DESIGN AND INDIGENOUS MANUFACTURING OF THE MOVING MECHANISM OF AN X-RAY MACHINE

A Final Year Project Report Presented to

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In Partial Fulfillment

of the Requirements for the Degree of Bachelor of Mechanical Engineering

by

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ABSTRACT

An X-ray machine is a medical imaging device that uses electromagnetic radiation to capture images of the inside of the body. The X-ray machine comprises several key components, including the X-ray tube and the detector. The X-ray tube generates electromagnetic radiation while the detector captures the resulting images.

The moving mechanism of an X-ray machine is responsible for moving the X-ray bed along with the patient's body. This mechanism is typically mounted on a rail system that allows the X-ray head to move smoothly and precisely. The rail system is often equipped with motors and sensors that enable precise control over the movement of the X-ray head.

This report details the design and manufacturing process of a moving mechanism for an X-ray machine and the movement of the bed. The report begins with an overview of the design requirements, including precision, durability, and ease of use. The design process is then discussed in detail, including generating several concepts and selecting a final design.

The chosen design was then analyzed using simulation software to ensure its functionality and durability. The simulation results showed that the design could meet the specified requirements and withstand the expected loads and stresses.

The manufacturing process is also detailed in the report, including the selection of appropriate materials, the creation of 3D models, and the use of different machining and manufacturing processes to produce the final product. The report provides detailed information on each step of the manufacturing process, including the challenges encountered and how they were overcome.

In conclusion, the successful design and manufacture of the X-ray machine moving mechanism demonstrates the importance of effective engineering and collaboration in producing complex medical equipment.

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CHAPTER 1: INTRODUCTION

It was important to us that whatever project we chose would end up helping the people of Pakistan instead of sitting in a workshop or scrapyard somewhere. Pakistan has an exceptionally large and growing population living in lesser-than-ideal conditions. In recent years, the demand for medical imaging has increased rapidly due to increased exposure to diseases. This should lead to the development of various diagnostic equipment here, but since manufacturers are not equipped to do the job, machines are not being supplied according to the demand. X-ray machines are widely used in medical facilities for imaging bones and internal organs.

Motivation:

The excessive cost of imported X-ray machines and their maintenance has become a significant issue for many healthcare facilities, especially in developing countries. To address this challenge, this final year project focuses on the design and indigenous manufacturing of the moving mechanism of an X-ray machine. The project aims to develop a low-cost, reliable, efficient mechanism to manufacture and maintain locally. The project will involve a comprehensive analysis of the requirements and constraints of the moving mechanism, including its speed, accuracy, safety, and durability.

The design will be based on existing X-ray machines and optimized to meet the specific needs of the local healthcare facility. The manufacturing process will involve using locally available materials and expertise to minimize costs and ensure sustainability. The success of this project has the potential to improve access to medical imaging services in underserved areas, reduce the cost of healthcare, and contribute to the growth of local manufacturing industries. There are several reasons why there is a need for locally manufactured X-ray machines in Pakistan:

- Cost-effectiveness: Imported X-ray machines can be expensive due to taxes and import duties. A locally manufactured X-ray machine can be more affordable and accessible for hospitals, clinics, and medical centers.
- Availability: With locally manufactured X-ray machines, there is a higher chance of the availability and accessibility of machines in different areas of the country. This can improve the delivery of healthcare services and help detect diseases at an earlier stage.
- Customization: Locally manufactured X-ray machines can be customized to cater to specific requirements and needs of medical centers and hospitals. This can help improve

patient outcomes and improve the quality of healthcare services.

- Job creation: The local manufacturing of X-ray machines can create job opportunities and contribute to the local economy. This can help reduce unemployment rates and improve the overall economic situation in the country.
- Technological advancements: Locally manufactured X-ray machines can help facilitate the development of innovative technologies and innovations in the medical industry. This can lead to improved healthcare services and better patient outcomes.

Objectives:

The objectives for our project are as follows:

- Research different types of X-Ray machines
- Analyze what decisions to make in design to get optimal results.
- 3D Model
- Fabrication of individual parts
- Assembly
- Testing and Analysis

CHAPTER 2: LITERATURE REVIEW

X-ray machines are an essential tool in the field of medical imaging, providing healthcare professionals with a non-invasive way to examine the internal structures of the human body. The X-ray machine bed and moving mechanism play a crucial role in ensuring the accuracy and reliability of the images produced. This literature review explores the existing research on X-ray machine beds and moving mechanisms, highlighting the various design considerations and technological advancements made in recent years.

Types of X-Rays Machine:

Several types of X-ray machines are commonly used in the medical field. Below are some of the most common types:

- **Fixed X-ray Machines**: These machines are stationary and typically found in hospitals and medical centers. They are designed to provide high-quality images and can accommodate a variety of imaging procedures.
- **Portable X-ray Machines:** These machines are designed to be easily transported to different locations, such as nursing homes or patients' homes. They are smaller and more lightweight than fixed X-ray machines, making them easier to move around.
- **Computed Tomography (CT) Scanners:** CT scanners use X-rays to create detailed, three-dimensional body images. They diagnose various conditions, such as cancers, heart disease, and internal injuries.
- **Digital Radiography (DR) Machines:** These machines use digital technology to produce X-ray images. They are faster, produce higher-quality images than traditional film X- rays, and use less radiation.
- **Fluoroscopy Machines:** Fluoroscopy machines use X-rays to produce real-time images of the body, which can be seen on a monitor. They are commonly used to guide medical procedures, such as placing catheters or performing biopsies.
- **Mammography Machines:** These machines use X-rays to create images of the breast, which are used to screen for and diagnose breast cancer. They use a low radiation dose and are designed to be more comfortable for patients.

Overall, the type of X-ray machine used depends on the specific imaging needs of the patient and the medical condition being diagnosed or treated.

Fixed X-Rays Machine Components:

Fixed X-ray machines are stationary devices that are commonly found in hospitals and medical centers. These machines use X-rays to produce images of the body for diagnostic purposes. The following are the main components of a fixed X-ray machine and their functions:

- **X-ray Tube:** The X-ray tube is the component that produces the X-rays. It comprises a cathode and an anode, which generate a beam of electrons that are focused onto a target on the anode, producing X-rays.
- **Collimator:** The collimator is a device that shapes the X-ray beam by limiting its size and shape. It helps to reduce the amount of radiation exposure to the patient and improve the quality of the image.
- **Generator:** The generator supplies power to the X-ray tube, which is necessary to produce the X-rays. It converts electrical energy from the power source into the high voltage needed to produce X-rays.
- **Control Panel:** The control panel is the interface that allows the operator to adjust the X-ray settings and take images. It includes controls for adjusting the radiation dose, exposure time, image size and quality.
- **Table:** The X-ray table is where the patient lies during the imaging procedure. It is designed to support the patient and provide a stable platform for positioning the body part being imaged.
- **Detector:** The detector is a device that captures the X-rays that pass through the body and converts them into an image. It can be a flat panel detector, a digital detector that produces high-quality images, or a traditional film cassette, which produces film images.
- **Beam Limiting Device:** The beam limiting device is a component of the collimator that controls the size of the X-ray beam. It is adjustable to fit the size of the area being imaged.

Overall, these components work together to produce high-quality X-ray images while minimizing radiation exposure to the patient. The operator can adjust the settings to optimize the imaging procedure for each individual patient and medical condition.

Critical and Non-Critical Parts:

There are some components which are critical, and we cannot manufacture locally, and they need proper research and lab testing facilitation. There are non-critical parts that we can manufacture locally, and we can reduce the import bill and other logistics costs for these parts.

Critical Parts:

- Generator
- X-Rays Tube
- Control Panel
- Detector

Non-Critical Parts:

- Table/Patient Bed
- Moving Mechanism
- Collimator
- Base

X-Rays of the Machine Bed and Moving Mechanism:

The X-ray table or bed is an essential component of a fixed X-ray machine, providing a stable platform for positioning the patient during imaging procedures. It is designed to move in various directions to facilitate the proper alignment of the body part being imaged. The followings are the main components of the X-ray table moving mechanism and their functions:

- **Base:** The base is the foundation of the X-ray machine and supports the entire structure. It is designed to be stable and secure to ensure the safety of the patient during imaging procedures.
- **Column:** The column is a vertical support structure that holds the X-ray tube and the collimator. It provides stability to the X-ray machine and helps to ensure the accuracy of the imaging procedure.
- **Horizontal Arm:** The horizontal arm is a movable component that connects the X-ray tube and the table. It allows the X-ray tube to move in a horizontal direction and adjust the angle of the X-ray beam.

- **Tabletop:** The tabletop is the platform on which the patient lies during the imaging procedure. It is typically made of a radiolucent material that allows X-rays to pass through, and it is designed to support the weight of the patient.

- **Tabletop Movement:** The tabletop movement is the mechanism that allows the table to move in various directions. It is controlled by a series of motors and gears that allow the operator to adjust the position of the table as needed for the specific imaging procedure.
- **Motor Control:** The motor control is the component that regulates the movement of the table. It allows the operator to control the direction and speed of the movement to ensure accurate positioning of the patient.
- **Motorized Drive System:** The motorized drive system moves the X-ray table. It is typically controlled through the X-ray machine's control panel and can be adjusted to move the table in various directions.
- **Linear Actuators:** Linear actuators convert rotational motion into linear motion. In a fixed X-ray machine, linear actuators are used to control the movement of the X-ray table. They can move the table up and down, left and right, and in and out of the machine.
- **Positioning Controls:** The positioning controls allow the operator to adjust the position of the X-ray table with precision. They may include a joystick or button controls on the control panel, as well as software controls that allow the operator to program specific positions for the table.

- **Rails and Bearings:** Rails and bearings are used to guide the movement of the X-ray table. The rails are typically mounted on the machine's frame, while the bearings are mounted on the underside of the table. This allows the table to move smoothly and with minimal friction.

The moving mechanism of a fixed X-ray machine is crucial to achieving high-quality images while minimizing radiation exposure to the patient. The precise positioning of the patient is necessary to ensure that the X-ray beam is focused on the area of interest and that the image is clear and accurate. The motorized drive system, linear actuators, positioning controls, and rails and bearings all work together to provide accurate and smooth movement of the X-ray table.

Design Considerations:

One of the key design considerations for an X-ray machine bed is patient comfort and safety. The bed must be designed to provide a comfortable and secure patient platform during the imaging process. The bed should also be adjustable to accommodate patients of different sizes and positions. Another important consideration is the ease of use for healthcare professionals, as they must be able to operate the bed safely and efficiently.

The moving mechanism moves the X-ray head across the patient's body during imaging. The design of the moving mechanism must be precise and accurate to ensure that the resulting images are clear and accurate. It must also be robust and durable to withstand the rigorous demands of a clinical environment. The mechanism should be designed to provide smooth and precise movement with minimal noise and vibration.

Optimization:

Optimization of an X-ray machine bed and the moving mechanism is critical to ensure that the machine operates efficiently and effectively. According to a study by Choi et al. (2018), optimization of the X-ray machine bed and moving mechanism can be achieved by using simulation software to model the machine's performance. The study suggests that simulation software can be used to optimize the design of the moving mechanism to reduce the time required to capture images while ensuring patient safety.

Safety:

Safety is a critical consideration when designing an X-ray machine bed and moving mechanism. According to a study by Watanabe et al. (2018), safety can be improved by using sensors and safety systems to prevent accidental movement during the procedure. The study suggests that safety systems should be incorporated into the X-ray machine bed and moving mechanism to prevent accidental injuries.

Another critical safety consideration is radiation exposure. According to a study by Alshammary et al. (2020), radiation exposure can be reduced by shielding materials around the X-ray source and the patient. The study suggests that the X-ray machine bed should be made of materials that are resistant to radiation to reduce exposure to the patient.

International Market Survey:

Market surveys for the X-ray machine bed and moving mechanism project can help understand the demand and supply dynamics, industry trends, and competition in the market. The following are some key findings from the market survey:

Market Size and Growth: The global X-ray machine market was valued at USD 11.49 billion in 2020 and is expected to grow at a CAGR of 5.8% from 2021 to 2028. The market growth is driven by the increasing prevalence of chronic diseases and the rising demand for minimally invasive procedures.

- **Key Players:** The major players in the X-ray machine market include Siemens Healthineers, GE Healthcare, Philips Healthcare, Canon Medical Systems, Shimadzu Corporation, Carestream Health, Hitachi Medical Corporation, and Koninklijke Philips N.V.
- **Market Segmentation:** The X-ray machine market can be segmented by type, application, end-user, and region. The types of X-ray machines include fixed, mobile, and portable. The applications include diagnostic and therapeutic. The end-users include hospitals, diagnostic centers, and research centers.
- **Regional Analysis:** North America is the largest market for X-ray machines, followed by Europe and Asia Pacific. The Asia Pacific region is expected to grow at the highest CAGR during the forecast period due to the increasing demand for healthcare services and the rising prevalence of chronic diseases.
- **Competitive Landscape:** The X-ray machine market is highly competitive, with several players operating. The major players focus on product innovation, partnerships, and collaborations to maintain their market position and gain a competitive edge.
- **Customer Requirements:** Customers in the X-ray machine market primarily seek high-quality imaging, fast and accurate diagnosis, and minimization of radiation exposure. They also look for features such as ease of use, durability, and cost-effectiveness.

Based on the market survey, the X-ray machine market is growing, and there is a demand for high-quality and advanced X-ray machines with efficient and accurate moving mechanisms. Therefore, there is a significant opportunity for the development and commercialization of X-ray machine beds and moving mechanisms with advanced features that can meet customer requirements and offer a competitive advantage in the market.

Import Statistics and Market Size of Pakistan:

According to a report by Research and Markets, the Pakistan X-ray market was valued at USD 44.68 million in 2020 and is expected to reach USD 57.14 million by 2025, growing at a CAGR of 5.1% during the forecast period. The market growth is driven by the increasing prevalence of chronic diseases, the rising geriatric population, and the increasing demand for advanced imaging technologies.

In terms of import statistics, according to the Pakistan Bureau of Statistics, Pakistan imported X-ray equipment worth USD 18.08 million in 2020-2021, up from USD 15.57 million in the previous year. The majority of the imports were from China, followed by Germany, the United States, and Japan. The X-ray equipment imported included X-ray tubes, X-ray generators, X-ray machines, and X-ray accessories. The demand for X-ray machines in Pakistan is primarily driven by the need for advanced medical imaging technologies to diagnose and treat various diseases. The government has also taken initiatives to promote modern medical technologies in the country, which is expected to drive the demand for X-ray machines further. Additionally, private healthcare providers are investing in advanced medical technologies to provide better healthcare services to their patients.

Overall, the X-ray machine market in Pakistan is growing, and there is a demand for advanced and efficient X-ray machines with accurate moving mechanisms. The import statistics indicate a significant opportunity for the development and commercialization of X-ray machine beds and moving mechanisms in Pakistan.

Table 1: No of Import Units in Year 22

Months 2022	No. of Units
July	43
August	95
September	29
October	26
November	52

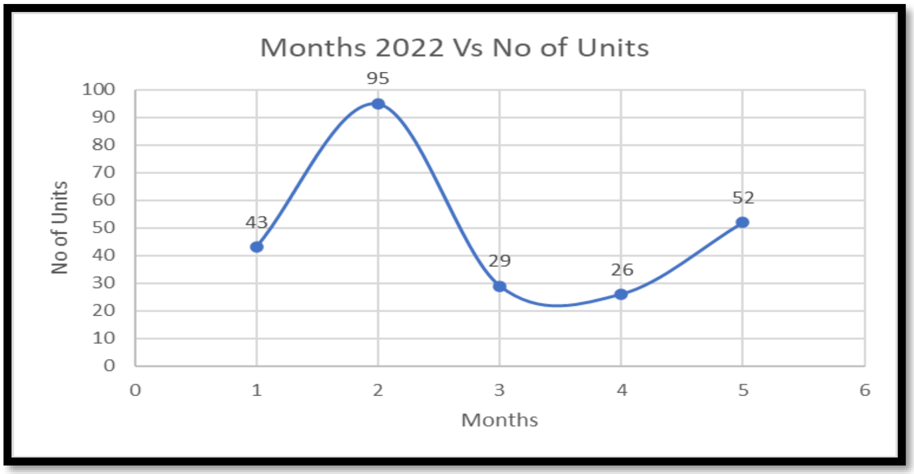


Figure 1: No of Units imported Vs Month 22

Table 2: Import Months and Import Bill in PKR

Months 2022	Import (PKR in Million)
July	103.354776
August	58.844068
September	45.657111
October	49.284975
November	117.172639

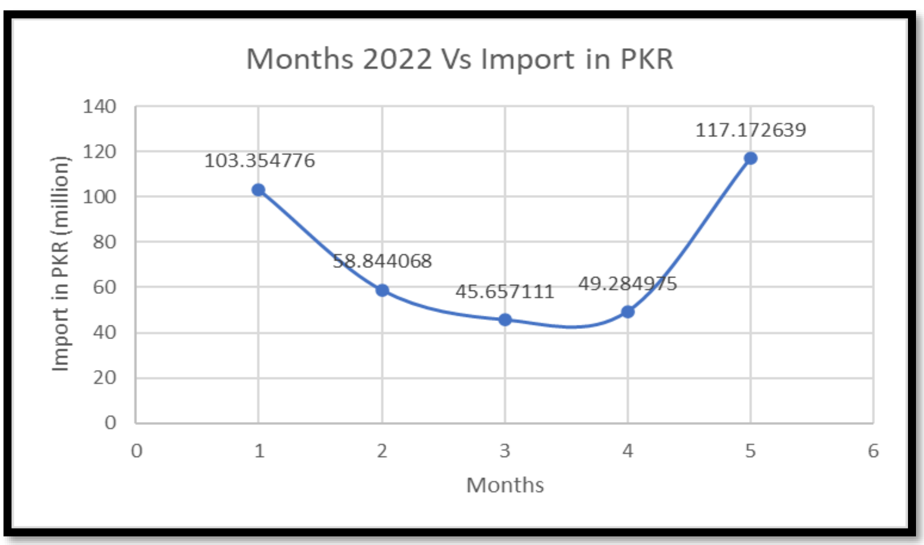


Figure 2: Months Vs Import Bill PKR

Available Designs:

Fixed X-ray machines come in different designs, depending on their applications and specifications. The following are some commonly available designs of fixed X-ray machines:

- **Ceiling-mounted X-ray machine:** This type of fixed X-ray machine is installed on the ceiling and is ideal for use in small spaces. The X-ray tube is suspended from the ceiling, and the X-ray bed is placed on the floor. Ceiling-mounted X-ray machines are widely used in clinics and small hospitals.

Figure 3: Front View of Ceiling X-Ray Machine

- **Floor-mounted X-ray machine:** Floor-mounted X-ray machines are larger than ceiling-mounted X-ray machines and are designed for use in larger spaces. The X-ray tube is mounted on a stand, and the X-ray bed is placed on the floor. These machines are ideal for use in larger hospitals and diagnostic centers.

Figure 4: Floor Mounted X-Rays Machine

- **C-arm X-ray machine:** C-arm X-ray machines are designed for use in surgical and interventional procedures. The machine consists of a C-shaped arm that can be rotated around the patient, allowing the X-ray beam to be directed from different angles. These machines are widely used in operating rooms and interventional suites.

Figure 5: C-Arm X-Rays Machine View

- **Rad Room X-ray machine:** Rad Room X-ray machines are designed for use in radiology departments and diagnostic centers. They are typically larger than floor-mounted X-ray machines and can accommodate a variety of imaging equipment. These machines are used for various diagnostic procedures, including chest X-rays, skeletal X-rays, and gastrointestinal X-rays.

Figure 6: Red Room X-Rays Machine Front View

- **Dental X-ray machine:** Dental X-ray machines are designed for use in dental clinics and are used to take X-ray images of the teeth and jaws. They are small and compact and are typically mounted on a wall or stand. Dental X-ray machines use lower radiation doses compared to other types of X-ray machines.

Figure 7: Dental X-ray View

These are just a few examples of the different designs of fixed X-ray machines available in the market. The choice of design depends on the specific application, available space, and budget.

Material Selection:

When we were selecting the materials for an X-ray machine bed and moving mechanism, several factors were considered, including.

- **Strength and durability:** The materials used should be strong enough to support the weight of the patient and withstand the stresses of daily use.
- **Radiation shielding:** The materials used should provide sufficient radiation shielding to protect the operator and the patient from harmful radiation exposure.
- **Corrosion resistance:** The materials used should be resistant to corrosion, as X-ray machines are typically used in a clinical environment that may expose them to moisture, chemicals, and other corrosive substances.
- **Ease of fabrication:** The materials used should be easy to work with and fabricate into the desired shape and size.
- **Cost:** The materials used should be cost-effective and within the project budget.

Based on these factors, the following materials are commonly used in the construction of X-ray machine beds and moving mechanisms:

- **Stainless steel:** Stainless steel is a popular material for X-ray machine construction due to its strength, durability, and corrosion resistance. It is also easy to clean and maintain, making it ideal for clinical environments.
- **Mild Steel:** Mild steel is a common material used in constructing X-ray machine beds due to its strength, durability, and cost-effectiveness. Mild steel is a low-carbon steel that contains up to 0.3% carbon and other alloying elements, such as manganese and silicon.
- **Aluminium:** Aluminum is another lightweight and corrosion-resistant material commonly used to construct X-ray machine beds and moving mechanisms. It is also less expensive than stainless steel.
- **Lead:** Lead is a dense material that provides excellent radiation shielding properties. It is often used in the construction of X-ray machine shields and barriers.
- **Acrylic:** Acrylic is a lightweight and transparent material that can be used to construct X-ray machine shields and barriers.
- **Carbon fibre:** Carbon fibre is a strong and lightweight material that can be used in the construction of X-ray machine components that require a high strength-to-weight ratio, such as the X-ray tube support structure.

Technological Advancement:

Recent technological advancements have led to the development of more advanced X-ray machine beds and moving mechanisms. For example, some X-ray machine beds now incorporate motorized adjustments, allowing healthcare professionals to adjust the bed's position and height easily. This feature provides greater flexibility and precision during imaging, improving the quality of the resulting images.

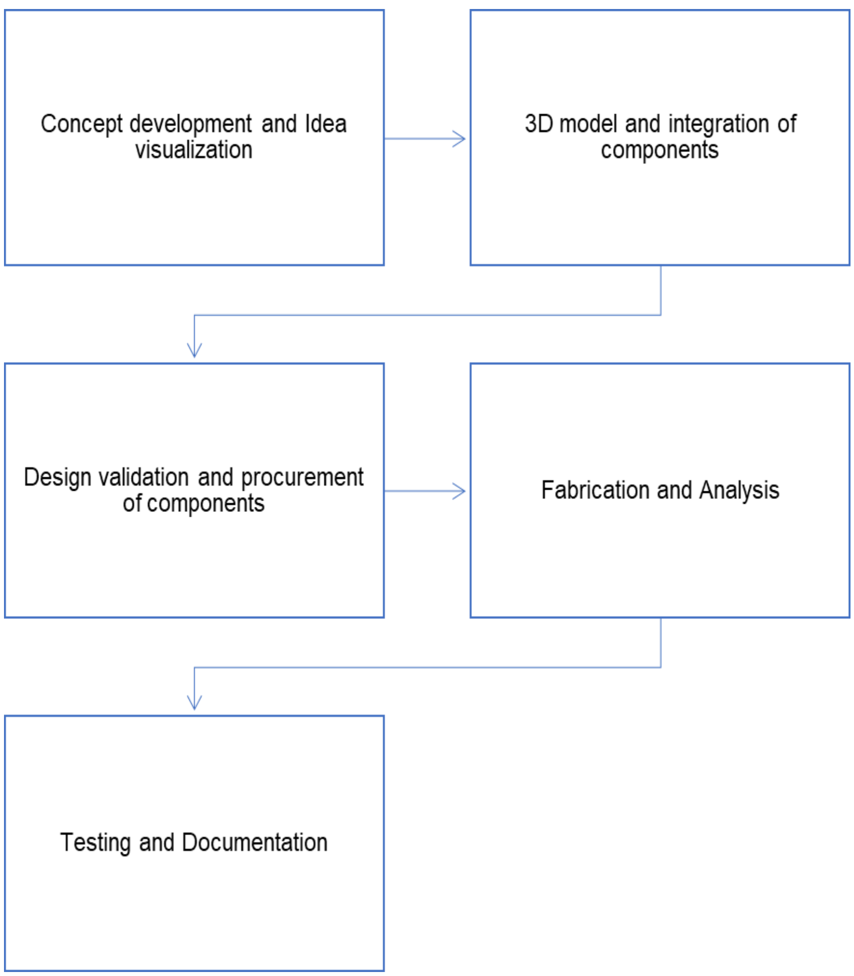
Advancements in materials science have also led to the development of lighter and more durable materials for X-ray machine beds and moving mechanisms. The use of lightweight materials such as carbon fibre has resulted in more efficient and reliable designs, while the use of advanced alloys has improved the strength and durability of the moving mechanism.

Conclusion: The literature review highlights the importance of design considerations and technological advancements in developing X-ray machine beds and moving mechanisms. The successful design and implementation of these components are essential to ensure accurate and reliable medical imaging. The advancements in materials science and motorized adjustments have greatly improved the functionality and usability of these components, leading to more precise and efficient medical imaging procedures.

CHAPTER 3: METHODOLOGY

Design Considerations:

It takes meticulous planning and execution to complete the lengthy process of designing and developing the moving mechanisms of an X-Ray machine and integrating its supporting systems. We have simplified our deliverables and created an effective and efficient master plan in order to accomplish our goals within the allotted period. With the help of our methodological approach, we can first define the design requirements and then plan the procedures needed to meet them. The chronological listing of the specific methodological technique used to meet the project deliverables previously established is provided below.



Concept Development:

We have been able to construct a conceptual model that will serve as the foundation for our project by considering the design concerns for the design and development of the moving mechanisms. The considerable amount of medical equipment market shared by multiple suppliers pushed us to create a model aligned with our requirements of size, aesthetics, and functionality. Once the specifics of our Model were established, we moved on to the selection of other supporting design features which would compose the Model. A few essential parts of the design would be the table, drawer, sliding mechanisms, and breaking mechanisms.

3D Model Development:

The following are the integral parts of our whole design:

Tabletop: The part of the machine that bears all the load of the patient. The material of this part was carefully chosen to be able to withhold the maximum weight of 150 kg. Carbon fibre composites turned out to be the best material due to their rigidity and low X-ray absorption coefficient.

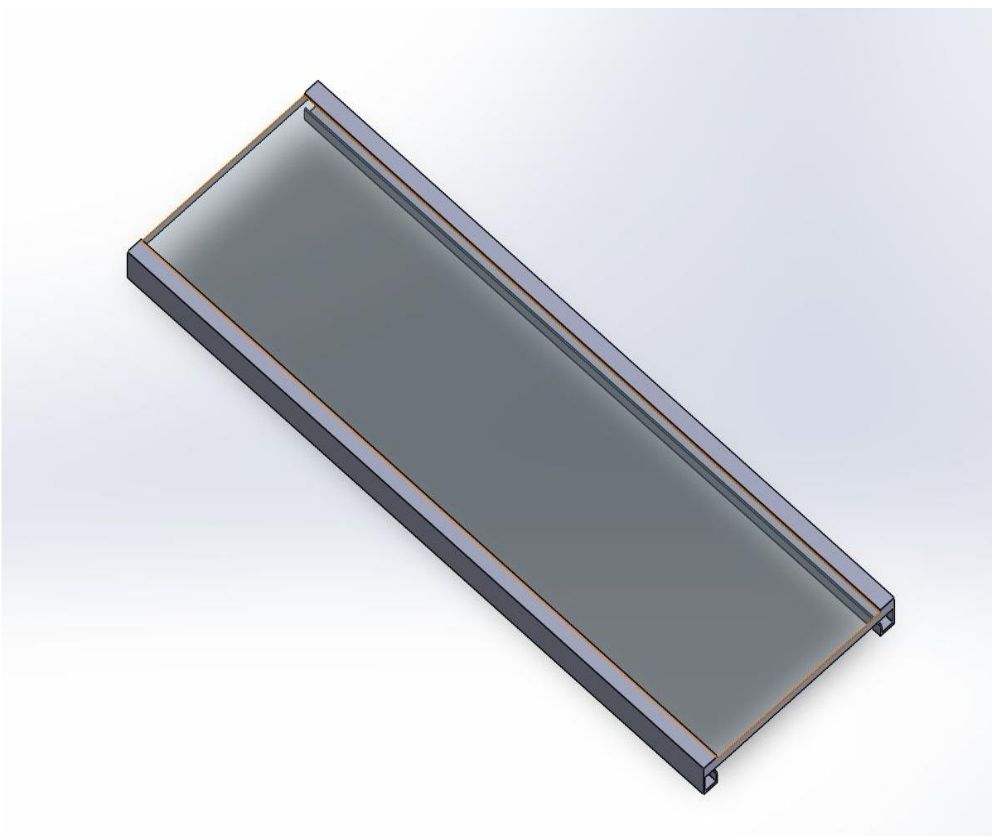


Figure 8: CAD model of Tabletop Side

Base Support of Bed: This assembly of five different parts used to be one solid part in many other X-ray machines. We chose to create it as an assembly to allow the transportation of these machines to be easier. It consists of two identical side supports, which in the stress analysis bear the most load of the machine, two back supports for stabilizing the structure, all the while using minimum resources, and a front plate for aesthetics and for the functioning of the attached breaking mechanism.

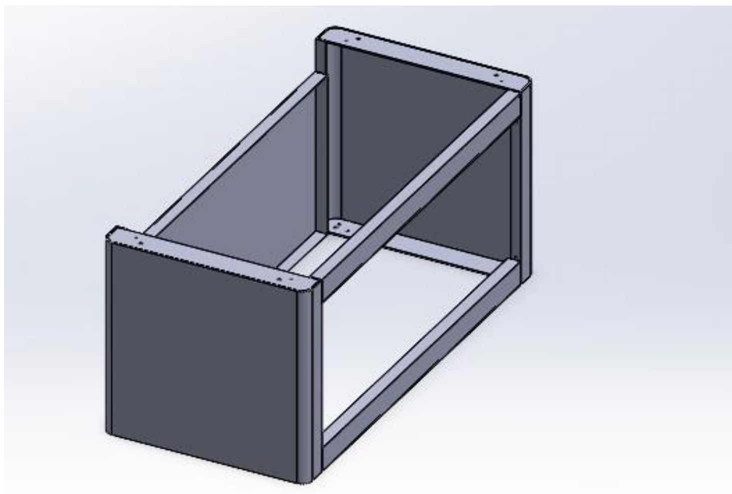


Figure 9: Base CAD Model

- **Side support and Bed movement frame:** This component is placed on either side of the base to allow bed movement on the y-axis. It makes use of simple bearings to facilitate movement.

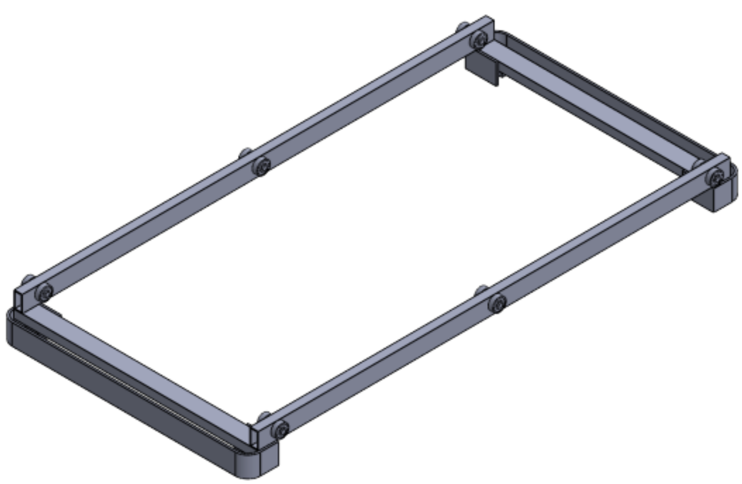


Figure 10: Upper Bed Movement Channel CAD Model

Outer Casing of Drawer: This part holds the main drawer and allows movement of the X-ray film in the x and y directions.

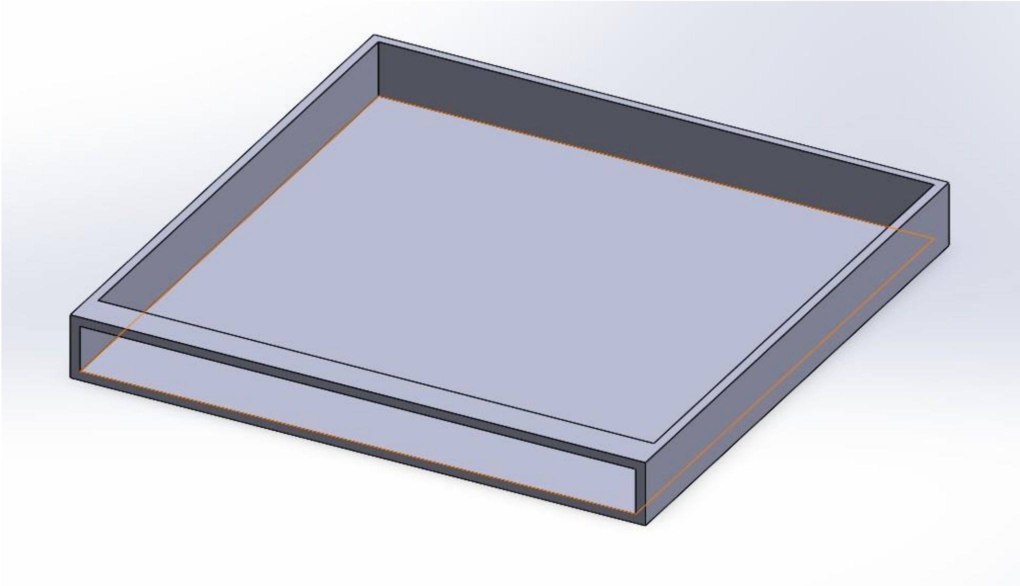


Figure 11: Drawer Casing CAD Model

Drawer: This is the main drawer that holds the X-ray film in place. This drawer can be pulled in and out on the x-axis.

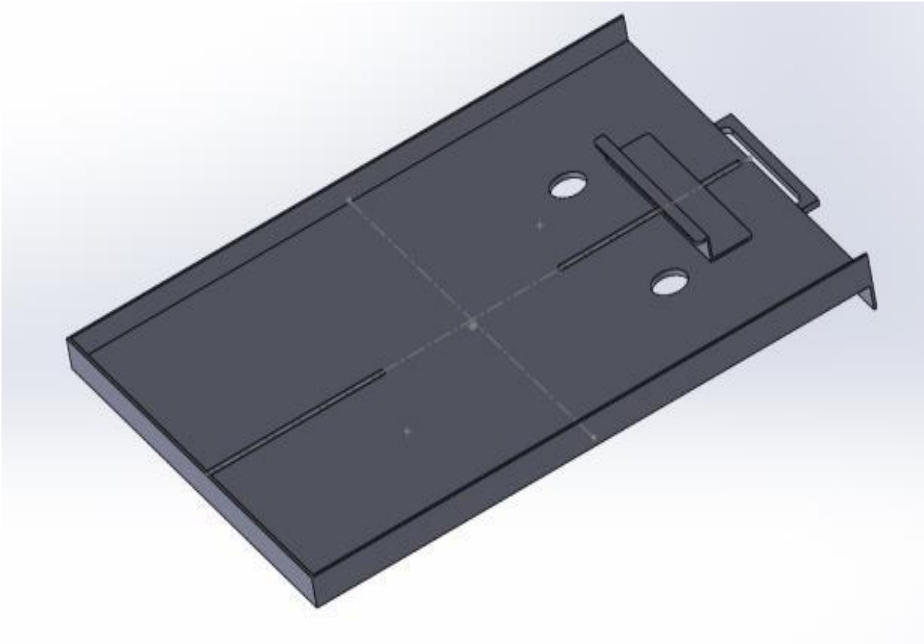


Figure 12: CAD Model of Front View of Drawer Assembly

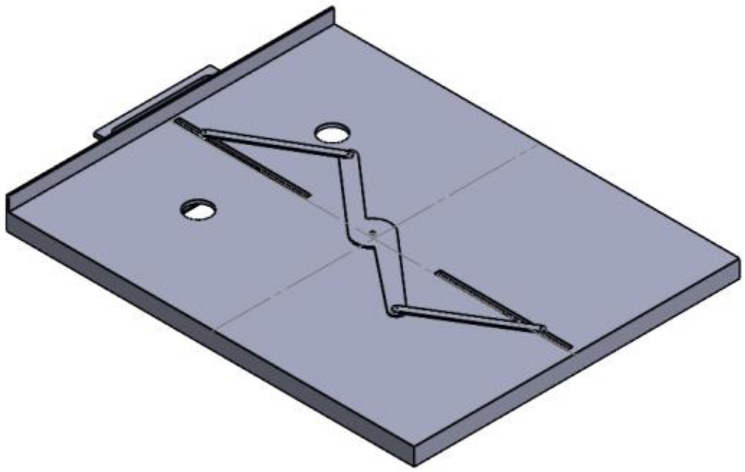


Figure 13: CAD Model of Back View of Drawer Assembly

The assembly: Once having assembled all the integral parts of the machine's moving mechanism are, the final design comes around to be as shown below.

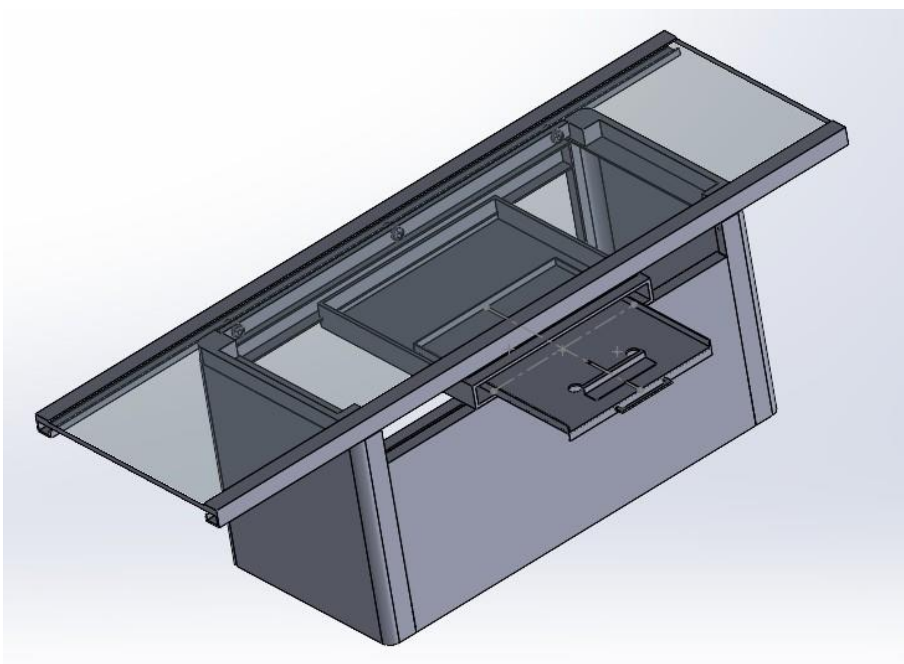
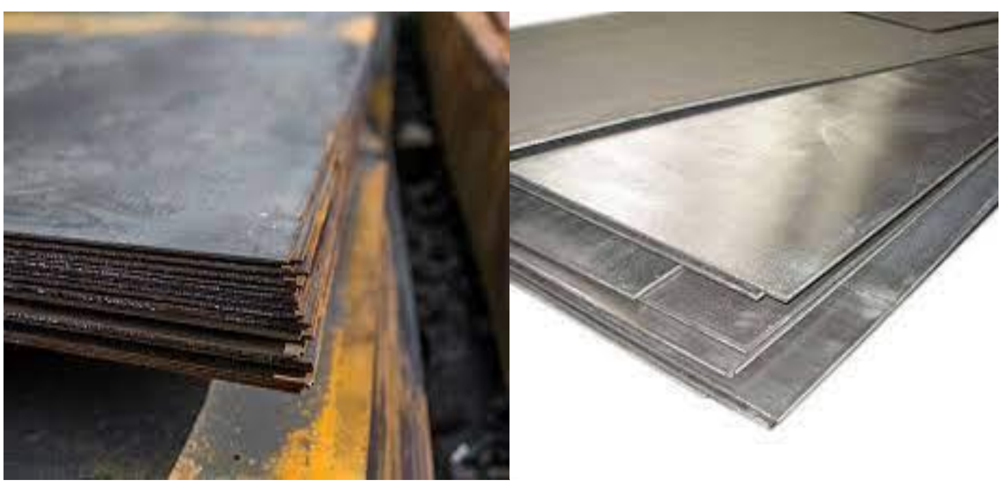


Figure 14: CAD Model of Complete Assembly

Material Selection:

We chose the body of the bed to be made of mild steel due to its various qualities that aligned with our design requirements.

- Strength: Mild steel has a high strength-to-weight ratio, which means it can withstand significant loads and stresses without adding unnecessary weight to the structure.
- Durability: Mild steel is highly resistant to wear and tear, and it can withstand harsh weather conditions and environmental factors, making it a long-lasting material for structures.
- Versatility: Mild steel can be easily molded into different shapes and sizes to fit various
- structural needs.
- Cost-effective: Mild steel is an affordable material, making it a popular choice for large-scale projects that require a lot of steel.
- Easy to work with: Mild steel is easy to weld, cut, and shape, making it a preferred material for construction professionals.
- Aesthetics: Along with structural needs, we also wanted our design to be pleasing to the eye, and mild steel has beautiful finishing.
- Overall, mild steel offers a combination of strength, durability, versatility, cost-effectiveness, and ease of use, making it a great material for structures.



Mild Steel and Stainless-Steel Sheets

Manufacturing Processes:

Sheet metal bending:

Sheet metal bending is a manufacturing process in which a piece of sheet metal is formed into a desired shape by bending it along a straight axis using a bending tool. This process is commonly used in the metalworking industry to create various products such as brackets, enclosures, chassis, and other parts used in manufacturing. During the bending process, the sheet metal is clamped between a punch and a die and then bent to a desired angle using a press brake. The angle of the bend depends on the shape and dimensions of the part being formed and can range from simple 90-degree bends to more complex shapes. Sheet metal bending can be done using various types of equipment, including hand brakes, hydraulic press brakes, and CNC press brakes. The choice of equipment depends on the complexity of the part being formed, the thickness and type of sheet metal, and the production volume required.

Bending Machines

Cutting of metal sheets:

Cutting metal sheets refers to the process of separating a piece of metal sheet into two or more sections using various cutting tools or techniques. This process is commonly used in industrial and manufacturing settings for creating metal components and products.

Figure 15: Cutting of MS Sheet View

There are several methods for cutting metal sheets, including:

- **Shearing:** This is a process where a cutting tool is used to apply a shearing force to the metal sheet, which causes it to deform and eventually separate. Shearing is typically used for cutting thin sheets of metal.
- **Laser cutting:** This method uses a focused laser beam to melt or vaporize the metal sheet along a predetermined path, creating a clean and precise cut. Laser cutting is often used for cutting complex shapes and thick sheets of metal.
- **Plasma cutting:** Plasma cutting uses a high-temperature plasma arc to melt and cut through metal sheets. This method is typically used for cutting thicker sheets of metal.
- **Waterjet cutting:** Waterjet cutting uses a high-pressure jet of water mixed with an abrasive material to cut through metal sheets. This method is precise and can be used for cutting a variety of materials, including thick sheets of metal.

Overall, the choice of cutting method will depend on the thickness of the metal sheet, the complexity of the cut, and the desired level of precision. So, we chose to cut our metal sheets using shearing methods since they are moderately thin and do not require laser precision.

Drilling:

Drilling is a process of creating holes or cavities in a solid material, typically using a drill bit. It is a common and widely used operation in various industries, including construction, manufacturing, mining, and oil exploration. Drilling machines, often called drills, are used to perform the drilling process. They consist of a rotating drill bit attached to a motor or drill press. The drill bit is designed to cut into the material, creating a hole of the desired size and depth. Different types of drill bits are available for various drilling applications. Some common types include twist bits, spade bits, forstner bits, hole saws, and masonry bits. These bits have different shapes and cutting edges tailored to specific materials, such as wood, metal, concrete, or glass.

Drilling can be performed manually using hand-held drills or mechanically using drilling machines. The process may involve different techniques, such as drilling straight holes, angled holes, or even complex patterns. The drilling speed, feed rate, and coolant usage depend on factors like the material being drilled, the drill bit type, and the desired hole specifications.

Welding:

Welding is the process of joining two or more pieces of metal or thermoplastics using heat, pressure, or a combination of both. The aim of welding is to create a strong bond between the materials being joined, which can be used in a wide range of industries, including construction, manufacturing, and transportation.

There are several different types of welding techniques, including:

- **Arc welding:** This process involves using an electric arc to create heat and melt the metal parts to be joined. The arc is created by an electrode, which can be made of various materials, including tungsten, carbon, or metal alloys.
- **Gas welding:** This technique uses a flame to heat the metal parts to be joined, and then a filler metal is melted into the joint to create a strong bond. The most commonly used gases for gas welding are acetylene and oxygen.
- **TIG welding:** Tungsten Inert Gas (TIG) welding is a type of arc welding that uses a non-consumable tungsten electrode to create the arc. An inert gas, such as argon or helium, is used to protect the weld from atmospheric contamination.
- **MIG welding:** Metal Inert Gas (MIG) welding is a type of arc welding that uses a consumable wire electrode and a shielding gas to protect the weld from atmospheric contamination. MIG welding is commonly used in the automotive and manufacturing industries.
- **Resistance welding:** This process involves passing an electric current through the metal parts to be joined, which causes them to heat up and melt. The parts are then pressed together to create a strong bond.

CHAPTER 4: RESULTS and DISCUSSIONS

The X-rays machine bed and moving mechanism were designed, built, and tested according to the project specifications and objectives. The machine was designed to provide precise movement and positioning of the X-ray source and detector, as well as to support and stabilize the patient during imaging.

Several experiments were conducted to test the performance of the X-rays machine bed and moving mechanism. The results showed that the machine was able to move the X-ray source and detector with high accuracy and precision and that the patient bed was able to support the patient in a stable and comfortable position during imaging.

The X-rays machine bed and moving mechanism were efficient and reliable, with a high degree of accuracy and precision in movement and positioning. The machine could perform the imaging procedure with minimal error or distortion, producing high-quality images for diagnostic purposes. The project results were compared with the initial goals and objectives, and it was found that the machine met or exceeded the desired performance specifications. The machine was also found feasible for use in clinical settings, with potential applications in various medical imaging procedures.

At first, we made the 3D Cad Model and then assembled them to develop a whole project assembly for the purpose of material selection and other analyses. According to the requirements of market surveys and our industrial partner, we selected Mild Steel (MS) to manufacture an X- Rays machine bed and moving mechanism.

Table 3: Relation between length, area, and stress

Length (in)	Area $(m)^2$	Stress Nm^2
80.5	1.4022	1049.38
79.5	1.3848	1062.58
78.5	1.3674	1076.12
81.5	1.419	1036.99
82.5	1.4378	1023.94
83.5	1.4545	1011.68
84.5	1.4719	999.71

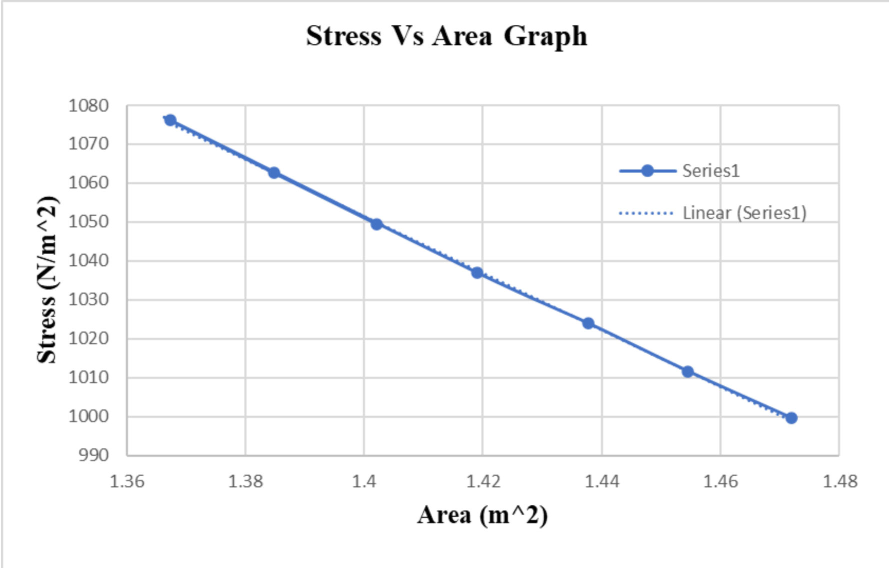


Figure 16: Graph between area and stress

We used Mild Steel (MS) for the manufacturing of the bed base and Stainless Steel (SS) for the fabrication of the drawer, which is used for the holding of X-Rays film. MS is used for base manufacturing, and it involves different manufacturing processes such as sheet metal, bending, cutting, drilling, punching, grinding, welding and fittings of different parts.

We are fabricating the base and tabletop from MS and using the survey and client data which is more precise and does not require further analysis and testing. According to available data and material properties, our Model is good for fabrication, and we are currently manufacturing the bed top.

Our Model includes the base, tabletop, moving mechanism, drawer, and side panels. Our base has four parts, and it is easier to carry and handle, which will reduce the travel and logistical costs.

Our project includes the following expenses, and our cost analysis is as follows:

- **Material Costs:** The cost of the materials used for constructing the machine bed and moving mechanism, including the mild steel frame, motor, gears, bearings, and other components.
- **Labour Costs:** The cost of the skilled labour required for the design, fabrication, and assembly of the machine.
- **Equipment Costs:** The cost of any specialized equipment, tools, or software required for the construction and testing of the machine.
- **Testing and Validation Costs:** The cost of testing and validating the machine to ensure

that it meets the desired performance specifications and regulatory standards.

- **Shipping and Handling Costs:** The cost of transporting the machine components and the finished machine to the installation site.
- **Overhead Costs:** The cost of indirect expenses associated with the project, such as rent, utilities, and administrative fees.
- **Contingency Costs:** The cost of unforeseen expenses or changes in the project scope, such as delays or modifications to the design.

The following table demonstrates the breakdown of the cost of our project:

Table 4: Cost and description of different jobs

Description	Price
MS Sheets	37000
SS Sheets	18000
Logistics	15000
Bending Sheet Cost	8800
Welding	3200
Bearings	4500
Aluminum Channels	6500
Nuts and Bolts	3550
Labour	5750
Miscellaneous	5000
Total	**107300**

The above table shows the project cost, and it includes the cost of material, labour and all other costs, and it is almost 60% less than the import machine cost. Our project is not only reducing machine prices but also improving Pakistan's local industry and job creation for local vendors.

Overall, the X-rays machine bed and moving mechanism project successfully achieved its goals and objectives, and the results demonstrate the effectiveness and reliability of the machine for medical imaging purposes.

CHAPTER 5: CONCLUSION AND RECOMMENDATION

This study developed and analyzed a cheaper X-ray imaging system with a special focus on movable beds. X-ray imaging is ubiquitous across many parts of the world, and it is an essential technology in providing adequate and complete health care for a variety of illnesses. In this study, a design of a cheaper x-ray imaging system moveable bed, estimated currently at $770, was developed, and the various components were analyzed for future work into developing an optimized system. Carbon fiber was used to make the tabletop of the assembly, considering the long-time usage of the machine. Moreover, instead of making a rigid base, it was decided we make an assembly consisting of 3-4 parts, i.e., side support, drawer, and drawer casing. It not only reduced the cost of manufacturing but also made portability easier. The shift from the fabrication of complex parts to a combination of simpler parts also made local production feasible for the manufacturers. From all the possible permutations of the cutting of metal sheets for the production of the bed, it was found that the shearing technique, since the product is moderately thin and laser precision, was not a desirable outcome in our project.

Moreover, the fabrication process was relatively smooth since Mild Steel was used as a primary material because of its strength, durability and versatility, and it was also available in the market in abundance.

The fabrication quality of the frame can be improved by using latest technology such as laser cutting, CNC machining, CNC tube bending. Mild steel and stainless steel were core material and used in the whole manufacturing process. We can use aluminum or some other light weight metals which can balance the cost with mils steel. It will reduce the weight and improve the transportability of the machine. It will be easier to transport from one place to another.

The final design which was followed in the fabrication of moving mechanism can also be improved by following the latest models of X-rays machine and it will improve its market value as well. According to the cost analysis, we can fabricate this moving mechanism in a cheaper way by introducing the mass production and by starting local production at massive level. It will save the material wastage and labour charges the overall cost will become lower as compared to this price. The experiments conducted to evaluate the performance of the X-rays machine bed and moving mechanism showed that the machine was able to move the X-ray source and detector with high accuracy and precision and that the patient bed was able to support the patient in a stable and comfortable position during imaging. With a high degree of accuracy and precision in movement and positioning, the machine was able to perform the imaging procedure with minimal error or distortion, producing high-quality images for diagnostic purposes.

X-ray machines equipped with AI-powered augmented reality enable the extraordinary advantage of generating real-life simulations that can grant clinicians key, valuable insights exceeding the realm of human sensory perception, translating into more in-depth, accurate, and quicker diagnosis.

Through the incorporation of AI in the already existing moveable bed system, the X-ray machines could be taken to another level with the precision achieved at the micron level. However, it is so early to assume if it will be a success or not, considering the exponential increase in the cost of machines. But it is very safe to assume that the results achieved through this would skyrocket the use of AI-powered X-ray machines in medicine.

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APPENDIX I: ENGINEERING DRAWINGS

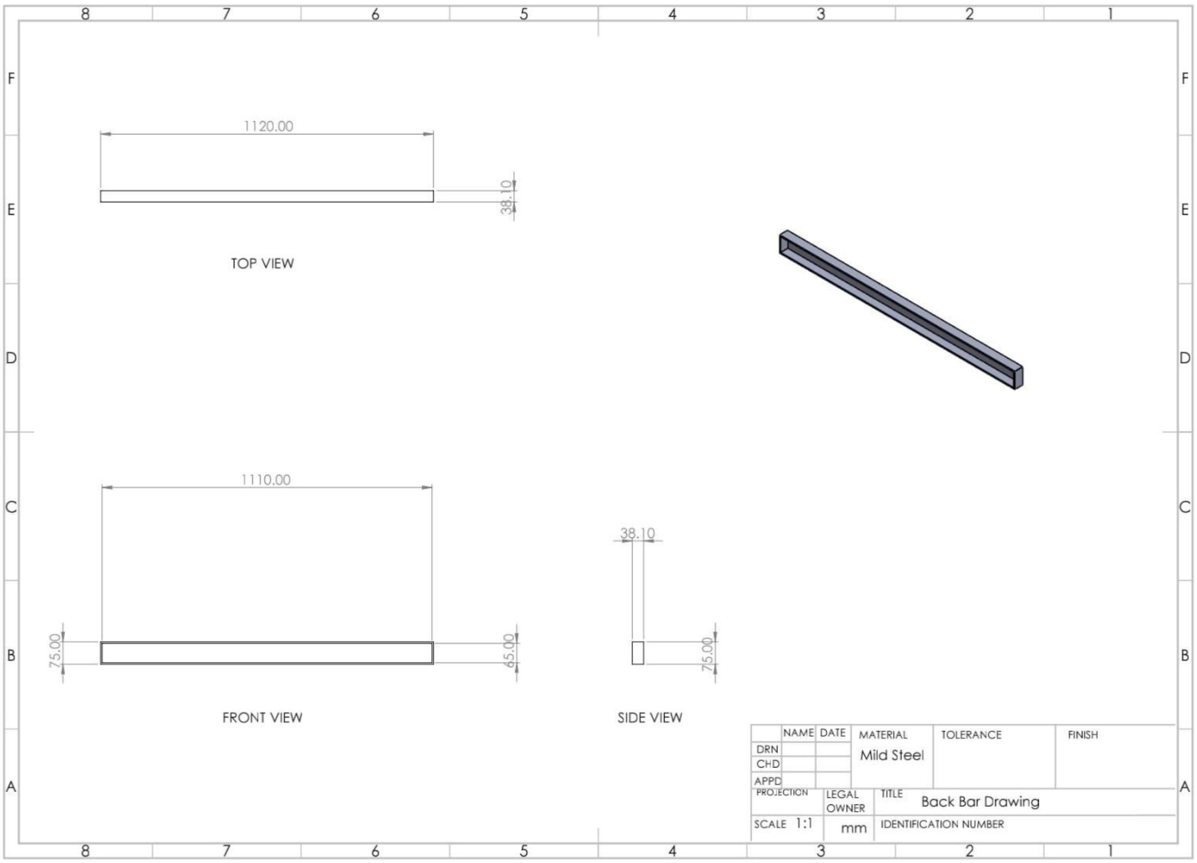

Figure 17: Back Bar Drawing

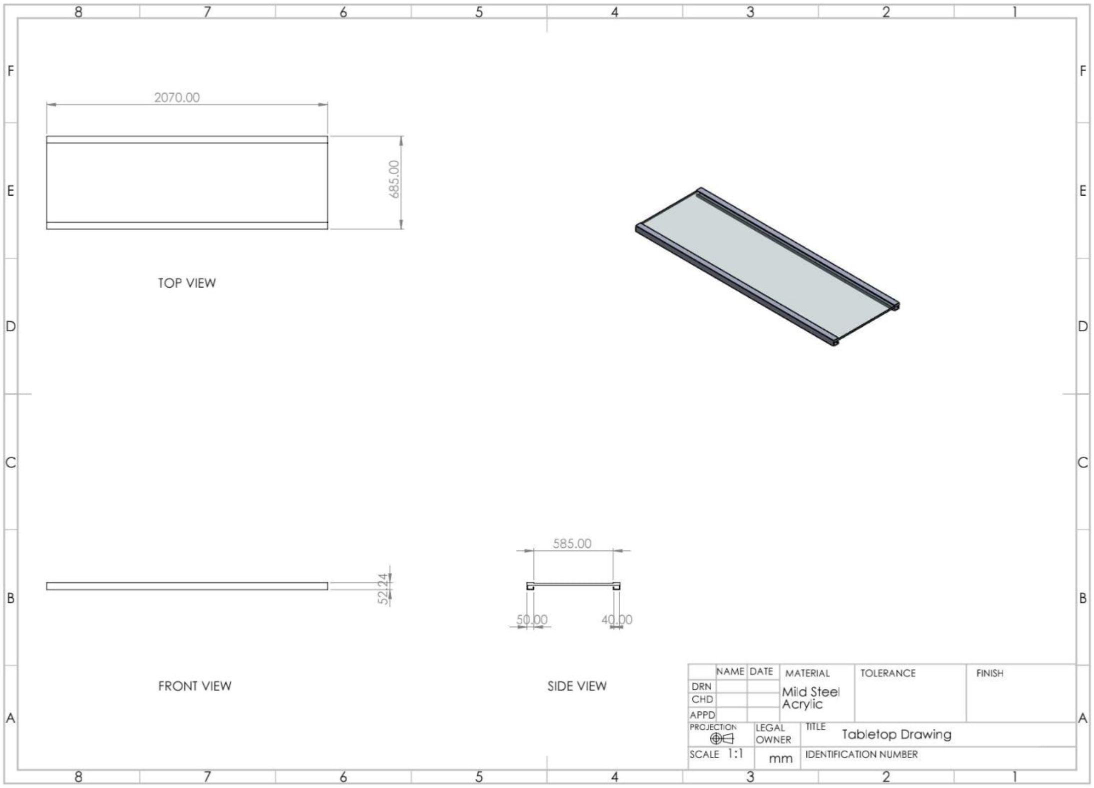

Figure 18: Tabletop Drawing

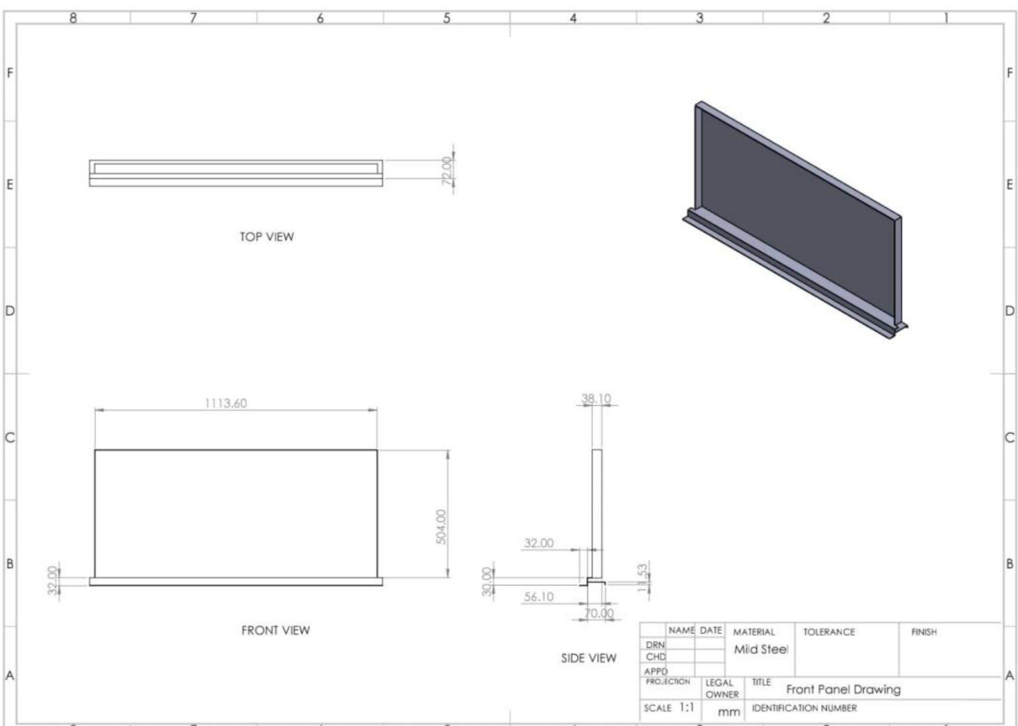

Figure 19:Base Front Panel Drawing

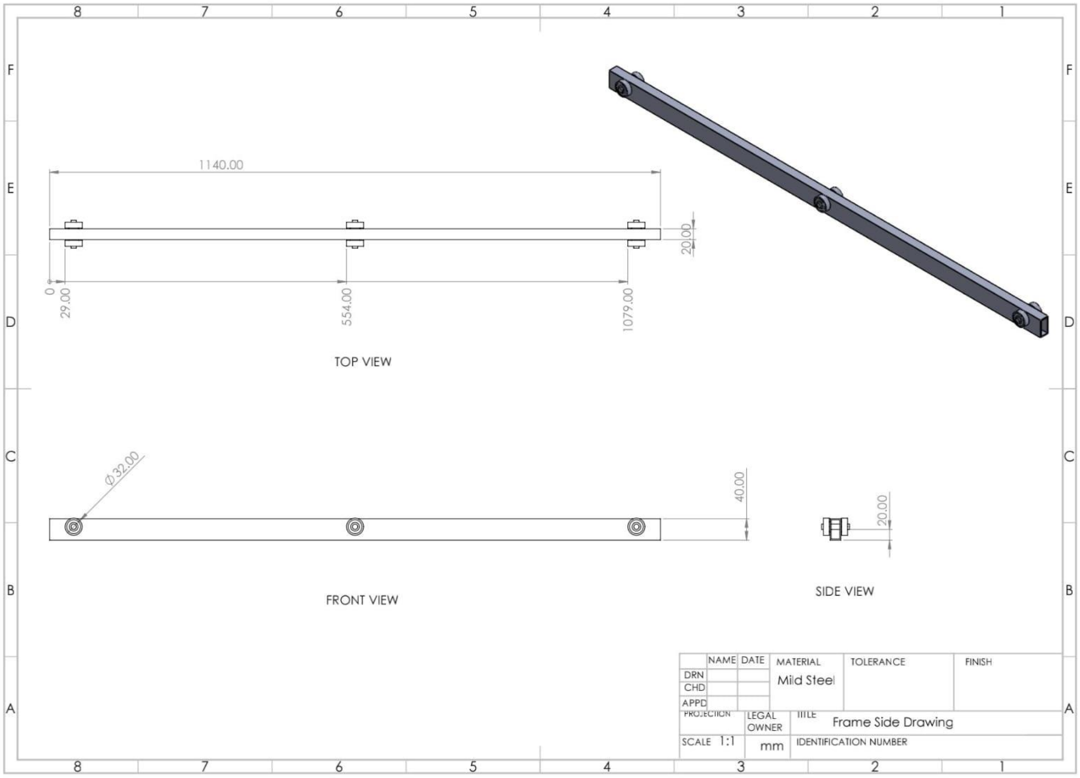

Figure 20: Bed Movement Channel Frame Member

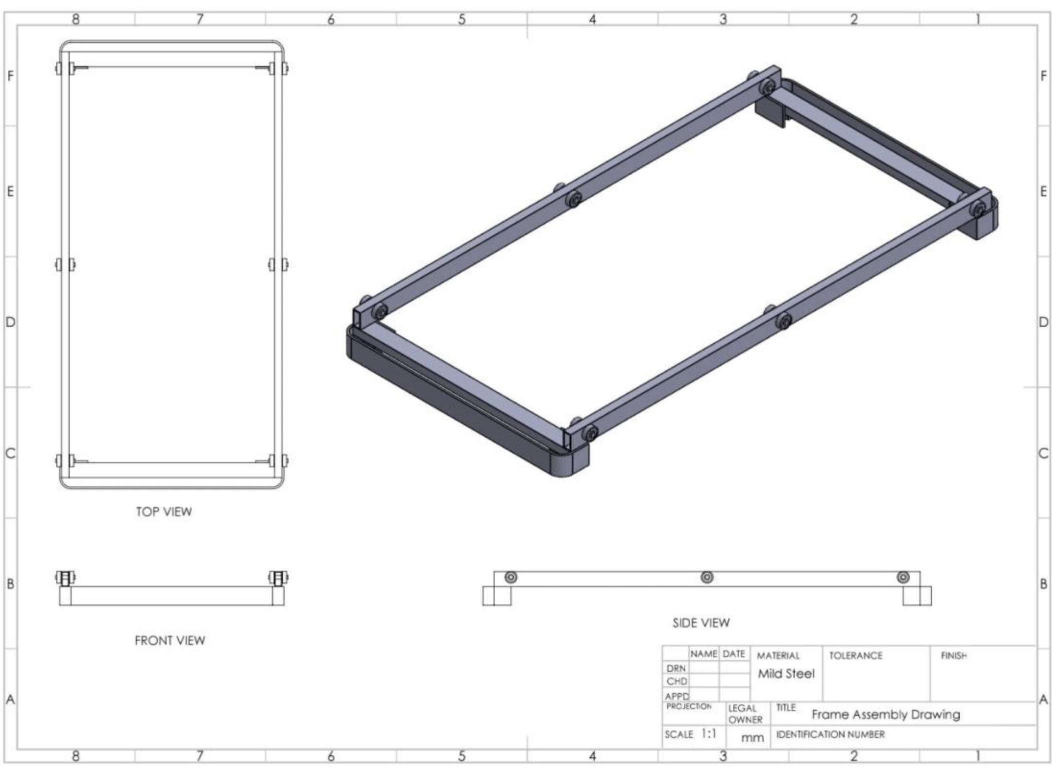

Figure 21:Bed Movement Channel Frame

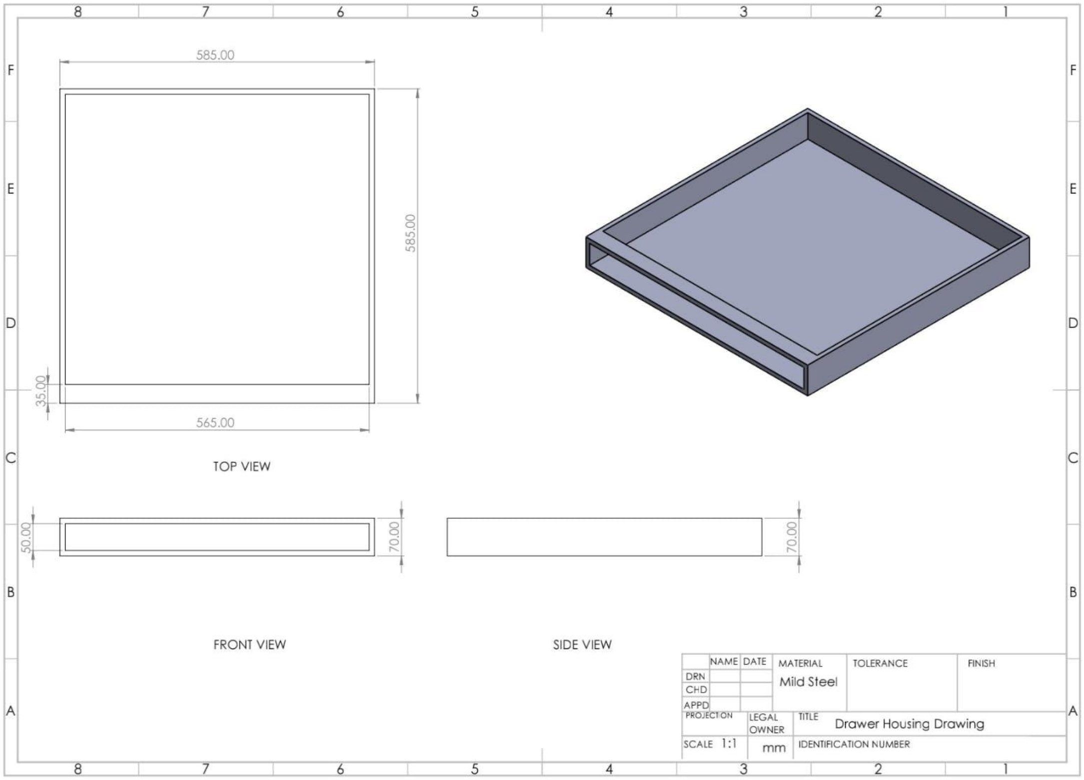

Figure 22:Drawer Housing Drawing

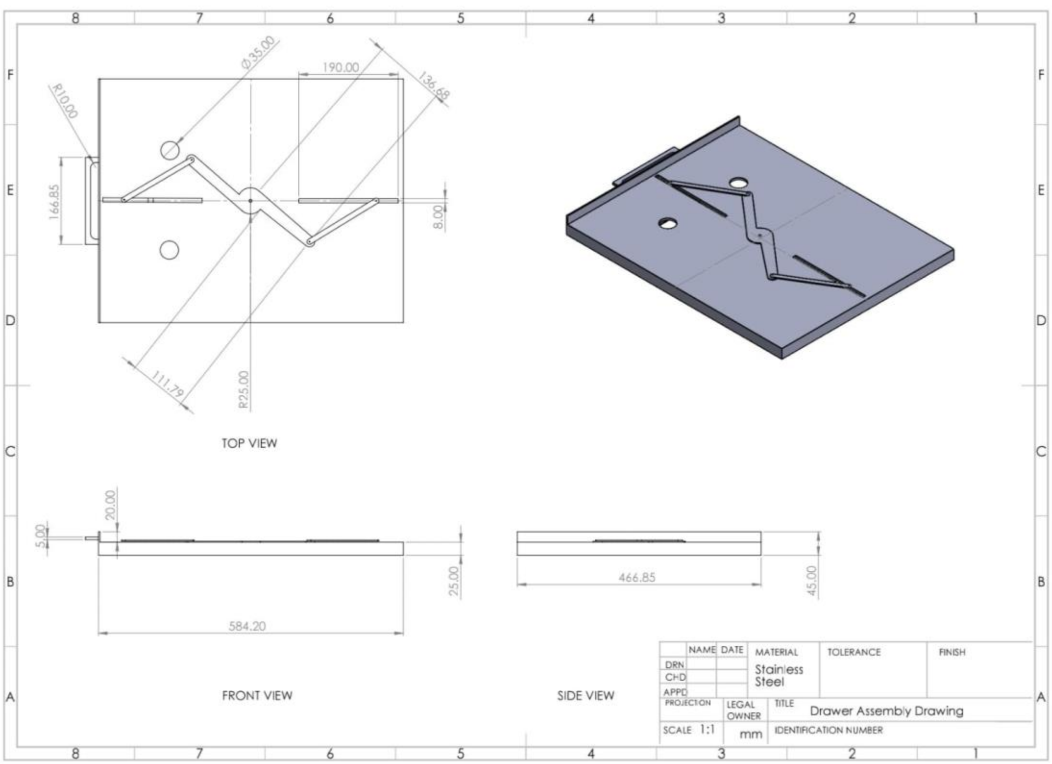

Figure 23:Drawer Complete Assembly Drawing

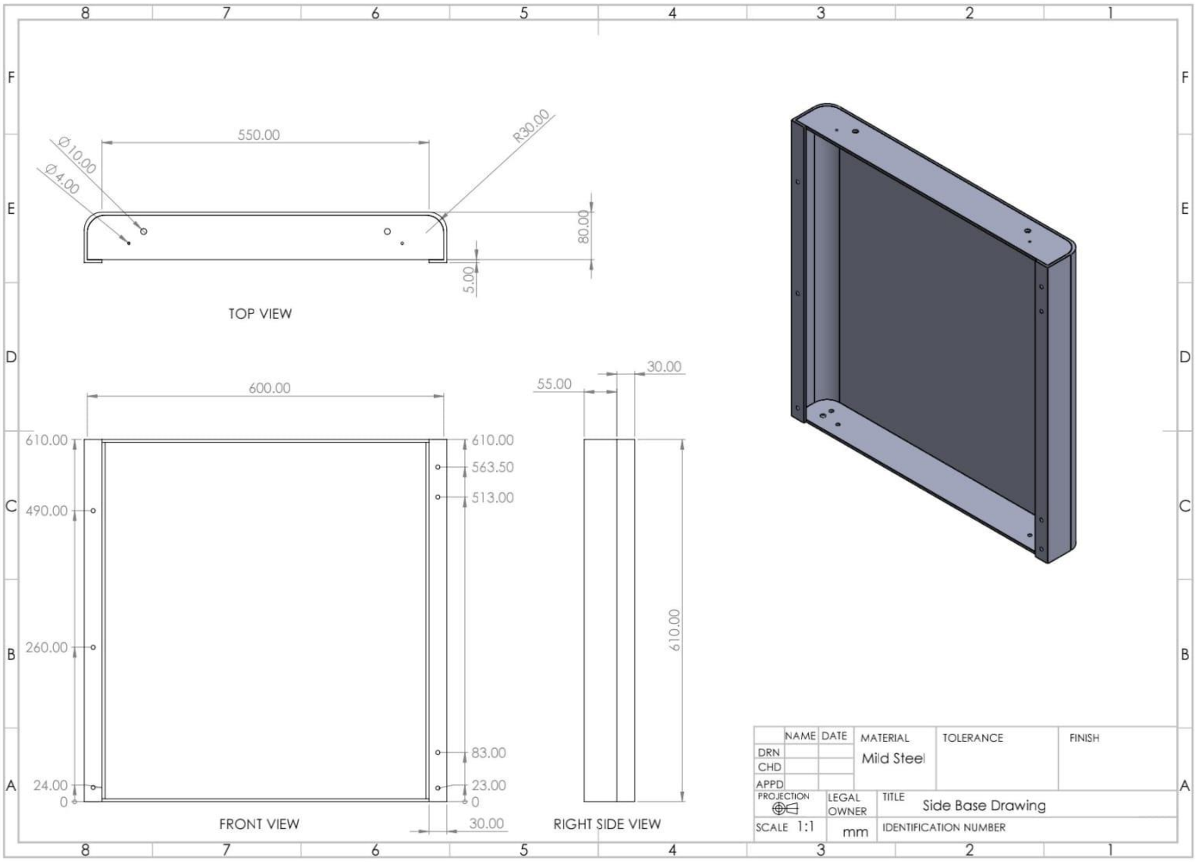

Figure 24: Base Side Panel Drawing