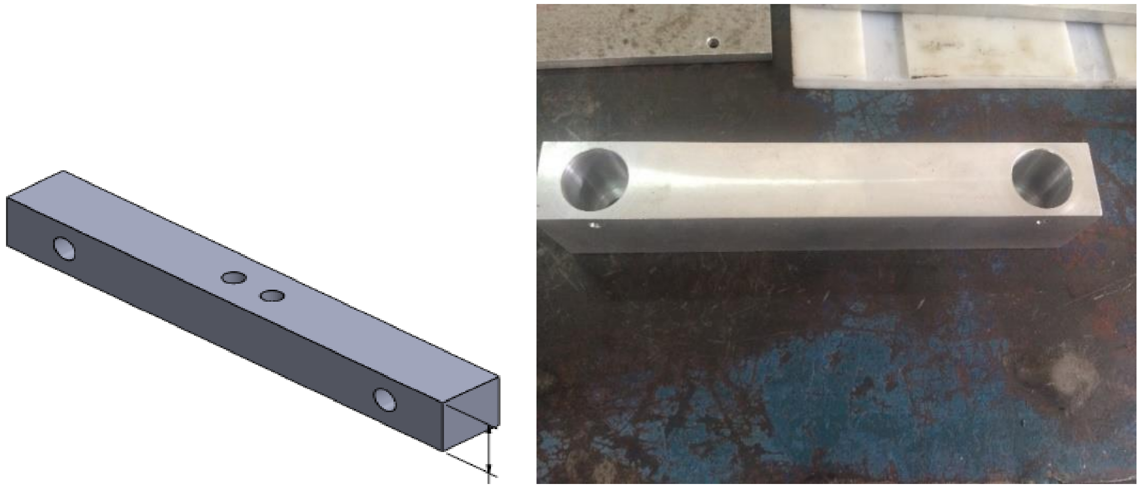


Figure (3.9): Fork Part 1

The above mentioned details need strong frame for the project which includes strong materials in very appropriate sizes. There are important calculations in the measurements of the different parts in the main frame and the rectangle profile is necessary in this case as it is shown in figure (3.10). In the left side the part is divided into two parts after getting the space needed for the installation stage and the place for the project in testing the different mechanical and electrical operation. In addition, the frame is designed to present the spaces needed for freely movement and to fix the motors as well.

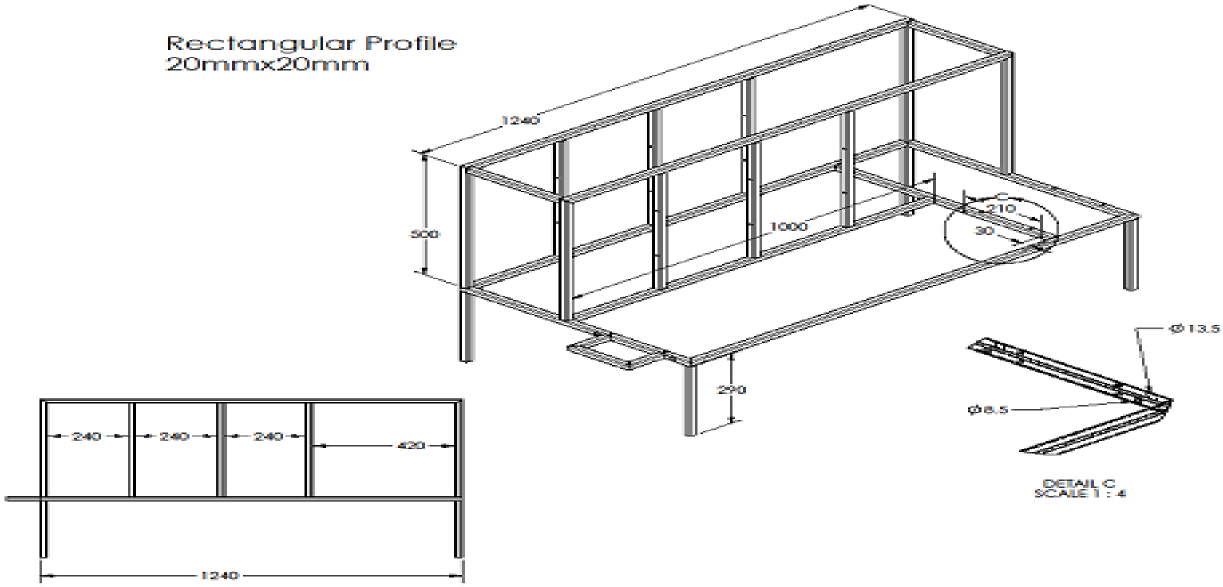


Figure (3.10): Main Part

In the design there is a sprocket end plate as it is shown in figure (3.11) where the machine thread connect the plate with chain and the motors in two parts making different horizontal sizes. The motor was very necessary to choose the area to fit the sprocket plate.

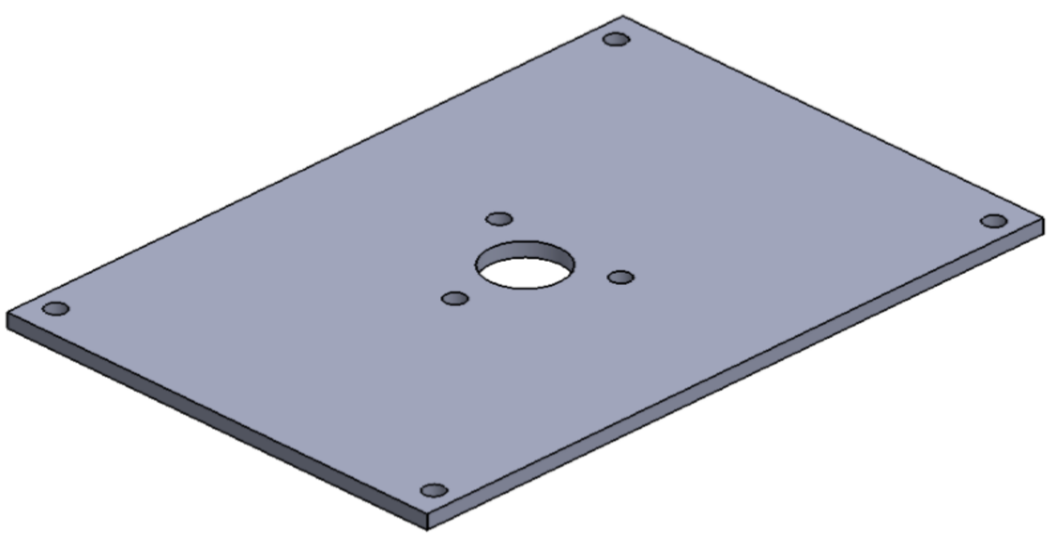


*Figure (*3.11): Sprocket End Plate

The project is designed for one rack by using one load and to follow with another. In the other rack, it is designed to flow through in the systematic mechanical movement which depends on the input and output process in two sides or for the opposite side.

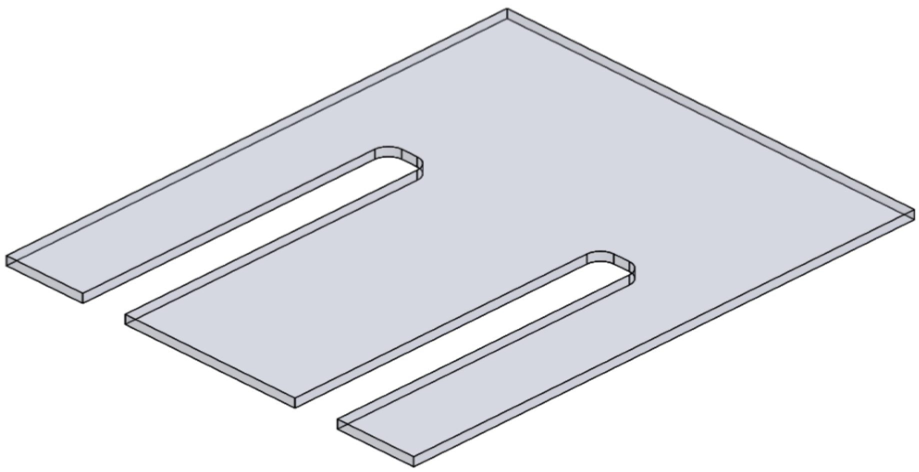


*Figure (*3.12): Rack

3.7 Apparatus Building Assembly

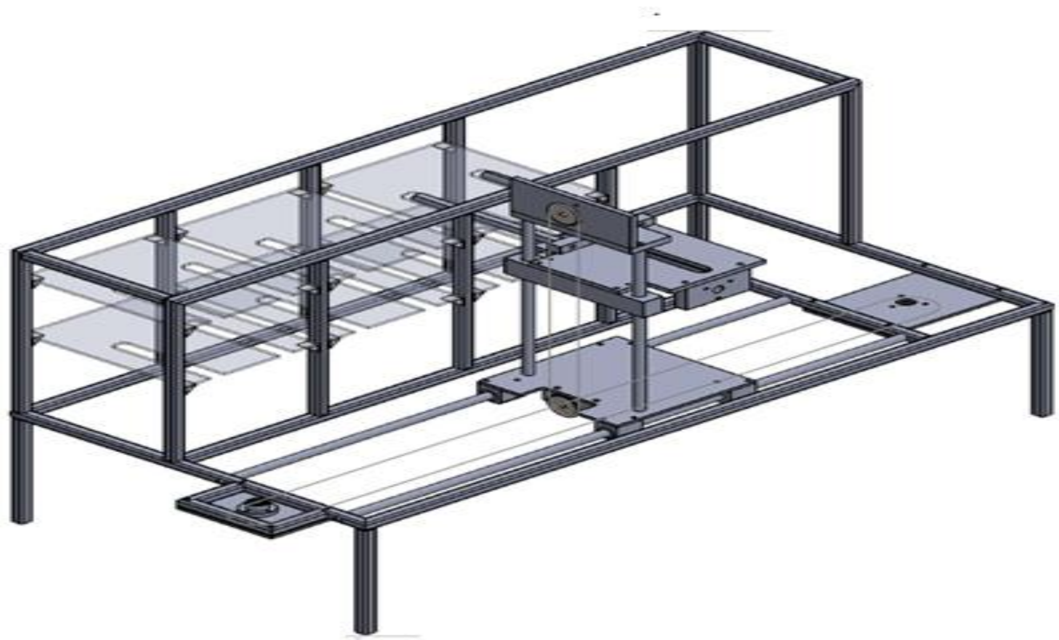


Figure (3.13): ASRS Sample Design

The main part according to the functions of the ASRS has been design for building the apparatus using specific materials. The clamps are fixed in the different parts of the design for the mechanical functions and in electrical parts. The shape was also design in rectangular profile which was made of fiber glass which works as insulators for the different areas that contact with screws and electrical wiring. The rectangular profile was also in the two opposites after measuring the different spaces where they carried the slider bearings with different types of screws. The coupling parts and sprockets were mostly used in the different main parts because the movement of the wheels and racking systems will require effective materials. The availability of the materials works effectively with the different mechanical parts and for the functions of the motor clamp which has been responsible for the operation system as well. Some materials depended on metal materials for the motor shaft part to be supporting for the gear box which was made of fiber glass to be durable in the weight of the different parts. The quality of the materials including electric wiring and the different screws in mechanical system is completely flexible of the vertical, horizontal and shuttle movements.

3.8 Servo Motor Mechanical Operation

Servo motors have been chosen practically to servo the mechanical operation in our system. The project has needed three motors in the operation system after testing the amount of electricity needed in each stage. It was found that these kinds of motors could utilize in applications that work for serving effective mechanical operations. Servo motors have the advantages of small in size with high efficiency in supplying power for the whole project mechanical components. The importance of the size in servo motors is that could be fixed in the back of the main frame which support the quality of safety. The quality of the efficiency of these motors had been tested before buying three motors for the project. Each of those motors has been connected with electrical power supply and these are commonly used in many industrial applications.

Figure (3.14): servo motor CNC

According to the components of the servo motors it was significant to get the qualified specifications including the control circuit which can meet the resistance changes in movements and other torques. The control circuit also could calculate how much movement depending on the power of the gear system. In more description to the operation part of Servo motor, when the shaft is at the desired position, power supply will be stopped. In case of the opposite, the motor is turned in the proper direction depending on the electrical pulses. So the speed of the motor is proportional between the actual position and the desired position.

3.9 Servo Controller

Servo motors have been controlled by sending an electrical pulse of variable width. There are three ranges for the electrical pulses in a minimum pulse, a maximum pulse, and repetition rate. The benefits could be calculated when turning 90 degrees in either direction for a total of 180 degrees movement which could serve the project's operation. This could help the project when in handling items in half circle movement.

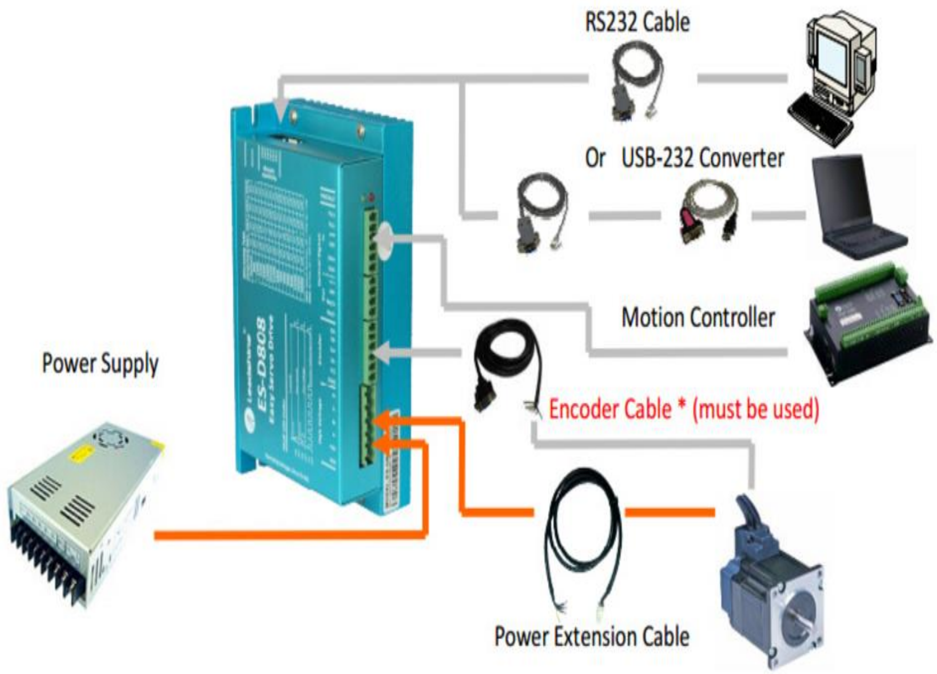


Figure (3.15): The guts of a servo motor and an assembled servo controller

3.10 Storage Configuration

According to the mechanical and electronic design the ASRS proposed a unit load in automatic movement in the operation system which handles according to the loads units in the design specific pallets. The options of the storage in the main system have been divided into three depth levels which are single, double and multiple for configuring the mechanical components to be used in the store with double and multiple levels. This has been done in the design for some identical units to work with loading and unloading operations. The movement of this part has been in the opposite sides depending on racking which was fixed in the main mechanical part. Those components were fixed accurately as it has been shown. The mechanical components and electrical parts were shown in table (3.1) in both of the two products. It had been decided to get single deep configuration to get access for the other components which have been implemented in testing stage especially in the storage part. In this stage it has been a good chance for making comparison in operation to all of the components that allow accessibility in equal operation with the results in simplified movements with both of the retrieval and storage.

Table (3.2) Conversion tables

Torque Units	Units Speed	Conversion Factor
oz-in	RPM	0.00074
oz-in	rad/sec	0.0071
in-lb	RPM	0.0118
in-lb	rad/sec	0.1130
ft-lb	RPM	0.1420
ft-lb	rad/sec	1.3558
N-m	RPM	0.1047

Chapter 4

4. System analysis

4.1 Subsystem 1(Electrical Part)

According to the system of ASRS that undertaken by mechanical systems, the importance of the parts took serious modifications in this phase for accurate movements with the required components, there are some explanations to change some arrangements. The motor capacity was measured to allow flexible movements in different directions. It is planned to get accurate calculation to the mechanical parts in the project system. This would be in place of the workshop where all of these calculations can reflect the expected movements.

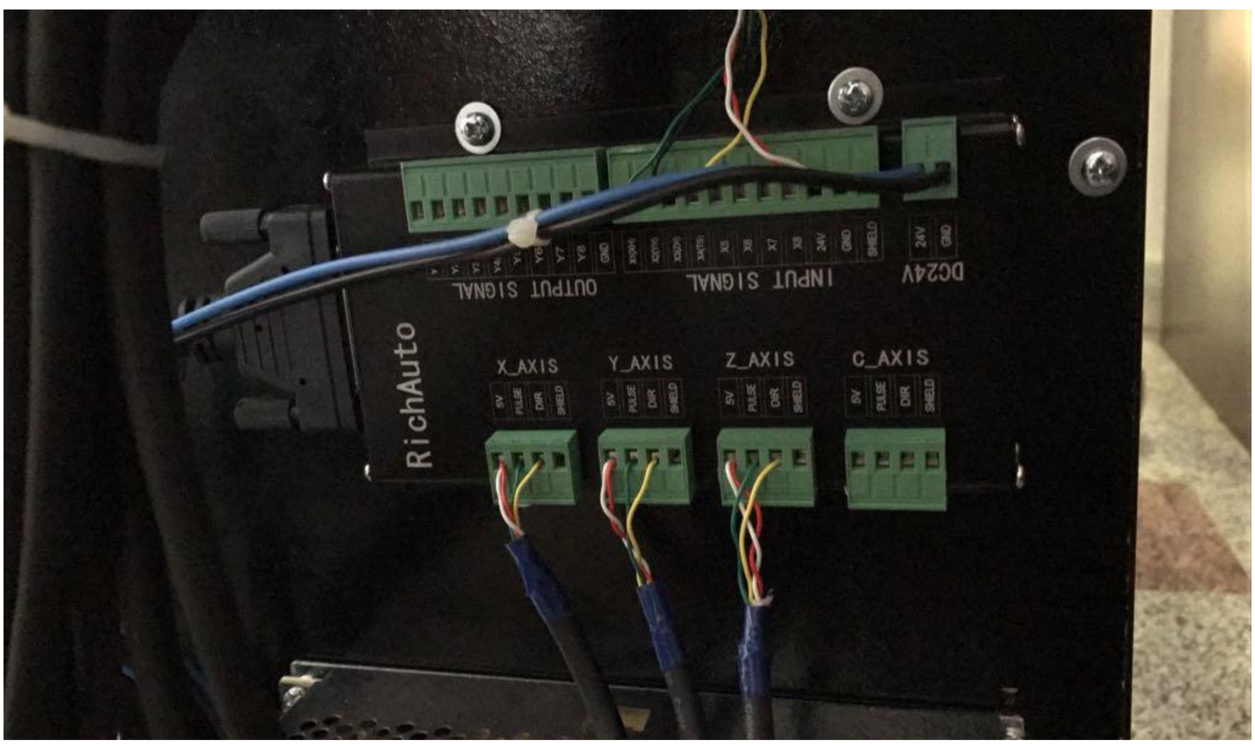


*Figure (*4.1): Electrical connections with the three axes

In the part of the mechanical components with motors, the positions may face some difficulties according to the size of space left around the motors. In addition, it is expected to get general equations. In addition, the general equations will be helpful to measure the torque unit (s) where it will be possible to fix the required speed in the movements of the racks in front and behind the motor systems. The mechanical options seemed very limited so that it should be modified with some changes in calculations using electrical facilities. Figure (4.1) refers to the electrical connections with the three axes which have supplied the electricity for the motor operation system. Moreover, it has showed the main power supply in DC 24V for electrical power mechanical distribution.

In the electrical phases, it would be necessary to check the power system for the advantages of getting proper calculations in the electric gear motor. In the beginning, the voltages change for different time because of changing some mechanical components in motors. This reflected the necessity to keep all in similar voltages according to the expected calculation for speed and the power supplies to the whole project.

It is helpful for testing the endurance of the structure and the frame after external mechanical and electrical tests using the calculations and the general equations in the team considerations. Some of the mechanical parts may need tests inside the project because of voltage change. The team has already agreed on providing extra organizer for electric connectors in different voltage. The main source will be divided into different voltages to be used with support of the small power supplies in two parts in the project. The parts also need to get the second testing according to change in parameter for measuring the capacity of the project. This depends on successful tests to the motor mechanism and the flexibility of the two belts. The movements from different direction will be considered in supporting the capacity of motor support mechanically and electrically.

Theoretically, the design and the structure will be I regular tests for ensuring the quality of using the accurate software programs in different parts of the project. The ability of using the three functions in general tests will be in the advantages of focusing on the main areas that may need to be improved. The quality of using appropriate methodologies in testing may support the quality of the electronically, mechanical, and electrical parts. Mechanically, there are some frictional losses that can be noticed for the primary tests to the components in separate calculations. The matter will be different in measuring the calculations inside the project with taking notes about the speed and the calculations from the general equations.

There are also some considerations to the physical calculations to the power in specific rates for the advantages of proper work in the project mechanical performance. In addition, the quality of using connectors among the motors could be helpful to the mechanical movements. The calculations that depend on some physical problems will be used to measure the output of the power system according to given distance. These will give proper calculations to the measurements to the crane and to the movements vertically and horizontally which are considered long distances to the power of one motor in specific voltages. The velocity and acceleration will be also in consideration for the power production that affects the mechanical components so that the arrangements between the effort and the power production should be urgently needed in testing process.

4.2 Subsystem 2 (Controller System)

*Figure (*4.2): Three controllers

There have been three controllers as it has been shown in figure (4.2) where the three controllers were fixed over the three axes and each controller has been connected with each axis. In more details, the controllers are very necessary to be connected with the panel for effective mechanical movements.

Another test could be likely in implementation for the bearings because of their significant roles to control the movements of the belts and the crane and for fixing the main frame. The functions of the bearings affected the measurements for the rolling system that is controlled by the size and the quality of common bearings. As the power and the amount of voltage were calculated, the level and the movements that control rotation should be also tested for the different functions of the common bearings. I the main frame it is obvious that the mechanical parts can be shown directly depending on the durability of bearings in the bottom areas. The frame also was comprehensively designed for the mechanical parts take place in different positions. So the accurate measurements for the main frame were calculated in different positions. The general equations helped effectively in positioning power supplies to facilitate the functions of the common bearings and the other types.

In some mechanical tests for the main frame, it would be necessary to get different tests before and after fixing the expected mechanical and electrical components. This will help the project to get appropriate and accurate figures for the final calculation in the final shape of the project. Accordingly, the equations of the main system in the capacity of power and the durability of physical parts can give clear indications with other parts such as the crane system. The other part that also needs effective work is the bearing holder that is necessary to be fixed in the right place as it was illustrated through the previous figures in chapter (3).

4.3 Overall Results, analysis and discussion

In servo motors, electrical power (P_{el}) is converted to mechanical power (P_{mech}). In addition to frictional losses, there are power losses in Joules/sec .

$$\mathbf{P_{el} = P_{mech} + P_{j\ loss}}$$

Physically, power is defined as the rate of doing work. For linear motion, power is the product of force multiplied by the distance per unit time. In the case of rotational motion, the analogous calculation for power is the product of torque multiplied by the rotational distance per unit time.

$$\mathbf{P_{rot} = M \times \omega}$$

Where:

P_{rot} = rotational mechanical power
M = torque
ω = angular velocity

The most commonly used unit for angular velocity is rev/min (RPM). In calculating rotational power, it is necessary to convert the velocity to units of rad/sec. This is accomplished by simply multiplying the velocity in RPM by the constant (2 x ∏) /60:

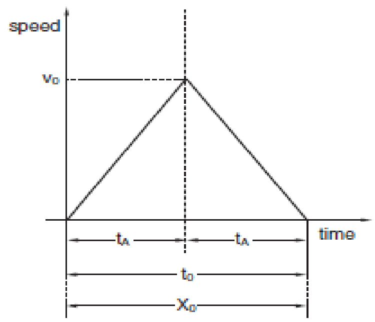
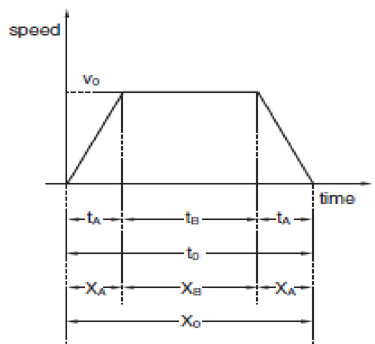
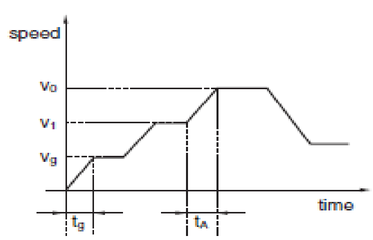
$$\omega_{rad} = \omega_{rpm} \times (2\prod)/60$$

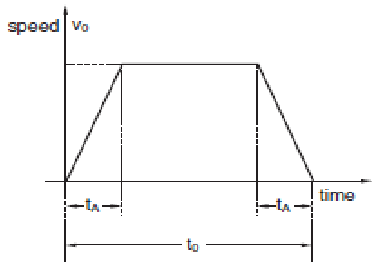
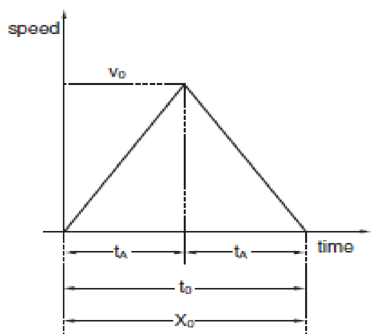
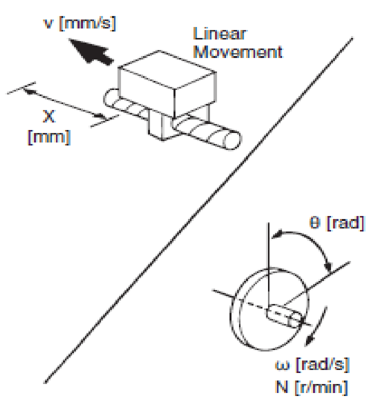
in order to select a servo motor for any application see the chart and formuals table below that may help you for choosing the right motor for your applicatrtion and do the proper calcutlion before you choose it :

Calculations:

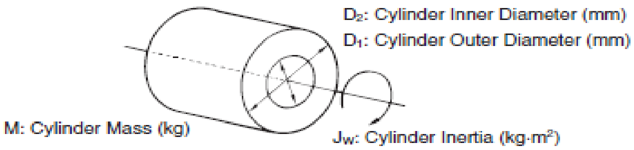
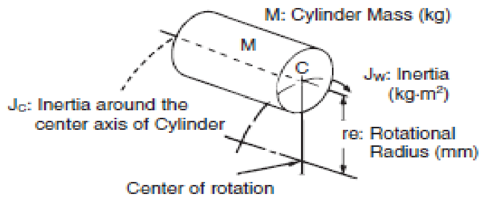
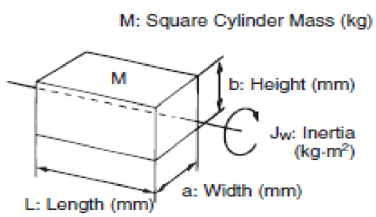
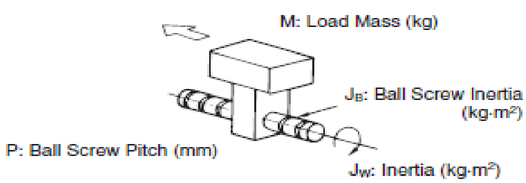
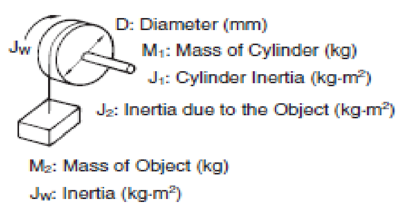
Formulas

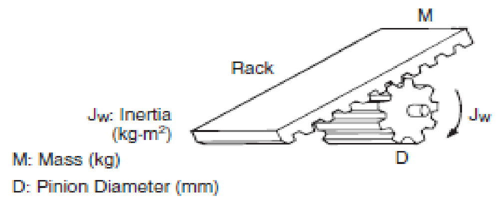
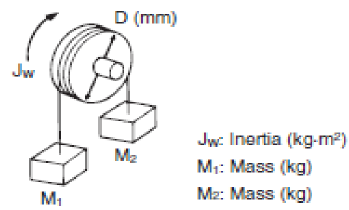
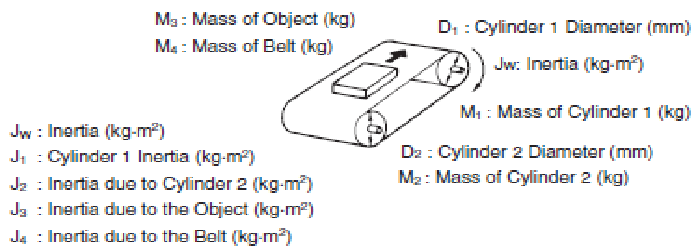
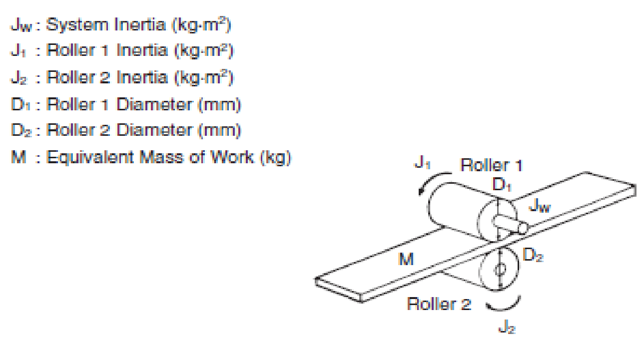
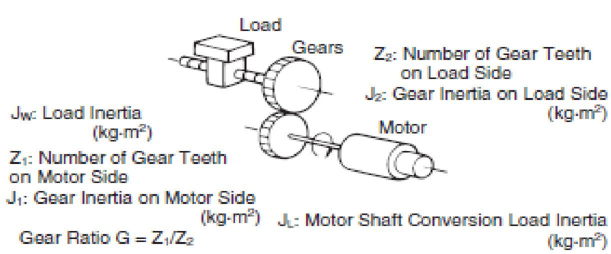
■Formulas for Operating Patterns

Triangular		**Maximum Speed** $V_0 = \frac{X_0}{t_A}$ **Acceleration/Deceleration Time** $t_A = \frac{X_0}{V_0}$ **Travel Distance** $X_0 = V_0 \cdot t_A$ X_0: Distance Moved in t_0 Time (mm) V_0: Maximum Speed (mm/s) t_0: Positioning Time (s) t_A: Acceleration/ Deceleration Time (s)
Trapezoid		**Maximum Speed** $V_0 = \frac{X_0}{t_0 - t_A}$ **Acceleration/Deceleration Time** $t_A = t_0 - \frac{X_0}{V_0}$ **Total Travel Time** $t_0 = t_A + \frac{X_0}{V_0}$ **Constant-velocity travel time** $t_B = t_0 - 2 \cdot t_A = 2\frac{2 \cdot X_0}{V_0} - t_0 = \frac{X_0}{V_0} - t$ **Total Travel Distance** $X_0 = V_0 (t_0 - t_A)$ **Acceleration/Deceleration Travel Distance** $X_A = \frac{V_0 \cdot t_A}{2} = \frac{V_0 \cdot t_0 - X_0}{2}$ **Constant-velocity travel distance** $X_B = V_0 \cdot t_B = 2 \cdot X_0 - V_0 \cdot t_0$
Speed and Slope When Ascending	 Speed Gradient $\alpha = \frac{V_g}{t_g}$	**Ascending Time** $t_A = \frac{V_0 - V_1}{\alpha}$ **Ascending Time (t_A) including distance moved** $X_A = \frac{1}{2} \alpha \cdot t_A^2 + V_1 \cdot t_A$ $= \frac{1}{2} \frac{(V_0 - V_1)^2}{\alpha} + V_1 \cdot t_A$ **Speed after Ascending** $V_0 = V_1 + \alpha \cdot t_A$

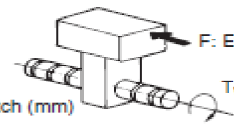
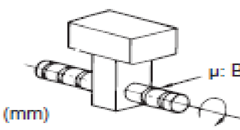
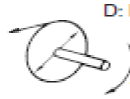
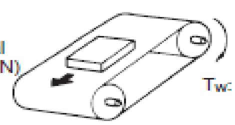
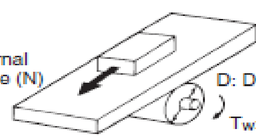
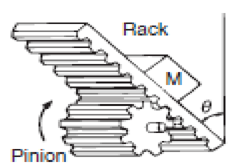
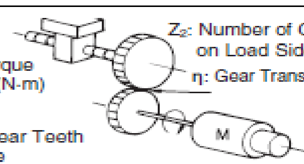
<table>
<tr>
<td>Speed and Slope Trapezoid pattern</td>
<td>
</td>
<td>
Conditions for Trapezoidal Operating Pattern
$$X_0 < \frac{t_0^2 \cdot \alpha}{4}$$
Maximum Speed
$$v_0 = \frac{t_0 \cdot \alpha}{2} \left(1 - \sqrt{1 - \frac{4X_0}{t_0 \cdot \alpha}}\right)$$
Ascending Time
$$t_A = \frac{v_0}{\alpha} = \frac{t_0}{2} \left(1 - \sqrt{1 - \frac{4X_0}{t_0 \cdot \alpha}}\right)$$
X_0: Positioning Distance (mm)
t_0: Positioning Time (s)
t_A: Acceleration/Deceleration Time (s)
v_0: Maximum Speed (mm/s)
α: Speed Gradient
</td>
</tr>
<tr>
<td>Speed and Slope Triangular Pattern</td>
<td>
</td>
<td>
Conditions for Triangular Operating Pattern
$$X_0 \geq \frac{t_0^2 \cdot \alpha}{4}$$
Maximum Speed
$$v_0 = \sqrt{\alpha \cdot X_0}$$
Ascending Time
$$t_A = \sqrt{\frac{X_0}{\alpha}}$$
</td>
</tr>
<tr>
<td>Rotating Part</td>
<td>
</td>
<td>
Perform the following unitary conversions
<table>
<tr><th>Linear Movement</th><th>Rotating Movement</th></tr>
<tr><td>X: Distance (mm)</td><td>θ: Angle (rad)</td></tr>
<tr><td>v: Speed (mm/s)</td><td>ω: Angular Velocity (rad/s)</td></tr>
</table>
$$\left(\omega = \frac{2\pi \cdot N}{60}\right)$$
(N: Rotating Speed (r/min))
</td>
</tr>
</table>

■Inertia Formulas

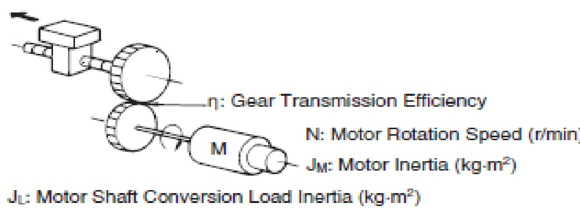
Cylindrical Inertia		$J_W = \frac{M(D_1^2 + D_2^2)}{8} \times 10^{-6}$ (kg·m²)
Eccentric Disc Inertia (Cylinder which rotates off the center axis)		$J_W = J_C + M \cdot re^2 \times 10^{-6}$ (kg·m²)
Inertia of Rotating Square Cylinder		$J_W = \frac{M(a^2 + b^2)}{12} \times 10^{-6}$ (kg·m²)
Inertia of Linear Movement		$J_W = M\left(\frac{P}{2\pi}\right)^2 \times 10^{-6} + J_B$ (kg·m²)
Inertia of Lifting Object by Pulley		$J_W = J_1 + J_2$ $= \left(\frac{M_1 \cdot D^2}{8} + \frac{M_2 \cdot D^2}{4}\right) \times 10^{-6}$ (kg·m²)

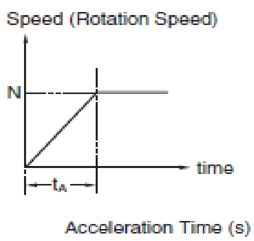
<table>
<tr><th></th><th></th><th></th></tr>
<tr><td>Inertia of Rack and Pinion Movement</td><td>
</td><td>$J_W = \frac{M \cdot D^2}{4} \times 10^{-6}$ (kg·m²)</td></tr>
<tr><td>Inertia of Suspended Counterbalance</td><td>
</td><td>$J_W = \frac{D^2 (M_1 + M_2)}{4} \times 10^{-6}$ (kg·m²)</td></tr>
<tr><td>Inertia when Carrying Object via Conveyor Belt</td><td>
</td><td>$J_W = J_1 + J_2 + J_3 + J_4$
$= \left(\frac{M_1 \cdot D_1^2}{8} + \frac{M_2 \cdot D_2^2}{8} \cdot \frac{D_1^2}{D_2^2} + \frac{M_3 \cdot D_1^2}{4} + \frac{M_4 \cdot D_1^2}{4}\right) \times 10^{-6}$
(kg·m²)</td></tr>
<tr><td>Inertia where Work is Placed between Rollers</td><td>
</td><td>$J_W = J_1 + \left(\frac{D_1}{D_2}\right)^2 J_2 + \frac{M \cdot D_1^2}{4} \times 10^{-6}$
(kg·m²)</td></tr>
<tr><td>Inertia of a Load Value Converted to Motor Shaft</td><td>
</td><td>$J_L = J_1 + G^2 (J_2 + J_W)$ (kg·m²)</td></tr>
</table>

■Load Torque Formulas

Torque against external force		$T_W = \frac{F \cdot P}{2\pi} \times 10^{-3}$ (N·m)
Torque against frictional force		$T_W = \mu Mg \cdot \frac{P}{2\pi} \times 10^{-3}$ (N·m)
Torque when external force is applied to a rotating object		$T_W = F \cdot \frac{D}{2} \times 10^{-3}$ (N·m)
Torque of an object on the conveyer belt to which the external force is applied		$T_W = F \cdot \frac{D}{2} \times 10^{-3}$ (N·m)
Torque of an object to which the external force is applied by Rack and Pinion		$T_W = F \cdot \frac{D}{2} \times 10^{-3}$ (N·m)
Torque when work is lifted at an angle.		$T_W = Mg \cdot \cos\theta \cdot \frac{D}{2} \times 10^{-3}$ (N·m)
Torque of a Load Value Converted to Motor Shaft		$T_L = T_W \cdot \frac{G}{\eta}$ (N·m)

■Acceleration/Deceleration Torque Formula





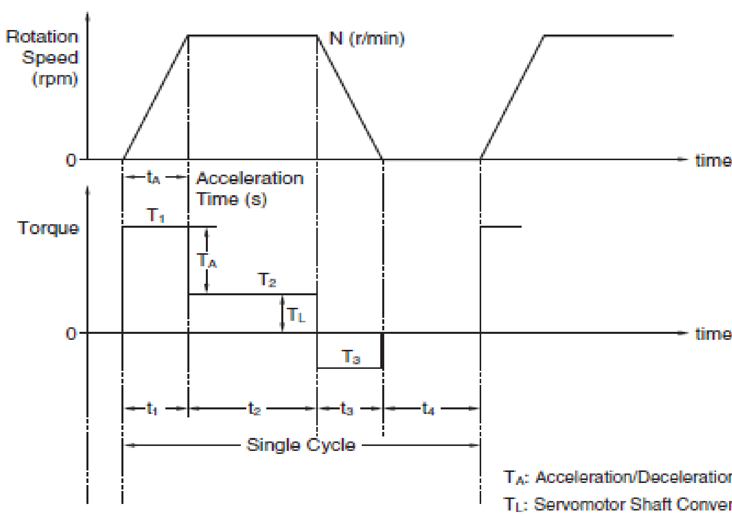
N: Rotation Speed (r/min)

T_A: Acceleration/Deceleration Torque (N·m)

Acceleration/Deceleration Torque (T_A)

$$T_A = \frac{2\pi N}{60 t_A}\left(J_M + \frac{J_L}{\eta}\right) \text{ (N·m)}$$

■Calculation of Maximum Momentary Torque, Effective Torque



T_A: Acceleration/Deceleration Torque (N·m)

T_L: Servomotor Shaft Converted Load Torque (N·m)

T_1: Maximum Momentary Torque (N·m)

Trms: Effective Torque (N·m)

Maximum Momentary Torque (T_1)

$T_1 = T_A + T_L$ (N·m)

Effective Torque (Trms)

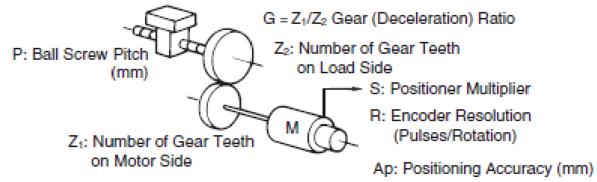
$$Trms = \sqrt{\frac{T_1^2 \cdot t_1 + T_2^2 \cdot t_2 + T_3^2 \cdot t_3}{t_1 + t_2 + t_3 + t_4}} \text{ (N·m)}$$

$T_2 = T_L$ (N·m)

$T_3 = T_L - T_A$ (N·m)

$t_1 = t_A$ (N·m)

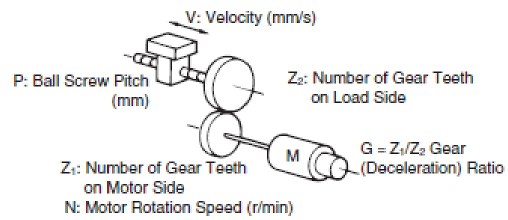
■**Positioning Accuracy**



Positioning Accuracy (A_P)

$Ap = \frac{P \cdot G}{R \cdot S}$ (mm)

■**Straight Line Speed and Motor Rotation Speed**



Motor Rotations

$N = \frac{60V}{P \cdot G}$ (r/min)

Voltage:48V

- Motor Type :Stepper Motor
- Power Supply :DC
- Model Number:HBS86H+86HBM80-01-1000
- Power:700W
- speed:2500RPM
- encoder:1000
- Torque:8NM
- Shaft size: 40mm

Specifications

Electrical Specifications

Parameter	Min	Typical	Max	Unit
Input Voltage	30	60	100	VDC
	20	-	70	VAC
Output Current	0	-	8.2(Peak)	A
Pulse Input Frequency	0	-	200	kHz
Logic Signal Current	7	10	16	mA
Isolation Resistance	500	-	-	MΩ

Operating Environment

Cooling	Natural Cooling or Forced cooling	
Operating Environment	Environment	Avoid dust, oil fog and corrosive gases
	Storage Temperature	-20℃ — 65℃ (-4℉ — 149℉)
	Ambient Temperature	0℃ — 50℃ (32℉ — 122℉)
	Humidity	40%RH — 90%RH
	Operating Temperature (Heat Sink)	70℃ (158℉) Max
Storage Temperature	-20℃ — 65℃ (-4℉ — 149℉)	
Weight	580 g (9.88 oz)	

Regarding to our calculation this servo motor more than enough to move objects more than 40kg since we are lifting objects 5 to 10 kg and 20-30

$$\omega_{rad} = \omega_{rpm} \times (2\prod)/60$$

$$2500*2\prod/60=261.666$$

$$V=\omega*r =2.61.666*20/1000=5.23m/s$$

Axis	Wight load	Torque load	Speed	Actual speed
x	50	8N.M	5.23m/s	0.16m/s
y	30	8N.M	5.23m/s	0.26m/s
z	10	8N.M	5.23m/s	0.8m/s

Chapter 5

5. Project Management

5.1 Project Plan:

This project plan was designed in comprehensive method to cover the work tasks and to implement the different work solids. It was completely necessary to discuss the objectives and the goals of the project before the plan brainstorming that include the also the responsibilities and the actions of the project. The following schedule “Table: 5.1” has included in details the explanation of the tasks and next it has shown the responsibilities for the different processes. In addition, the project plan concerned with the time management and the expertise supervision with the technical tasks and to follow the project’s structure.

Table (5.1) The main tasks

No.	Task	Description	Time
1	Stage 1: Design and components	Providing materials and building the structure with accurate measurements.	**Week 1:3**
2	Stage 2: Storage and retrieval machine structure	The process of transferring the loads from storage area to the delivery in another area using this machine with its different components.	**Week 3:4**
3	Stage 3: Storage modules	Provided in one unit that load containers of the stored materials with different parts built for this purpose.	**Week 4:6**
4	Stage 4: Testing	Recording the tests for successful conclusions and to treat with unexpected troubleshooting.	**Week 7:11**
5	Stage 5: Calculation	Calculate the time and the different sizes that help in successful operation.	**Week 11:12**
6	Stage 6: Data analysis and evaluation	All data collected from tests and after notes recorded will be in analysis and evaluation processes to practice modifications and adjust the required stages in final test for mechanical and electronically evaluation.	**Week 12:16**

In the table (5.2), there is clear description to the different stages in details to show the main items in the plan according to the time schedule with the progress percentage to the work done. In the table, the details referred to the quality of work according to the tasks and the roles of building the project.

Table (5.2) The description of the stages

Week	Plan Description	Progress's Percent
1	In the first stage, roughly design of the machine with Stating the first bill of material, specification and selecting of the parts and requirements needed.	**100 %**
2	In the second stage, second design draft that resulting from the literature review and come up with final design.	**100 %**
3	When we visiting workshop, it was important to Look at what is available in the market, what part need to be order or manufactures if needed.	**100 %**
4	In the part of the virtual design, there was concern with the apparatus in solid works.	**100 %**
5	In the final design, the team had to collect final bill of material after we identify them.	**100 %**
6	Purchasing parts depended on manufacturing all the required parts and components according to the system specifications where some parts were under manufacturing operation.	**100 %**
7	During manufacturing the frame which is considered the main part, all parts were fit in and firmly installed.	**100 %**
8	In the stage of assembly of the manufacturing parts, it should be done after finalizing all relevant parts in the main frame.	**100 %**
9	Motors purchasing order	**100 %**

5.2 Contribution of Team Members

Table 5.3 shows the effective contribution to the team members with the assigned tasks in the different stages. It shows also the fully participation according to the appropriate order of the plan. It may be indifferent percentages in some parts; however, it is obvious how the rest of the team members were assigned to complete the work tasks according to the responsibilities as one of the main parts in the project action plan.

Table (5.3) tasks & Contribution

Task	Al aqeel	Al samih	Almutairi	Al-Ghazal	Al-Mahasnah
Stage 1: Design and components	**100%**	**100%**	**100%**	**100%**	**100%**
Stage 2: Storage and retrieval machine structure	**100%**	**100%**	**70%**	**70%**	**100%**
Stage 3: Storage modules	**100%**	**100%**	**100%**	**70%**	**70%**
Stage 4: Testing	**70%**	**70%**	**70%**	**100%**	**70%**
Stage 5: Calculation	**100%**	**100%**	**100%**	**100%**	**100%**
Stage 6: Data analysis and evaluation	**100%**	**100%**	**100%**	**100%**	**100%**
Stage 1: Design and components	**100%**	**100%**	**100%**	**100%**	**100%**

5.3 Project Execution Monitoring:

Meetings: According to the team schedule for the project tasks, the team was assigned to meet every Thursday for distributing the tasks and to share more ideas. In addition, it is necessary to review previous tasks including assessment and work evaluation. This could help the team to review the instructions under the supervision of the professor advice and guidance.

Testing: After passing the weeks and going through the tasks in the design and the structure, it is important to have comprehensive overview. It is about the mechanical and technical parts by testing the validity of manufacturing parts and testing the operation system. It is assigned for specific tasks and specific team members to go through the reading tasks for changes and the modifications that are needed in the project's structure and in mechanical parts.

5.4 Challenges and Decisions Making:

Available parts and components: the first bill of the materials sowed the importance of using appropriate parts that are in need to start the operation system. The requirements of the projects are always reviewed to get manufacturing parts or in some stages it is necessary to ask for manufacturing new parts and components.

Motors: This is an important part to go through different types of motors that should help the design and to operate the system effectively. According to the calculations and the types of equations, most of the motors need some modifications especially with the sizes and to quality of efficiency with wiring system. It was helpful to review some previous works that guided the team to avoid troubleshooting and to adapt electrical system for appropriate operation.

Visiting workshops: this is a necessary part to support the quality of practical tasks in the plan using the knowledge with the experience in the workshops. This task takes much time in testing components and to have professional experiments to review the power system and to adjust the main frame before testing mechanical parts.

Calculations: this task depends on the mechanical knowledge and professionalism in dealing with mathematical equations that are suitable to different mechanical tasks. Some challenges in this part delayed implementing testing part because of the different modifications with the main frame and in the final design.

Analysis and evaluation: the task of evaluating work design and different mechanical parts need critical tasks for analyzing movements in different directions and the quality of power system that work with the motion system and the capacity of power system.

Chapter 6

6. Project Analysis

6.1 Life-Long Learning

It was a good opportunity to have a project related to the major we have studied and practical experiences with specific areas. We have explored some of our potential to deal with mechanical and electrical parts in new design and structures for the Automated Storage and Retrieval System. Since we decided to work with this system ASRS, we have collected enough information about previous work and to get details about the ideas related to the system and how it could serve people in many different fields.

As the team was used to practicing the process of investigation to the websites and the international companies used similar ideas, there were important competencies of communications. As it was assigned for the different members, it has been to access the topic in Google to complete the design or to get help for some of our failure attempts. The international companies have used ASRS introduced important data about using software programs effectively.

Mechanically, it has not been enough to have theoretical information to start practical mechanical work so that handling with components and mechanical parts should be important. During our courses we checked the figures and how to make calculations with power supplies and to measure the torques, distances and speed with some equations. Practically the issue had different, but it could not be fair to ignore data in our major courses. As any project had needed practical experiences we had counted many attempts in testing components and the effectiveness of mechanical and electrical parts to get the appropriate design for the project operation. Before listing the main points in our new knowledge for the project, it is necessary also to point to the importance of sing practical skills. Firstly, intrapersonal and interpersonal communication skills were always in place because the team was necessary in continuous contacts according to the work plan and to deal with the main stages that helped in the process of design and to discuss the tasks of each member. Secondly, Work organization as a part of the skills in leadership and team work was tangible in all tasks through the team meetings and to implement the tasks individually and to be collected for practical work in group. All of the team members had enough motivation to work together and to cooperate during all relevant processes in the project. Thirdly, as normal in solid works especially in mechanical and electrical work, there were barriers and mistakes which unexpectedly were occurred. The team as a group was professional to analyze the wrong calculations or failure tests especially in the final stages. This reflected the qualities of dealing with dilemmas and to critically think for possible solutions. Actually there were many lessons in this part and technically the team members cooperatively arranged the roles and tasks to solve all of those unexpected mistakes. Solving those dilemmas also motivated us to recheck all parts in testing process. In the following list there are parts of our technical and practical knowledge regarding the project:

- Mechanical data about ASRS
- Electrical motors modifications
- Selecting supporting components from machines and bearings
- New knowledge of using hardware parts and the importance of robotics in such systems that how they could be more helpful
- The importance of mechanical and electrical tests for the internal and external parts
- Practical software programs that helped in flexible movements

- Management skills that helped in organizing solid works and recording needs and the requirements of the different parts in the system
- Time management and teamwork competencies

6.2 Impact of Engineering Solutions

The main idea of the project was to introduce unique services for commercial and industrial fields. In addition, the quality of coping new technology empowered the team to think in a way to solve the problems that storekeepers and workers to suffer in transferring different items with different weights and many other problems. The significance in that point was the size and the cost of the machine. The project will be produced to solve some of these problems because small business cannot get a machine with thousands of dollars for simple tasks while the cost of laborers may be less.

In the advantages of using the ASRS it is a way for using the benefits of technology and mechanical features. It was noticed in many companies' visions how they concerned with customer services using simple mechanical and technical systems with the different shapes of ASRS after finding many difficulties in high places to make use from stores' places. In many industries, it is costly to get traditional methods for getting productions quickly for customers' delivery services. ASRS makes the tasks easy without the high costs of traditional cranes with limited functions. The project software programs have sufficient abilities to organize the production in all places with any heights. In addition, there were some difficulties to have progress in production for many factories because of the stores' space where the amount of production was more than the space. In providing places in horizon and vertical space, ASRS could go further to organize the required items with arrangement for the rest of the items through serial numbers for each item. The importance of using ASRS will not reduce the number of workers in the companies to effect on social cases, but the project needs professionalism of using ASRS which reflect the level of developing people work with it. Some companies suffer from the cost of labor in fields that can use ASRS instead which will reduce the liabilities of the companies. Moreover, manufacturers also complain from some wrong actions regarding the process of delivery which reflected bad impression to the customers. ASRS have the solutions with simple orders and simple software programs that can save both of money and time. Manufacturers in the field of commerce suffer from the cost of cranes repairing and maintenance which affect the factories' budgets while ASRS can save this part and save costs of the factories' liabilities.

The invention has made big change and great impact on the process of handling materials and controlled the procedures of inventory in many commercial and industrial fields. The main location for the system is the warehouse where all inventories and handling processes are there. The values of using the system are considered very effective for manufacturers and storekeepers where their work became easier than before.

There have been also some advantages regarding the environmental issues especially when using electrical and mechanical integrated process supported by technology to protect the closed areas in the stores from exhausting systems that pollute the air and influences on people health in the worksites. Some factories have different locations for the stores which cost them lots of time and money to move from a place to a distant place using the cranes that use oil. This created polluted areas between the stores and factories. ASRS has complete features for conservation without causing any pollution.

6.3 Contemporary Issues Addressed

Most of logistics centers in the companies all over the world have specific areas for receiving and delivery goods in different sizes of warehouses. In addition, companies in Dammam, Jubail, and Jeddah, for example, depend on transforming goods and materials from seaports and also in the different international and domestic airports in the shipping processes. According to the industrial developments especially in these areas, it was a must to find solutions to the problems of the transferring and shipping which require professionalism in the transporting techniques. The system has the quality of supporting these processes in the picking areas and effectively and in work stations for dispatching and packaging as well.

The integrated system in our project is interested in many different processes that keep the quality of health in manpower and safety in priority. The integrated design of the project offers:

- Automated processes and retrieval services for goods and materials
- Intelligent services in the project performance with high quality for help in storage services and in different operations
- Fits difficult tasks and ergonomic operations that most of storekeepers and technicians face in their work in commercial and industrial fields in particular
- Managing the operations in warehouses with accurate results in receiving and delivery systems
- Continuous installation visualization
- Continuous maintenance and services

Chapter 7

7. Conclusion

7.1 Conclusion

ASRS stands for Automated Storage and Retrieval System depending on mechanical structure and design. The operation system depends on Servo motor and mechanical components that enable the system to move in different directions and to handle different weights in narrow areas. The importance of mechanical orders has already been designed for storage services in small places in limited and unlimited weights with simple developments in the calculations of the mechanical components. There are many advantages for the project especially in academic services such as transferring and organizing university libraries. It can also be used n homes for organizing items. The main function for the ASRS is to be used in warehouse for storage and retrieving systems. The design of the project is applicable for development to be used in various services with simple mechanical changes.

The design of the project has been approved to serve commercial services and there are special systems used for industrial services. The quality of the system in mechanical methodology showed better performance concerning with the organization of materials in correct orders. The problem in delivery items in different specifications has been recorded by clients. The old-fashioned design depended on manual system using laborers with cost in liabilities of the company. In addition, the better used system in this field was the project depends on software programs, but the components and technology tools are very costly with expensive spare parts and maintenance. So mechanical design is considered the best solution for the same functions and it also saves money and time.

The project has passed with different five stages in design and components in stage one where the objectives were to provide materials and to build the structure. In the second stage, there was special methodology for the storage and retrieval machine depending on the Servo motor and the pallet rack frame for the loading and unloading services. The other mechanical components were to control movements in available places. The third stage was about the storage modules that used a unit for loading containers. The fourth stage focused on testing the components and the quality of mechanical operation. It also focused with the calculations to provide appropriate equations after the correct orders of the functions in mechanical methodology. The last stage was to analyze the date after testing and to qualify mechanical system in successful operation.

It was necessary from the beginning to focus on the solid works depending on the different materials such as wood, aluminum, plastic, and steel. The importance of the final design was to use the quality of the final frame and the mechanical components with the motors and the operation system. In our project we had several types about the mechanism, structures and installation to describe our solid works. The shape was also the design in a rectangular profile which was made of fiber glass which works as insulators for the different areas that contact with screws and electrical wiring. It was necessary for testing the endurance of the structure and the frame after external mechanical and electrical tests using the calculations and the general equations in the team considerations. In addition, the general equations were helpful to measure the torque unit (s) where it was possible to fix the required speed in the movements of the racks in front and behind the motor systems. The mechanical options seemed very limited so that it should be modified with some changes in calculations using electrical facilities. This project plan was designed in comprehensive method to cover the work tasks and to implement the different work solids. It was completely necessary to discuss the objectives and the goals of the project before the plan brainstorming that include the also the responsibilities and the actions of the project.

7.2 Recommendations

It would be necessary to providing materials and building the structure with accurate measurements. The project should be more effective to the process of transferring the loads from storage area to the delivery in another area using this machine with its different components. It had better support in one unit that load containers of the stored materials with different parts built for this purpose. The team should have accurate records for the tests for successful conclusions and to treat with unexpected troubleshooting. The calculation should be in accurate methodology using the management of the time and the different sizes that should in successful operation. All data collected from tests and after notes recorded should be in analysis and evaluation processes to practice modifications and adjust the required stages in final test for mechanical and electronically evaluation. In the part of the virtual design, there was concern with the apparatus in solid works. That affected the final design, the team had to collect final bill of material after we identify them. Actually there were many lessons in this part and technically the team members cooperatively arranged the roles and tasks to solve all of those unexpected mistakes. Solving those dilemmas also motivated us to recheck all parts in testing process. In the following list there are parts of our technical and practical knowledge regarding the project.

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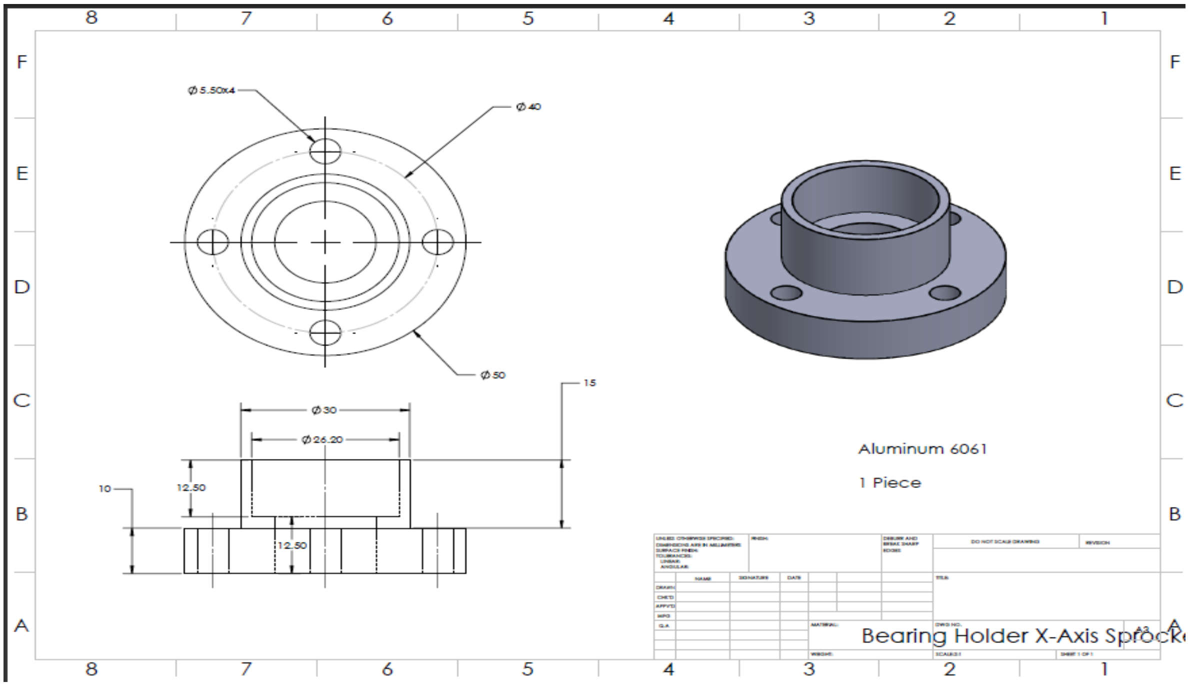
Westfalia.(2015). Increase warehouse efficiency with an AS/RS. Retrieved March 30, 2017, from https://www.westfaliausa.com/products/automated-storage-retrieval-systems

Appendix (1) Figures


Ø 5.50x4
Ø 40
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15
10
12.50
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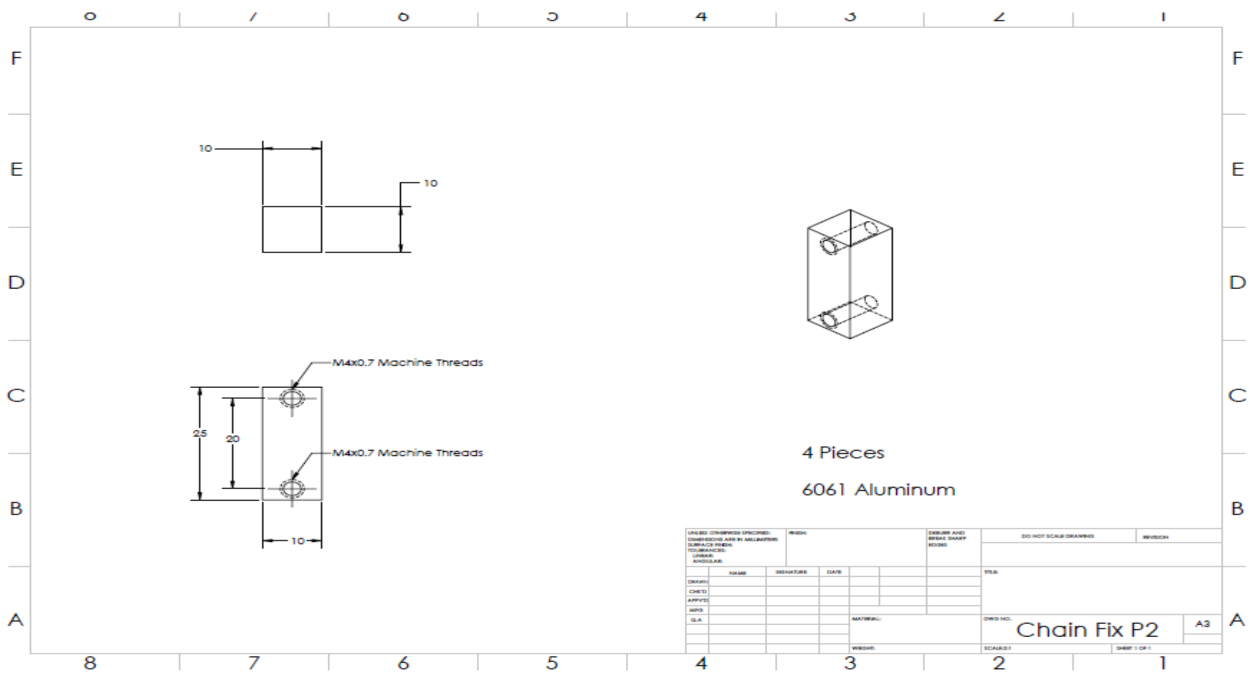
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25
20
10
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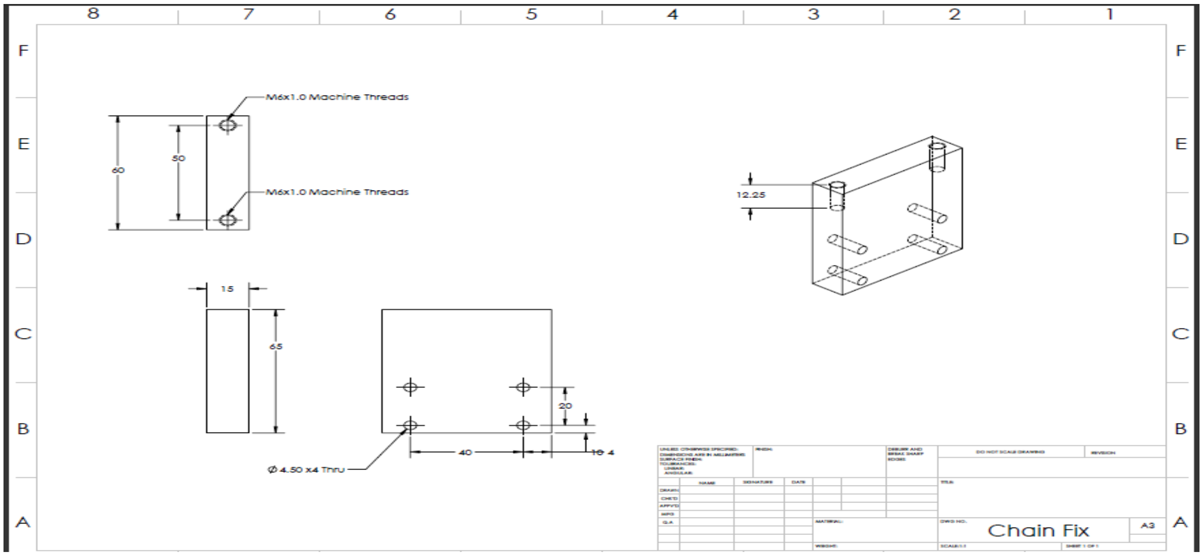
Chain Fix P2
A3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Ø 4.50 x4 Thru
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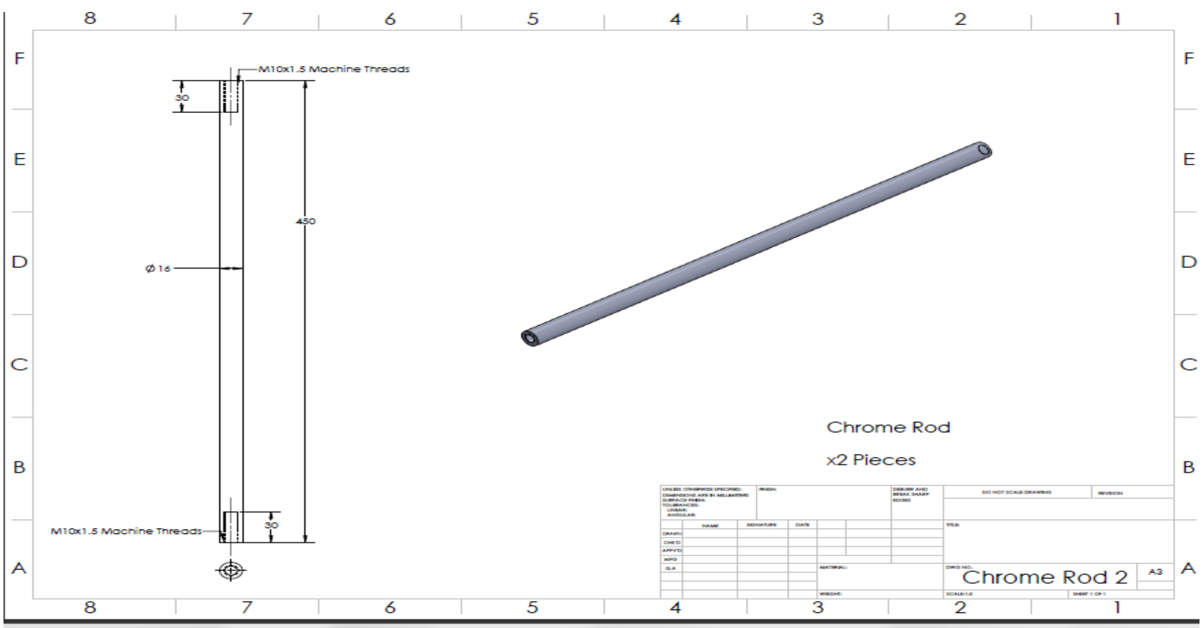
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30
450
Ø 16
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30
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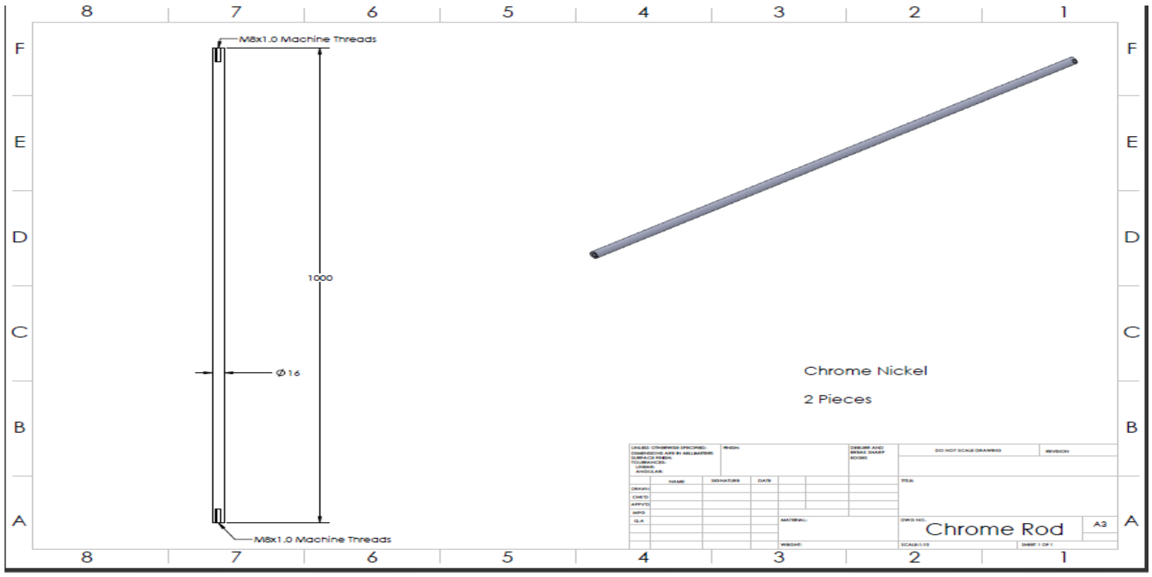
x2 Pieces
Chrome Rod 2
A3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Chrome Nickel
2 Pieces
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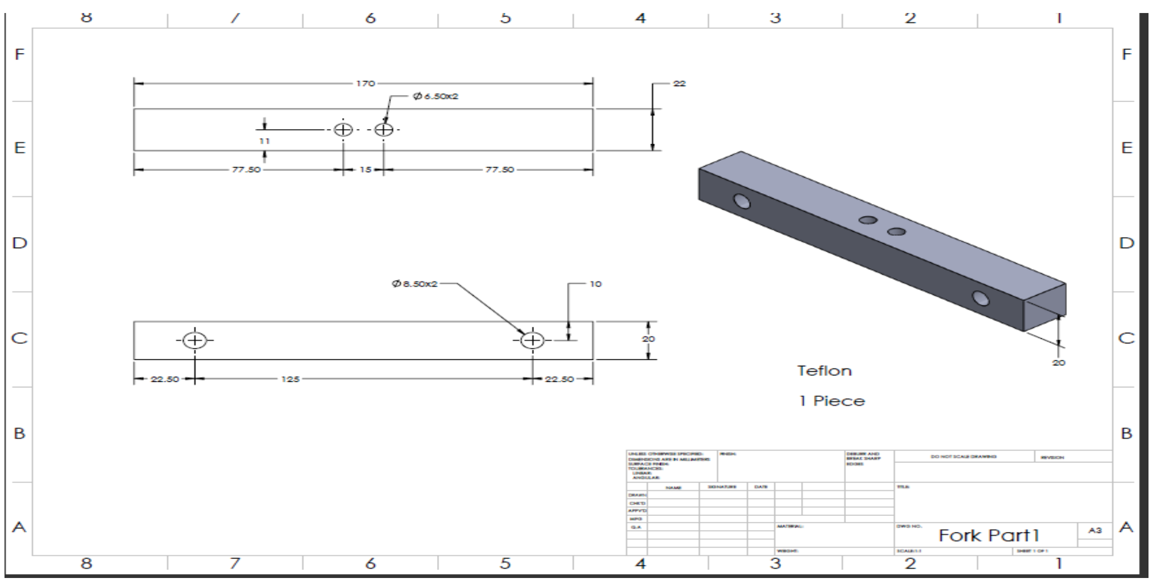
A3


170
Ø6.50x2
22
11
77.50
15
77.50
Ø8.50x2
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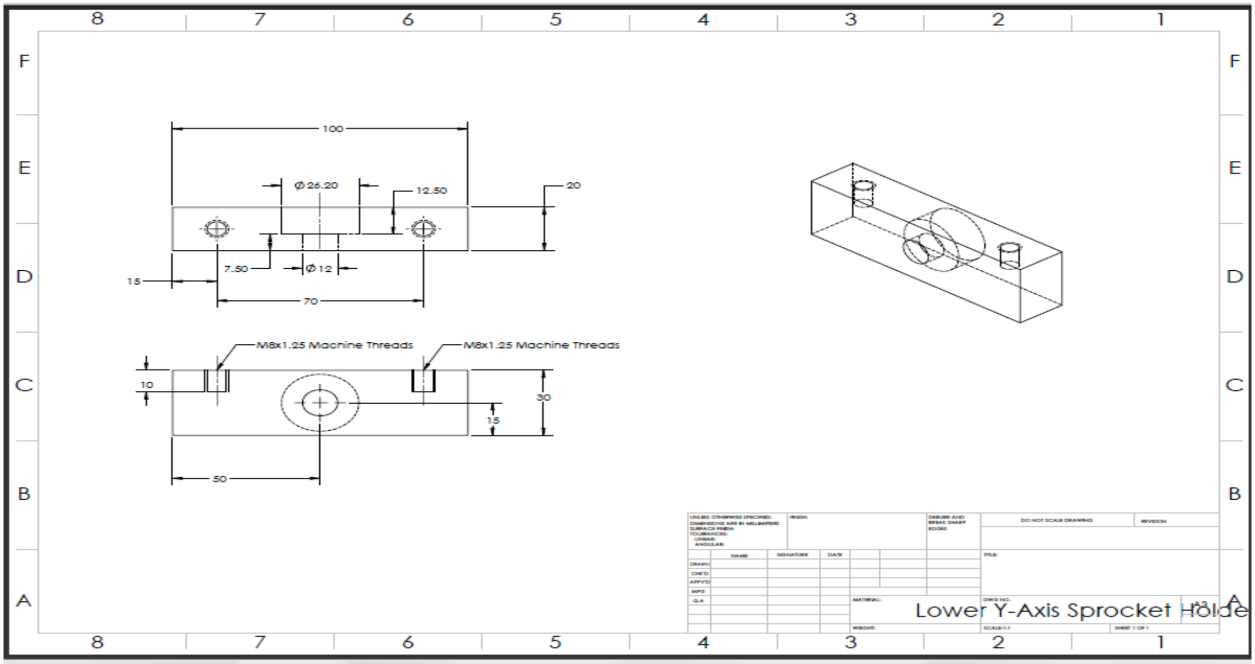
20
Teflon
1 Piece
Fork Part1
A3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Ø 26.20
12.50
20
7.50
Ø 12
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70
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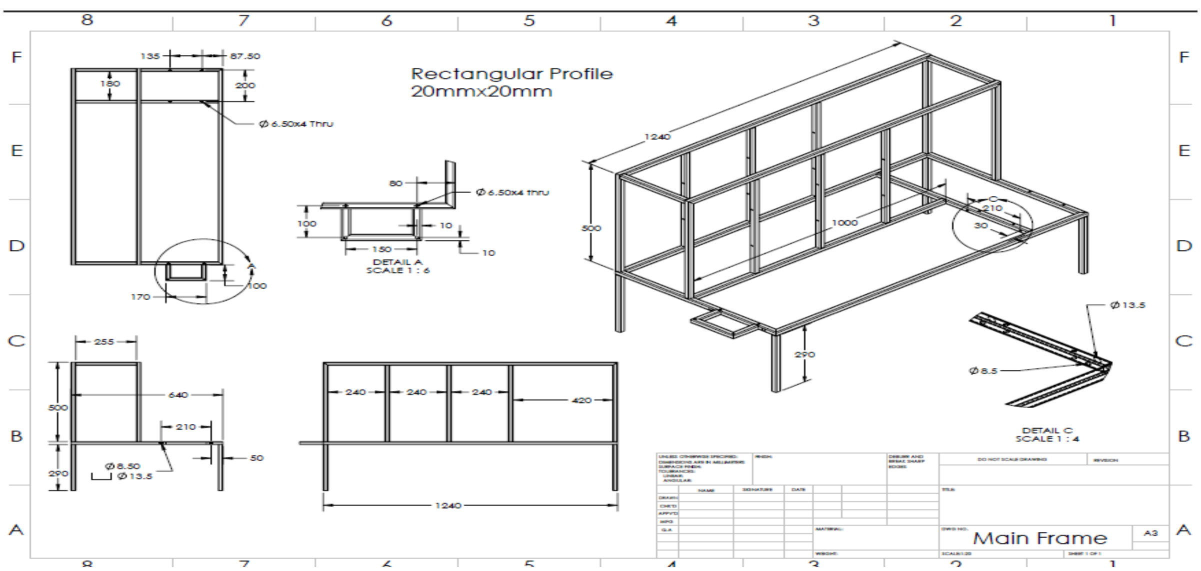
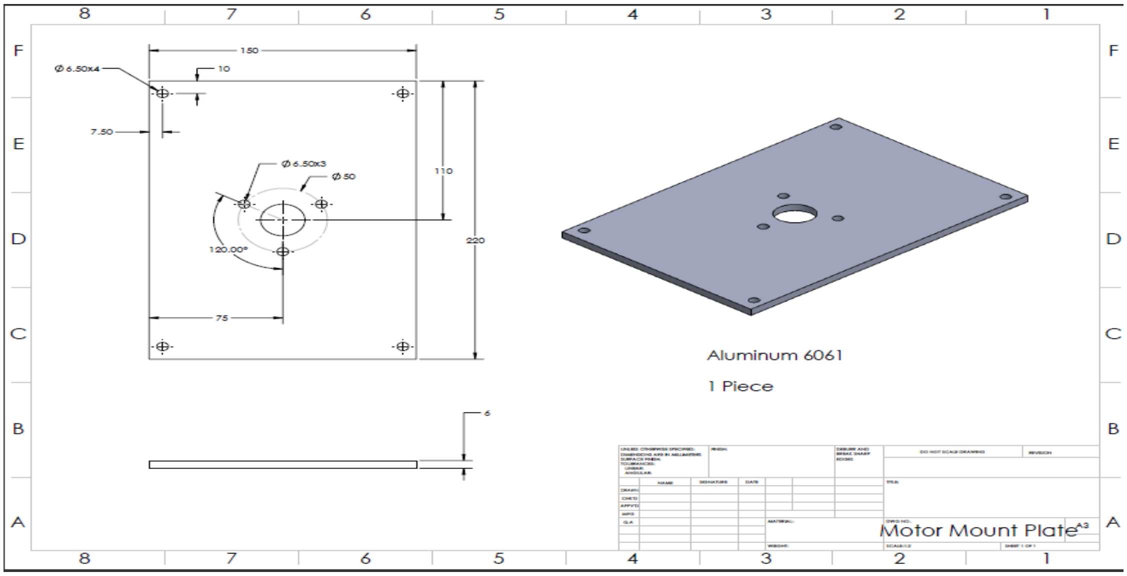
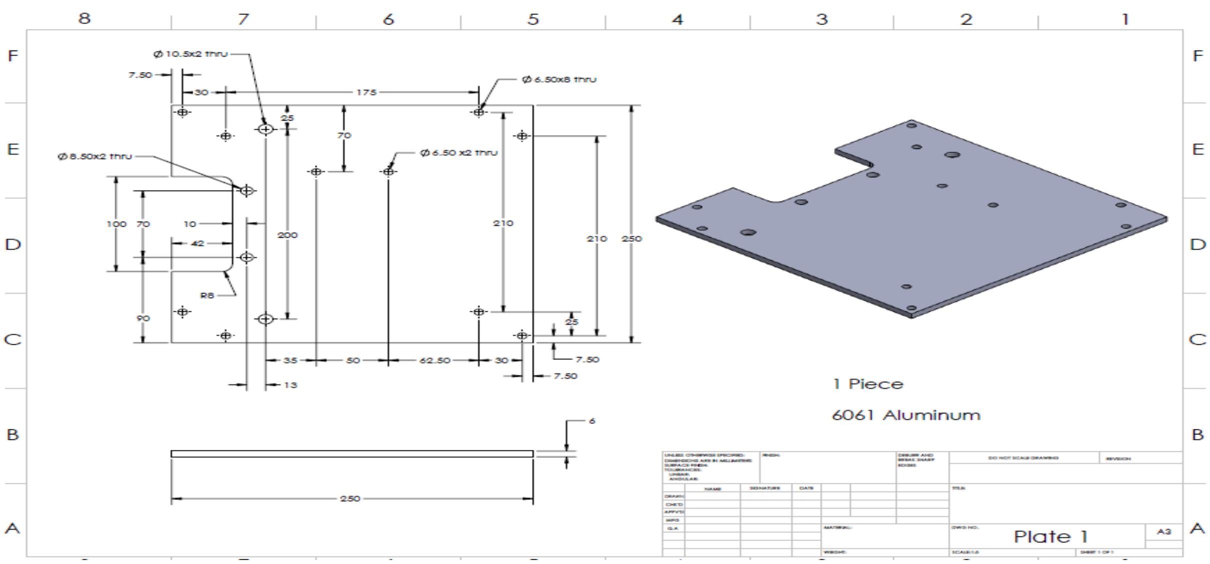
M8x1.25 Machine Threads
10
30
15
50
Lower Y-Axis Sprocket Holde

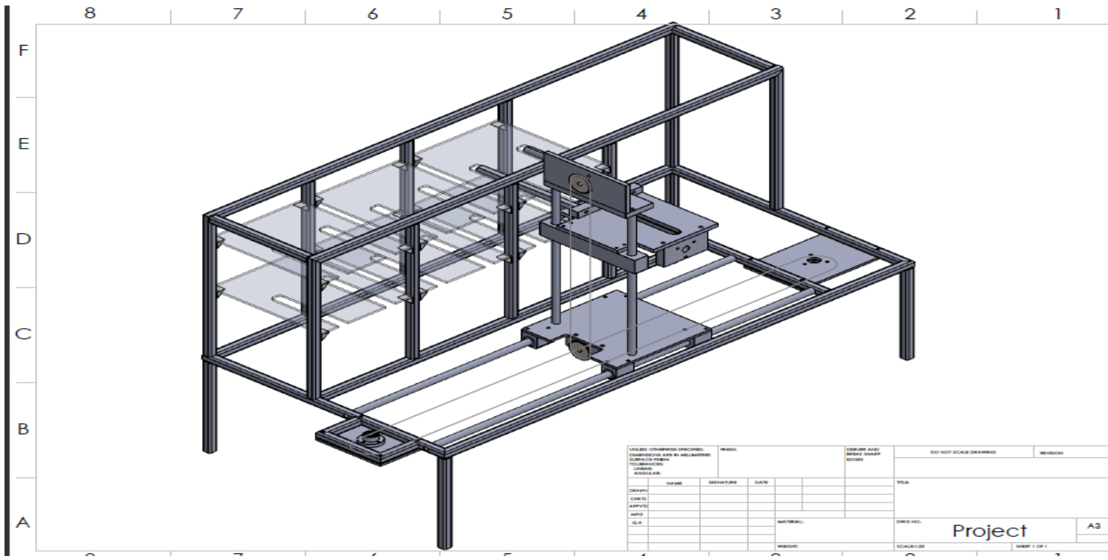

135
87.50
180
200
Ø 6.50x4 Thru
Rectangular Profile
20mmx20mm
80
Ø 6.50x4 thru
100
10
150
10
DETAIL A
SCALE 1 : 6
1240
500
1000
210
30
170
100
Ø 13.5
255
640
500
210
290
Ø 8.50
Ø 13.5
50
240
240
240
420
1240
290
Ø 8.5
DETAIL C
SCALE 1 : 4
Main Frame
A3

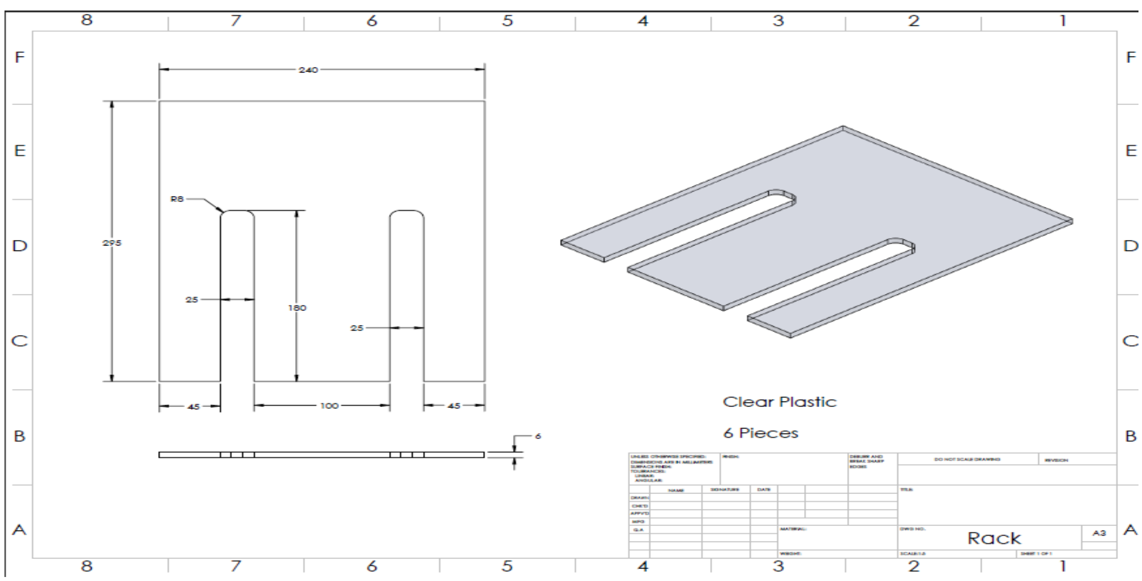


Ø 6.50x4
150
10
7.50
Ø 6.50x3
Ø 50
110
220
120.00°
75
6
Aluminum 6061
1 Piece
Motor Mount Plate
A3



Ø 10.5x2 thru
7.50
30
175
Ø 6.50x8 thru
25
70
Ø 8.50x2 thru
Ø 6.50 x2 thru
100
70
10
42
200
210
210
250
R8
90
25
35
50
62.50
30
7.50
7.50
13
6
250
1 Piece
6061 Aluminum
Plate 1
A3


Project
A3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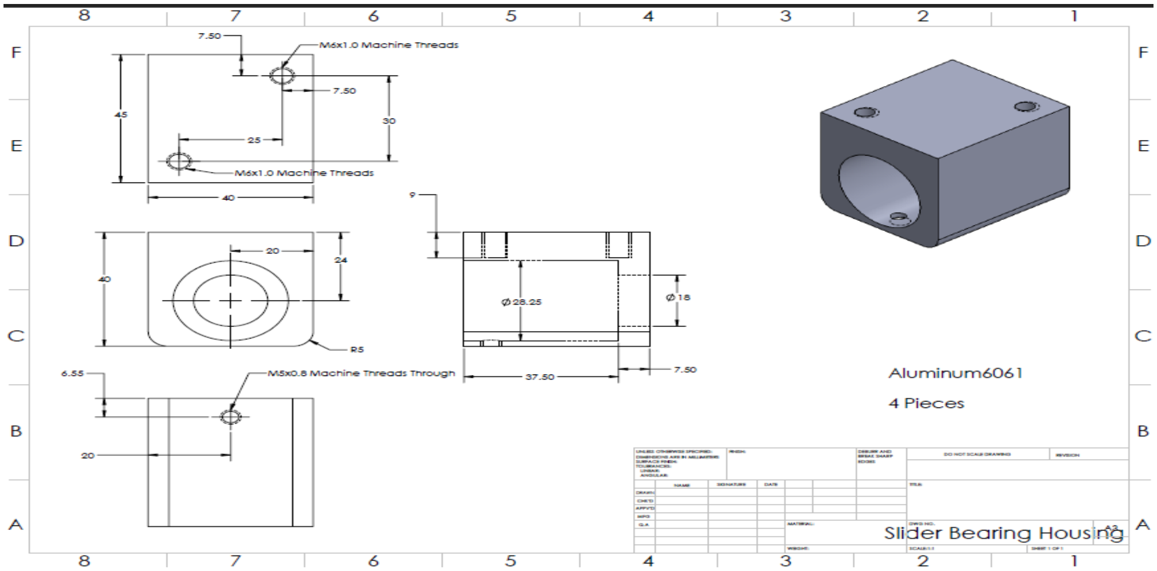
295
R8
25
180
25
45
100
45
6
Clear Plastic
6 Pieces
Rack
A3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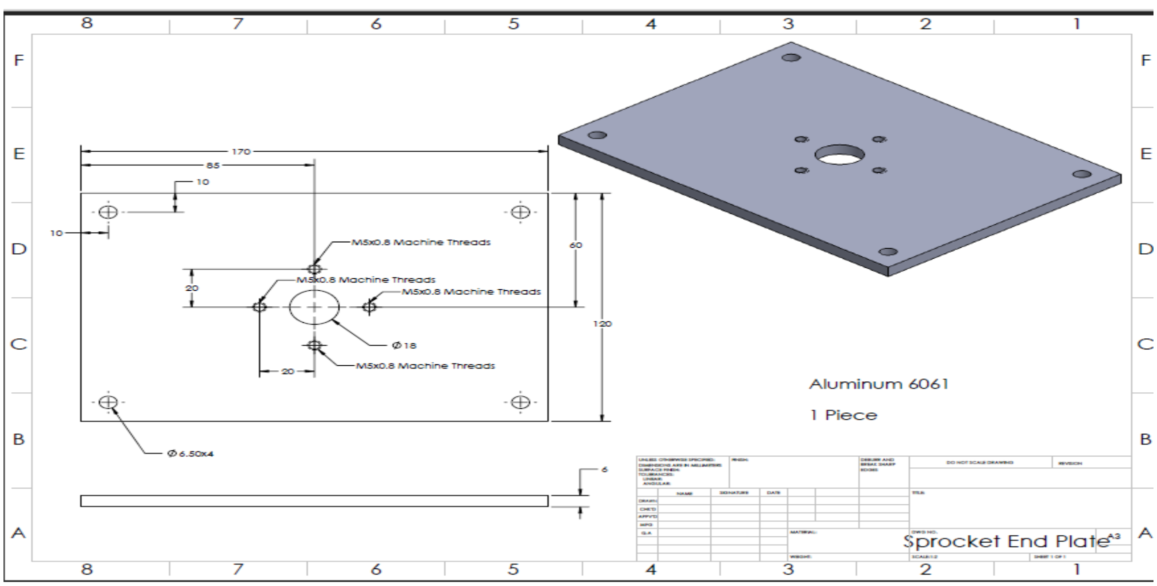
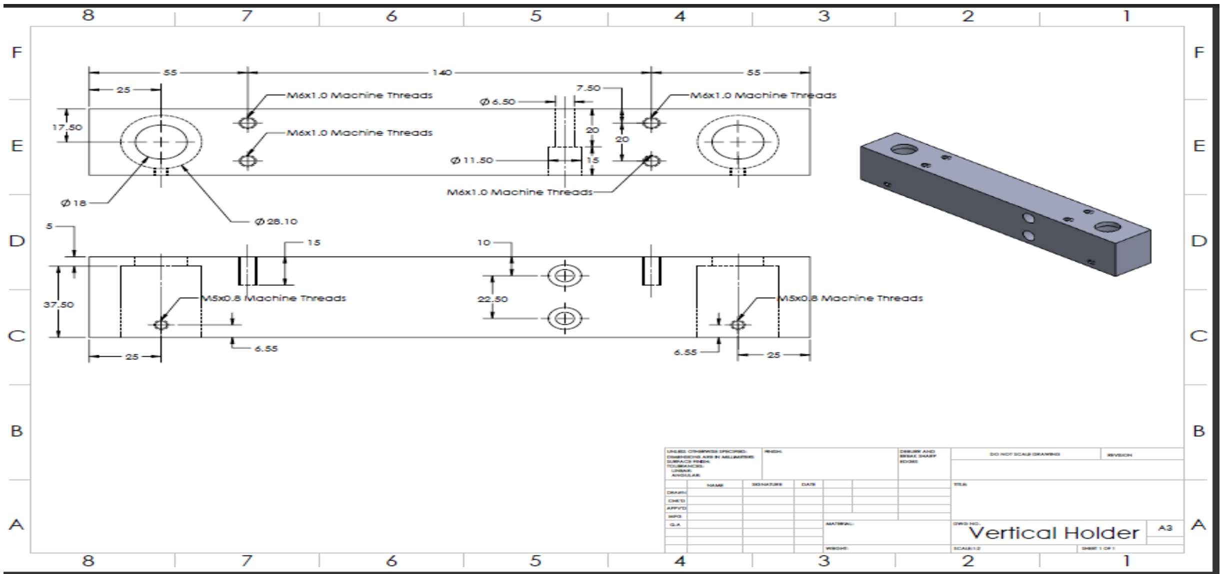
M6x1.0 Machine Threads
M5x0.8 Machine Threads Through
Aluminum6061
4 Pieces
Slider Bearing Housing


M5x0.8 Machine Threads
M5x0.8 Machine Threads
M5x0.8 Machine Threads
M5x0.8 Machine Threads
Aluminum 6061
1 Piece
Sprocket End Plate



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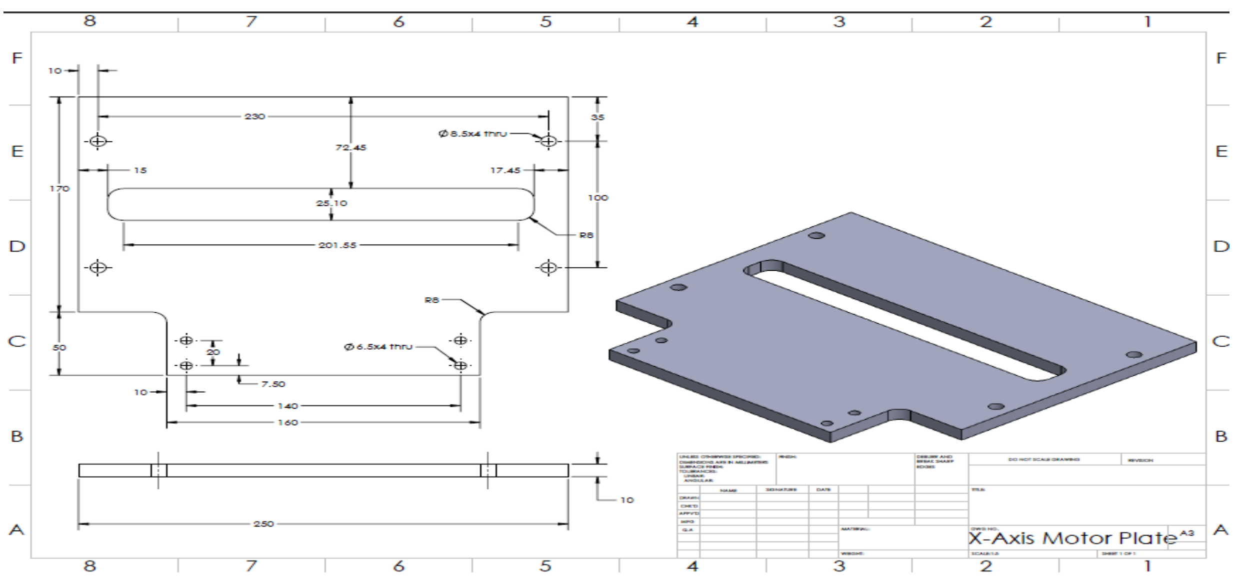
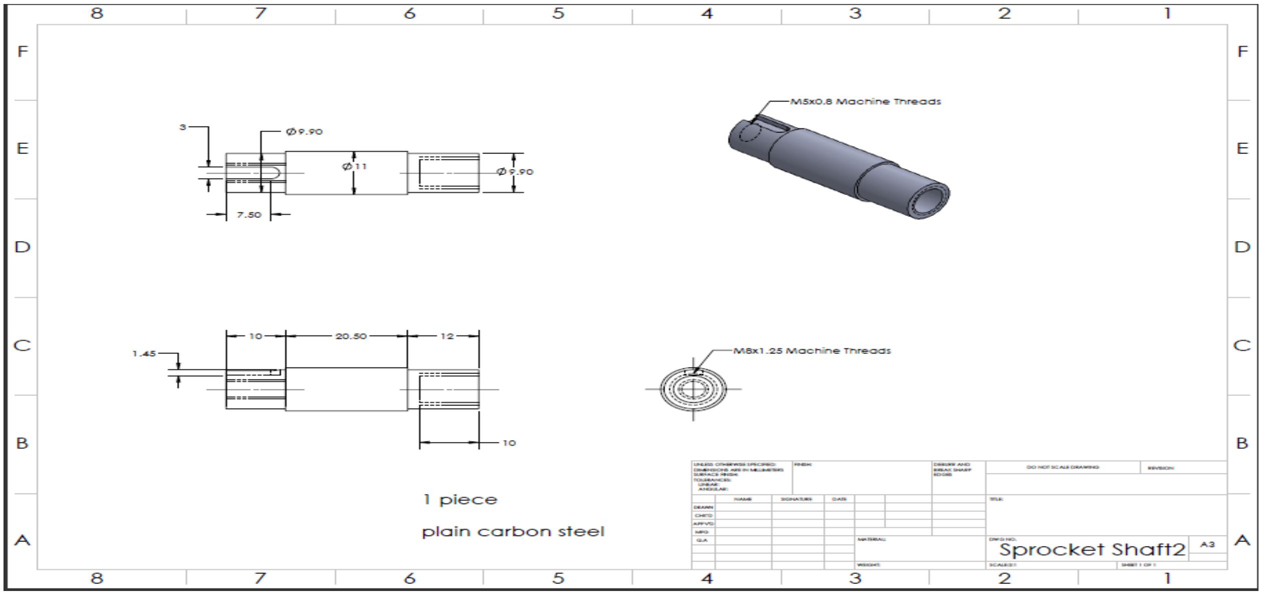
M5x0.8 Machine Threads
Vertical Holder



Ø 6.5x4 thru
X-Axis Motor Plate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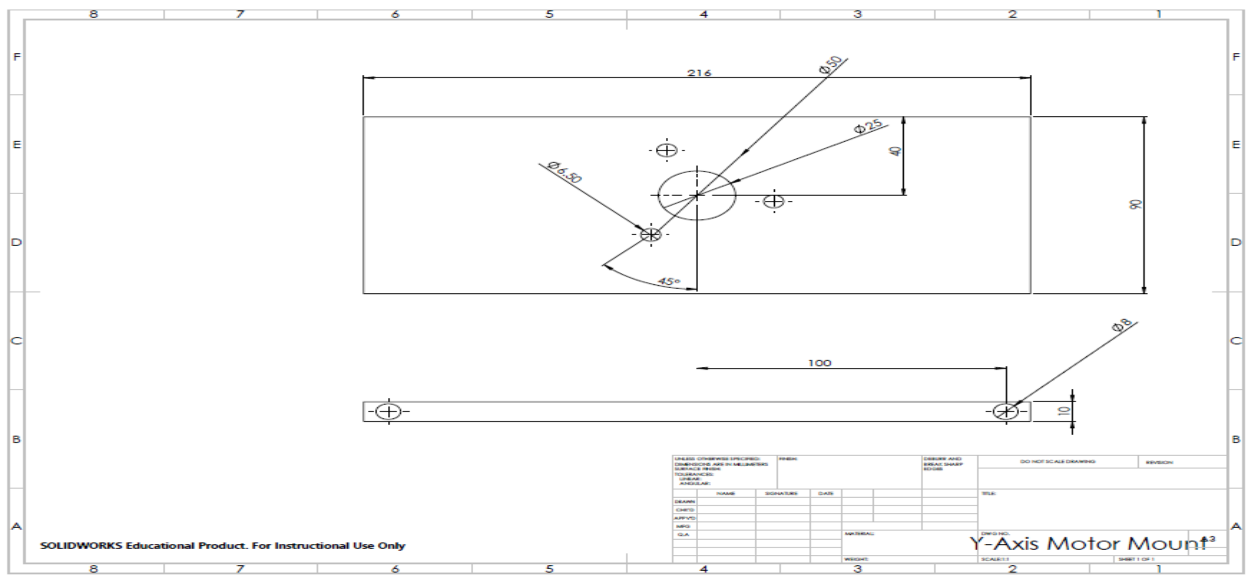
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100
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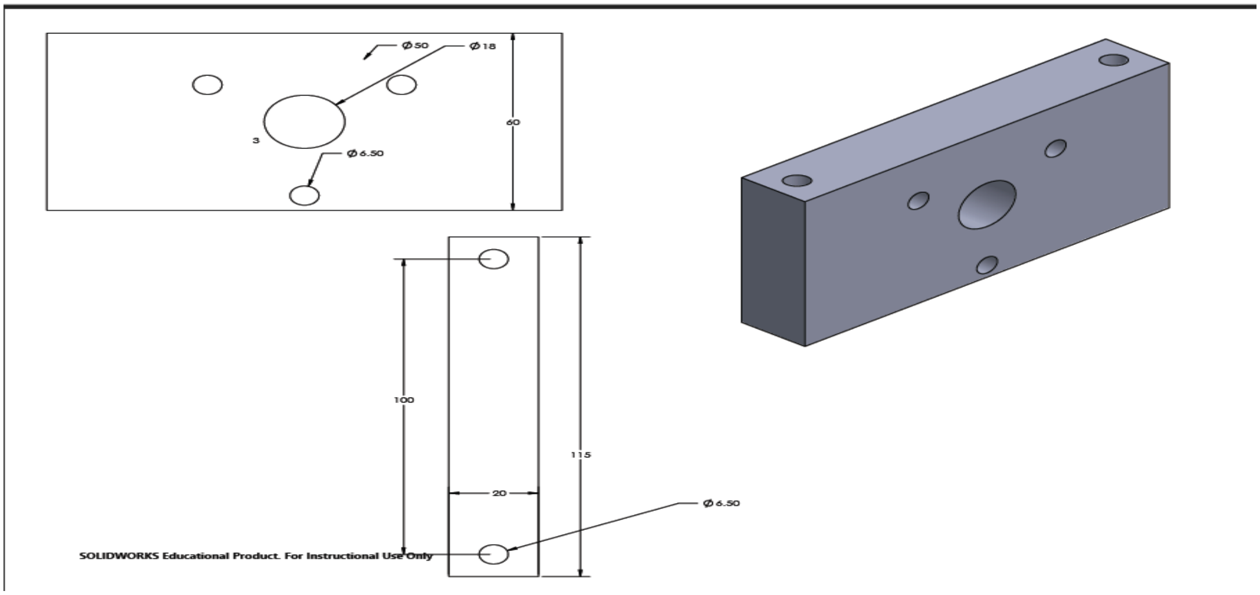
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Ø 18
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3
Ø 6.50
100
115
20
Ø 6.50
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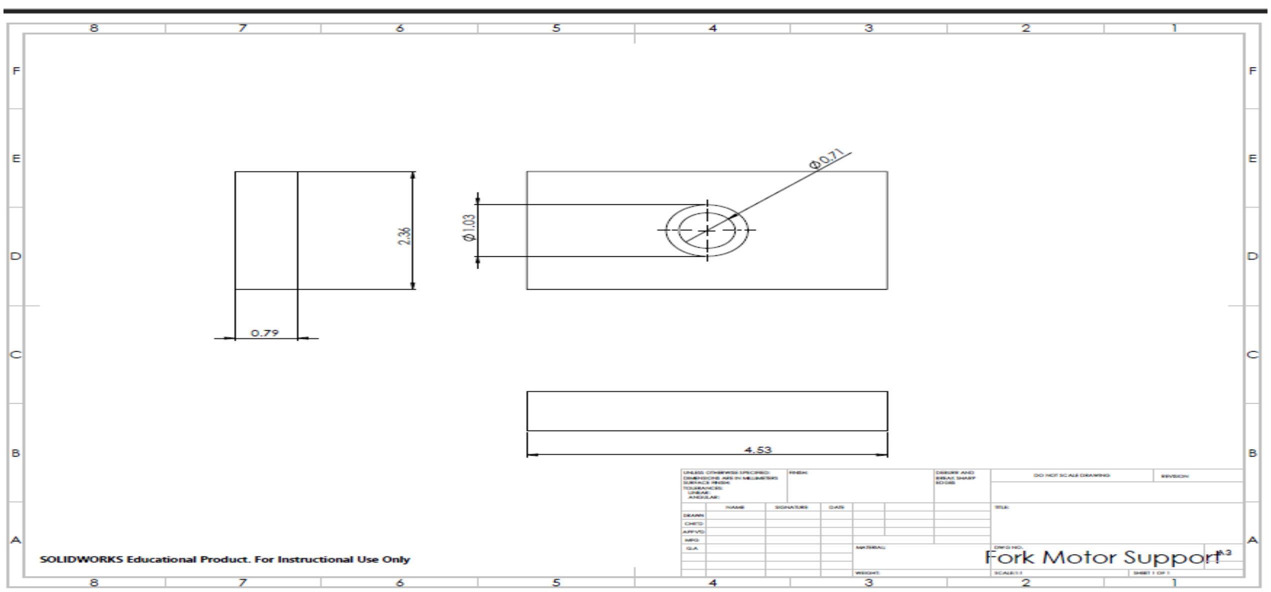
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Fork Motor Support
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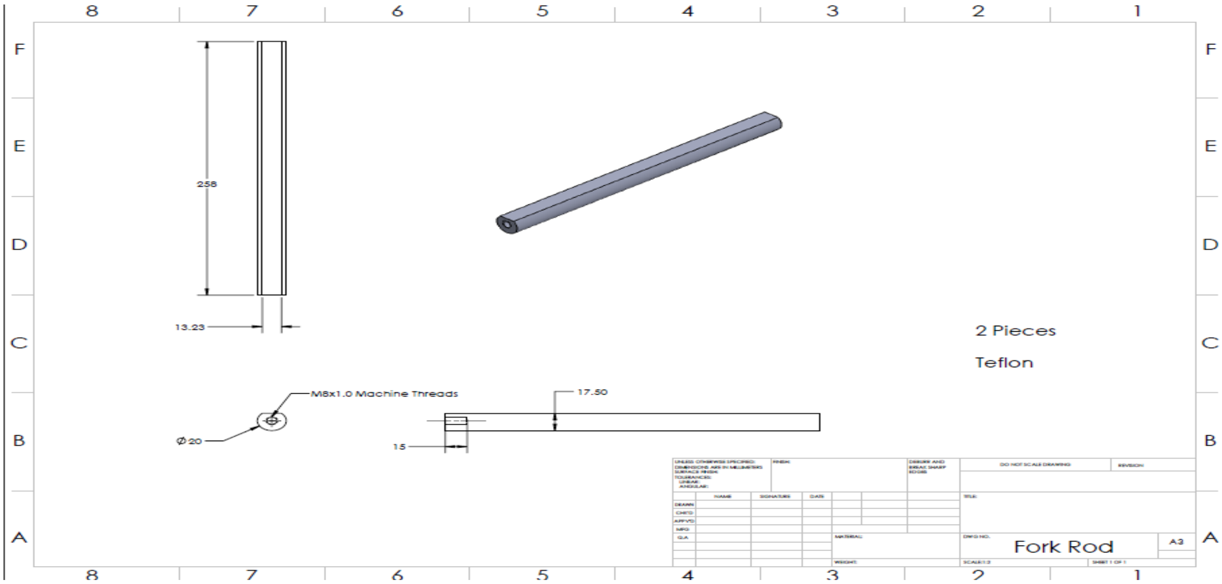
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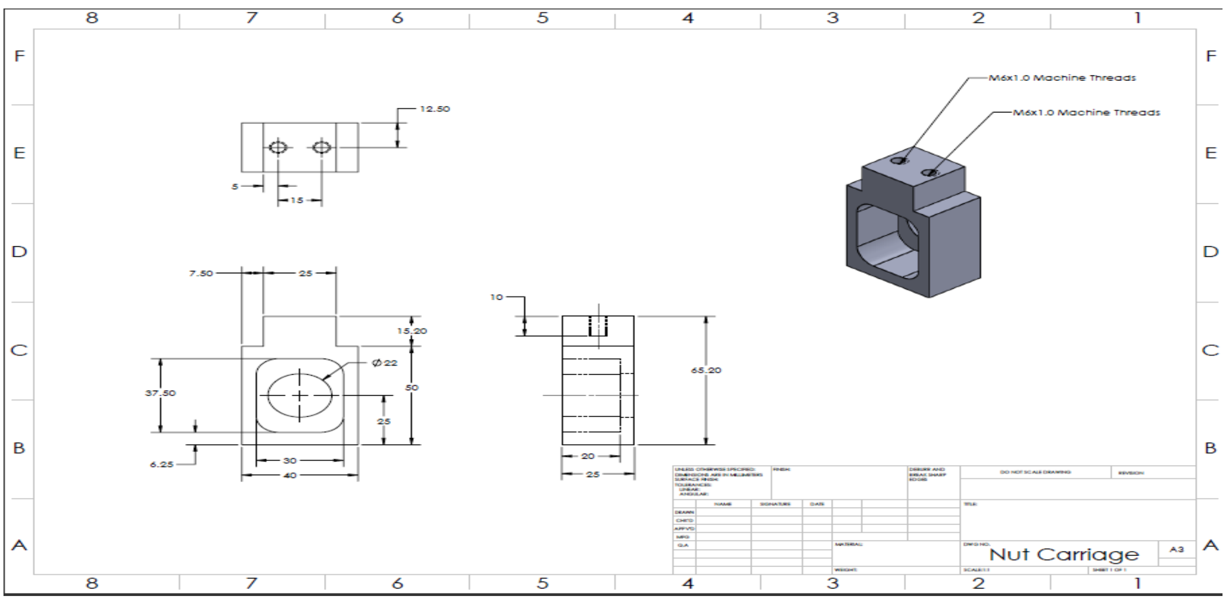
Ø20
17.50
15
2 Pieces
Teflon
Fork Rod
A3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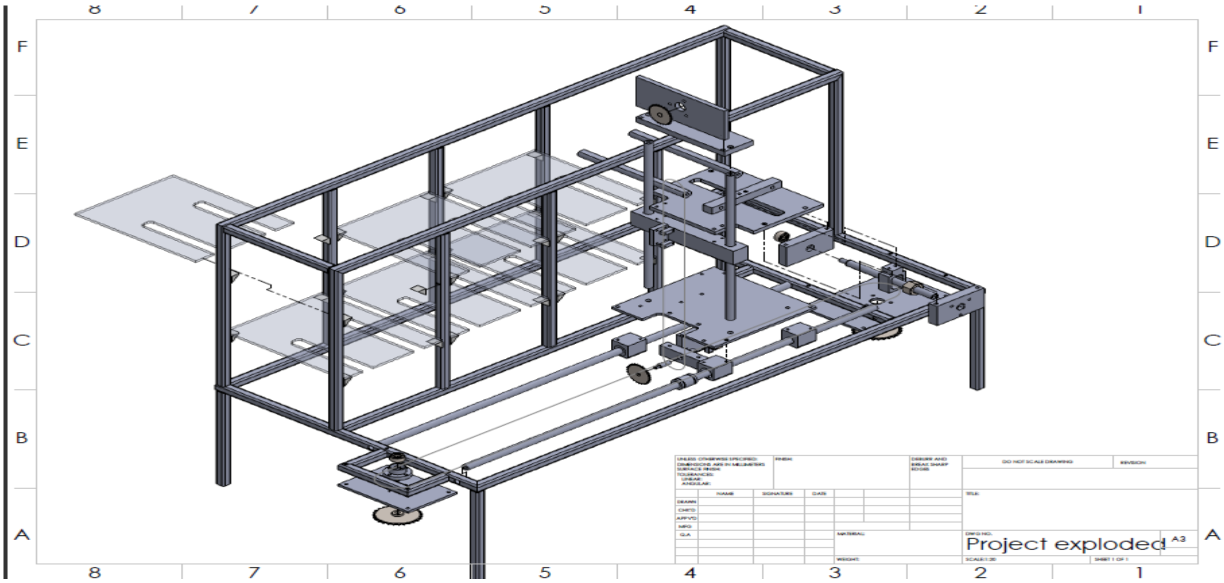
20
25
Nut Carriage
A3



DRWG NO.
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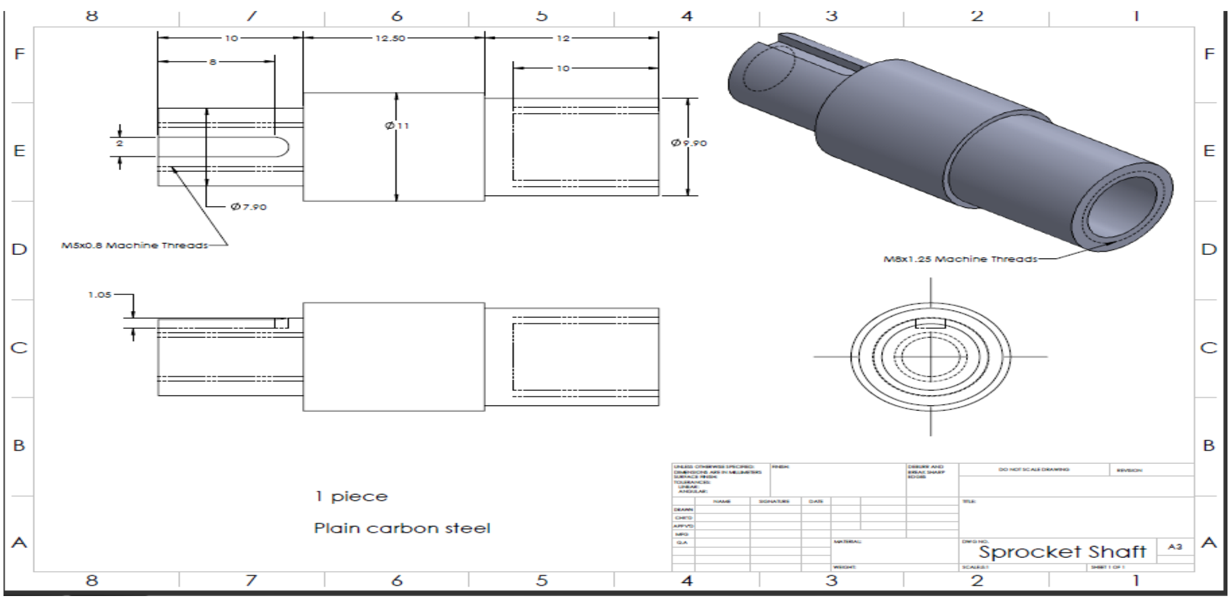

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12.50
12
10
Ø11
Ø9.90
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Ø7.90
M5x0.8 Machine Threads
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1.05
1 piece
Plain carbon steel
Sprocket Shaft
A3

Appendix (2) Tables