MINISTRY OF EDUCATION AND SCIENCE OF
UKRAINE NATIONAL TECHNICAL UNIVERSITY OF UKRAINE
"IGOR SIKORSKY KYIV POLYTECHNIC INSTITUTE"
INSTITUTE OF MECHANICAL ENGINEERING
Department of Manufacturing Engineering

The defense allowed:
Acting head of the department
Oleksandr Okhrimenko
____

Diploma project
Level of higher education – first (bachelor)
Program subject area – 131 “Applied Mechanics”
Educational Program “Manufacturing Engineering”

Topic: «Manufacturing Process Planning for the Part "Bearing Support"»

Developed by:
Student of the IV year of study, group MT-03
Hassan Mashhadizadeh _____________

Supervisor:
Ph.D, associate professor Volodymyr Korenkov _____________

Reviewer:
Ph.D, associate professor Kholavik Olga _____________

I certify that in this diploma project there are no borrowings from the works of other authors without proper references.

Kyiv-2024

National Technical University of Ukraine

“Igor Sikorsky Kyiv Polytechnic Institute”

Educational and Research

Institute of Mechanical Engineering

Department of Manufacturing Engineering

Level of higher education – first (bachelor)

Specialty – 131 “Applied Mechanics”

Educational and Professional Program “Manufacturing Engineering”

APPROVED

Head of the department

______ Oleksandr OKHRIMENKO

«___»_____________2024

ASSIGNMENT

for the diploma project to the student

________Hassan Mashhadizadeh____

1. Topic of the diploma project: Manufacturing process planning for part "Bearing Support "
project supervisor: Volodymyr Korenkov, PhD, associate professor
approved by the University Order dated «___» _____2024 No_______

2. The deadline for the student to submit a diploma project «**10**» **June** 2024

3. Initial data for the project:
Drawings of the product “Bearing Support”;
Material: ISO 185 JL 200 Gray Cast Iron;
Production Volume: 3000 units per year

4. The content of the explanatory note, a list of tasks to be developed:
Chapter 1. Calculation of workpiece deformations
Chapter 2. Manufacturing process planning
Chapter 3. Fixture design
Chapter 4. Economic calculations

5. A list of graphic and illustrative material
- Presentation of the Chapter 1 results: 1 sheet A1
- Drawing of a part and a blank – 1 sheet A1

- Manufacturing operation presentation – 2 sheets A1
- Results of NC-program development – 1 sheet A1
- Drawing of the workpiece clamping device – 1 sheet A1
- Presentation of the project – 5-10 PowerPoint slides

6. Consultants for chapters of the project

Chapter	Surname, initials, and position of consultant	Signature, date	
		Issued the task	Accepted the task
1	Volodymyr Korenkov, PhD, associate professor		
2	Volodymyr Korenkov, PhD, associate professor		
3	Volodymyr Korenkov, PhD, associate professor		
4	Volodymyr Korenkov, PhD, associate professor		

7. Issue date of the assignment: 20 May 2024

CALENDAR PLAN

No	Stages of the diploma project implementation	The deadline for the stages of the diploma project	Notes
1	Chapter 1. Calculation of workpiece deformations	25 May 2024	
2	*Presentation of the Chapter 1 results: 1 sheet A1*	25 May 2024	
3	*Drawing of a part and a blank – 1 sheet A1*	25 May 2024	
4	Chapter 2. Manufacturing Process Planning	31 May 2024	
5	*Manufacturing Operations Presentation - 2 sheets of A1 Format*	31 May 2024	
6	*Results of NC-program development – 1 sheet A1*	31 May 2024	
7	Chapter 3. Fixture design	7 June 2024	
8	*Drawing of the workpiece clamping device – 1 sheet A1*	7 June 2024	
9	Chapter 4. Economic calculations	10 June 2024	
10	Presentation	10 June 2024	

Student Hassan Mashhadizadeh

Supervisor Volodymyr Korenkov

ABSTRACT

Bachelor's thesis on the topic “Manufacturing Process Planning for the Part "Bearing Support"”. It consists of 104 sheets of A4 format and contains 48 figures and 4 tables.

The purpose of this work is to develop the process of manufacturing the "Bearing Support" part. The first chapter is devoted to calculation of workpiece deformations. The sequence of the production process was developed, including the selection of CNC machines, cutting tools, cutting conditions, etc. For two specific production processes, the fixture was selected and the corresponding settings were developed. Economic calculations for the first plant have been carried out.

The graphic part consists of 6 sheets of Al format, as follows:

1. Calculation of workpiece deformations
2. Drawings and 3D models of the "Bearing Support" part and blank
3. Manufacturing operation presentation
4. Fixture setup for the 1st manufacturing operation
5. Fixture setup for the last manufacturing operation
6. Results of CNC code development

TABLE OF CONTENT

The Core of Manufacturing Engineering

Manufacturing engineering emerges as a critical member of the constituents of the current industrial sector since it amalgamates the manufacturing procedures with the engineering concepts. Indeed, its primary purpose is to ensure increased productivity, cost containment, and consistent, quality output across fields and sectors. Closely related to the structure and functions of the production systems, Manufacturing engineers ensure that the production outputs are efficient and of the highest quality with the help of various technologies like automation or Robotics technologies. To this end, their skills are essential in solving the challenges of modern manufacturing industry as precision and efficiency requirements continue to rise.

Manufacturing engineers are also tasked with having a close relationship with the functioning of production systems since they are involved with its creation or formulation in their daily working lives. This involves auditing the current processes in light of the factors of production to determine areas that require improvements, designing new procedures and ways that enhance production and efficiency, and incorporating technology to provide solutions to complex business operations. Automation and robotics, therefore, stand out as critical in that respect since they can help cut down on human traffic, eliminate associated human error, and expedite processes. Using such technologies, manufacturing engineers improve manufacturability of products and design production systems capable to fulfill demand of contemporary markets.

Another responsibility that should not be overlooked in manufacturing engineering involves sustainability. Today, there is growing concern in the society on matters relating to environment and conservation of resources, the manufacturing engineers play a crucial role in regard to an environmentally sensitive production process. This comprises choosing low-cost and eco-friendly materials, using efficient systems that minimize waste production and energy usage in the production of Filipino handicrafts. Through applying sustainable manufacturing engineering, not only protects the environment but also decreases expenditure, leading to improvement of productivity of manufacturing operations.

Innovations in Manufacturing Engineering

Manufacturing engineering is a dynamic profession, with emphasis on the application and integration of these changes to improve the manufacturing process. Technological advancement is arguably one of the most profound shifts observed in organizations in the past years. Such as computer-aided design (CAD) and computer-aided manufacture (CAM) tools that can assist in the intricate design and actual manufacture of parts or products. Another innovative technology that is disrupting the conventional manufacturing facilities is additive manufacturing or more commonly referred to as 3D printing. It allows for designing thin-wall parts with high precision and a small amount of material removed and generally can help decrease the time taken to produce a part.

Also, the advancement in skills Industry 4. 0 the integration of cyber-physical systems, IoT, and big data analytics in manufacturing is changing the face of product design and development. They help in real-time tracking and on-line management of production processes, thus allowing manufacturers to address any changes apace. For instance, IoT might be used in the manufacturing floor of a company to gather data at different production steps so that the problems that may have gone unnoticed will be detected and rectified. Such high degrees of connectedness and information use are bringing about a methodical transformation of manufacturing into the wise industry.

Impact on Production Efficiency and Sustainability

Manufacturing engineering is a very crucial sub-discipline due to its contribution to improving manufacturing productivity and being an advocate for sustainability. The essence of manufacturing engineering is applied in designing manufacturing facilities and improving manufacturing processes and technologies to achieve higher production efficiency. This mostly encompasses cutting material, reducing time required per part, as well as cutting down time when the channel is not in operation. Companies are therefore able to achieve low costs that make products efficient while enhancing the competitiveness of the manufacturers in the global markets.

In addition, through identification and invention of methods of producing goods and services in a manner that is sustainable, the manufacturing engineers mark a positive step in making the world a better place to live in. This entails the adoption of energy efficiency principles through the adoption and utilization of renewable energy sources, recycling of various materials andpractices of green manufacturing. For instance, applied closed-loop systems that utilize waste materials as inputs to subsequent processes so that they can be recycled or reused minimize the impact of manufacturing. This makes LEs play a crucial role of promoting sustainability to avoid compromising the environment as industries expand.

Manufacturing process planning

Manufacturing process planning is a strategic activity which is carried out at a certain stage of a product's lifecycle and which is engrossed with a number of activities related to the processes of changing raw materials into finished products. In this process, forethought, material, time, and their utilization are understood and managed in a way to maximize performance to produce high quality products in the best possible time and at minimum cost. In this context, an attempt has been made to discuss in detail about the concept of manufacturing process planning area, its importance and the methods used in it.

Significance of Manufacturing Process Planning:

Manufacturing process planning is an important aspect in the manufacturing process that enables control of cost, increased efficiency and quality of products. Selecting the right equipment, choosing the right order of operations, and using resources efficiently all reduce the probability of long cycles, incorrect calculations, and general mistakes that are inevitable in a production line. In addition, through efficient process planning, manufacturers get to allocate the available resources efficiently, shorten the lead time as well improve their ability to shift quickly in reaction to the market forces that constantly change improving their competitiveness.

Key Components of Manufacturing Process Planning:

1. **Product Design Analysis:** It is therefore clear that before the start of the manufacturing process it is important to review the design of a product to be manufactured in order to understand the design features especially the tolerances of the product and other constraints applicable in the

manufacturing process. The analysis aids in identification of the number of processes and what specific ways are best suited for production.

2. **Process Selection:** Therefore, according to the specifications of the designed part, specific procedures incorporated in machining, casting, forging, or additive manufacturing are compared. Therefore, this description of the manufacturing process is influenced by other factors including properties of materials to be used, the quantity to be produced and the cost implications when choosing the best manufacturing process.
3. **Resource Allocation:** Manufacturing processes are the last decisions that are made after organizing resources such as manpower, machinery, tools, and materials. This eliminates wastage of valuable resources while also reducing the periods during which resources are idle since they are deployed to areas of high demand to achieve the greatest efficiency and value.
4. **Production Scheduling:** It is important for a production plan to include a detailed schedule of events, in order to establish the work flow of activities and manage the time effectively. Scheduling can be defined as the organization of work activities that require the successive ordering of operations, as well as the assignment of time intervals for each operation to be carried out and the taking into account of relations between different activities in order to improve the organization of work and production.
5. **Quality Assurance:** It becomes highly necessary that quality control measures are applied right from the production line to ensure high standards. Some of the quality assurance methods include inspection, testing, and ongoing monitoring, which assist in identifying flaws before the product is produced, and it complies with the laid specifications.

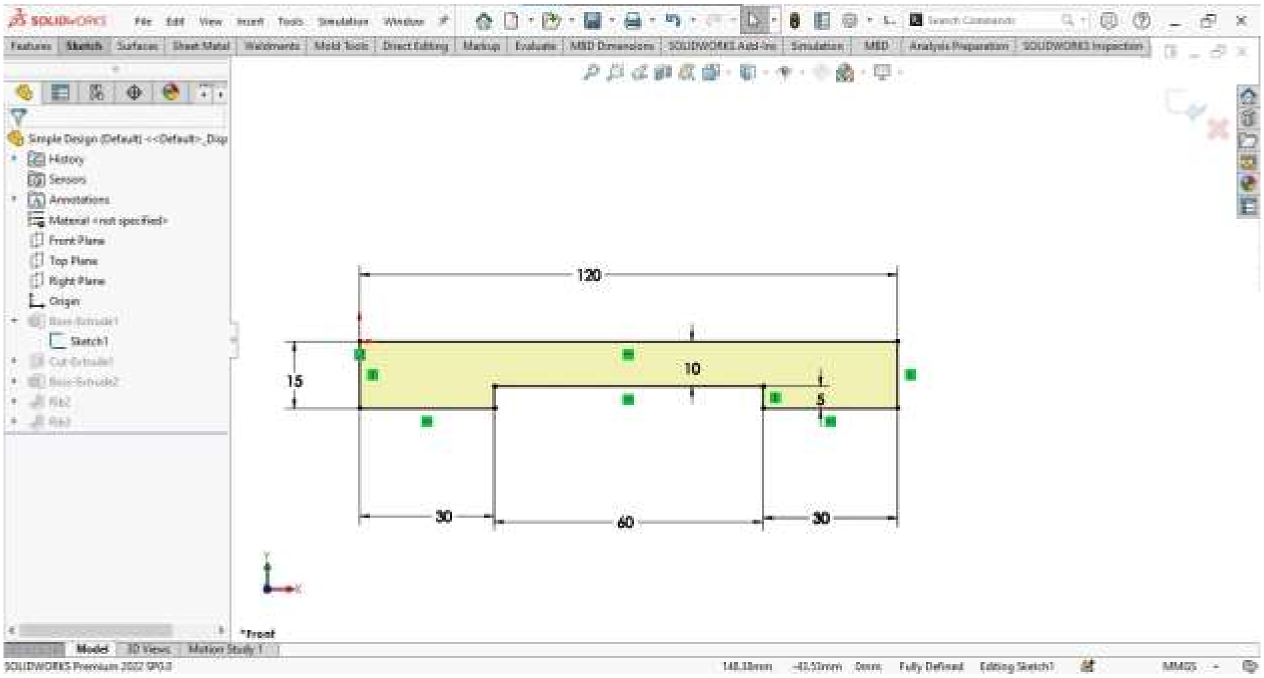
Methodologies for Manufacturing Process Planning:

1. **Computer-Aided Process Planning (CAPP):** To implement CAPP systems, the process planning tasks are performed automatically using computer algorithms and databases. CAPP systems can capture and codify knowledge of manufacturing processes and therefore help in rapidly generating process plans and thereby improving lead time differentiation.
2. **Simulation and Modeling:** Computer-based methods like discrete event simulation, or computer aided engineering (CAE) is used to study and also improve modes of manufacturing practically. By simulation, one gets a virtual look at various process conditions, where he can assess certain conditions as well as points of congestion and poor resource allocation and all this without having to use live testing.
3. **Lean Manufacturing Principles:** As a form of production, lean manufacturing disregards unnecessary operations, justifications, and expending of finances, time and energy. That is why such lean concepts and tools as JIT manufacturing and continuous improvement (or Kaizen) help organizations be efficient when it comes to planning their processes.

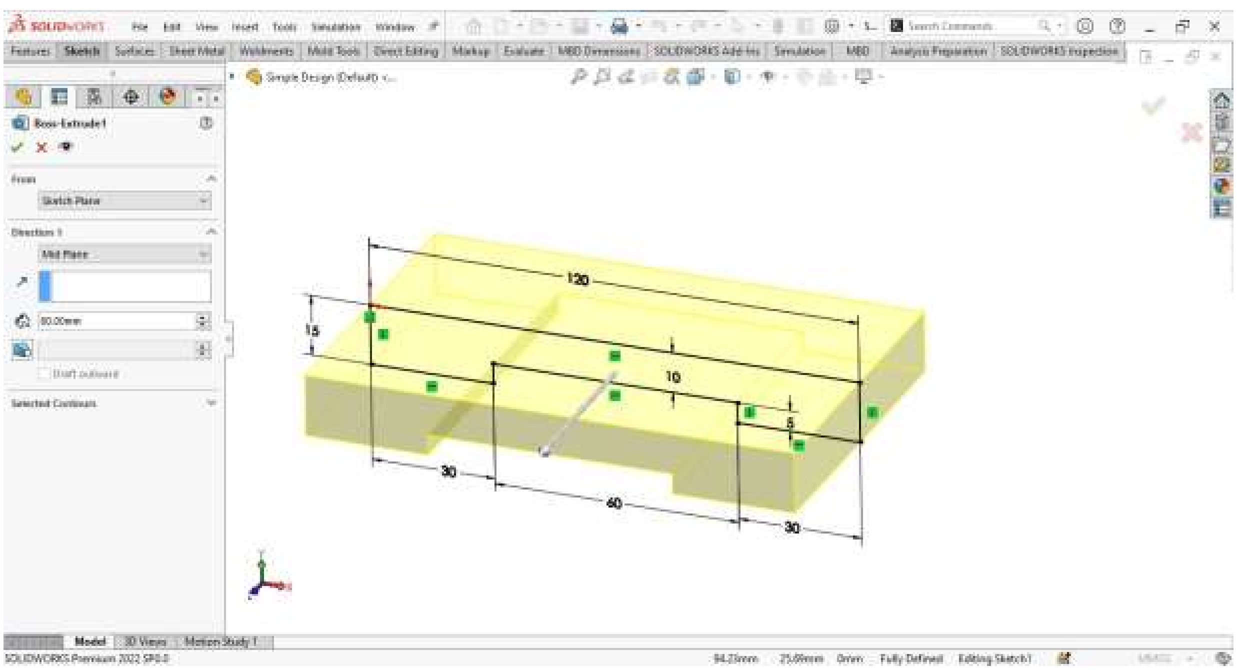
Design Using SolidWorks 2022 Bearing Support

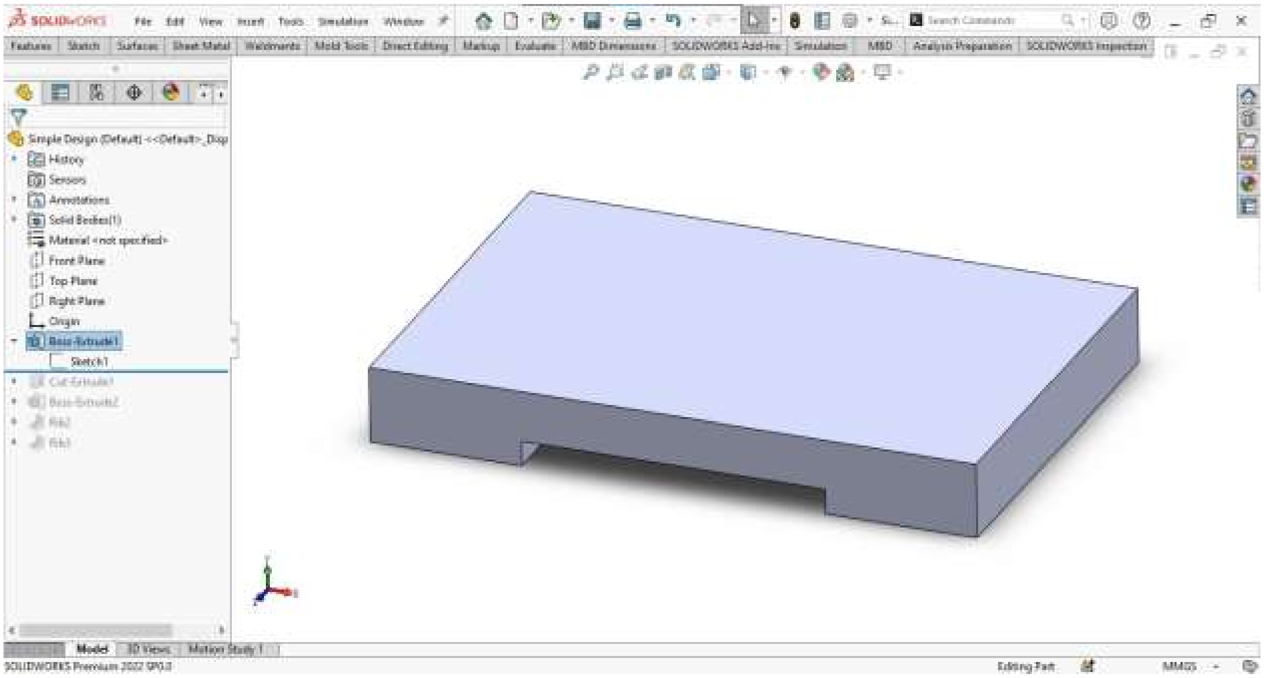
Initial Sketches

- Since I was given the dimensions of the website, I proceeded to draw the first conceptual designs from the layout appearance.

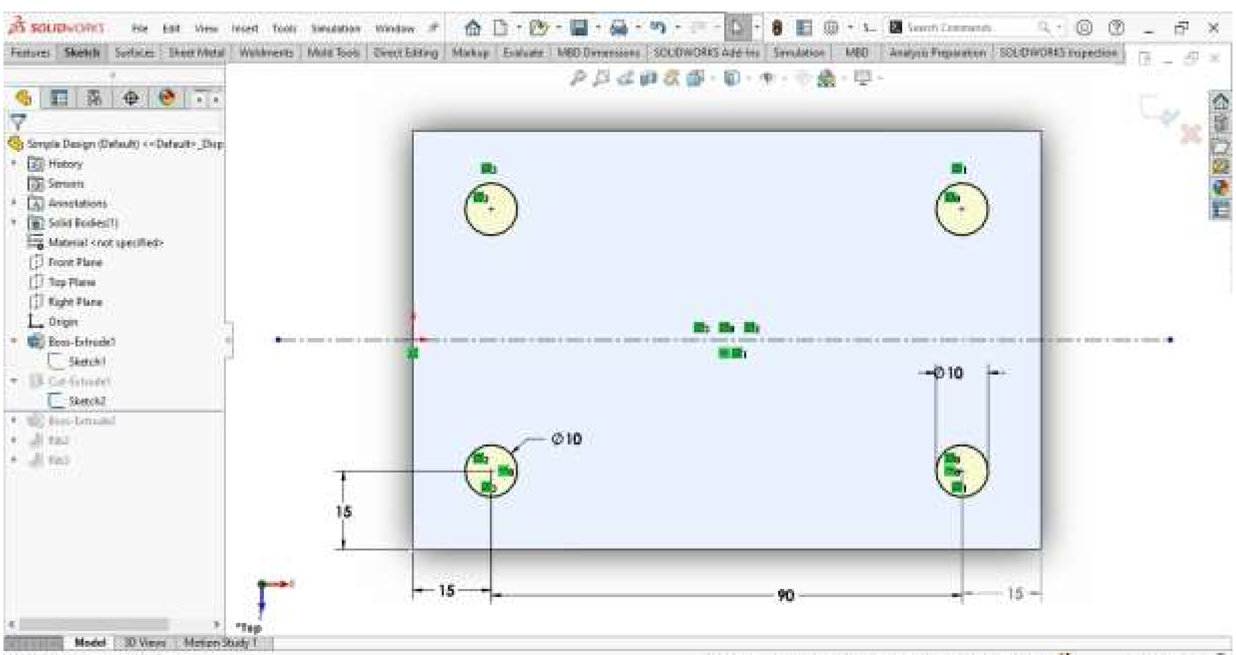


- Extruded the initial sketch to a height of 80mm.

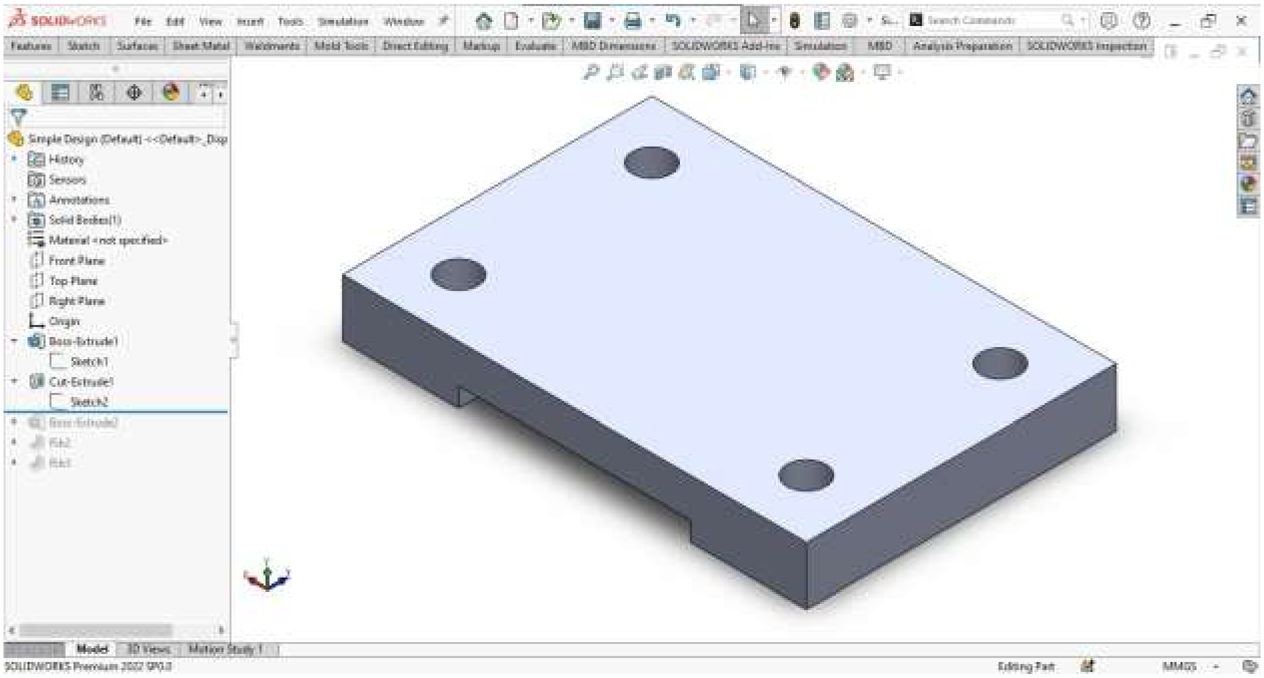




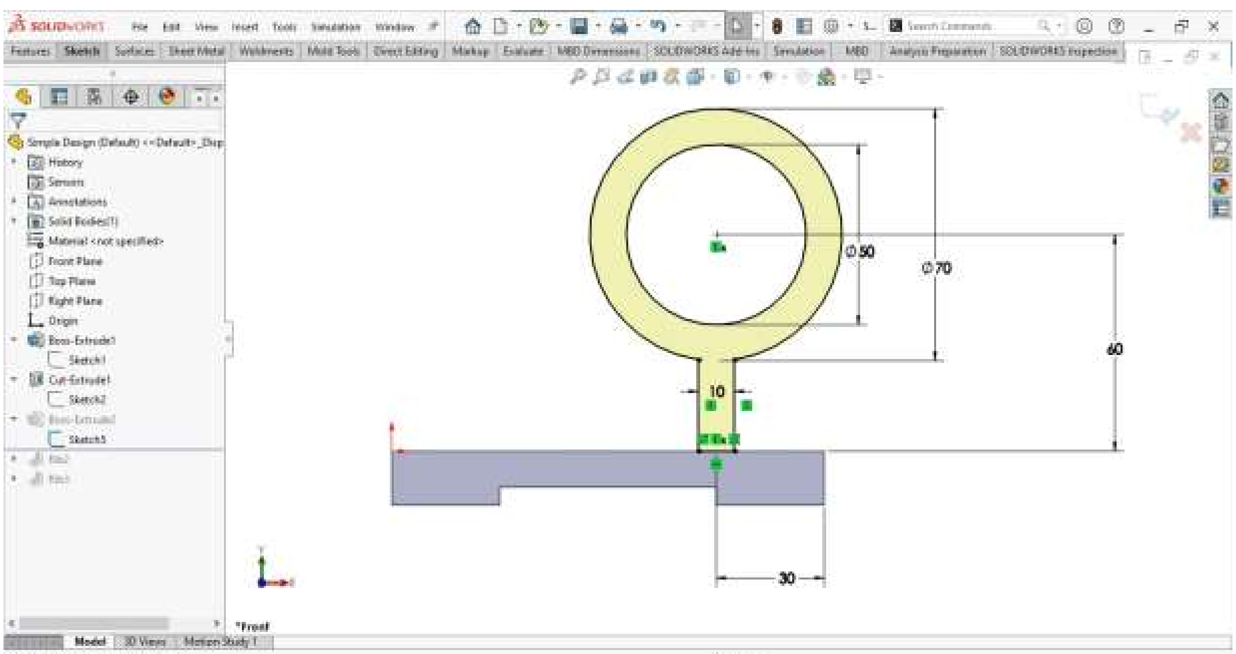
- Created a secondary sketch with dimensions of 10mm.



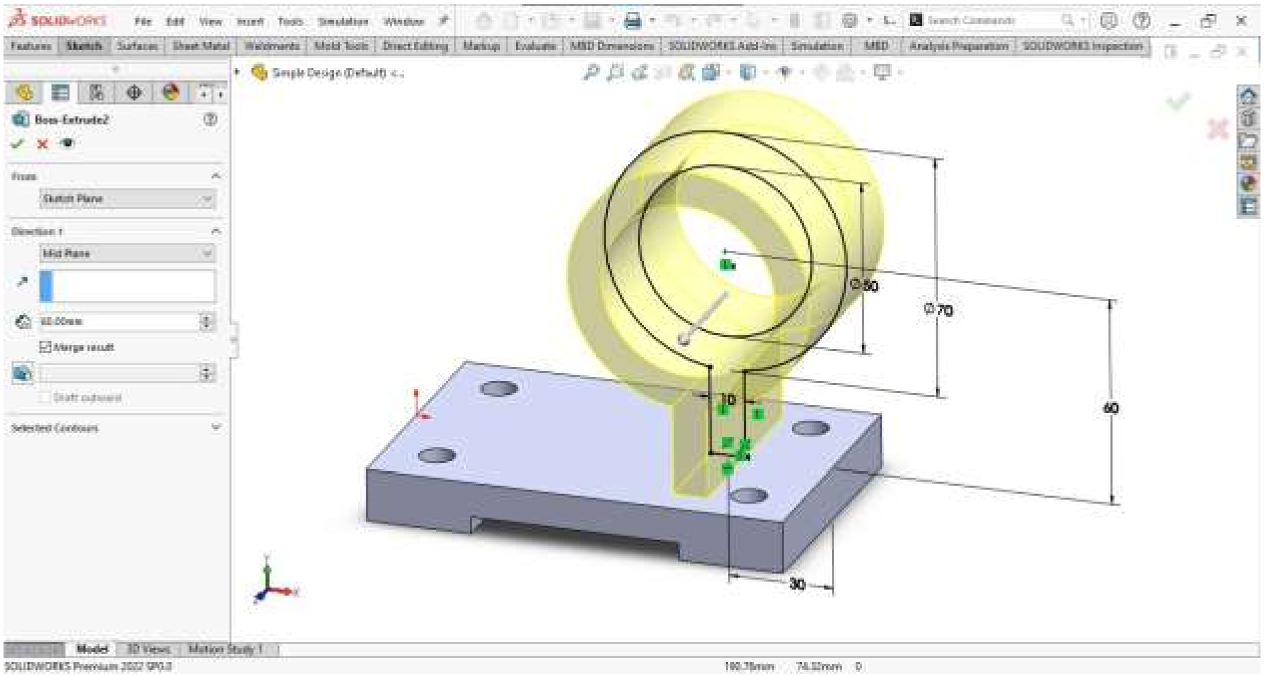
- Extruded Cut this secondary sketch using the "Blind" extrusion option.



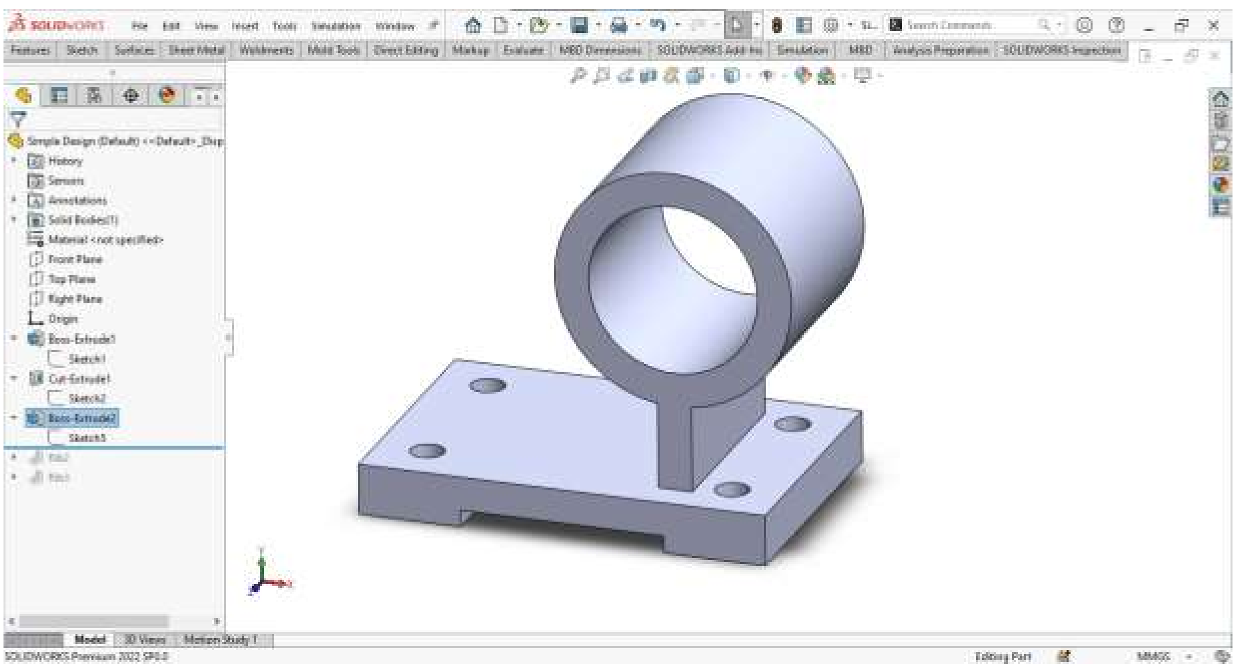
Made a new sketch on the front plane.

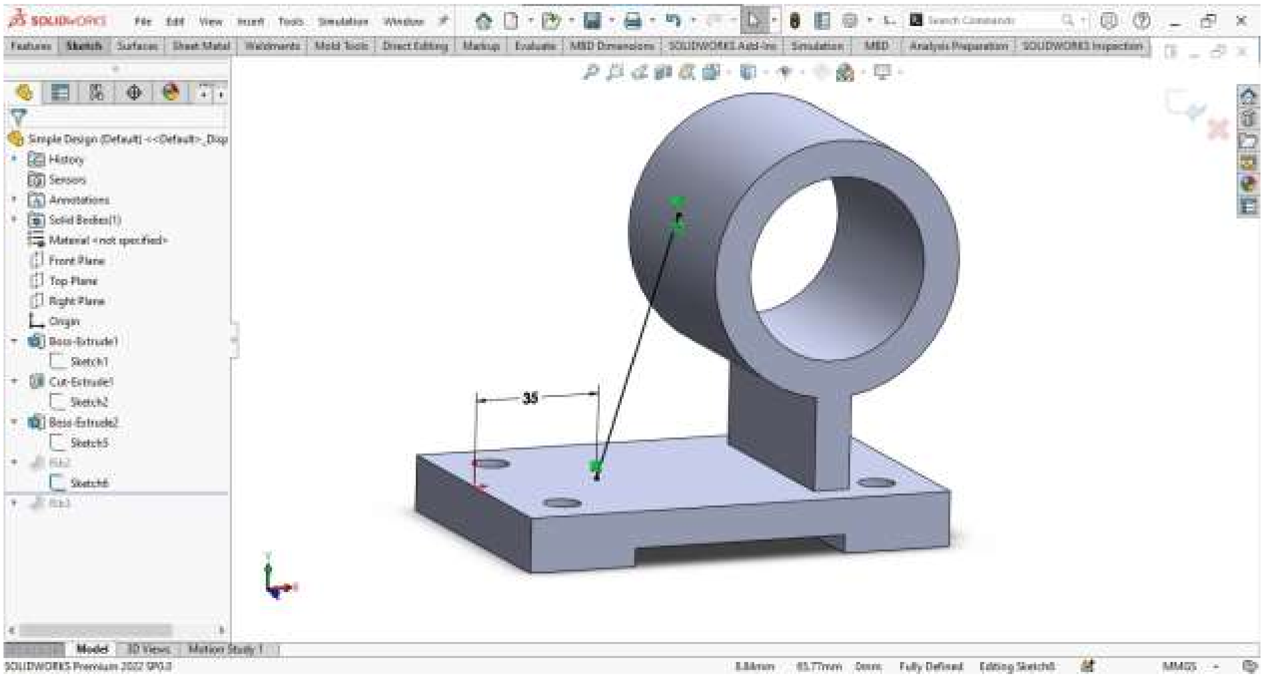


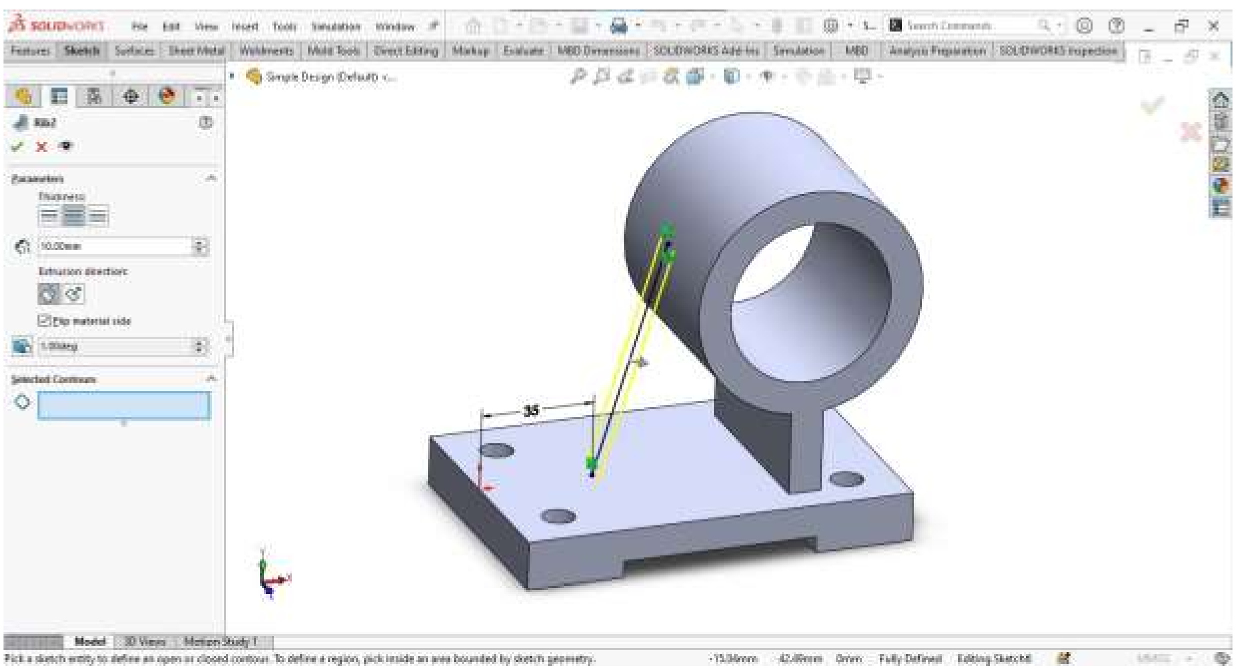
Extruded this sketch to a height of 60mm.

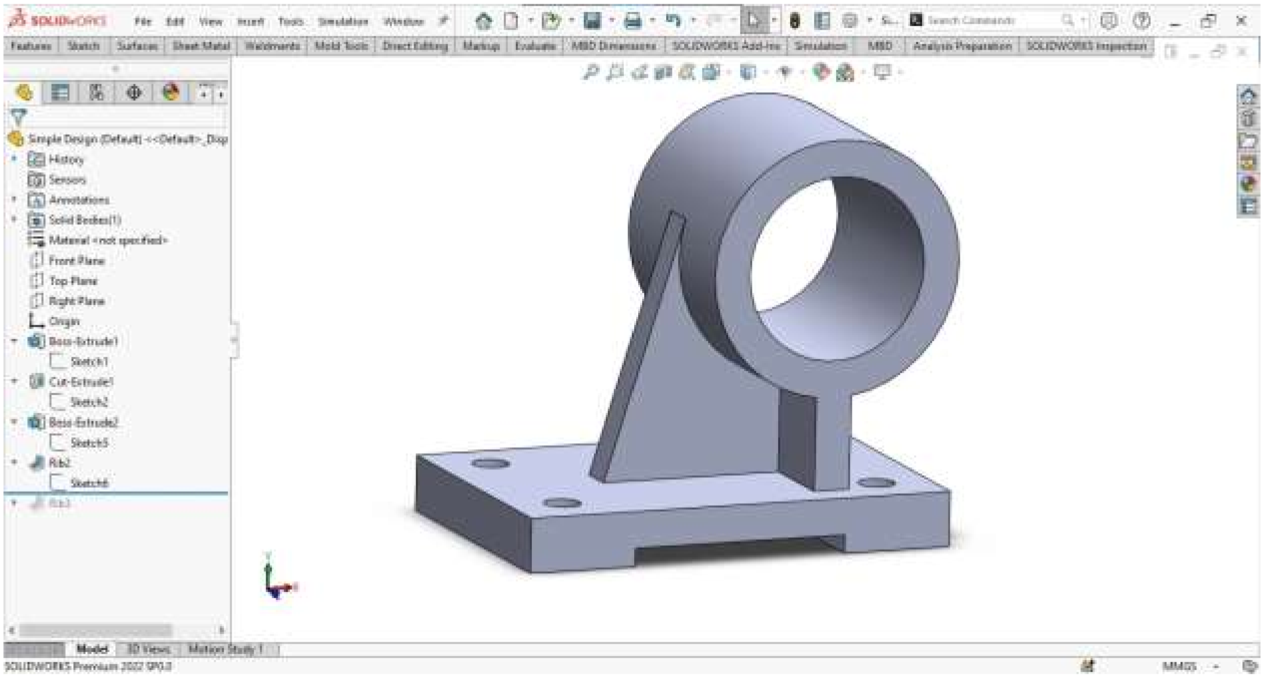


Added a rib on one side of the model.

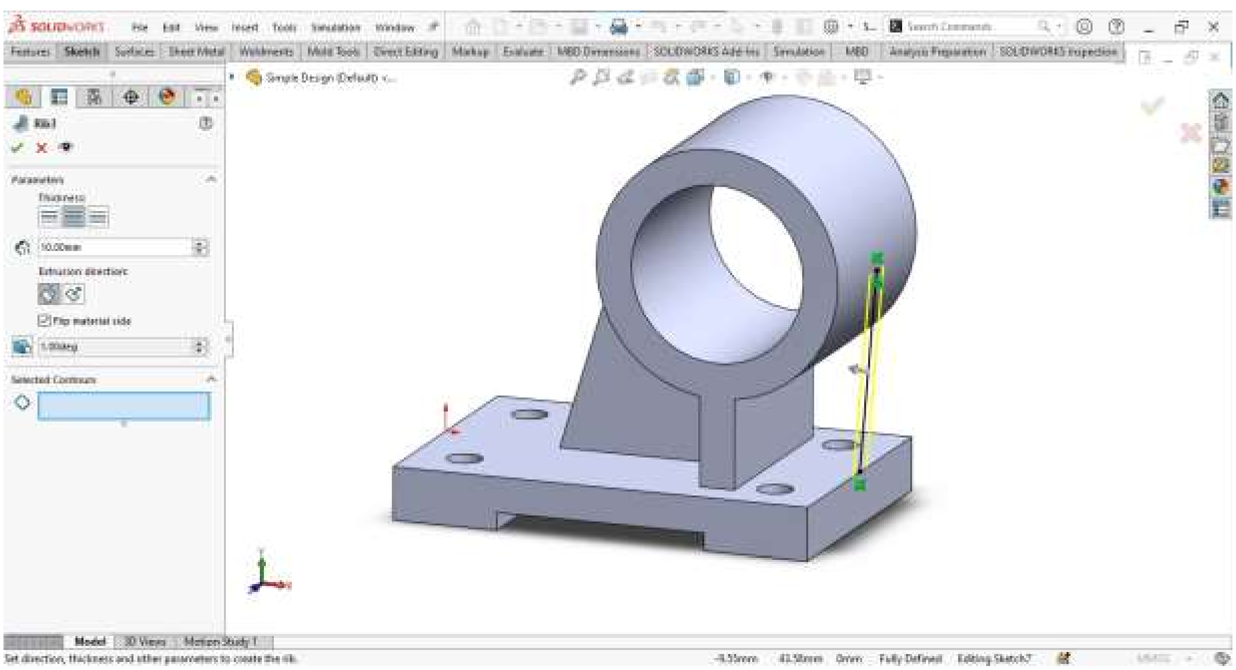



35
Simple Design (Default) <<Default>_Disp
History
Sensors
Annotations
Solid Bodies(1)
Material <not specified>
Front Plane
Top Plane
Right Plane
Origin
Boss-Extrude1
Sketch1
Cut-Extrude1
Sketch2
Boss-Extrude2
Sketch5
Sketch6
Model
3D Views
Motion Study 1
SOLIDWORKS Premium 2022 SP0.0
Fully Defined
Editing Sketch6

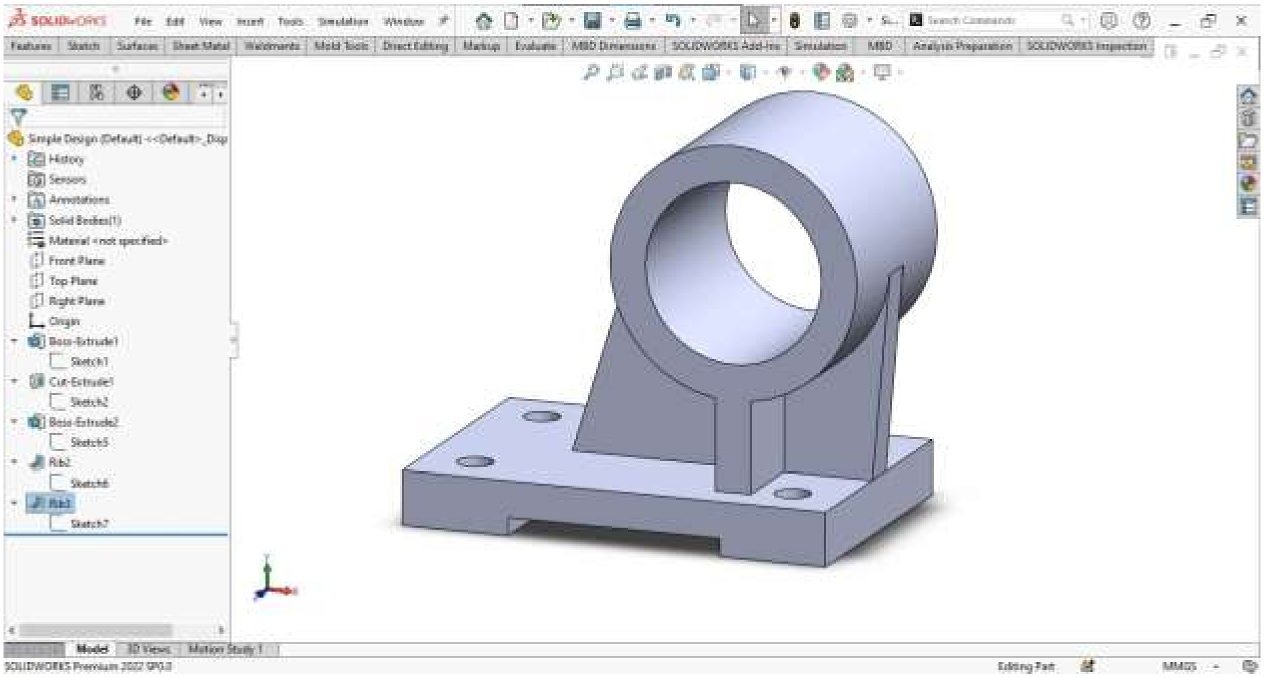

35
Rib2
Parameters
Thickness:
10.00mm
Extrusion direction:
Flip material side
1.00deg
Selected Contours
Model
3D Views
Motion Study 1
Pick a sketch entity to define an open or closed contour. To define a region, pick inside an area bounded by sketch geometry.
Fully Defined
Editing Sketch6

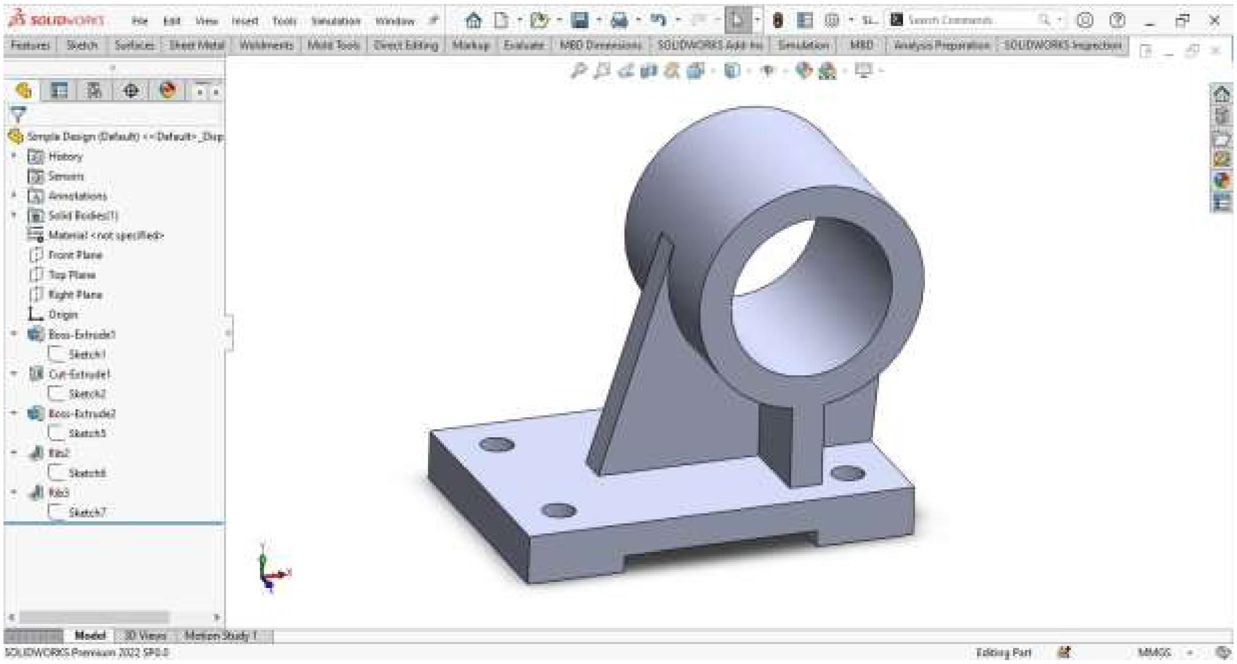


- Added a rib on the other side of the model.



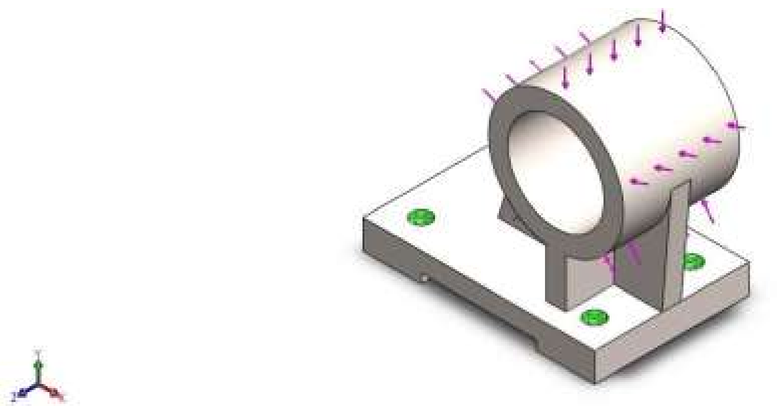
- Completed the design, resulting in the final 3D model of the bearing support.


SOLIDWORKS
File Edit View Insert Tools Simulation Window
Features Sketch Surfaces Sheet Metal Weldments Mold Tools Direct Editing Markup Evaluate MBD Dimensions SOLIDWORKS Add-Ins Simulation MBD Analysis Preparation SOLIDWORKS Inspection
Simple Design (Default) <<Default>_Disp
History
Sensors
Annotations
Solid Bodies(1)
Material <not specified>
Front Plane
Top Plane
Right Plane
Origin
Boss-Extrude1
Sketch1
Cut-Extrude1
Sketch2
Boss-Extrude2
Sketch5
Rib2
Sketch6
Rib3
Sketch7
Model 3D Views Motion Study 1
SOLIDWORKS Premium 2022 SP0.0
Editing Part
MMGS



Solidwoks Simulations

Model Information



Model name: Simple Design Current Configuration: Default

Solid Bodies			
Document Name and Reference	Treated As	Volumetric Properties	Document Path/Date Modified
Rib3 	Solid Body	Mass:2.06959 kg Volume:0.000268777 m^3 Density:7,700 kg/m^3 Weight:20.2819 N	C:\Users\lenovo\Desktop\Project File\Project File\Simple Design.SLDPRT Jun 10 02:33:57 2024

Study Properties

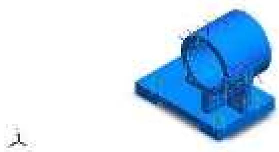
Study name	Static 1
Analysis type	Static

Mesh type	Solid Mesh
Thermal Effect:	On
Thermal option	Include temperature loads
Zero strain temperature	298 Kelvin
Include fluid pressure effect from SOLIDWORKS Flow Simulation	Off
Solver type	Automatic
Inplane Effect:	Off
Soft Spring:	Off
Inertial Relief:	Off
Incompatible bonding options	Automatic
Large displacement	Off
Compute free body forces	On
Friction	Off
Use Adaptive Method:	Off
Result folder	SOLIDWORKS document (C:\Users\lenovo\Desktop\Project File\Project File)

Units

Unit system:	SI (MKS)
Length/Displacement	mm
Temperature	Kelvin
Angular velocity	Rad/sec
Pressure/Stress	N/m^2

Material Properties

Model Reference	Properties	Components
	Name: **Alloy Steel** Model type: **Linear Elastic Isotropic** Default failure criterion: **Max von Mises Stress** Yield strength: **6.20422e+08 N/m^2** Tensile strength: **7.23826e+08 N/m^2** Elastic modulus: **2.1e+11 N/m^2** Poisson's ratio: **0.28** Mass density: **7,700 kg/m^3** Shear modulus: **7.9e+10 N/m^2** Thermal expansion coefficient: **1.3e-05 /Kelvin**	**SolidBody 1(Rib3)(Simple Design)**
Curve Data:N/A		

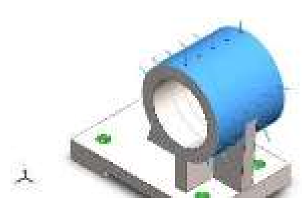
Loads and Fixtures

Fixture name	Fixture Image	Fixture Details

Fixed-1		**Entities:** **Type:**	**4 face(s)** **Fixed Geometry**

Resultant Forces

Components	**X**	**Y**	**Z**	**Resultant**
Reaction force(N)	**115.005**	**1,028.04**	**2.563e-05**	**1,034.45**
Reaction Moment(N.m)	**0**	**0**	**0**	**0**

Load name	Load Image	Load Details	
Force-1		**Entities:** **Type:** **force** **Value:**	**1 face(s)** **Apply normal** **10,000 N**

Mesh information

Mesh type	Solid Mesh
Mesher Used:	Blended curvature-based mesh
Jacobian points for High quality mesh	16 Points
Maximum element size	6.4553 mm

Minimum element size	0.322765 mm
Mesh Quality	High

Mesh information – Details

Total Nodes	16573
Total Elements	9725
Maximum Aspect Ratio	11.812
% of elements with Aspect Ratio < 3	98.8
Percentage of elements with Aspect Ratio > 10	0.0823
Percentage of distorted elements	0
Time to complete mesh(hh;mm;ss):	00:00:06
Computer name:	

Resultant Forces Reaction forces

Selection set	Units	Sum X	Sum Y	Sum Z	Resultant
Entire Model	N	115.005	1,028.04	2.563e-05	1,034.45

Free body forces

Selection set	Units	Sum X	Sum Y	Sum Z	Resultant
Entire Model	N	0.000228047	-5.38826e-05	7.3405e-05	0.000245555

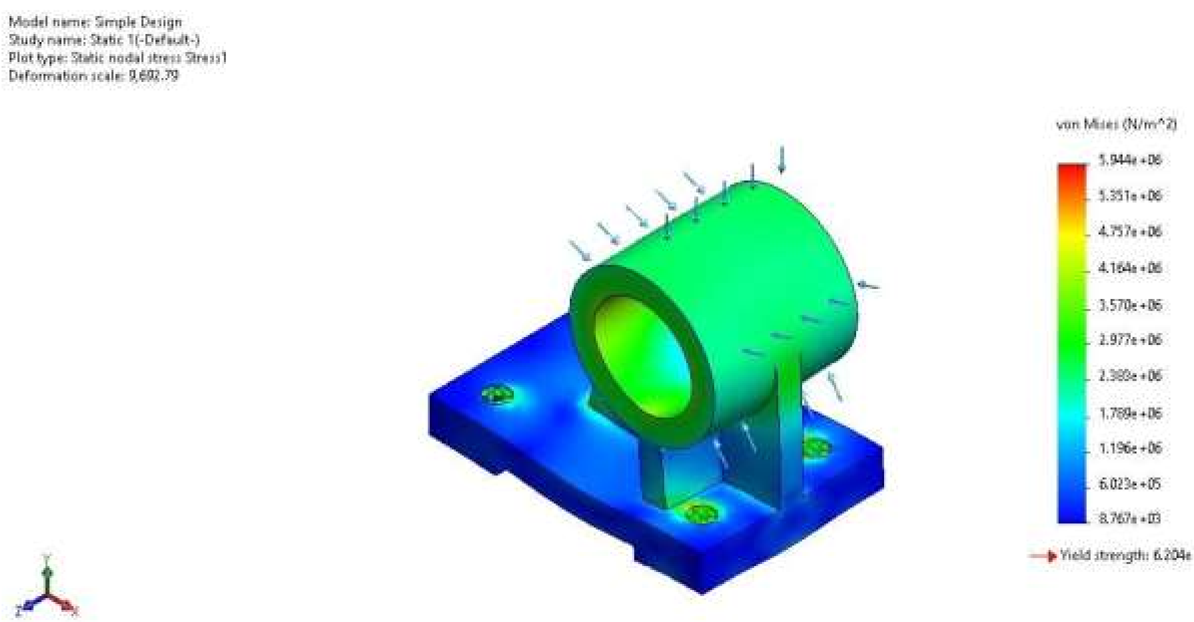
Free body moments

Selection set	Units	Sum X	Sum Y	Sum Z	Resultant
Entire Model	N.m	0	0	0	1e-33

Study Results

Stress

Name	Type	Min	Max
Stress1	VON: von Mises Stress	8.767e+03N/m^2 Node: 20	5.944e+06N/m^2 Node: 10644



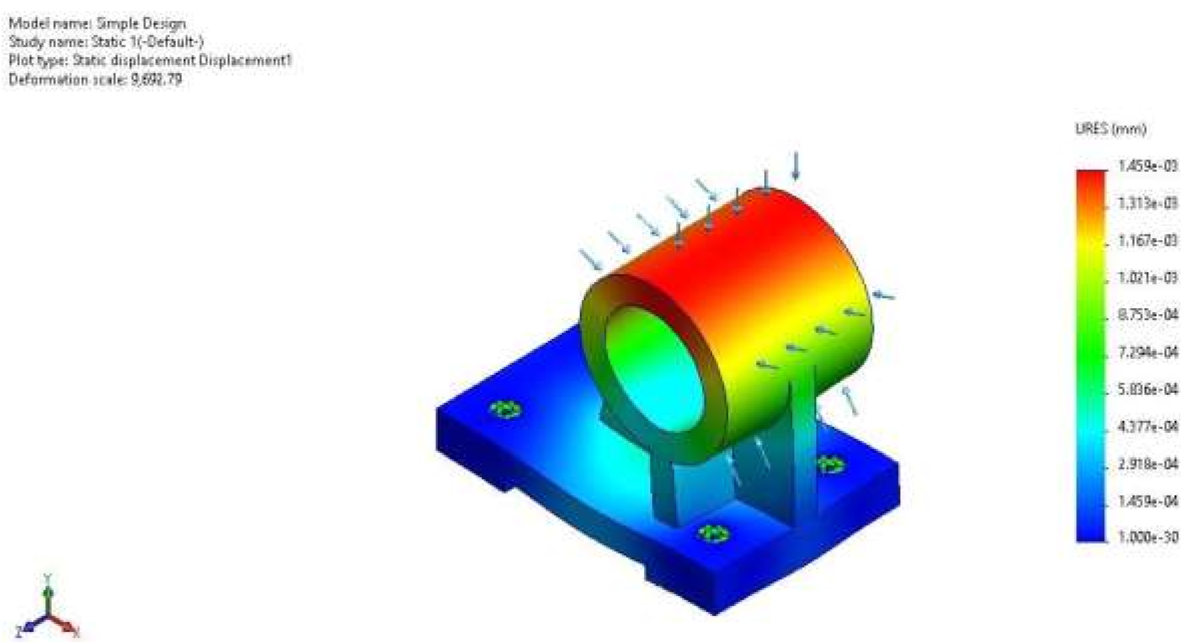
Simple Design-Static 1-Stress-Stress1

Results for Stress, Strain, and Displacement

Stress

- **Type:** von Mises Stress
- **Minimum Stress:** 8.767e+03 N/m² at Node 20
- **Maximum Stress:** 5.944e+06 N/m² at Node 10644

Displacements

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.000e+00mm Node: 21	1.459e-03mm Node: 16566
 Simple Design-Static 1-Displacement-Displacement1			

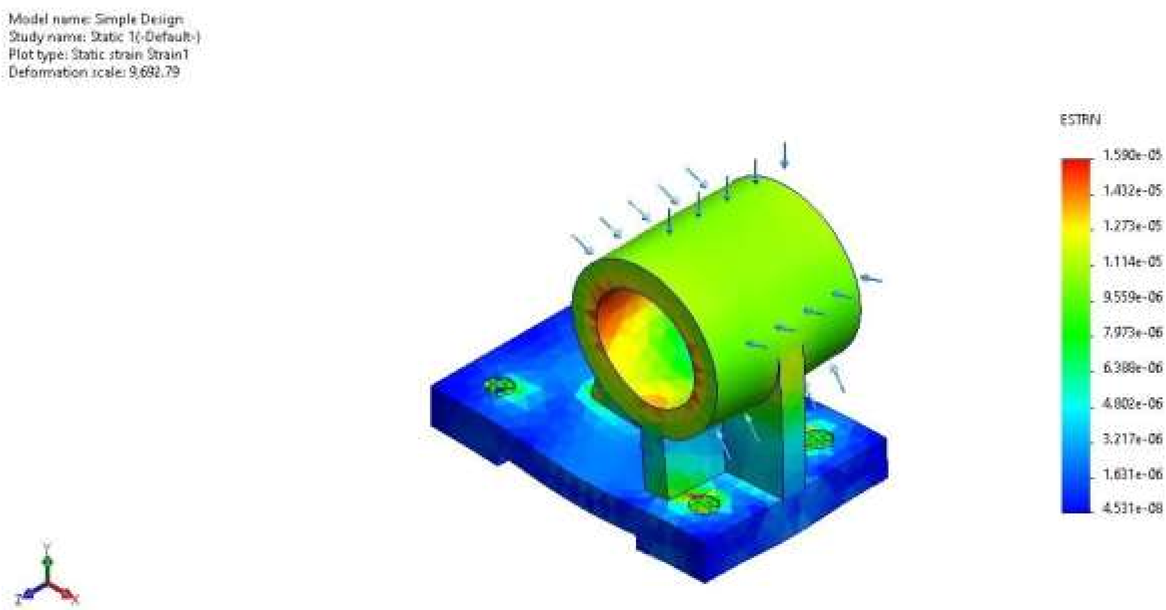
Displacement

- **Type:** Resultant Displacement

- **Minimum Displacement:** 0.000 mm at Node 21
- **Maximum Displacement:** 1.459e-03 mm at Node 16566

Strain

Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	4.531e-08 Element: 9189	1.590e-05 Element: 2391



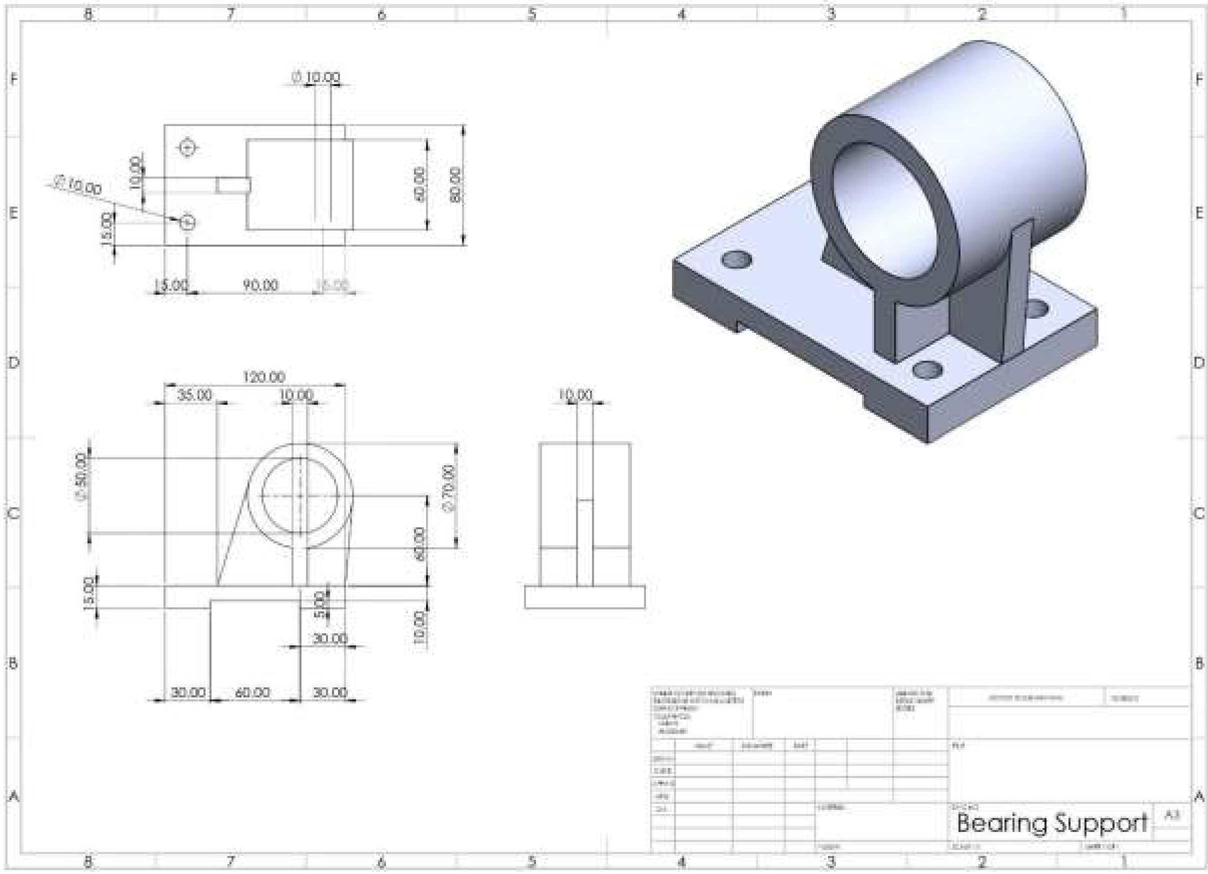
Simple Design-Static 1-Strain-Strain1

Strain

- **Type:** Equivalent Strain
- **Minimum Strain:** 4.531e-08 at Element 9189
- **Maximum Strain:** 1.590e-05 at Element 2391

These results show the stress, strain, and displacement experienced by the bearing support under the applied load of 10,000 N. The maximum von Mises stress is significantly lower than the yield strength of the material (6.20422e+08 N/m^2), indicating that the design remains within safe limits under the given loading conditions. The displacements are minimal, suggesting that the structure is quite stiff. The strain values also indicate a low level of deformation, which aligns with the small displacements observed

Technical Drawing



Ø10.00
Ø10.00
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90.00
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Ø50.00
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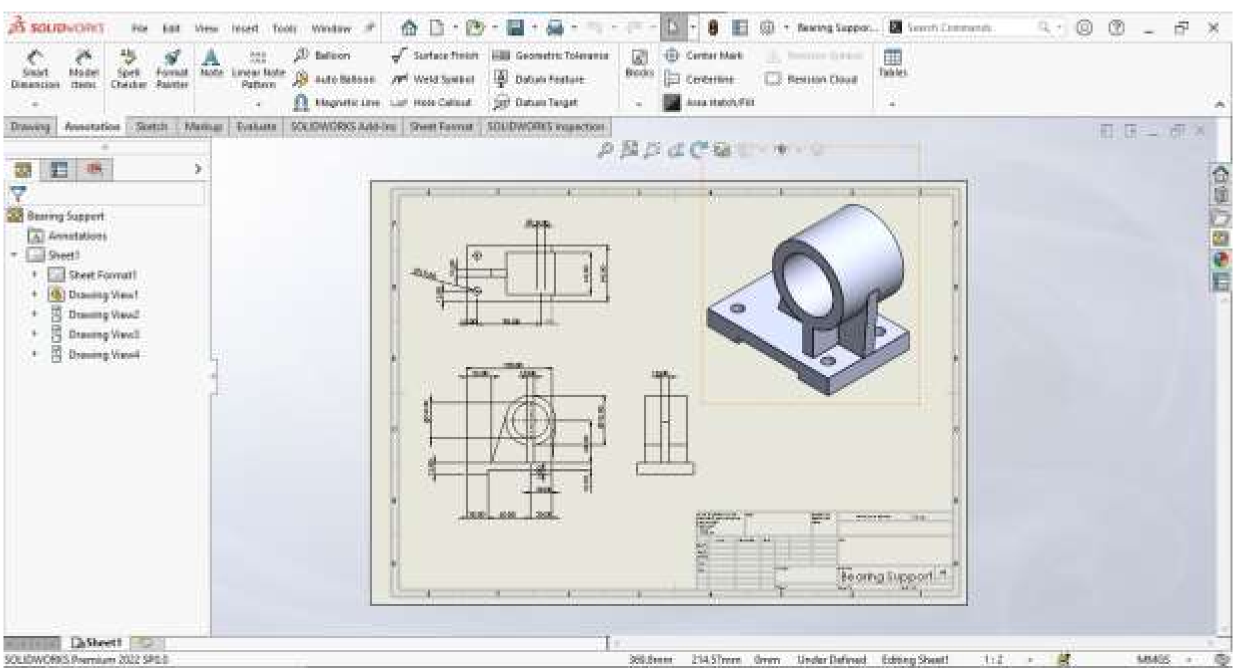
30.00
10.00
30.00
60.00
30.00
10.00
Bearing Support
A3

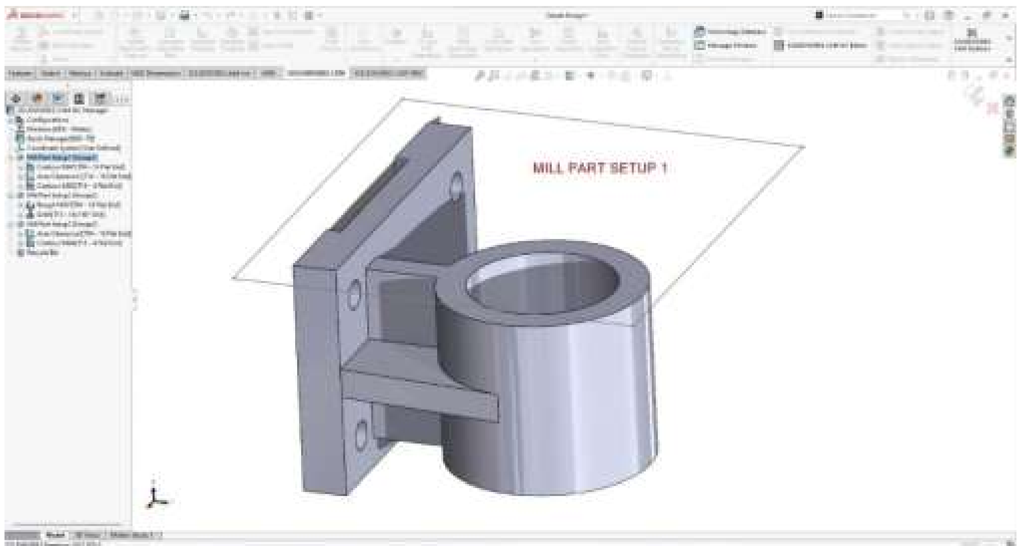


SOLIDWORKS
Smart Dimension
Model Items
Spell Checker
Format Painter
Note
Linear Note Pattern
Balloon
Auto Balloon
Magnetic Line
Surface Finish
Weld Symbol
Hole Callout
Geometric Tolerance
Datum Feature
Datum Target
Blocks
Center Mark
Centerline
Area Hatch/Fill
Revision Cloud
Tables
Drawing
Annotation
Sketch
Markup
Evaluate
SOLIDWORKS Add-Ins
Sheet Format
SOLIDWORKS Inspection
Bearing Support
Annotations
Sheet1
Sheet Format1
Drawing View1
Drawing View2
Drawing View3
Drawing View4
Bearing Support
Sheet1
SOLIDWORKS Premium 2022 SP0.0
Under Defined
Editing Sheet1
1 : 2
MMGS

Manufacturing operations

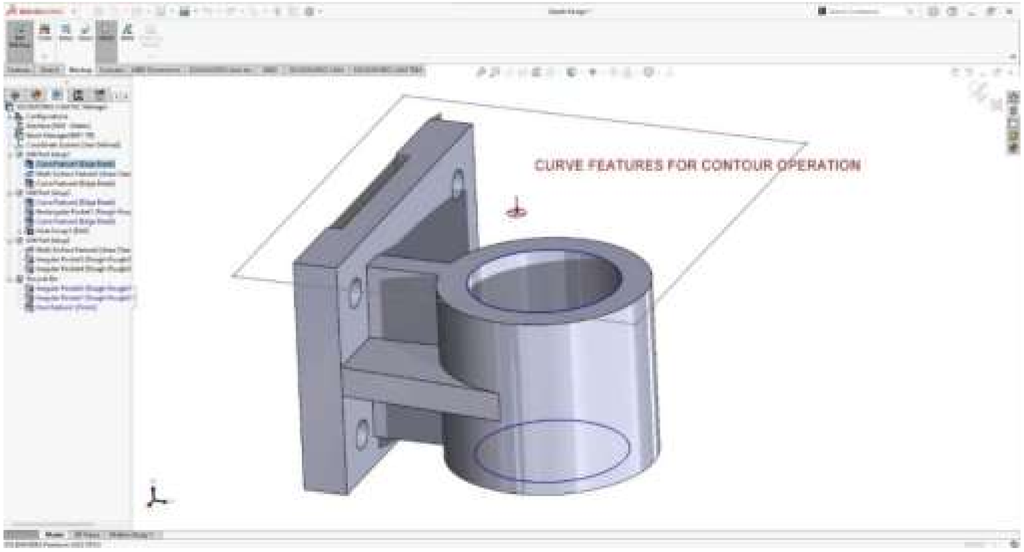
Selection of cutting tools & Selection of cutting modes

CNC Programing Mill Part Setup 1



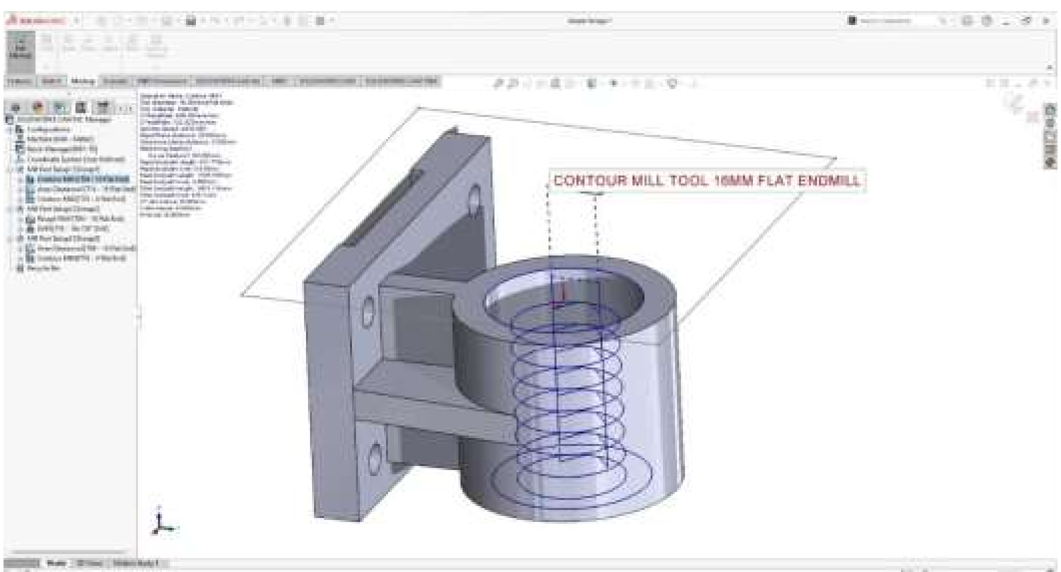
1. **Curve Features for Contour Operation:**

    - Define the curve features for the part to be contoured.
    - This includes selecting the contour geometry, ensuring the correct dimensions, and positioning on the workpiece.



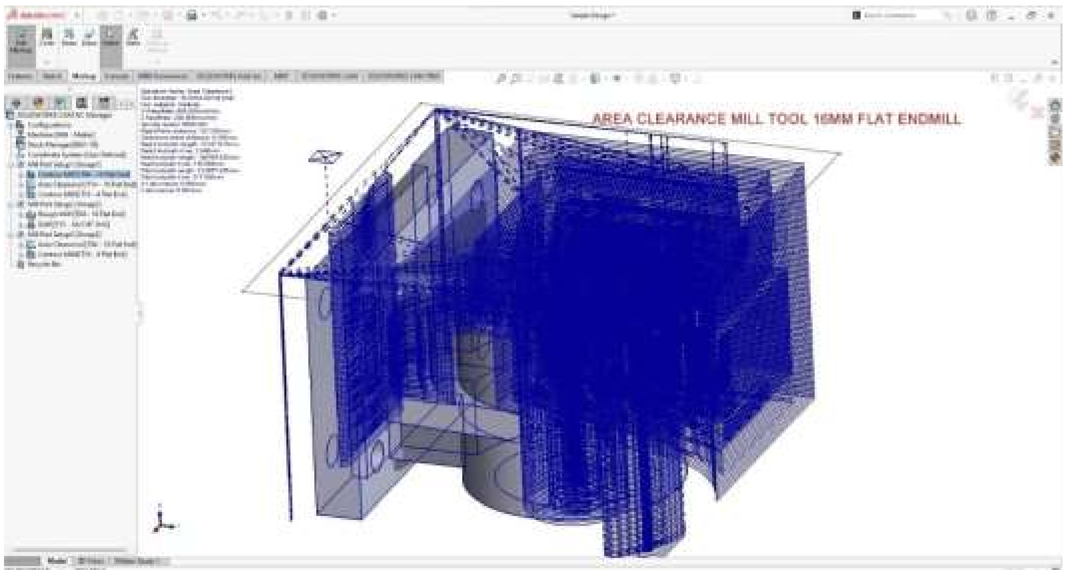
2. **Contour Mill Tool 16mm Flat Endmill:**

- Use a 16mm flat endmill for the contour milling operation.
- Set the spindle speed, feed rate, and cutting depth for the 16mm flat endmill.
- Execute the toolpath along the predefined contour.



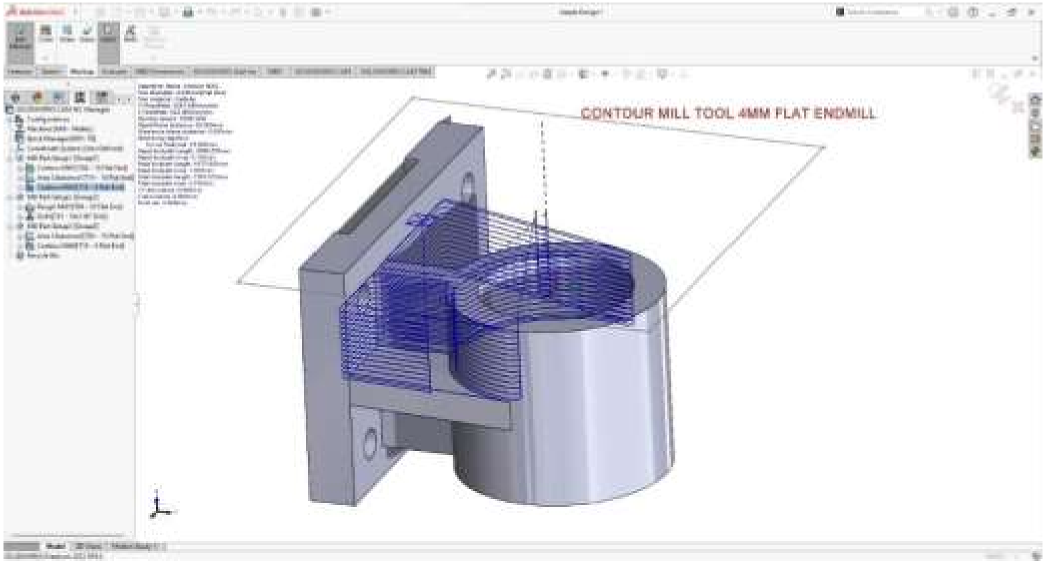
3. **Area Clearance Mill Tool 16mm Flat Endmill:**

- Use the same 16mm flat endmill for clearing larger areas of material around the contour.
- Define the area clearance strategy, such as zig-zag or spiral tool paths.
- Adjust the feed rate and cutting depth for efficient material removal.

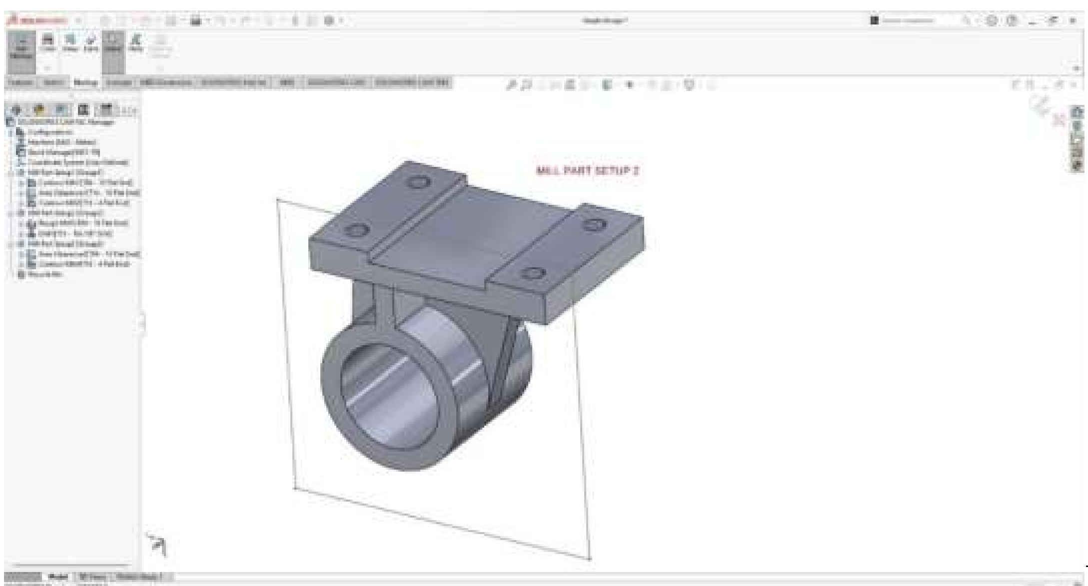


4. **Contour Mill Tool 4mm Flat Endmill:**

- Use a 4mm flat endmill with a great detail on cutting as the next step in contouring.
- Select the right spindle speed, feed rate and cutting depth with reference to the 4mm cuting tool.
- To meet the required tolerances and surface finish on finer elements, the contour milling should then be done.



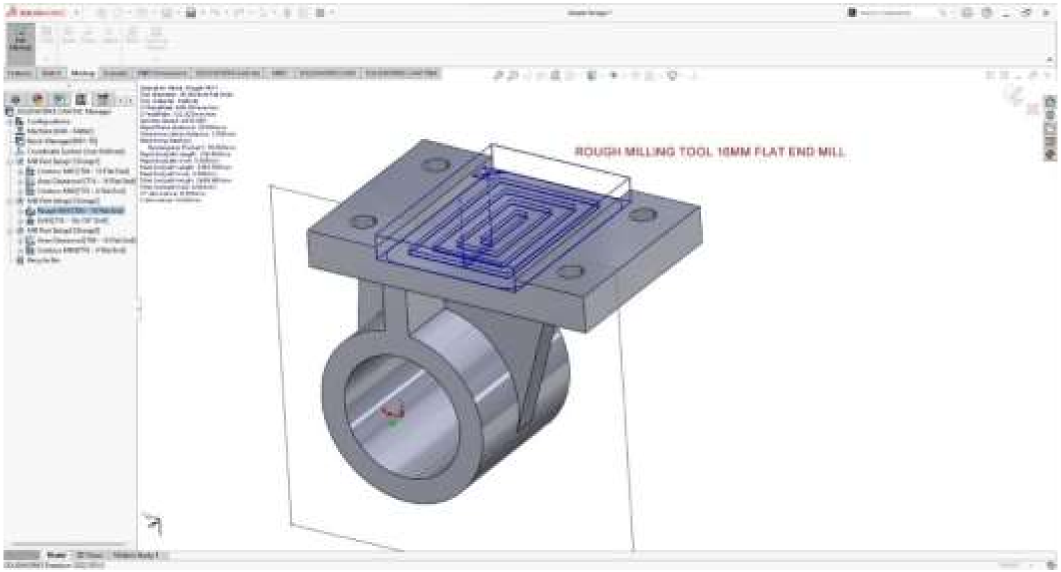
Mill Part Setup 2



]

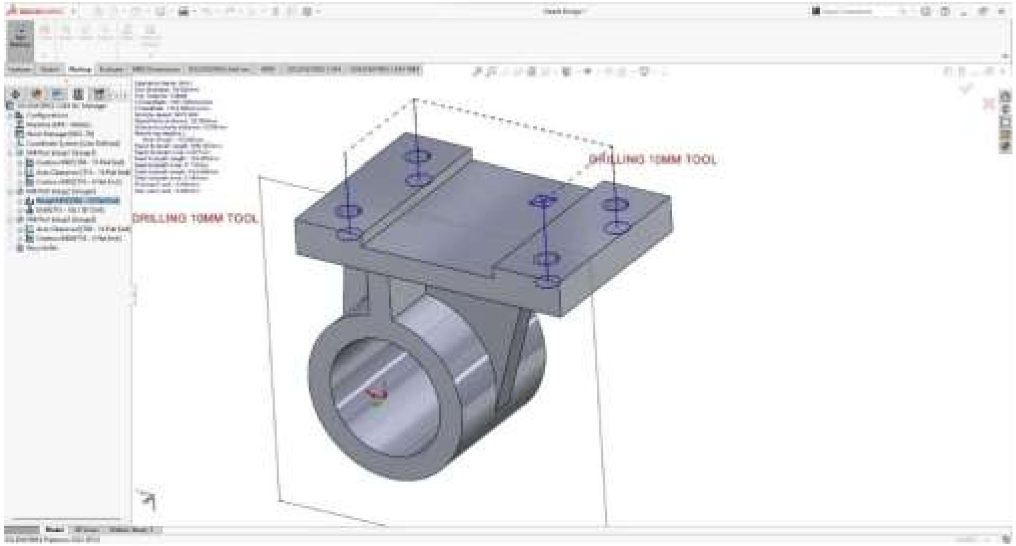
1. **Rough Milling Tool 16mm Flat End Mill:**
   - Begin with rough milling using the 16mm flat endmill to remove bulk material.
   - Define the rough milling parameters, including step-over, step-down, and feed rate.

- Execute the rough milling operation to prepare the part for finishing.

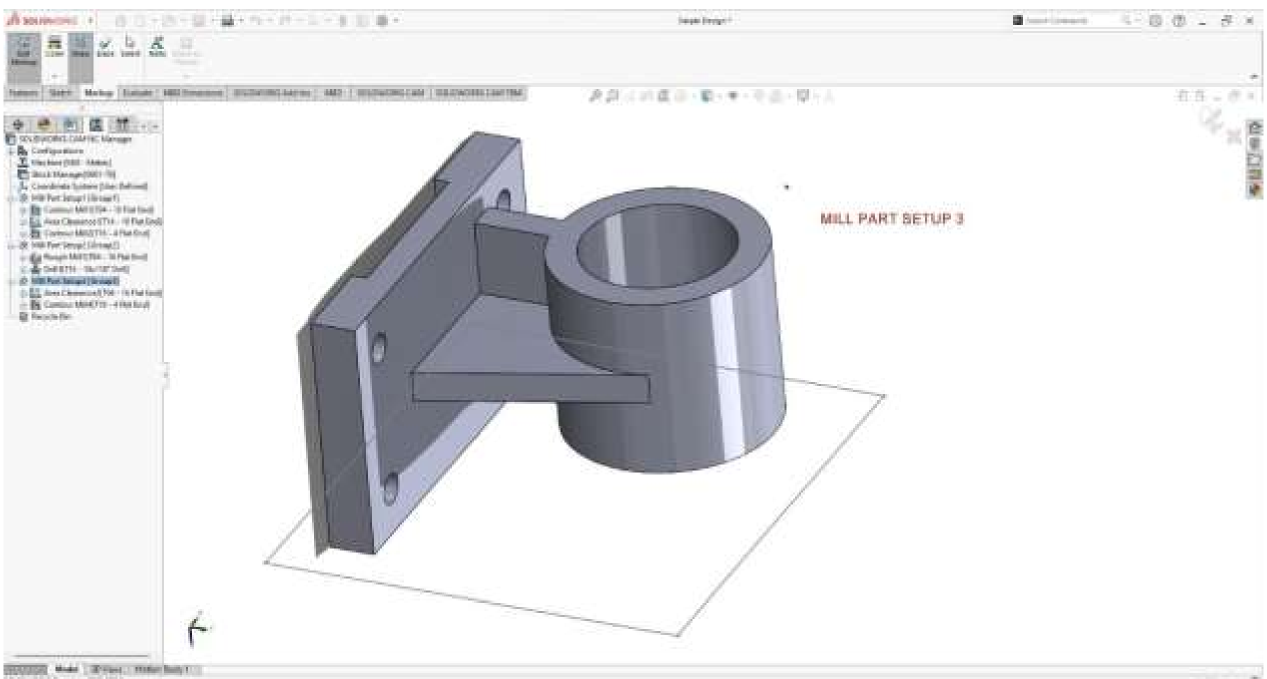


2. **Drilling 10mm Tool:**

- For drilling purposes, disassemble the bush and use a 10mm drill bit.
- Enter the spindle speed and feed rate for the 10mm drill to be used in cutting the disk.
- Drill at the intended locations and at the acceptable depth or as may be provided in the design documents.



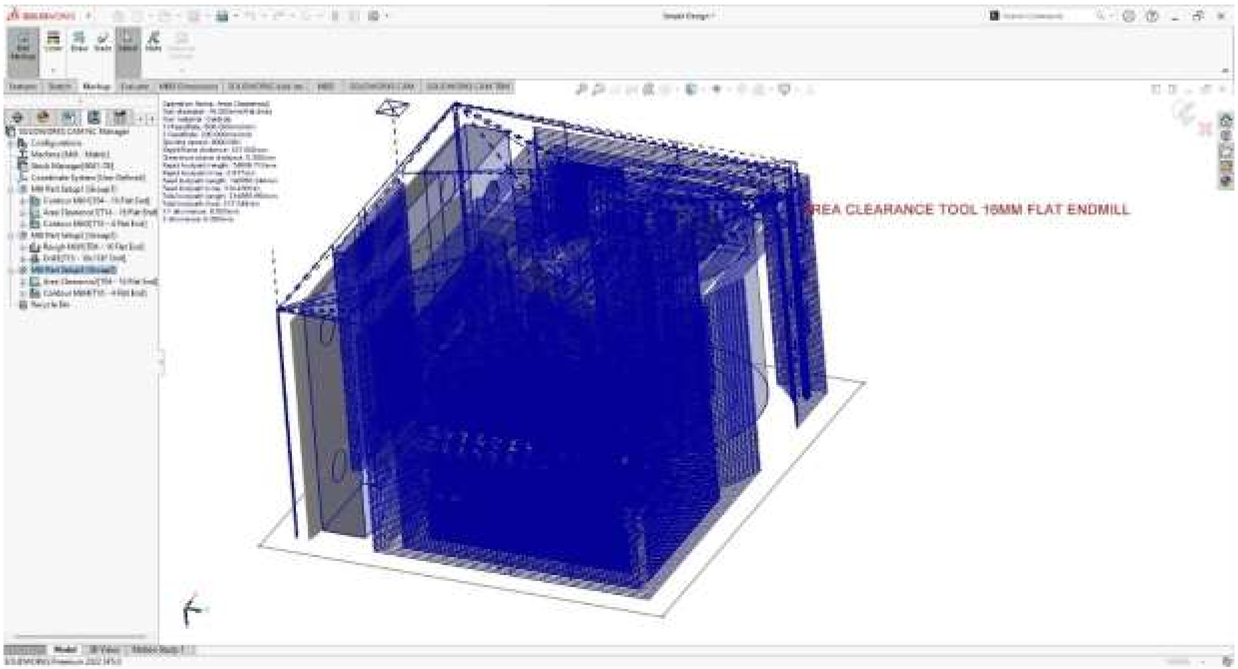
Mill Part Setup 3



1. **Area Clearance Tool 16mm Flat Endmill:**

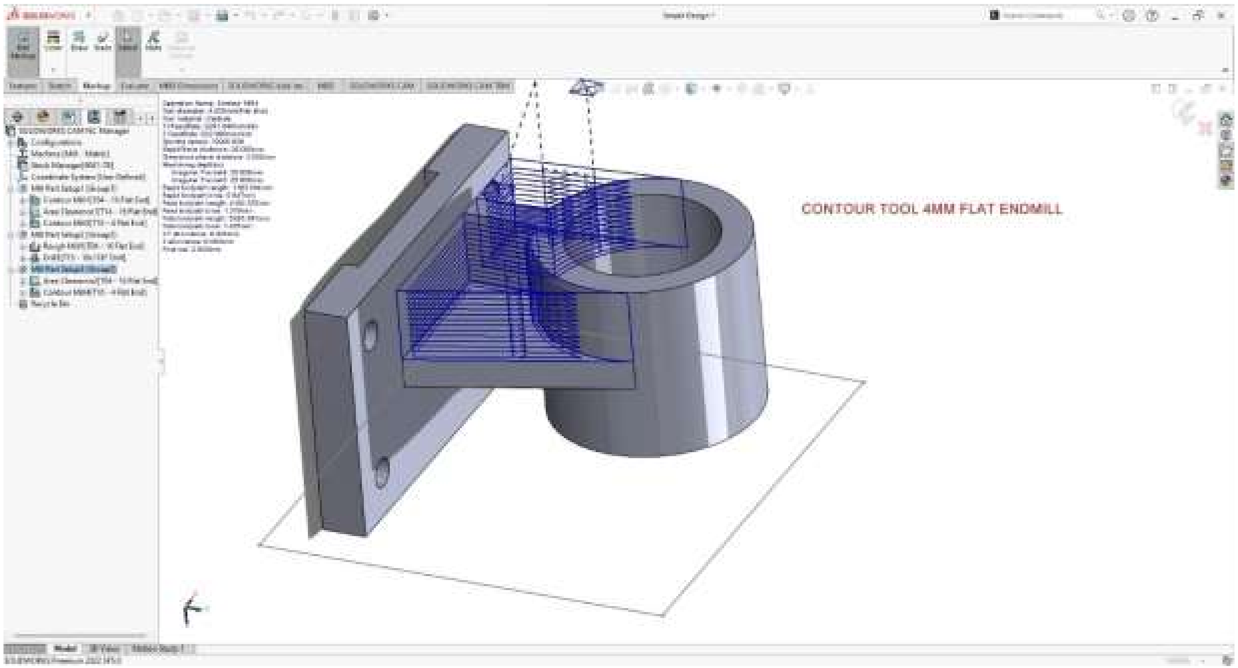
   - Use the 16mm flat endmill again for area clearance in the final setup.
   - Ensure the area clearance is performed to the correct depth and dimensions.

- Adjust the toolpath to clear any remaining material from previous operations.

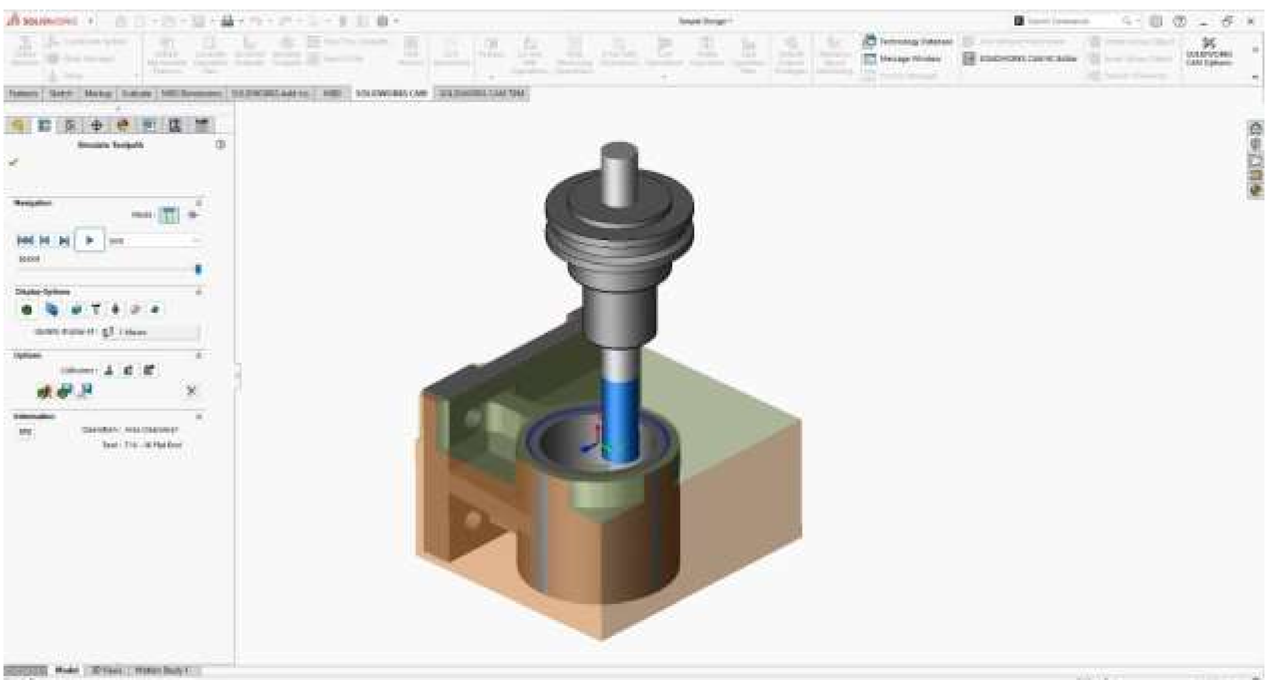


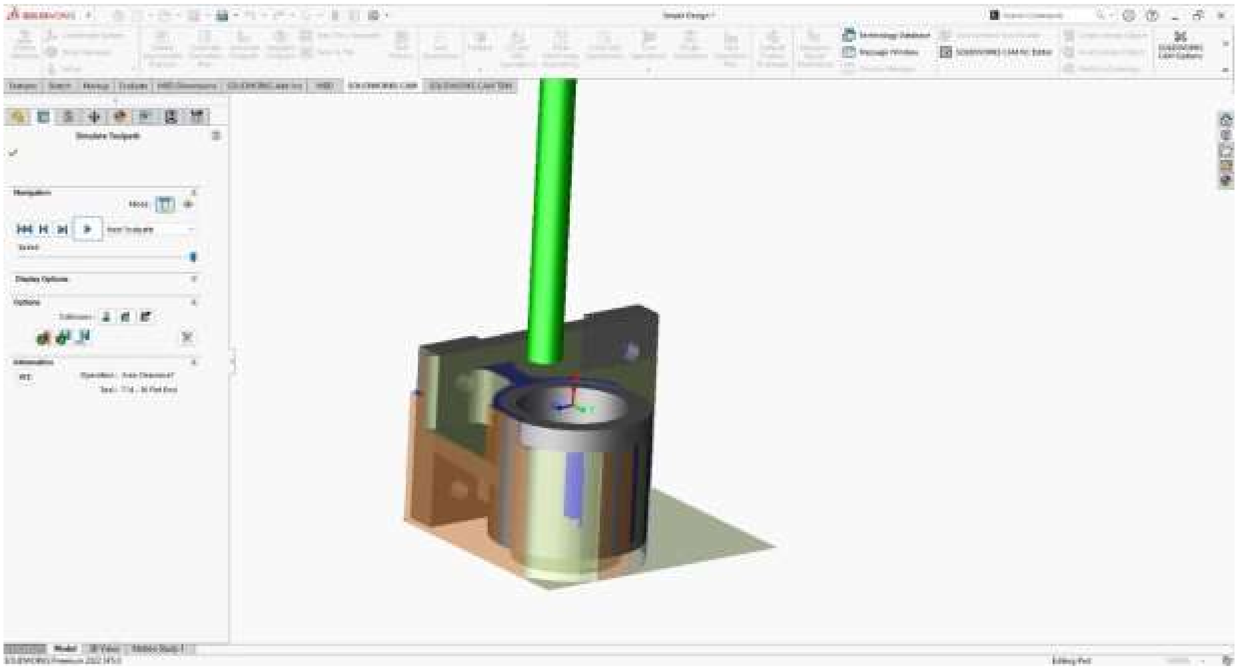
2. **Contour Tool 4mm Flat Endmill:**

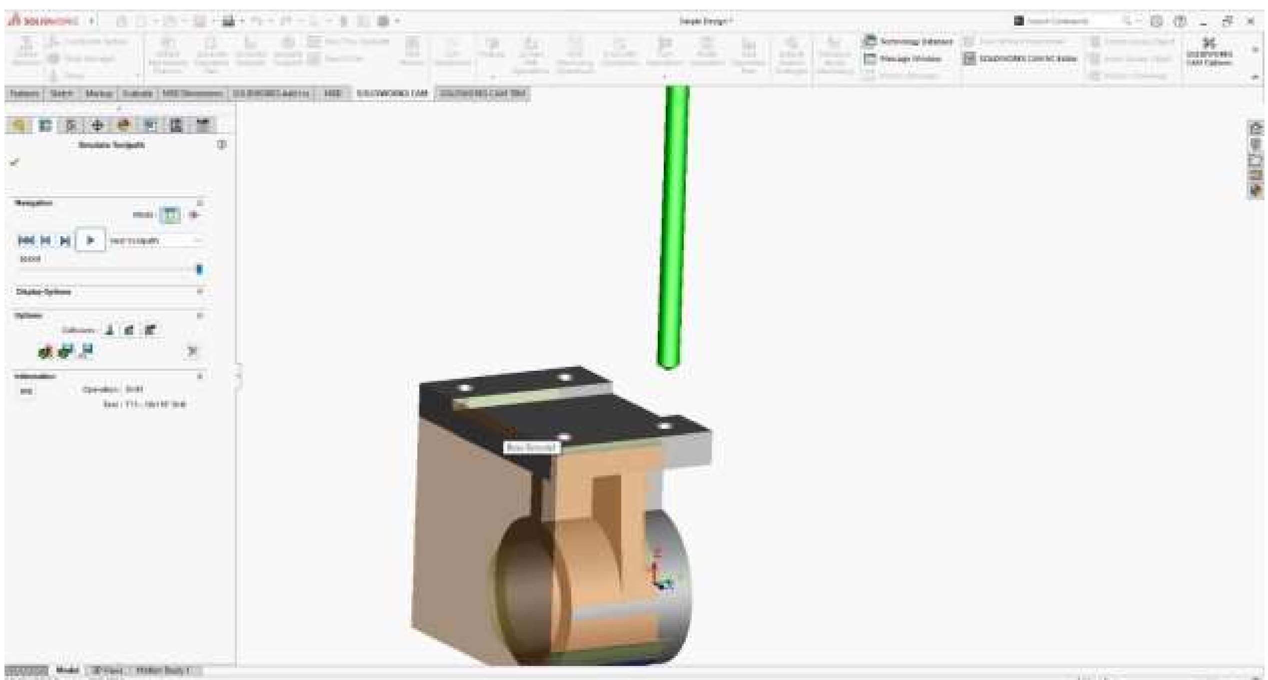
   - Finish the part with the 4mm flat endmill for final contour milling.
   - Set precise cutting parameters for the 4mm tool to achieve high accuracy and surface finish.
   - Plan the finishing contour milling operation from which the part can be made as per the required dimensions.

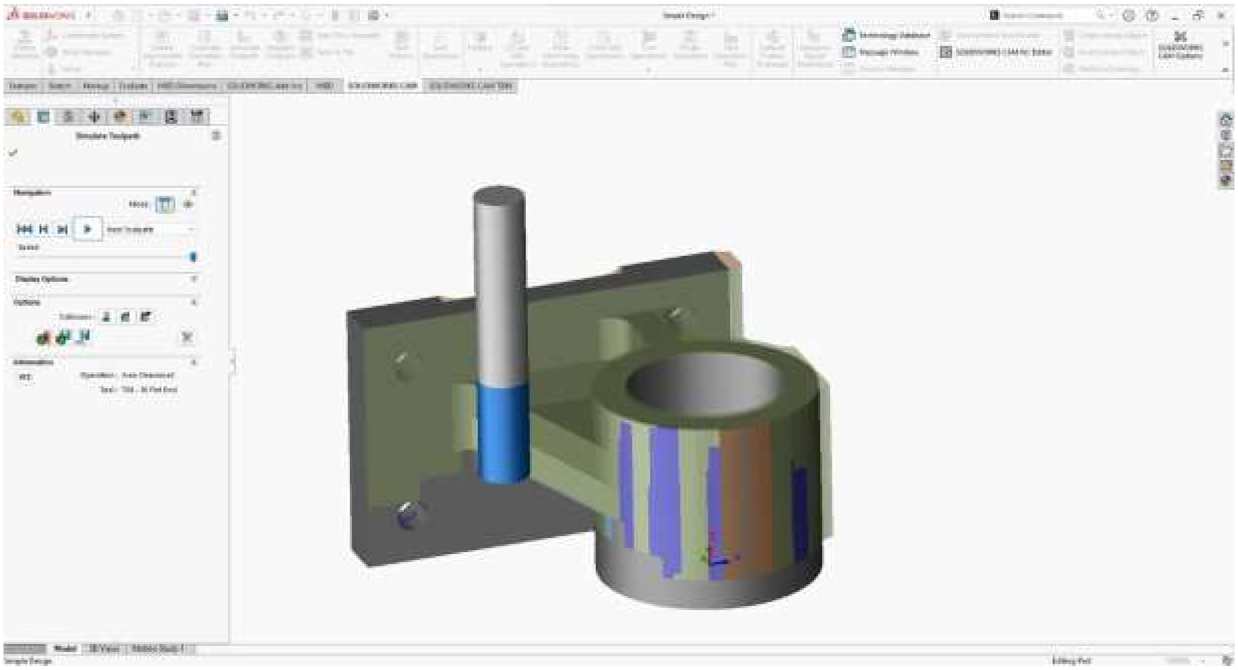


CNC Operation Simulation.





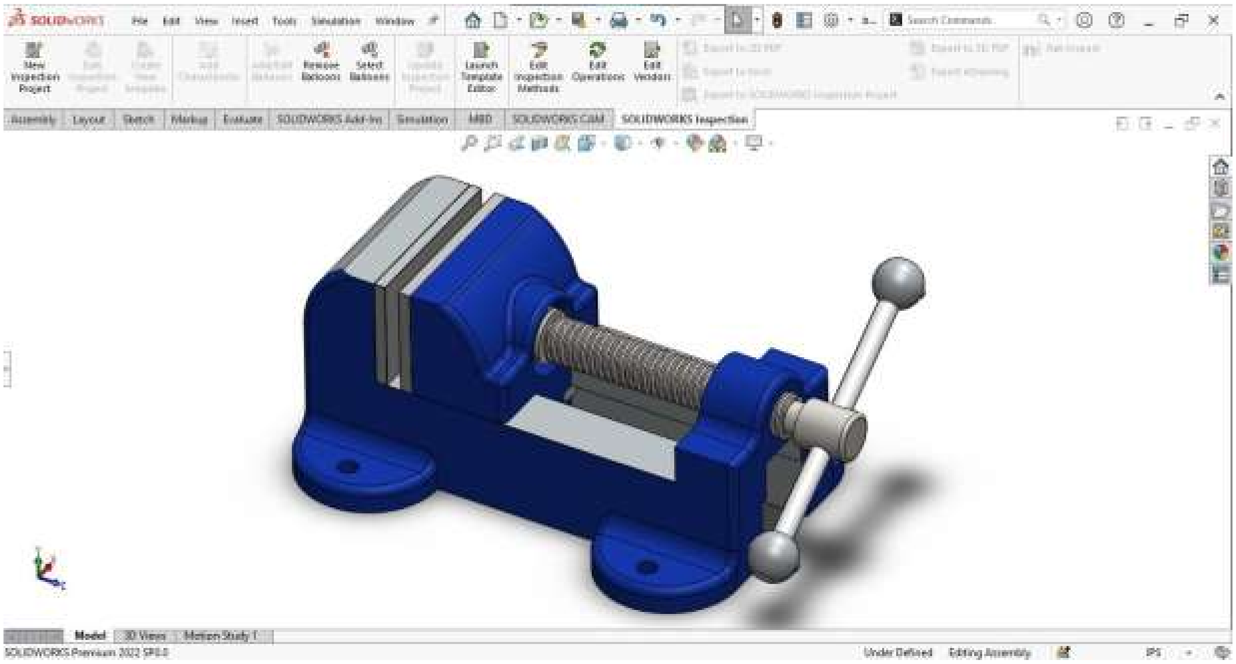




Fixture design

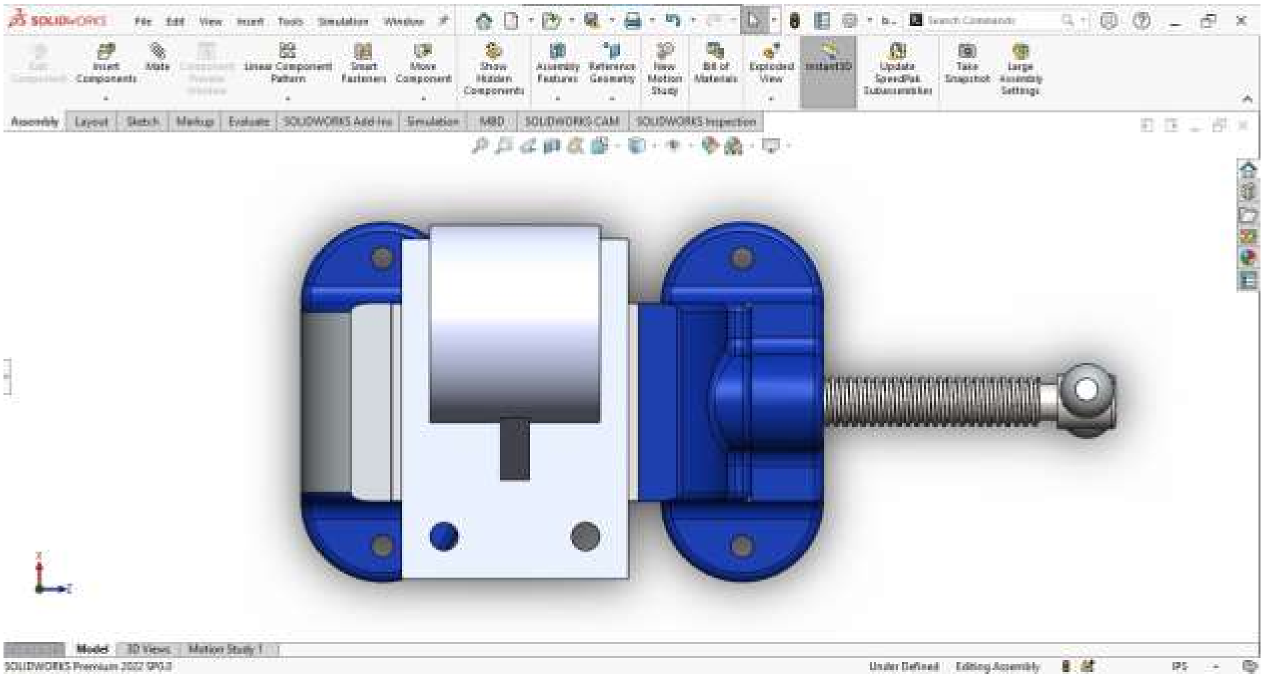
In the context of CNC machining, therefore, fixture design is arguably one of the most critical facets that will help determine the reliability, speed, and consistency when engaging in the manufacturing process. It is with a similar understanding of fixture design for this paper to focus on the more complex aspect of fixture design mainly used in the machining of bearing supports used in different mechanical applications. A proper design of the fixture not only holds the work piece appropriately but also holds the same in such a way that best conditions during the engineering can be achieved hence increasing on productivity as well as the quality of the work to be done.

Fixture Functionality and Requirements: As a tool in the CNC machining process, the primary role that a fixture plays is that of an accurate clamp where the workpiece is mounted and located before the machining processes are performed on it. In cases where bearing supports are involved, and such systems contain difficult shapes and narrow intervals, the fixture must capture these distinctive characteristics. Besides, aspects such as material choice, ease of loading and unloading loads, and ease of access to the machining zones in the load are other important facets in the fixture design.



Design Considerations: Designing a fixture for machining bearing supports entails a systematic approach that addresses various considerations:

1. **Workpiece Geometry:** Given that bearing supports are available varying in shapes as well as sizes, unique fixture designs are required having regards to the specific geometries. This can be achieved by hold and reuse of individual fixture parts or custom designing a fixture that fits the contours of the workpiece completely.



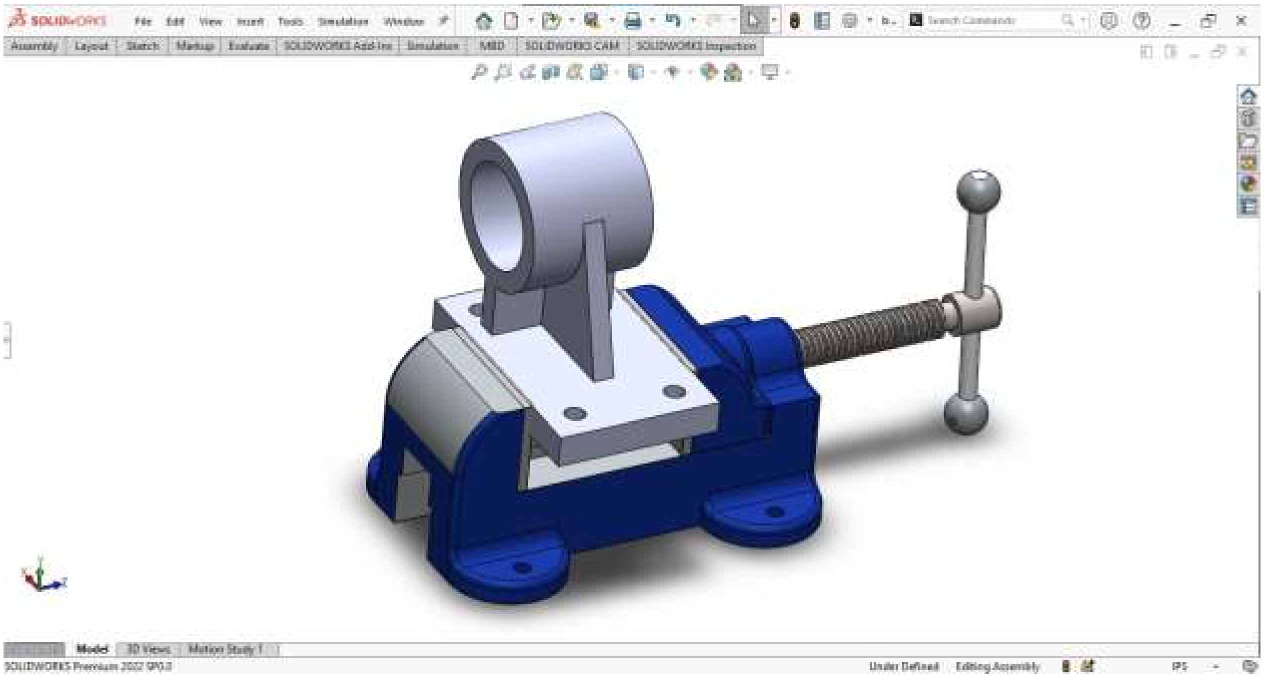
2. **Material Compatibility:** Bearing supports are typically made of metal such as Steel, Aluminum thus, fixtures must be designed capable of clamping these materials tightly without leading to distortion or damage while manually.

3. **Accessibility:** There should be freedom-of- access to the key locations for bearing support in the fixture design so that the necessary CNC tools can access a particular zone as planned.

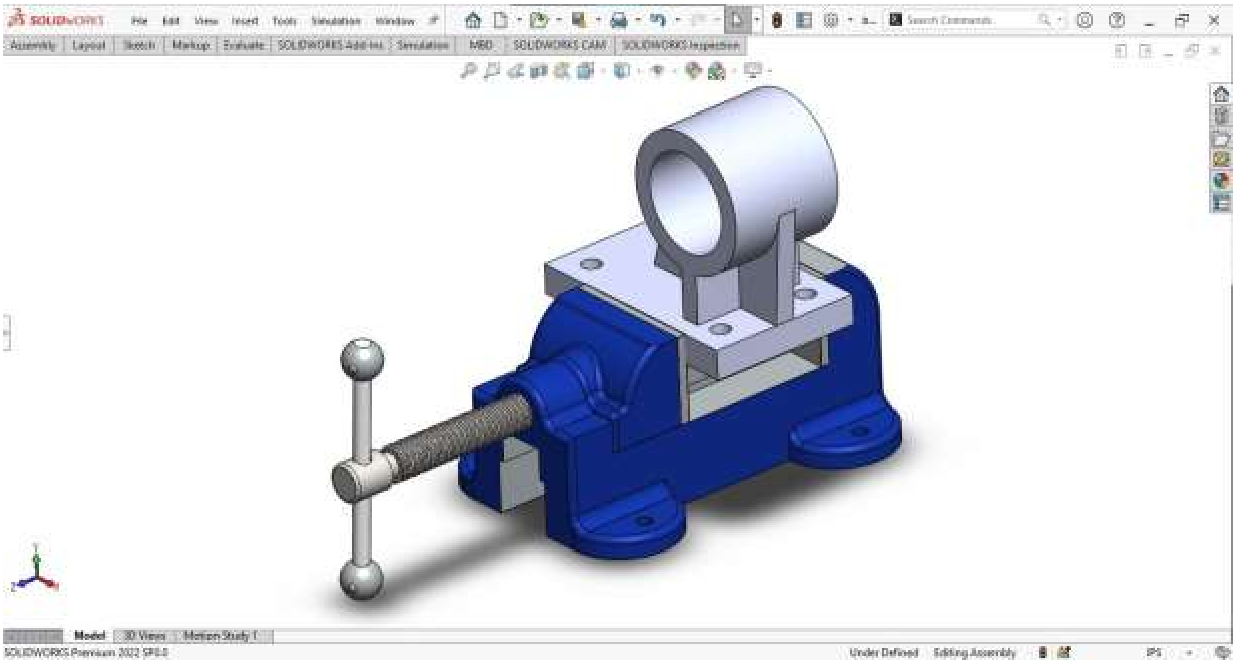
4. **Clamping Mechanism:** A good thinking for a workpiece clamping system is central to the machining process in the sense that it ensures the workpiece is held firmly in place. This can be achieved through the use of such fixtures as vices, clamps or develop special clamping members that conform to the geometry of the bearing support.

5. **Datum Points and Alignment:** Key tactics are setting correct datum points, and correctly positioning the workpiece in relation to those datum points because values of tolerance can multiply when dimensions are accumulated

across several operations.



6. **Chip Evacuation:** Proper chip management also remains critical specifically in machining so as to avoid issues, such as the accumulation of chips, that might reduce the surface finish and the durability of the cutting tool. Another requirement inherent to the fixture design is the issue of chip removal – the environment should be designed to have coolant channels or chip evacuation ports for this purpose.



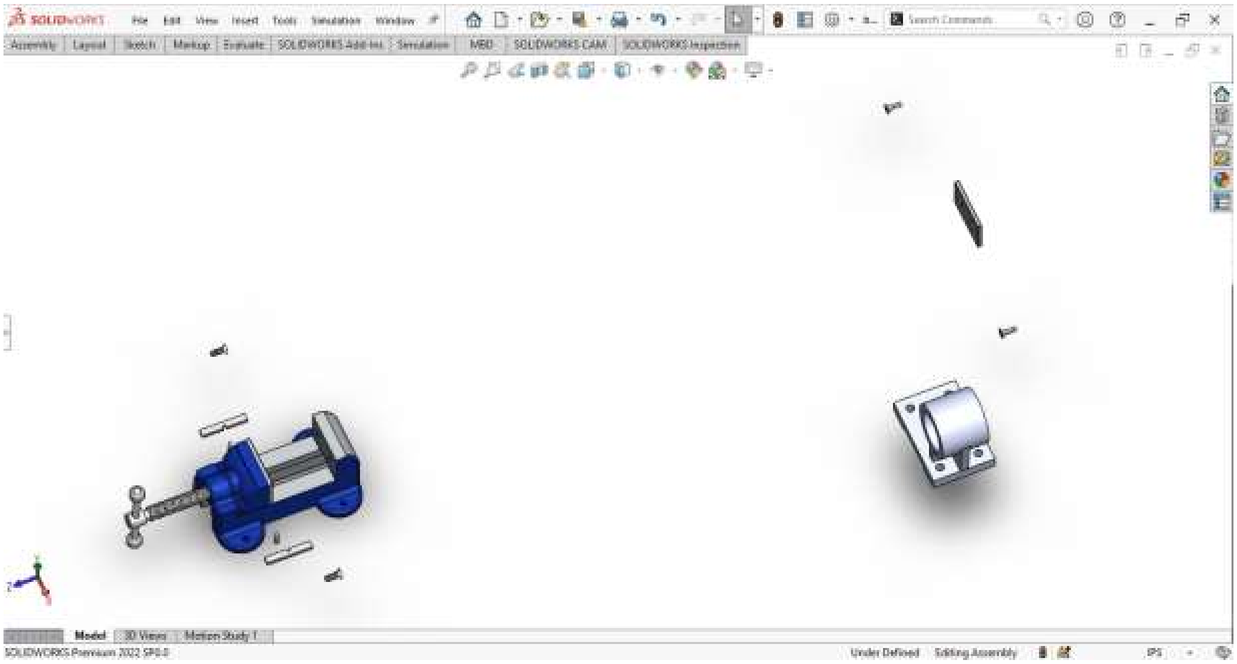
Optimization for CNC Machining: Apart from the parameter and features of the specific application, it is necessary to take advantage of substantial techniques and technologies dependent on CNC machining for improving the fixture efficiency and quality. This may include:

1. Utilizing Simulation Software: CAD models of fixtures can be used to check their geometry and functionality before manufacturing; more advanced software allows studies of clamping forces, interferences of clamped parts, and other crucial aspects to achieve minimal cycle times and maximal accuracy.

2. Modular Fixture Components: Subassemblies of fixtures are useful as they encourage the reusing of some constituent parts through the variations in the types of workpieces or in machining needs to call for changes in the fixture's design.

3. Adaptive Fixturing Systems: Modern applications such as adaptive fixturing systems that enable the use of sensors and actuators to change clamping

forces and part positioning during the process of cutting help in improving workpieces’ sizes and reducing the time taken in setting up.



General Issues

In essence, as a engineer, I work using inputs from different fields, each of which brings a different conception of the work that I am handling. In this reflection on general issue imperative in manufacturing engineering, I apply the concepts of economics, material resistance, theoretical mechanics and other relevant disciplines to explain the subjects that relates to manufacturing engineering and its prospects in today's society.

Economics plays a critical role in influencing different facets of manufacturing engineering from the general processes of production to issues of resource utilization, and competition within the market. The concepts like economies of scale, cost reasonability analysis, and supply chain management are important to manage the manufacturing operations successfully and sustaining the products sold in the marketplace. Describing the key areas of production cost and its control, one can state that current manufacturers have an opportunity to control their costs and explore the most effective ways of production due to the complexity of the modern business environment.

Materiel resistance is one of the simplest design/manufacture factors to consider when developing structures which can handle mechanical loads and environmental stresses. I apply material science to make a judgment on the characteristics of materials that will apply the best for a certain job. Quality attributes such as strength or hardness, elasticity, and fatigue resistance, apply in decision making on materials needed, and determine whether the components will meet such requirements, in addition to meeting safety standards. Due to develop new and better material and new techniques of making, engineers have the chance to increase the possibilities of improving the product's resilience and efficiency.

Theoretical mechanics serve as the theory on which the real mechanics rely in order to understand the behavior of mechanical systems and structures. Some of the application areas of mechanics include statics and dynamics, structural analysis that helps in evaluation of the performance and reliability of components of certain machines. One of my key tasks is evaluating and predicting of components using simulation and mathematical modeling that allows me to

find out how components would transform to outside forces and how one can redesign the components to achieve the desired level of performance. Therefore, through use of theoretical mechanics principles in my designs, I get to achieve creations that are not just effective, but also serviceable in real world practice with proper working and performance, as well as being safe.

Further, while academic knowledge of CNC programming, fixture design, and process planning is crucial for qualification, have practical skills to make those ideas come to life is vital. In CNC programming, I transform design input into machine control code by positioning the tool, defining the cutting operation's tactics, and estimating aspects such as speed, material removal rate, feeds, and cutting tools. Fixture design is quite an intensive discipline that involves assessment of the material properties, the machining methods as well as the geometric control procedures to come up with tool holders that effectively grasp on the work pieces during the machining processes. In the aspect of process planning, this ensures that the manufacturing operations are assembled in the best way possible while reducing the time that the equipment takes before it is up and running again, all directed towards the success of the manufacturing projects.

Therefore, considering all the aspects mentioned above, I can confidently address the sphere of manufacturing engineering and its essential intricacies as they are encompassed by my comprehensive outlook based on the specification of economics, the physical objection, theoretical apparatus and, not least, the practical expertise. While applying the knowledge of the diverse disciplines incorporated in the coursework, I am able to foster creativity, increase efficiency, and guarantee the quality of the products as they compete in the global economy. Being a manufacturing engineer, I believe in Perceiving, Analyze actions, Select and Implement, and Review action plans, as well as designing the manufacturing processes in conjunction with other manufacturing engineers to foster a culture of innovation in manufacturing engineering.

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CNC Codes

The NC (Numerical Control) code is provided in the attached text file accompanying this report. Due to the length of the program code. Please refer to the attached file for the complete NC code details.

Explanation

In this context, "NC codes" refer to the programming instructions used to control CNC (Computer Numerical Control) machines. These codes specify the movements and operations of the machine to produce a desired part. The length and complexity of NC programs can make it impractical to include them directly within a report, so they are often provided as separate attachments. This approach ensures that the document remains concise while still providing all necessary technical details.

```
O0001 N1 G21
N2 (16MM CRB 2FL 32 LOC) N3 G91 G28 X0
Y0 Z0
N4 T04 M06 N5 S4378 M03
N6 ( Contour Mill1 )
N7 G90 G54 G00 X-9.942 Y7.984 N8 G43 Z3.
H04 M08
N9 G01 Z-8. F122.323
N10 G41 D24 X-16.352 Y2.68 F366.969
N11 G17 G03 X-16.925 Y1.598 I1.02 J-1.233
N12 X-17. Y0 I16.925 J-1.598
N13 I17. J0 F489.293
N14 X-16.925 Y-1.598 I17. J0 N15 X-16.352 Y-
2.68 I1.593 J.15 N16 G40 G01 X-9.942 Y-7.984
N17 G00 Z3.
N18 Y7.984
N19 G01 Z-15.429 F122.323
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G03 X-16.925 Y1.598 I1.02 J-1.233 N22 X-17.
Y0 I16.925 J-1.598
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N477 G00 Z13.

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N617 X-56.807 Y1.891 N618 X-56.886 Y1.812
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N825 Y-81.435

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N854 G00 Z13.

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N893 G01 Z7. F200.
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N897 Y-81.448
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N925 G00 Z13.
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N934 X-51.147 Y-5.738 N935 X-51.11 Y-5.844 N936 X-51.051 Y-5.939 N937 X-50.971 Y-6.018 N938 X-50.877 Y-6.078 N939 X-50.771 Y-6.115 N940 X-50.66 Y-6.127 N941 X-9.348 Y-6.099 N942 X-9.219 Y-6.082 N943 X-9.098 Y-6.032 N944 X-8.995 Y-5.952 N945 X-8.915 Y-5.849 N946 X-8.866 Y-5.728 N947 X-8.849 Y-5.599 N948 Y-4.334
N949 X-8.866 Y-4.205 N950 X-8.916 Y-4.084 N951 X-8.995 Y-3.981 N952 X-9.099 Y-3.901 N953 X-9.219 Y-3.851 N954 X-9.349 Y-3.834 N955 X-50.66
N956 X-50.771 Y-3.847 N957 X-50.877 Y-3.884 N958 X-50.972 Y-3.944 N959 X-51.051 Y-4.023 N960 X-51.111 Y-4.118 N961 X-51.147 Y-4.223 N962 X-51.154 Y-4.279 N963 X-51.421 Y-4.401 N964 X-52.09 Y-4.418 N965 X-54.095 Y-4.278 N966 X-56.09 Y-4.138 N967 X-56.746 Y-4.156 N968 X-56.994 Y-4.279 N969 Y-11.466
N970 X-56.981 Y-11.577 N971 X-56.944 Y-11.683 N972 X-56.885 Y-11.777 N973 X-56.805 Y-11.857 N974 X-56.71 Y-11.916
N975 X-56.605 Y-11.953 N976 X-56.493 Y-11.965 N977 X-3.512 Y-11.929 N978 X-3.383 Y-11.912 N979 X-3.263 Y-11.862 N980 X-3.159 Y-11.783 N981 X-3.08 Y-11.679 N982 X-3.03 Y-11.559 N983 X-3.013 Y-11.429 N984 X-3.016 Y1.5 N985 X-3.033 Y1.629 N986 X-3.083 Y1.75 N987 X-3.162 Y1.854 N988 X-3.266 Y1.933 N989 X-3.386 Y1.983 N990 X-3.516 Y2.
N991 X-56.495
N992 X-56.606 Y1.987 N993 X-56.712 Y1.95 N994 X-56.807 Y1.891 N995 X-56.886 Y1.812 N996 X-56.946 Y1.717 N997 X-56.983 Y1.611 N998 X-56.995 Y1.5 N999 X-56.994 Y-4.279 N1000 X-57.334 Y-4.403