DESIGNING AND CONSTRUCTION OF AN ACTUATOR

A thesis submitted to the department of Mechanical and Chemical Engineering (MCE), Islamic University of Technology (IUT), in the partial fulfillment of the requirement for the degree of Bachelor of Science in Mechanical Engineering.

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DECLARATION

This is to certify that the work presented in this thesis is an outcome of the experiment and research carried out by the authors under the supervision of Prof. Dr. Md. Zahid Hossain and Dr. Mir Md. Maruf Morshed.

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We would also like to give thanks to all faculty members of the department for their advice and support throughout the project. All of us are indebted to our family members for their moral supports and prayers.

Although we tried our best to complete this thesis flawlessly, we seek apology if there is any mistake found in this report.

ABSTRACT

Actuator is a mechanism that puts something into automatic action.The goal of our project is to design and construct an actuator which will give an automatic action. For achieving this goal we needed to design a model of an actuator.By using designing software SOLIDWORKS we have proposed a design.After that we proceed with motion analysis of the system.From the analysis,we see that,we need some modification.Than we modified the design by consulting with our project teacher.When the designing part is completed,we look forward for its construction.Though we couldn’t establish the system completely in the lab yet,but if it is established in future then, It will supply and transmit a measured amount of energy for the operation of another mechanism or system.

Nevertheless, there remains ample room for further development and analysis.

CHAPTER 4-DESIGN EVALUATION:

CHAPTER 1

INTRODUCTION

1.1-ACTUATOR

An actuator is something that converts energy into motion. It also can be used to apply a force. An actuator typically is a mechanical device that takes energy — usually energy that is created by air, electricity or liquid — and converts it into some kind of motion. That motion can be in virtually any form, such as blocking, clamping or ejecting. Actuators typically are used in manufacturing or industrial applications and might be used in devices such as motors, pumps, switches and valves. An **actuator** is a type of motor for moving or controlling a mechanism or system. It is operated by a source of energy, typically electric current, hydraulic fluid pressure, or pneumatic pressure, and converts that energy into motion. An actuator is the mechanism by which a control system acts upon an environment. The control system can be simple (a fixed mechanical or electronic system), software-based (e.g. a printer driver, robot control system), or a human or other agent.

It is one that activates, especially a device responsible for actuating a mechanical device, such as one connected to a computer by a sensor link. a servomechanism that supplies and transmits a measured amount of energy for the operation of another mechanism or system. A mechanism that furnishes the force required to displace a control surface or other control element.

1.2-Energy Sources

Perhaps the most common type of actuator is powered by air and is called a pneumatic cylinder or air cylinder. This type of actuator is an air-tight cylinder, typically made from metal, that uses the stored energy of compressed air to move a piston when the air is released or uncompressed. These actuators are most commonly used in manufacturing and assembly processes. Grippers, which are used in robotics, use actuators that are driven by compressed air to work much like human fingers.

An actuator also can be powered by electricity or hydraulics. Much like there are air cylinders, there also are electric cylinders and hydraulic cylinders in which the cylinder converts electricity or hydraulics into motion. Hydraulic cylinders, which use liquids, are often found in certain types of vehicles.

Many actuators have more than one type of power source. Solenoid valves, for example, can be powered by both air and electricity. Alternatively, a solenoid can be powered by both hydraulics and electricity.

1.3-Types of actuator

A **hydraulic actuator** consist of a cylinder or fluid motor that uses hydraulic power to facilitate mechanical operation. The mechanical motion gives an output in terms of linear, rotary or oscillatory motion. Because liquid cannot be compressed, a hydraulic actuator can exert considerable force, but is limited in acceleration and speed.

A **pneumatic actuator** converts energy formed by compressed air at high pressure into either linear or rotary motion. Pneumatic energy is desirable for main engine controls because it can quickly respond in starting and stopping as the power source does not need to be stored in reserve for operation.

An **electric actuator** is powered by motor that converts electrical energy to mechanical torque. The electrical energy is used to actuate equipment such as multi-turn valves. It is one of the cleanest and most readily available forms of actuator because it does not involve oil.

A **mechanical actuator** functions by converting rotary motion into linear motion to execute movement. It involves gears, rails, pulleys, chains and other devices to operate.

1.4-Performance metrics

Performance metrics for actuators include speed, acceleration, and force (alternatively, angular speed, angular acceleration, and torque), as well as energy efficiency and considerations such as mass, volume, operating conditions, and durability, among others.

1.5-Applications of actuator

In engineering, actuators are frequently used as mechanisms to introduce motion, or to clamp an object so as to prevent motion. In electronic engineering, actuators are a subdivision of transducers. They are devices which transform an input signal (mainly an electrical signal) into motion. Electrical motors, pneumatic actuators, hydraulic pistons, relays, comb drives, piezoelectric actuators, thermal bimorphs, digital micromirror devices and electroactive polymers are some examples of such actuators.

Motors are mostly used when circular motions are needed, but can also be used for linear applications by transforming circular to linear motion with a lead screw or similar mechanism. On the other hand, some actuators are intrinsically linear, such as piezoelectric actuators. Conversion between circular and linear motion is commonly made via a few simple types of mechanism including:

- **Screw**: Screw jack, ball screw and roller screw actuators all operate on the principle of the simple machine known as the screw. By rotating the actuator's nut, the screw shaft moves in a line. By moving the screw shaft, the nut rotates.
- **Wheel and axle**: Hoist, winch, rack and pinion, chain drive, belt drive, rigid chain and rigid belt actuators operate on the principle of the wheel and axle. By rotating a wheel/axle (e.g. drum, gear, pulley or shaft) a linear member (e.g. cable, rack, chain or belt) moves. By moving the linear member, the wheel/axle rotates.

In virtual instrumentation, actuators and sensors are the hardware complements of virtual instruments.

1.6-SOLIDWORKS

SolidWorks is a 3D mechanical CAD (computer-aided design) program that runs on Microsoft Windows and is being developed by Dassault Systemes SolidWorks Corp., a subsidiary of Dassault Systemes, S. A. (Velizy, France). SolidWorks is currently used by over 2 million engineers and designers at more than 165,000 companies worldwide.

1.7**Modeling methodology**

SolidWorks is a Parasolid-based solid modeler, and utilizes a parametric feature-based approach to create models and assemblies.

Parameters refer to constraints whose values determine the shape or geometry of the model or assembly. Parameters can be either numeric parameters, such as line lengths or circle diameters, or geometric parameters, such as tangent, parallel, concentric, horizontal or vertical, etc. Numeric parameters can be associated with each other through the use of relations, which allows them to capture design intent.

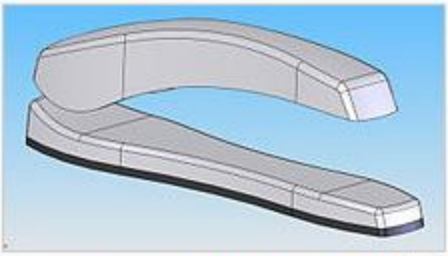
Design intent is how the creator of the part wants it to respond to changes and updates. For example, you would want the hole at the top of a beverage can to stay at the top surface, regardless of the height or size of the can. SolidWorks allows the user to specify that the hole is a feature on the top surface, and will then honor their design intent no matter what height they later assign to the can.

Features refer to the building blocks of the part. They are the shapes and operations that construct the part. Shape-based features typically begin with a 2D or 3D sketch of shapes such as bosses, holes, slots, etc. This shape is then extruded or cut to add or remove material from the part. Operation-based features are not sketch-based, and include features such as fillets, chamfers, shells, applying draft to the faces of a part, etc.

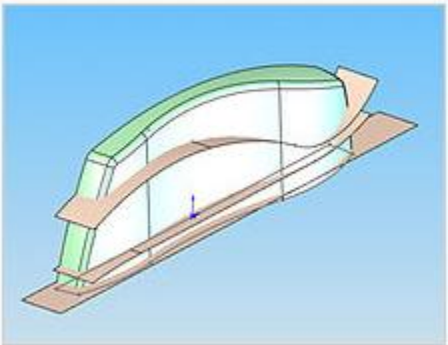
Building a model in SolidWorks usually starts with a 2D sketch (although 3D sketches are available for power users). The sketch consists of geometry such as points, lines, arcs, conics (except the hyperbola), and splines. Dimensions are added to the sketch to define the size and location of the geometry. Relations are used to define attributes such as tangency, parallelism, perpendicularity, and concentricity. The parametric nature of SolidWorks means that the dimensions and relations drive the geometry, not the other way around. The dimensions in the sketch can be controlled independently, or by relationships to other parameters inside or outside of the sketch.

In an assembly, the analog to sketch relations are mates. Just as sketch relations define conditions such as tangency, parallelism, and concentricity with respect to sketch geometry, *assembly mates* define equivalent relations with respect to the individual parts or components, allowing the easy construction of assemblies. SolidWorks also includes additional advanced mating features such as gear and cam follower mates, which allow modeled gear assemblies to accurately reproduce the rotational movement of an actual gear train.

Finally, drawings can be created either from parts or assemblies. Views are automatically generated from the solid model, and notes, dimensions and tolerances can then be easily added to the drawing as needed. The drawing module includes most paper sizes and standards (ANSI, ISO, DIN, GOST, JIS, BSI and SAC).



screen shot captured from a SolidWorks top-down design approach.



screen shot captured from a SolidWorks top-down design approach.

1.8-3D mechanical design applications

SolidWorks Standard

SolidWorks Professional

SolidWorks Premium provides a suite of product development tools mechanical design, design verification, data management, and communication tools. SolidWorks Premium includes all of the capabilities of SolidWorks Professional as well as routing and analysis tools, including SolidWorks Routing, SolidWorks Simulation, and SolidWorks Motion.

SolidWorks Education Edition provides the same design functionality but is configured and packaged for engineering and industrial design students.

1.9-Design validation tools

SolidWorks Simulation is a design validation tool that shows engineers how their designs will behave as physical objects.

SolidWorks Motion is a virtual prototyping tool that provides motion simulation capabilities to ensure designs function properly.

SolidWorks Flow Simulation is a tool that tests internal and external fluid-flow simulation and thermal analysis so designers can conduct tests on virtual prototypes.

SolidWorks Simulation Premium is a Finite Element Analysis (FEA) design validation tool that can handle some multiphysics simulations as well as nonlinear materials.

SolidWorks Sustainability is a product that measures the environmental impact of designs while they are modeled in SolidWorks.

1.10-Product data management tools

SolidWorks Workgroup PDM is a PDM tool that allows SolidWorks users operating in teams of 10 members or less to work on designs concurrently. With SolidWorks PDM Workgroup, designers can search, revise, and vault CAD data while maintaining an accurate design history.

SolidWorks Enterprise PDM is a PDM tool that allows SolidWorks users operating in teams at various separate facilities to work on designs concurrently. With SolidWorks Enterprise PDM, designers can search, revise, and vault CAD data while maintaining an accurate design history. Enterprise PDM maintains an audit trail, is compatible with a variety of CAE packages (AutoDesk, Siemens, PTC, Catia, etc.) to maintain interfile relations, and will manage the revisions of any document saved in the vault. Enterprise PDM also uses a workflow diagram to automatically notify team members when a project moves from one stage to the next, as well as tracking comments. Enterprise PDM is capable of interfacing with various MRP/ERP systems and can be used online to interface with customers and the supply chain.

'SolidWorks n!Fuze' is a cloud-based PDM tool that allows users operating in different locations to collaborate while providing many of the features of SolidWorks Enterprise PDM with less IT infrastructure in-house.

1.11-Design communication and collaboration tools

eDrawings Professional An e-mail-enabled communication tool for reviewing 2D and 3D product design data across the extended product development team. eDrawings generates accurate representations of **DWGgateway** is a free data translation tool that enables any AutoCAD software user to open and edit any DWG file, regardless of the version of AutoCAD it was made in.

Mobile eDrawings

SolidWorks Viewer is a free plug-in for viewing SolidWorks parts, assemblies, and drawings.

'**3DVIA Composer'**, now known as '**SolidWorks Composer'**, is a technical communications software that allows 3D views of models to be integrated into documents such as work instructions, internal or external manuals, marketing materials, or web applications. The 3D views can be updated automatically when the design updates, reducing the workload of the employee creating the technical document, as editing for changes is not as severe.

1.12- CAD productivity tools

SolidWorks Toolbox is a library of parts that uses "Smart Part" Technology to automatically select fasteners and assemble them in the desired sequence.

SolidWorks Utilities is software that lets designers find differences between two versions of the same part, or locate, modify, and suppress features within a model.

FeatureWorks is feature recognition software that lets designers make changes to static geometric data, increasing the value of translated files. With FeatureWorks, designers can preserve or introduce new design intent when bringing 3D models created in other software into the SolidWorks environment.

1.13- Specialty design tools

SolidWorks Routing,**SolidWorks Electrical**

SolidWorks Plastics is a mold design validation tool that was built into a solid modeling environment. It enables mold designers to quickly and easily validate whether a plastic injection-molded part can be filled.

SolidWorks MoldBase is a catalog of standard mold base assemblies and components. The package enables designers to generate a completely assembled mold base.

Print3D is a 3D printing feature that allows users to convert their 3D CAD model to an .STL file and then have it sent to specialty manufacturers for quote. The .STL files can be used to generate an instant binding quoted using the Quickquote technology.

DriveWorks Xpress DriveWorksXpress is rules-based design automation tool for engineers.

CHAPTER-2

2.1-literature review

In the recent past, it has been observed that the research in the field of actuator is unceasingly accruing immense importance in the modern science, due to the significant role in every field of applied sciences.Here is some work given from previous work.

2.1.1- A literature review on modeling and control design for electrostatic microactuators with fringing and squeezed film damping effects

A literature review concerning the modeling and control design aspects of electrostatic micro-actuators is presented in this article. The modeling issues of electrostatic micro actuators with fringing and squeezed film damping effects are presented followed by control strategies that have already been applied in such systems. As a special use, the analytic model and suboptimal robust control of a micro Cantilever Beam (μCB) with fringing and squeezed thin film damping effects is presented. The suspended clamped-free μCB can move via the application of an external electrically induced force. The nonlinear model of the μCB is linearized in multiple operating points with respect to the beam's tip-end displacement. A robust H_∞-controller relying on the LMI-theory is designed for the set of the resulting multiple operating models. Particular attention is paid in order to examine the stability issue within the intervals of the operating points. Simulation results investigate the efficacy of the suggested modeling and control techniques.

2.1.2- A generalized asymmetric play hysteresis operator for modeling hysteresis nonlinearities of smart actuators

Smart actuators such as shape memory alloy actuators, magnetostrictive actuators, and piezoceramic actuators show different symmetric and asymmetric hysteresis loops. Shape memory alloy actuators and magnetostrictive actuators, as an example, exhibit saturated output at maximum and/or minimum input. In this paper, a generalized Prandtl-Ishlinskii model is formulated to characterize hysteresis nonlinearities of different smart actuators. In this model, a generalized asymmetric play hysteresis operator is proposed and integrated with a density function to characterize different asymmetric hysteresis loops of smart actuators. This modified play hysteresis operator shows the capability to generate minor and major hysteresis loops with varying slopes of ascending and descending input-output curve. Moreover, this operator exhibits saturated major and minor input-output relationships. The capability ability of the proposed model to characterize hysteresis loops of different smart actuators is demonstrated by comparing its output with measured saturated symmetric and asymmetric hysteresis loops of SMA actuators and magnetostrictive actuators.

2.1.3- New actuators and their applications: from nano actuators to mega actuators

The present report describes R&D activities on new actuators undertaken at our laboratory at Okayama University for the past three years. These activities include various types of actuators, such as electromagnetic, electrostatic, piezoelectric, pneumatic, and hydraulic actuators, ranging in size and force from the nano to the mega range. These actuators are described in four categories: microactuators, power, intelligence, and novel principle.

2.1.4- A comparison of muscle with artificial actuators

'Artificial' actuator technologies under development include shape memory alloys, piezoelectric actuators, magnetostrictive actuators, contractile polymers and electrostatic actuators. The relevant properties of muscle are outlined and compared with a variety of artificial actuators. These and other actuators, such as regular and superconducting electromagnetic motors, internal combustion engines, hydraulic motors, pneumatic actuators, are reviewed and compared with muscle elsewhere.

2.1.5-Development of electromagnetic linear actuators for micro robots

For micro robotic applications, piezoelectric actuators are widely used, whereas electromagnetic actuators are not favored because of the complex structures and difficult fabrication. On the other hand, electromagnetic actuators have many merits that are suitable for robotic applications, such as relatively large displacement or stroke and no need of high voltage power supply. With the recent fast development of micro precision machining techniques, the fabrication of complex structures is no longer a problem. This paper presents our recent study of developing electromagnetic actuators for micro robotic applications, including a comparison between piezoelectric and electromagnetic actuators, design of two types of electromagnetic actuators, and fabrication and testing of a moving magnet tubular linear actuator.

2.1.6-Design and control of vast DOF wet SMA array actuators

A new concept for an actuator array is presented where a vast number of actuators are contained within a small volume and are controlled in a scalable sense. This vast degree-of-freedom system utilizes an array of shape memory alloy wires embedded within a network of fluidic vessels. A matrix manifold and valve (MMV) system routes fluid from hot and cold reservoirs in order to control an array of N^2 SMA actuators using only 2N valves. A prototype MMV system containing a 4 by 4 array of wet SMA actuators is designed and implemented. Control strategies suitable for controlling MMV system that uses 2N valves to control N^2 actuators are presented. Two different protocols are presented and evaluated. The system error increases without bound under certain input conditions, since all the actuators cannot be activated at the same time. Simulations show that system error starts to go out of bound when the individual actuator is activated 25% of the time for the 4 by 4 arrays of the actuators.

CHAPTER-3

METHODOLOGY:

In this project its methodology is divided into two parts:

- MODEL DESIGNING.
- MANUFACTURING.

3.1-MODEL DESIGNING

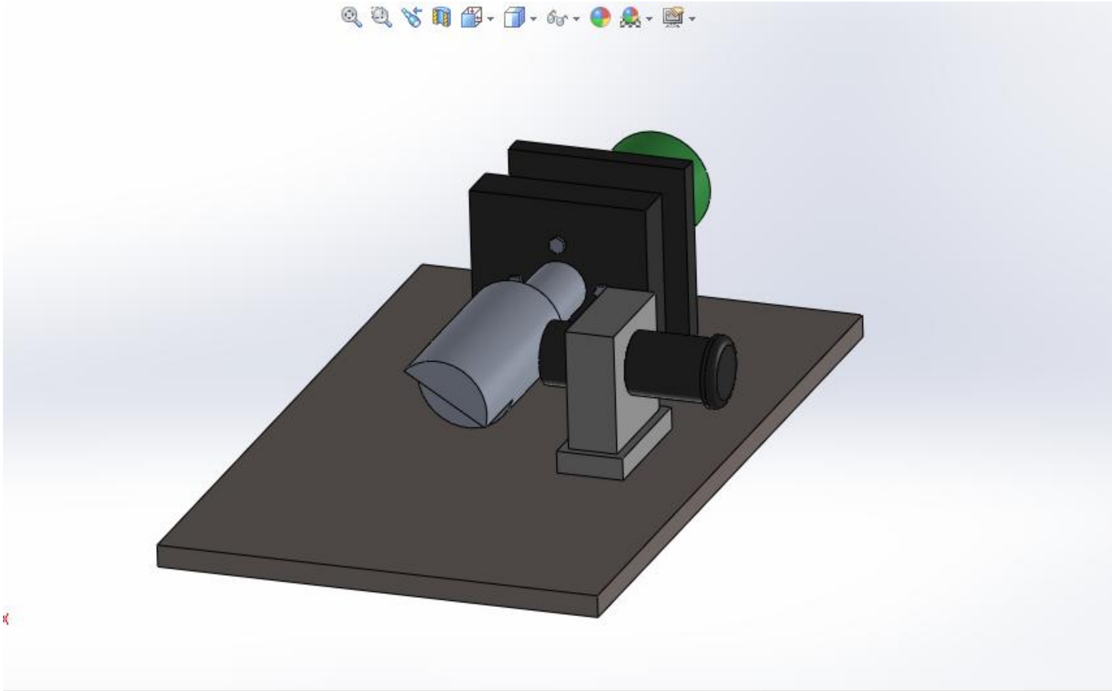
The model of the actuator is done by solidworks.At first in the solidworks several parts are designed.Than assembly of this parts are done to give the structure.

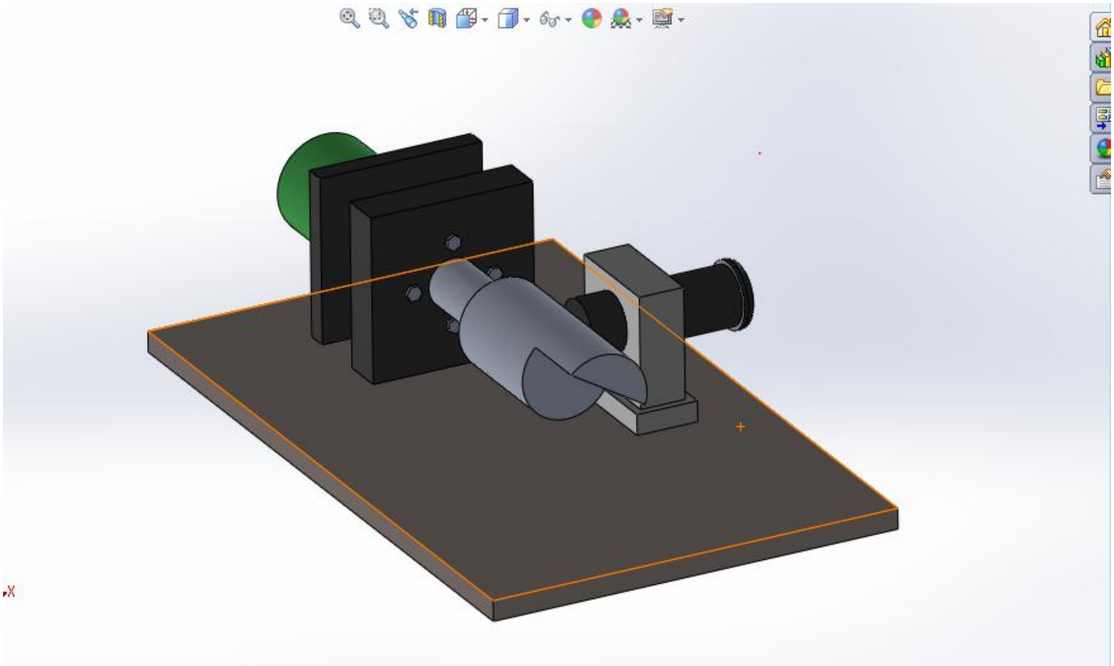
Parts designed-

- Motor.
- Main shaft.
- Auxiliary shaft.
- Base plate.
- Support.

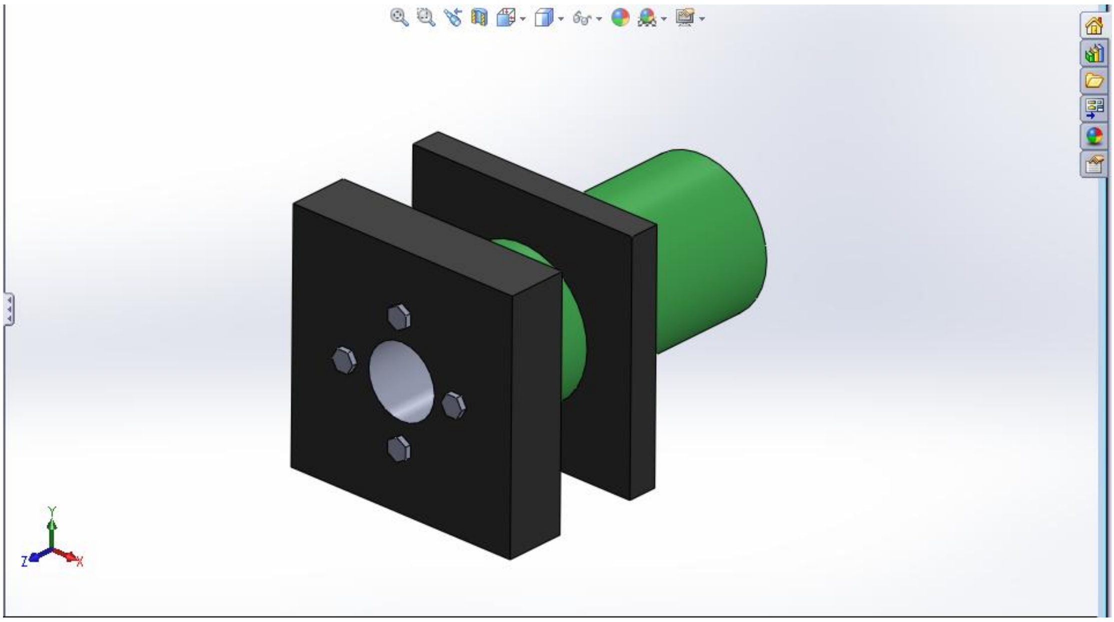
In designing at first the base plate is placed in the assembly.than motor is coupled with main shaft over it.Where main shaft is connected to auxiliary shaft.Auxiliary shaft is supported over base plate.Here motor will give the energy to the main shaft.for the copling it will have rotary motion and this rotary motion will converted to linear motion by auxiliary shaft.Design is given below from the solidworks window.

DESIGN:

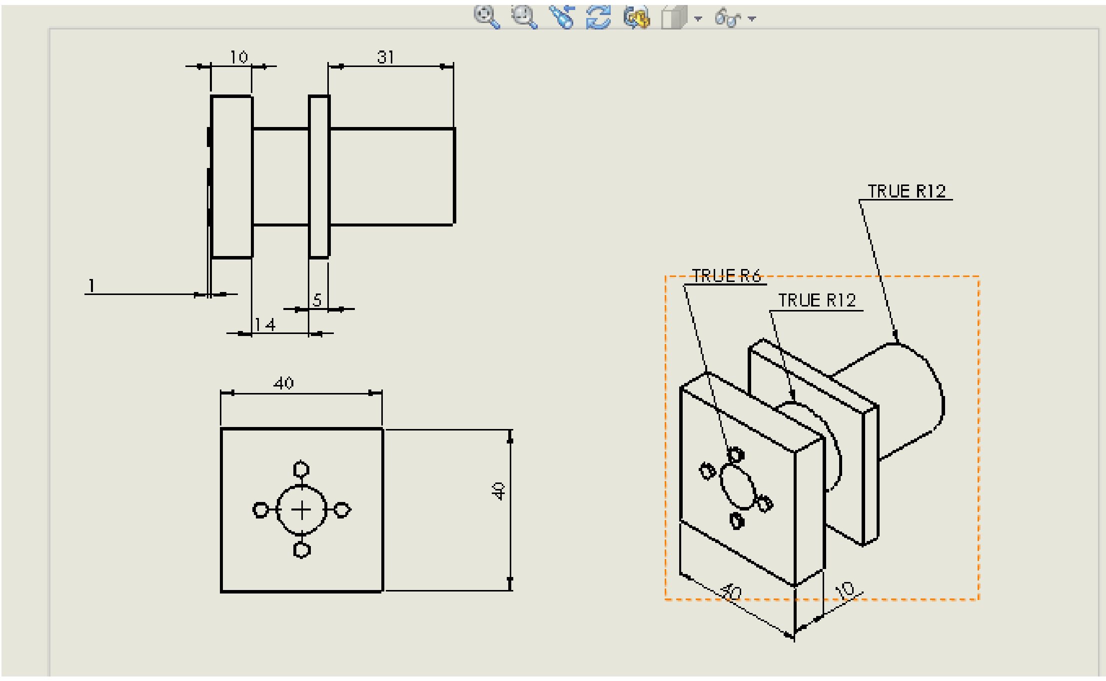




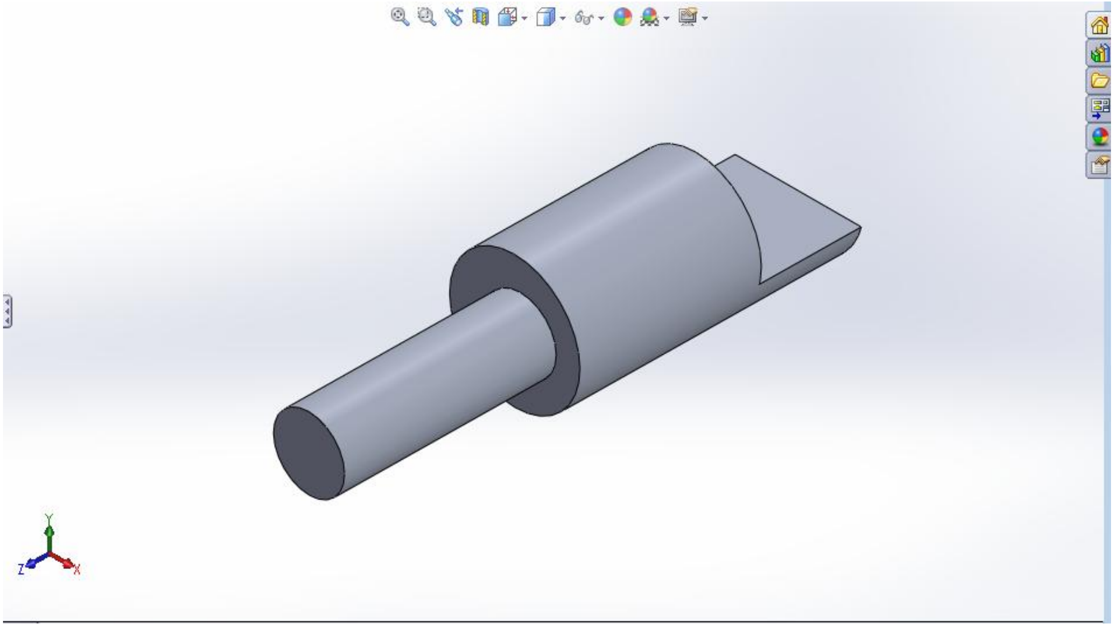
3.1.1-Motor



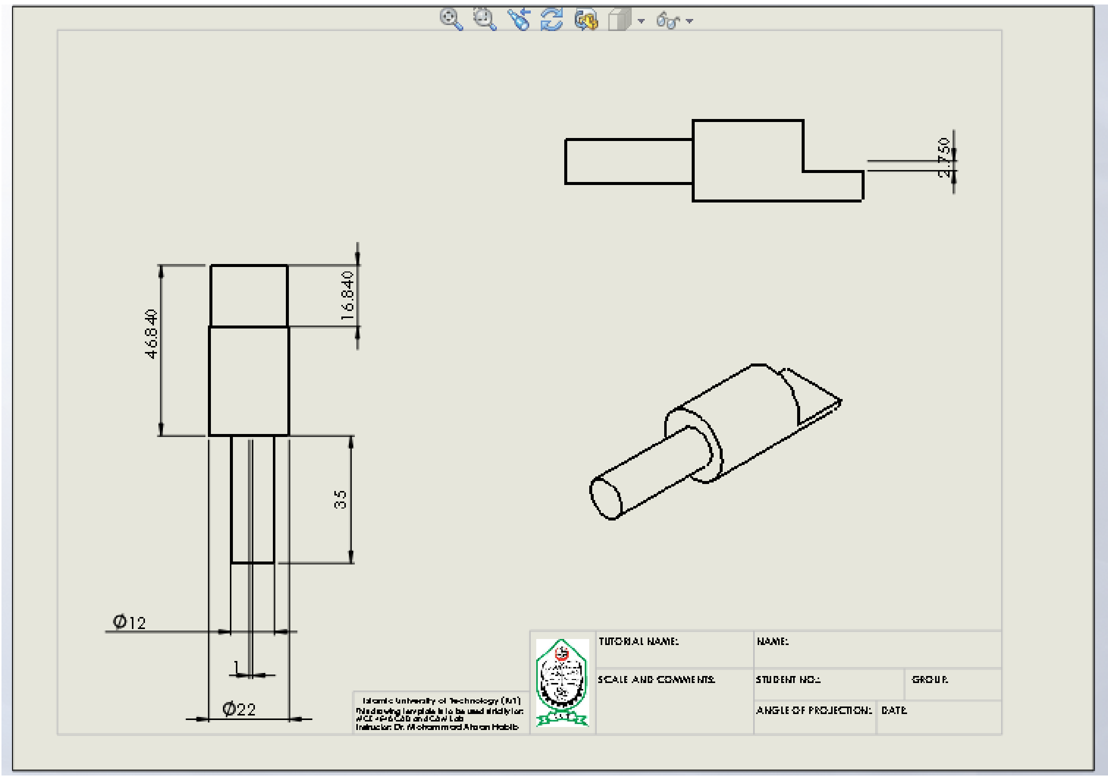
Motor dimension:



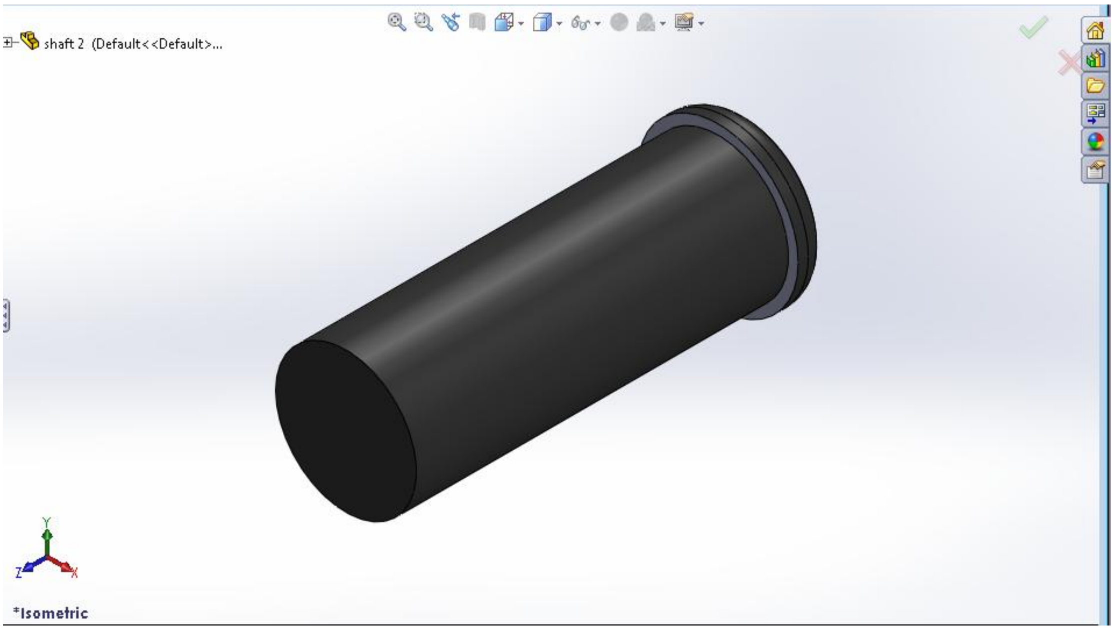
3.1.2-Main shaft:



Dimension:



3.1.3-Auxiliary shaft:



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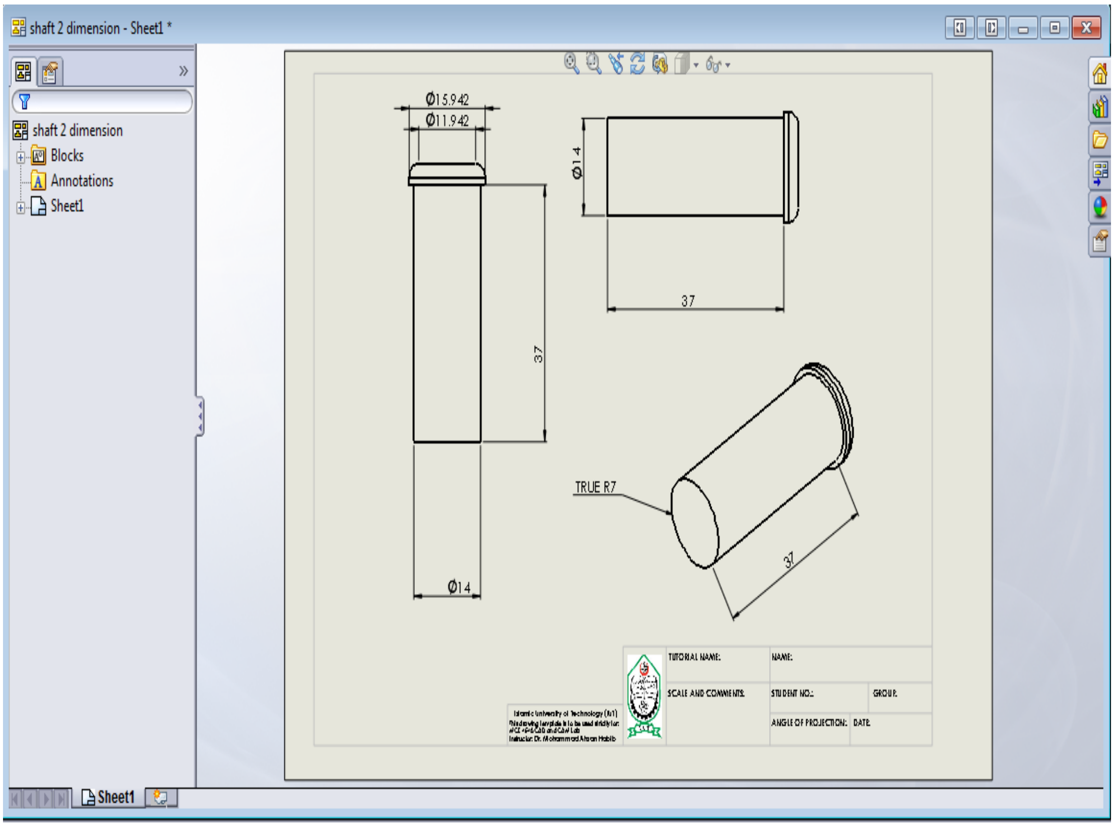
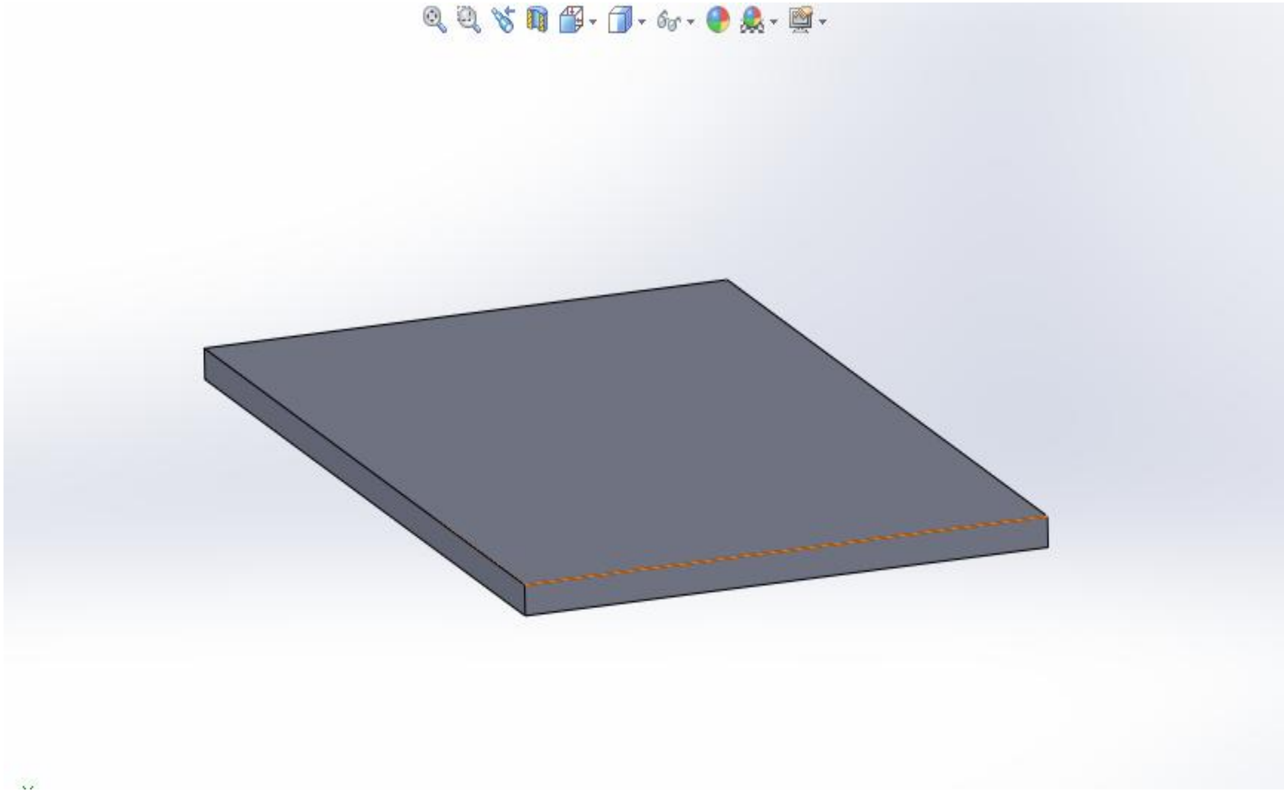


3.1.4-Base plate:



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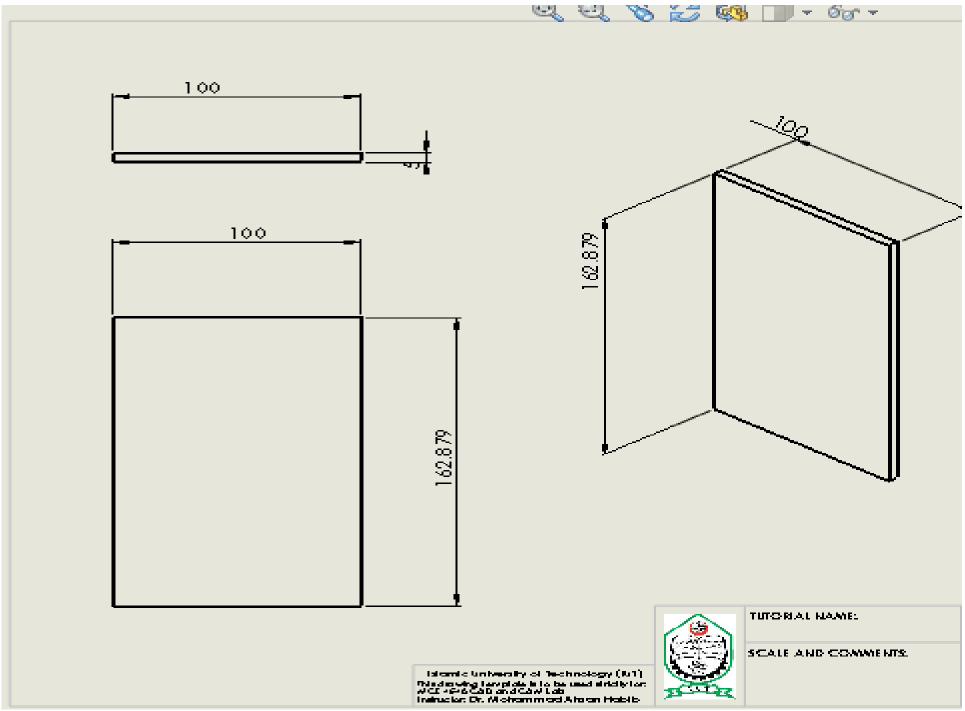
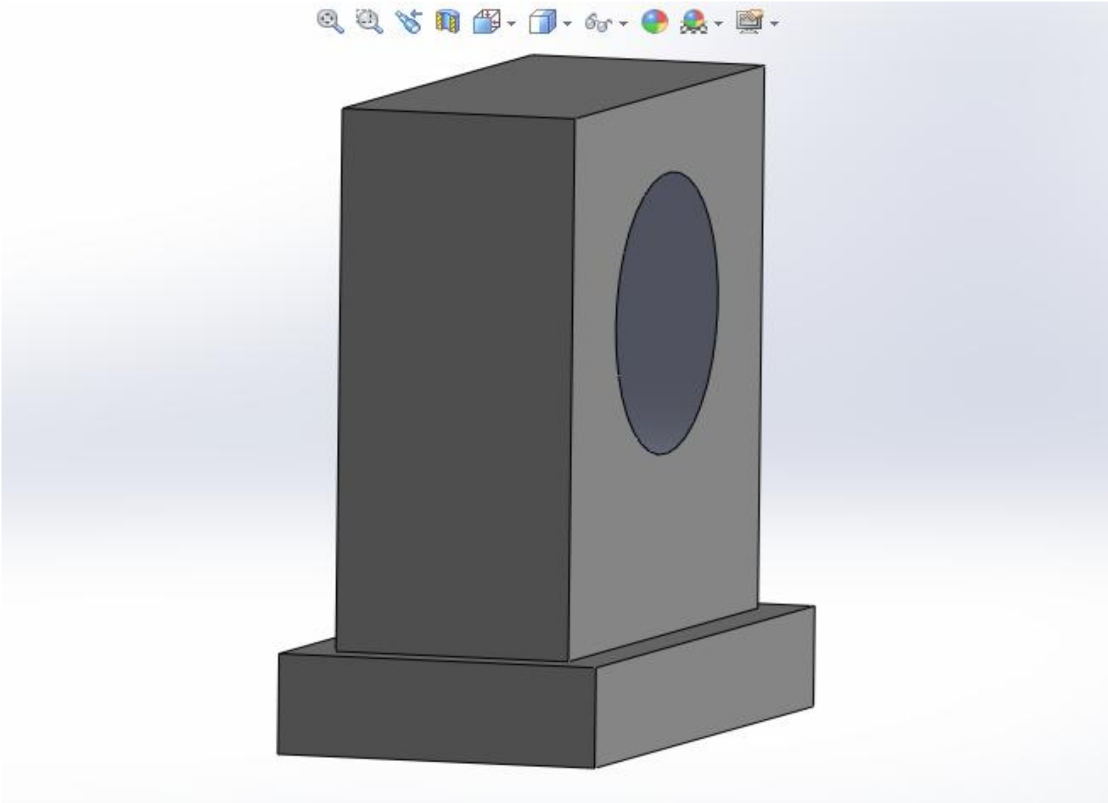


3.1.5-Support



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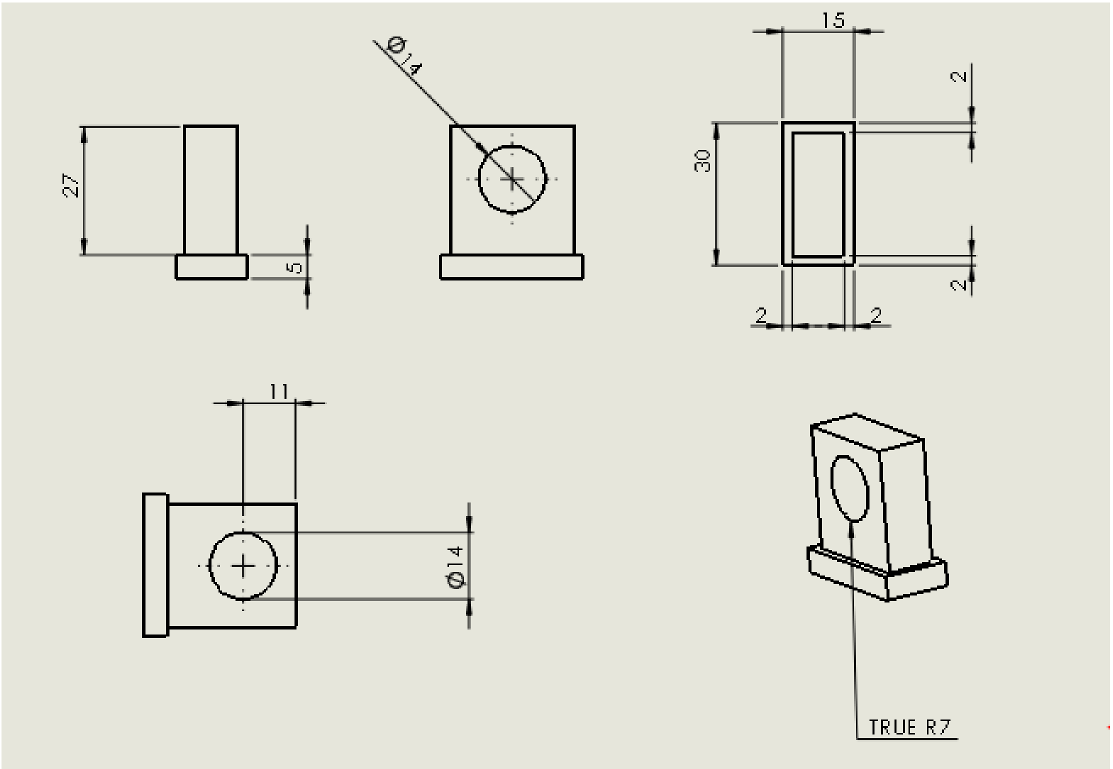
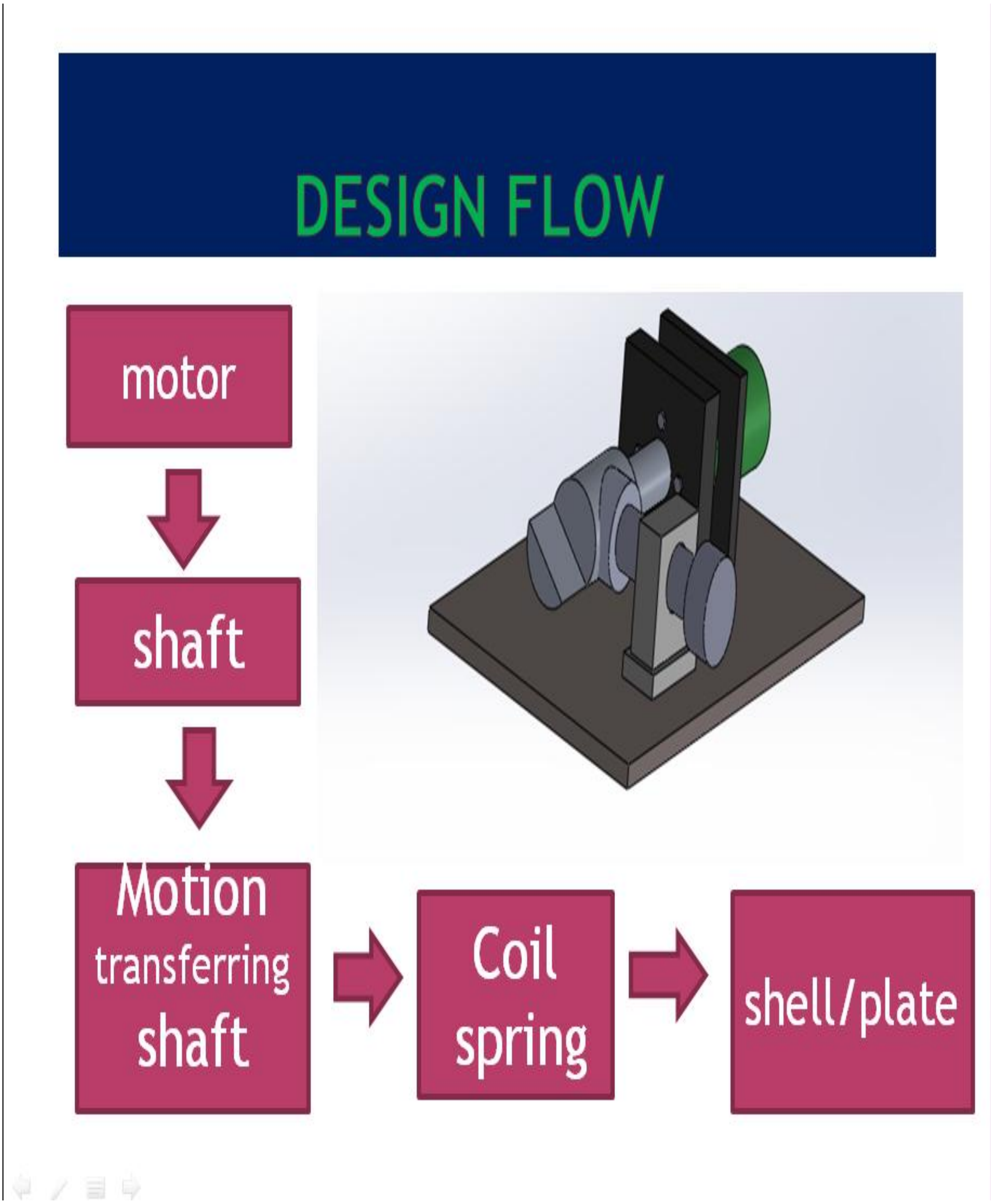


3.1.6-Design flow:



3.2-Manufacturing:

SHAFT MATERIAL

Material name: aluminium alloy
Model: AA6063
Specific gravity: 2.68 g/cm^3
Chemical composition by weight:
Silicon: .2 - .6%
Iron : max. .35%
Copper: max. .10%
Manganese: max .10%

- Magnesium : .45- .9%
- Chromium : max .10%
- Zinc : max .10%
- Titanium : max .10%

Mechanical Property:

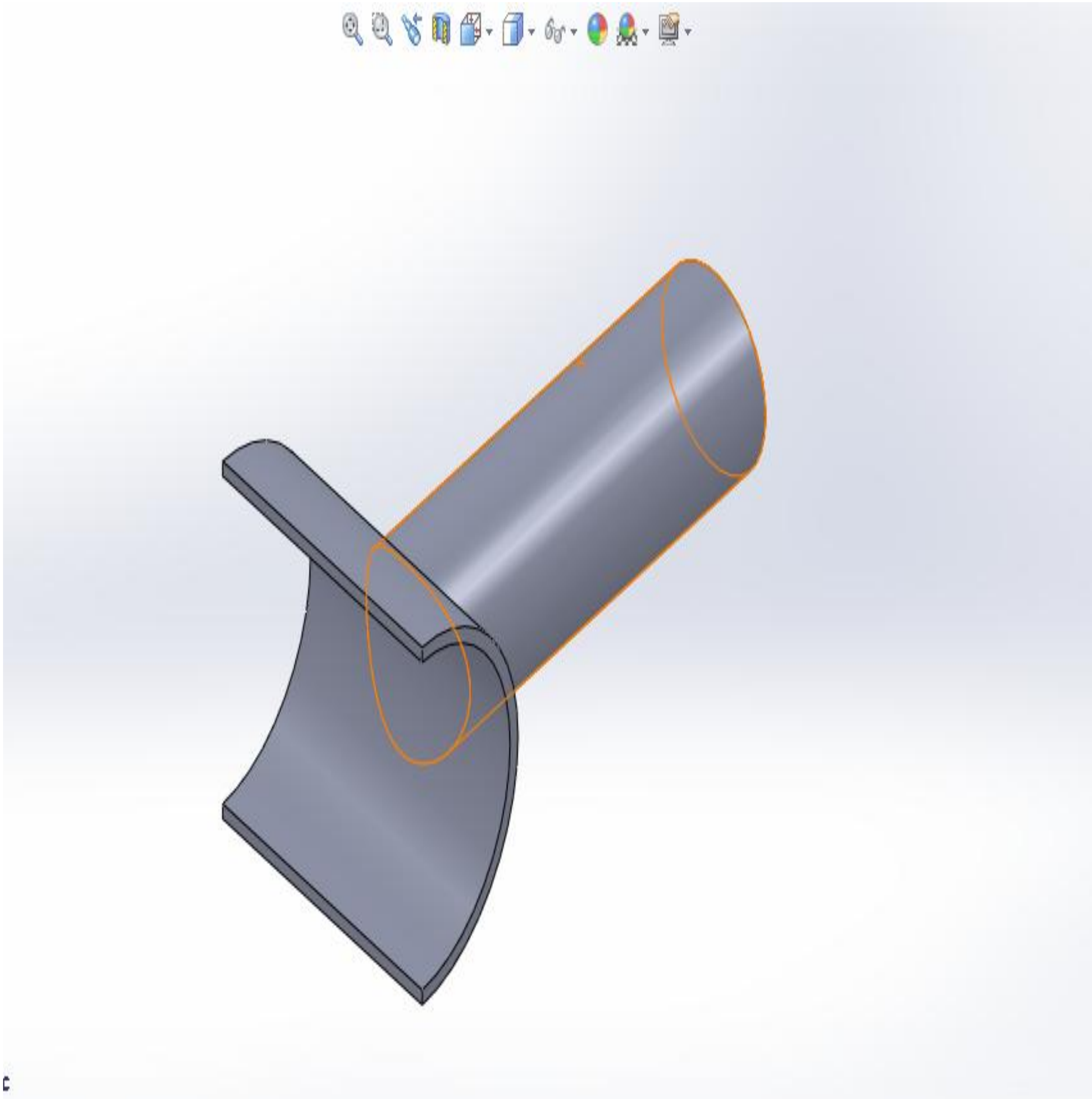
The mechanical property greatly depends on temper and heat treatment.

CHAPTER-4:

Design evaluation:

When the design is completed we have done some motion study to check the model.We observed that the design is accurate.

We propose another model of auxiliary shaft.it is given below:



CHAPTER-5

Conclusion:

In the project our main objective was to design and construct the model.the designing part is fully completed and construction is going on.here we propose a model of an actuator which can convert rotary motion into linear motion.the power source is given by a motor which is delivered to the main shaft and main shaft will give rotary motion.this rotary motion will actuate a linear motion by a auxiliary shaft. In this project we have already accomplished the design of the excitor.We are looking forward to construct the model and analyze its vibrating on the shell or plate We will construct the excitor practically to provide a 10N sinusoidal vibrational wave to the attached shell / plate.

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Electrical Machines and Systems, 2008. ICEMS 2008.

International Conference