DESIGN OF GANTRY LOADER MILLING MACHINE (GLMM)

DESIGN PROJECT REPORT

Submitted By,

SRIPRANAV RAMAKRISHNAN (99007971)

SANJAY S (99007972)

KRISHNA REDDYAPPKASA (99007973)

SARAVANAKUMAR (99007974)

PRANIT SAIBANNAVAR (99007934)

AKASH CHANDRANNAVAR (99007935)

Table of Contents

1. Problem Statement

It is required to design a gantry loader system for CNC milling machine for picking the workpiece from the specified location and place it on milling machine table/vice. The weight carrying capacity of the loader should be minimum 3kg. A vertical lift of 1500mm, horizontal travel of 1000mm is essential in the workpiece envelope.

You are required to design the mechanism for picking the work piece from the pickup location and transfer it to the table. The design should clearly provide the mechanism provided, design calculation and justify selection of any off the shell component like bolts, bearing, bushes, motors, couplings etc. You can select a gripper of your choice but you want to clearly specify its features and limitations.

2. Abstract

We have to find the two concept regarding gantry loader milling machine and we have to choose which one is better and we have to mention the reason and we choose rack and pinion method for both horizontal and vertical movement to pick the component of 3kg and we have choose servo motor and we have used 2 jaw gripper as an end effector to pick the component and another concept is lead screw mechanism we haven't used this concept as we cannot use this concept vertical movement so we have made calculations and 3D modelling for rack and pinion concept.

3. Software Used

Creo parametric 5.0 is used to design the CAD model of rack and pinion and gripper.

4. Selection

Selection for rack and pinion and supporting elements are discussed below.

4.1 Selection for Rack and Pinion

We used a catalog for Apex dynamics which is used for selection for rack and pinion. For vertical rack we have used Q8 carbon steel normalizing (heat treatment) and we have used Q8 H Q&T Alloy steel quenched tempered (heat treatment) for horizontal rack and for pinion we have used carbon steel and the reason that this material works well is due to the relative strength of the rack tooth in combination with the pinion.

For Vertical movement pinion:

Sl no.	Specification	Values
1.	**Module**	**2mm**
2.	**No of teeth**	**Np=20**
3.	**Pitch diameter**	**40mm**

For Horizontal movement pinion:

Sl no.	Specification	Values
1.	**Module**	**3mm**
2.	**No of teeth**	**Np=20**
3.	**Pitch diameter**	**60mm**

4.2 Selection for Motor, legs and grippers

We have used aluminum and alloys for supporting legs that’s because aluminum on its own does not have a high tensile strength unlike steel the strength of aluminum increases the colder it gets, whereas in steel becomes brittle at low temperatures and its resistance to corrosion and it wont break and its very strong and it readily forms alloys and so it’s easy to make into frame.

Selection for motor

For motor selection we have used a open source platform called as "Mitsubishi Motorizer Software" for the both vertical and horizontal movements on the basis of our calculations.

The motor specifications are mentioned below:

For Horizontal motor:

S. NO	SPECIFICATION	VALUES
1	Model No.	TM-RFM048G20
2	Driver No.	MR-J5-350G/G-N1/A
3	Motor type	Servo
4	Power Supply Voltage	200 V AC
5	Motor torque capacity	48 N-m
6	Drive Capacity	3.5kW
7	Max speed	200r/min

For Vertical motor:

S. NO	SPECIFICATION	VALUES
1	Model No.	HK-ST202AWJ
2	Driver No.	MR-J5-200G/G-N1/A
3	Motor type	Servo
4	Power Supply Voltage	200 V AC
5	Motor torque capacity	9.5 N-m
6	Drive Capacity	2kW
7	Max speed	2000 r/min

Material composition for grippers

Mass of to be lifted	> 3kgs
Model number	> AL 2000
Stroke length	> 13mm
Max payload friction grip	> 4.1kg
Max payload encompassing grip	> 8.3 kg
Grip force open/close	> 130N

5. Design Calculation

Design of the base of rack and pinion

Pinion design for horizontal movement

Pinion design for horizontal movement

Assumptions made :-

module $m = 3\,mm$

No of teeths $= n_p = 20$ ($20°$ FDI)

face width $= b = 12m = 36\,mm$

Pitch circle diameter $= d_p = mz = 60\,mm$

Addendum $= a = 1m = 3\,mm$

Addendum circle dia $= d_p + 2a = 66\,mm$

Dedundum $= d = 1.25m = 3.75\,mm$

Dedundum circle dia $= d_p - 2d = 52.5\,mm$

Tooth depth $= h = 2.25m = 6.75\,mm$

Pitch Size $= \pi m = 9.426\,mm$

tooth thickness $= s = \frac{\pi m}{2} = 4.713\,mm$

Mass of the system $= m = 100\,kg$

Velocity $V = 1.5\,m/s$

accelaration time $t_a = 0.5\,s$

Friction $\mu = 0.3$

diameter $d = 60\,mm$

Safety factor $= 1.5$

accleration due to gravity $g = 9.8\,m/s^2$

acclevation $a = \frac{V}{t_a} = \frac{1.5}{0.5} = 3\,m/s^2$

URBAN EDGE

Tangential force $F_n = (Mg\mu) + (Ma) + F = 694\ N$

Torque $T_N = \frac{F_n d}{2000} = 34.7\ Nm$

Design torque $T_{NV} = T_N(SF) = 52.05\ Nm$

Max Speed $N_V = \frac{V \times 19100}{D} = 477.5\ rpm$

Power $P = \frac{2\pi NT}{60} = 2603.03\ W$

Rack design for ~~Verti~~ Horizontal movement

module $m = 2mm$

face width $b = 12m = 24\ mm$

Circumference of pinion $= \pi$ (addendum circle dia)

$= \pi(66)$

$= 207.37\ mm$

Rack travel required $= 1000\ mm$

No of rotations taken by pinion to complete rack travel $= \frac{1000}{207.37} = 4.82$ revolutions

Pinion design for vertical movement

__/__/___

Specification of gear

Assumptions made :-

Pinion design for Vertical movement

module $m = 2\,mm$

No of teeths $= 20 = n_p$ (20° FDI)

face width $= b = 12m = 12(2) = 24\,mm$

Pitch Circle diameter $= d_p = mz = 2(20) = 40\,mm$

Addendum $= a = 1m = 2\,mm$

Addendum circle diameter $= d_p + 2a = 44\,mm$

Deddundum $= d = 1.25\,m = 2.5\,mm$

Deddundum circle diameter $= d_p - 2d = 35\,mm$

Tooth depth $= h = 2.25m = 4.5\,mm$

Pitch size $= \pi m = \pi(2) = 6.283\,mm$

Tooth thickness $= s = \frac{\pi m}{2} = 3.142\,mm$

Mass of the system $=$ ~~100 k~~ 40 kg

Velocity $v = 1.5\,m/s$

Accleration time $t_a = 0.5\,s$

friction $\mu = 0.3$

diameter $d = 40\,mm$

Safety factor $= 1.5$

accleration due to gravity $= g = 9.8\,m/s^2$

External force $F = 100\,N$

accleration $a = \frac{V}{t_a} = \frac{1.5}{0.5} = 3\,m/s^2$

tangential force $F_n = (Mg\mu) + (Ma) + F = 337.6\,N$

Torque $T_N = \frac{(F_n d)}{2000} = 6.752\,Nm$

Design torque $T_{NV} = T_N(SF) = 10.128\,Nm$

__/__/__

Max Speed $N_v = \dfrac{V \times 19100}{D} = 716.25$ rpm

Power $P = \dfrac{2\pi NT}{60} = 760$ W

Rack design for Verticle movement

module $m = 2$mm

face width $b = 12m = 24$mm

Circumference of pinion = π(addendum circle dia)

$= \pi(44)$

$= 138.24$ mm

Rack travel required = ~~1000mm~~ 1500mm

No of rotations taken by pinion to complete rack travel $= \dfrac{1500}{138.24} = \cancel{7.23}$ 10.85 revolutions.

Calculation of gripper

Design Calculation of gripper

Mass to be lifted = 6kgs

Weight to be lifted = 60N

Coefficient of friction = 0.3

Equating forces

$$2\mu F_g = W$$

$$F_g = \frac{W}{2\mu} = \frac{60}{2(0.3)}$$

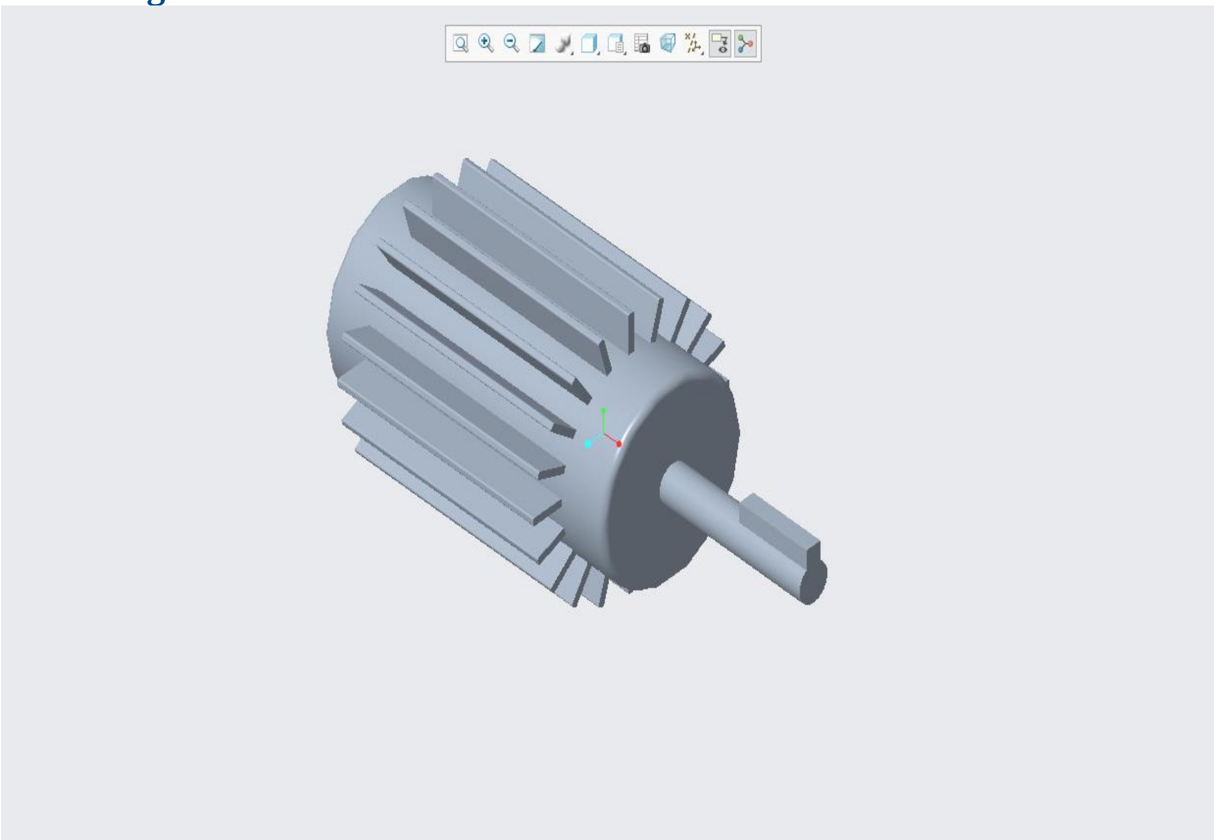
$$F_g = 100$$

factor of Safety = 2

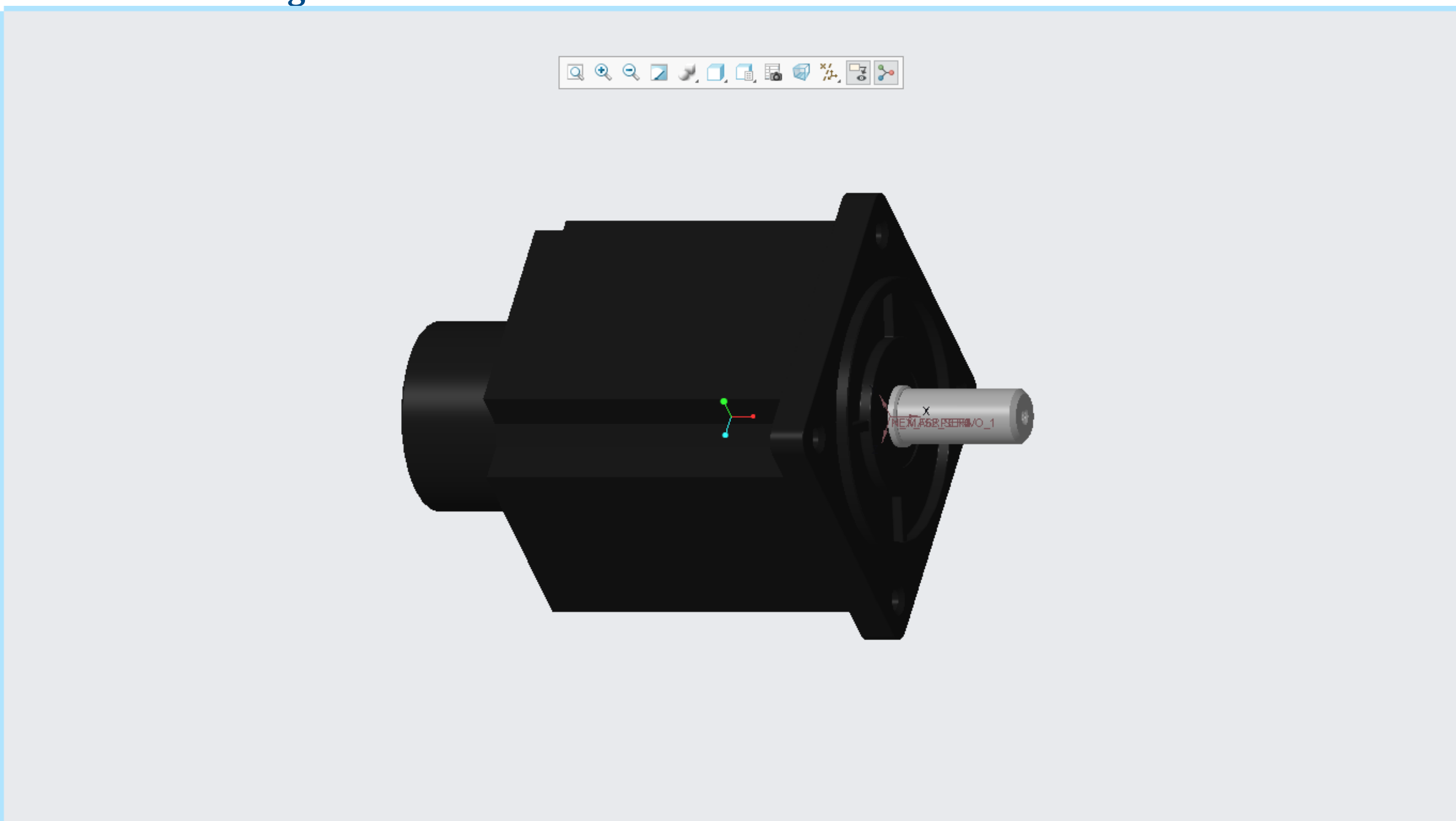
Clamping force = 200N

6. CAD Design

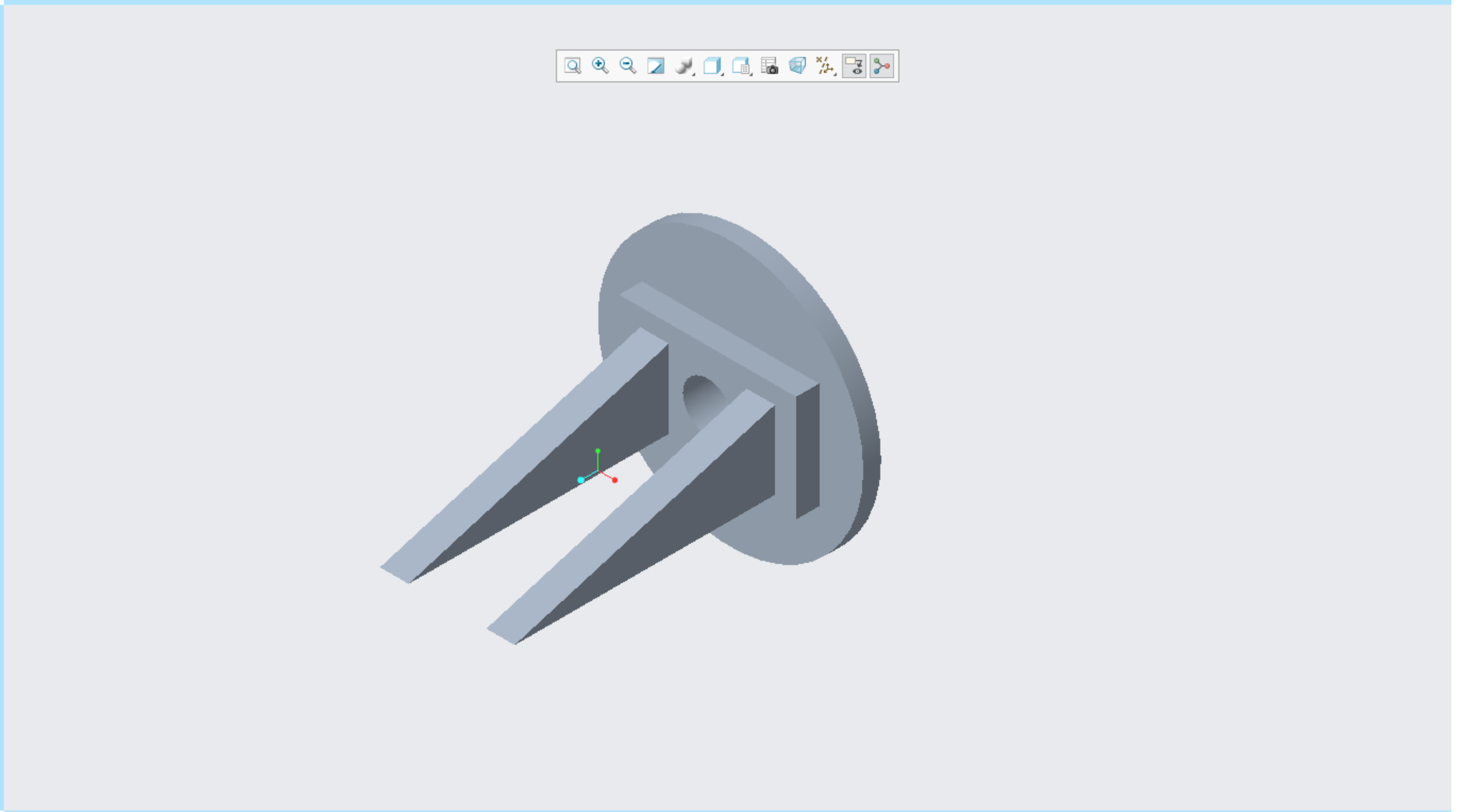
6.1 3D design of horizontal motor.



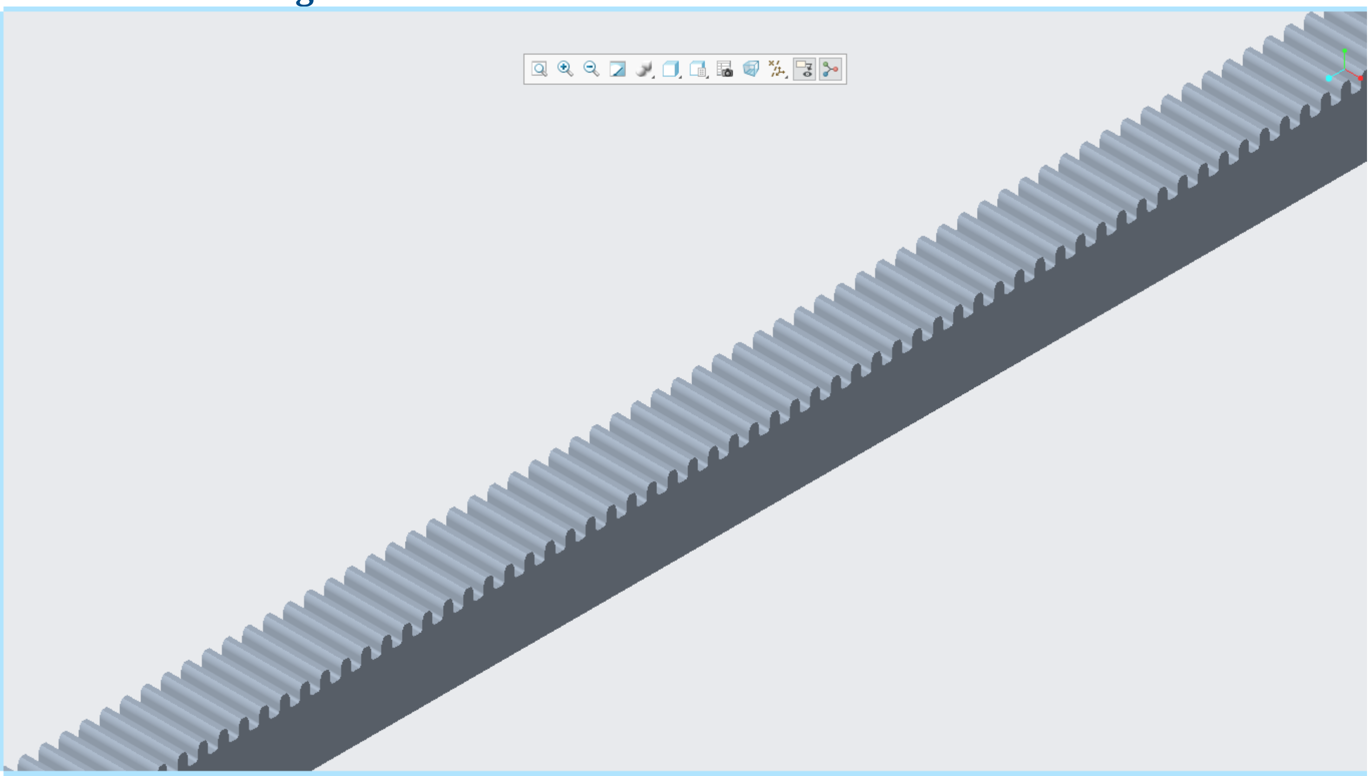
6.2 3D Design of vertical motor.



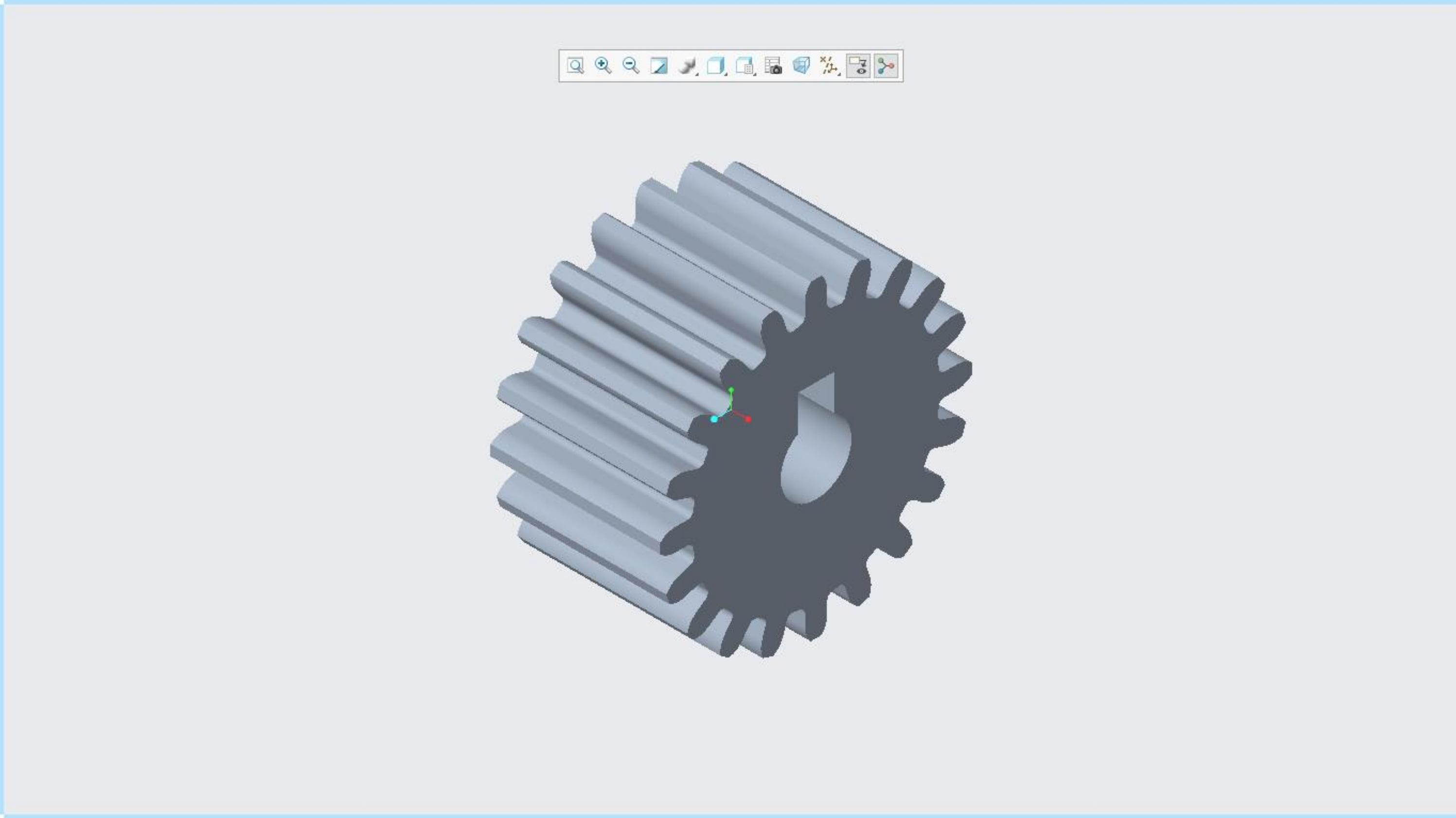
6.3 3D View of grippers.



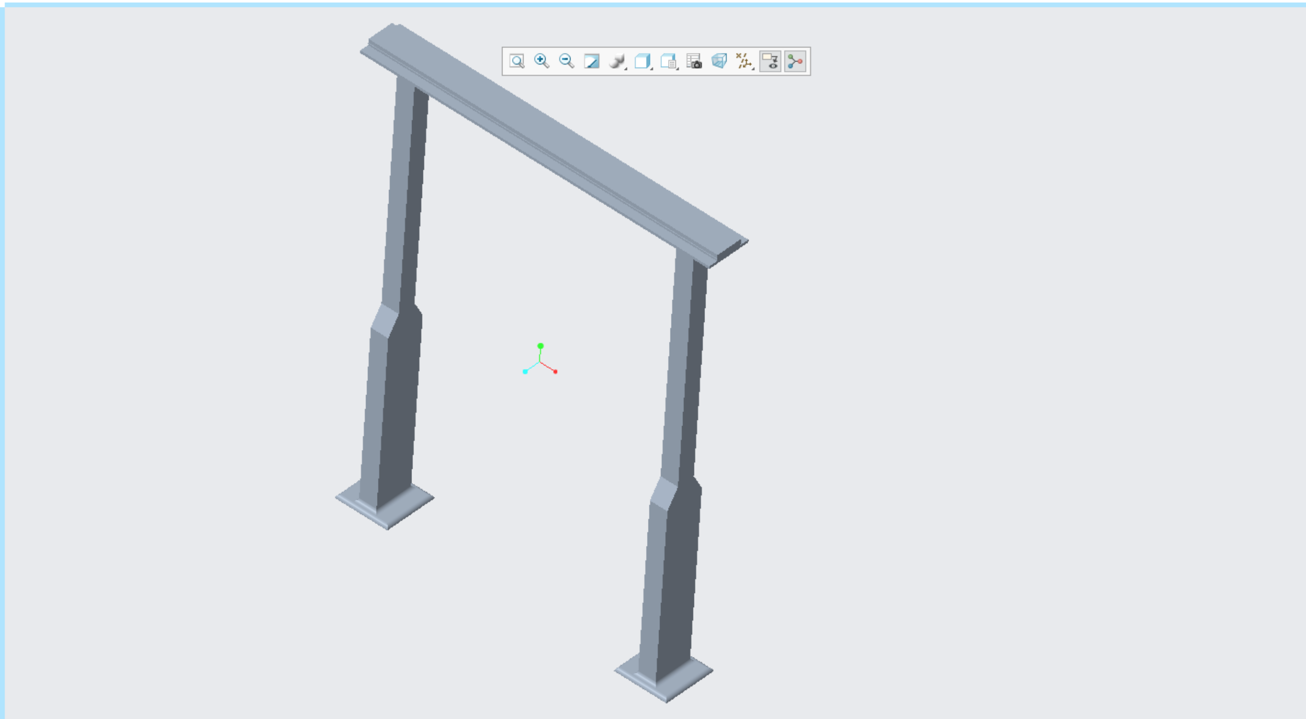
6.4 3D Design of rack.



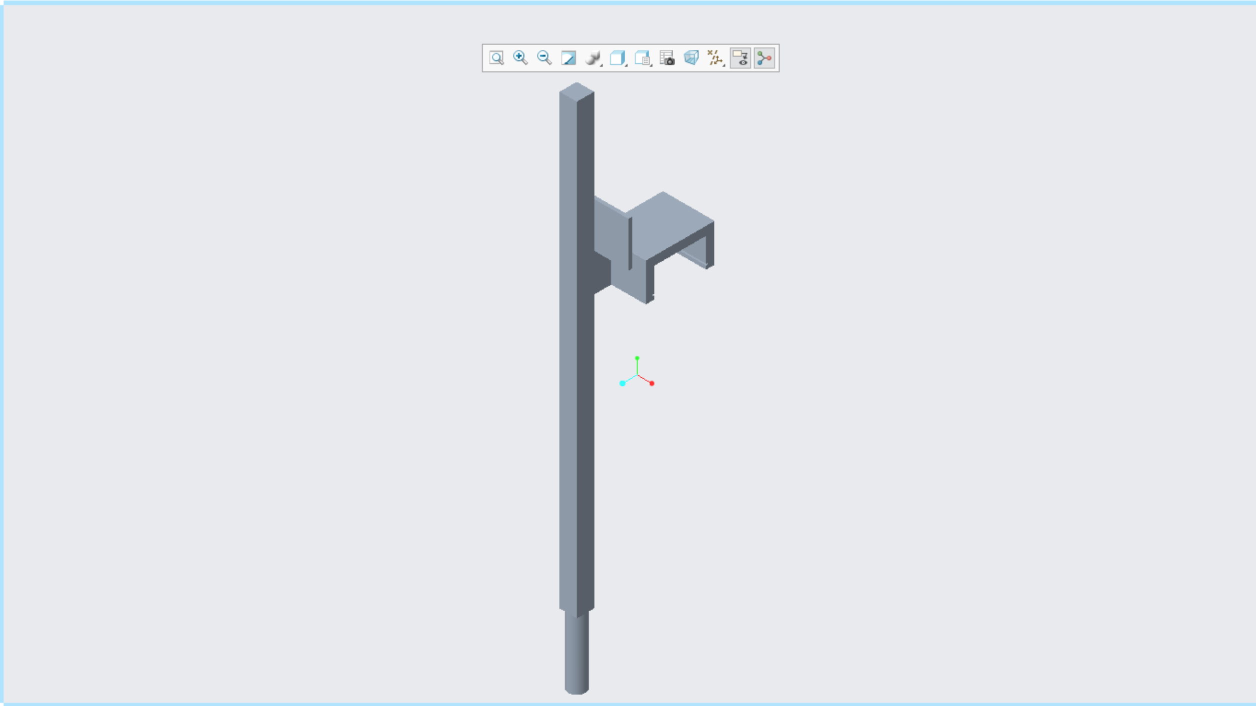
6.5 CAD Design of pinion.



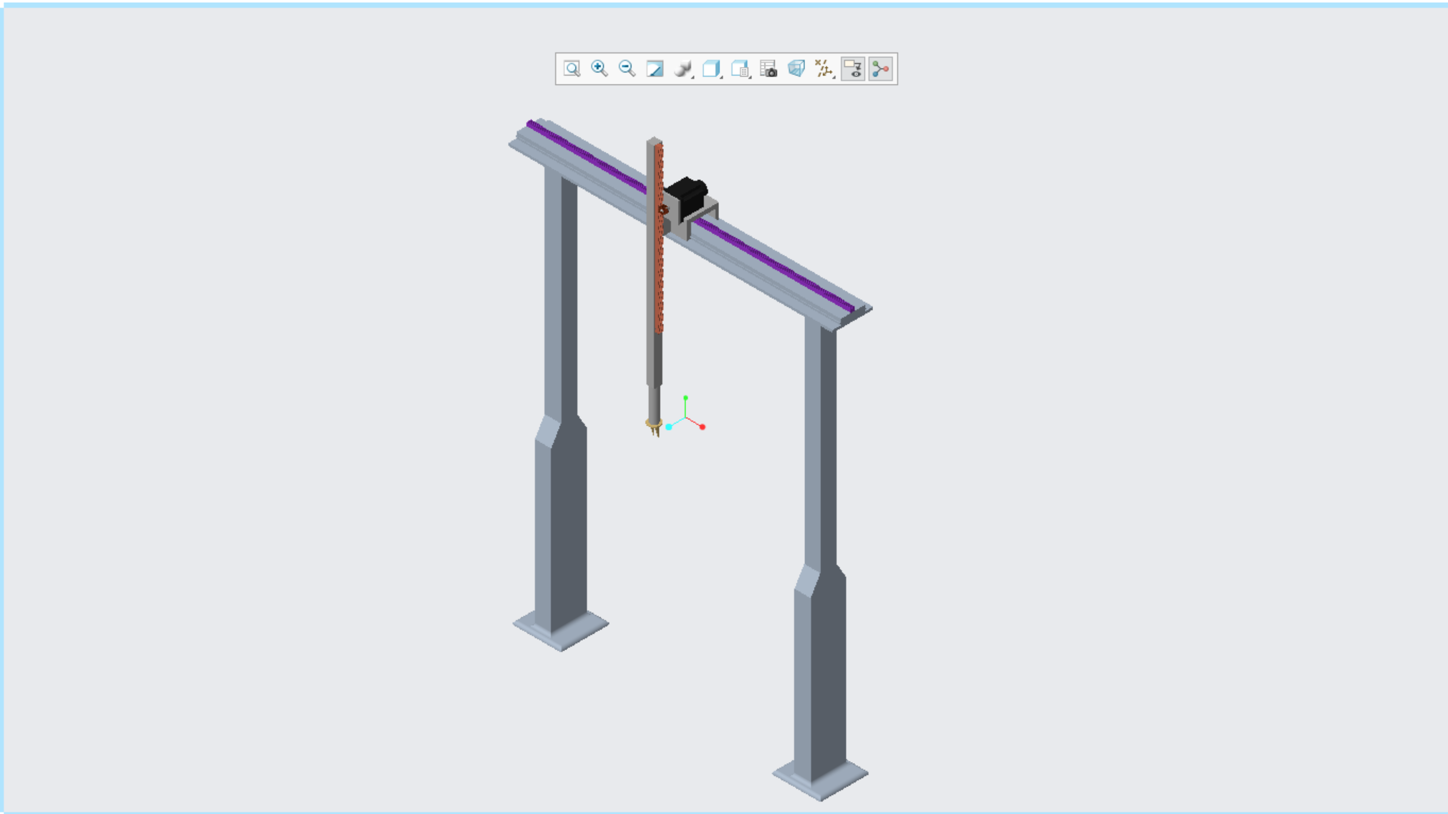
6.6 CAD Design of supporting legs.

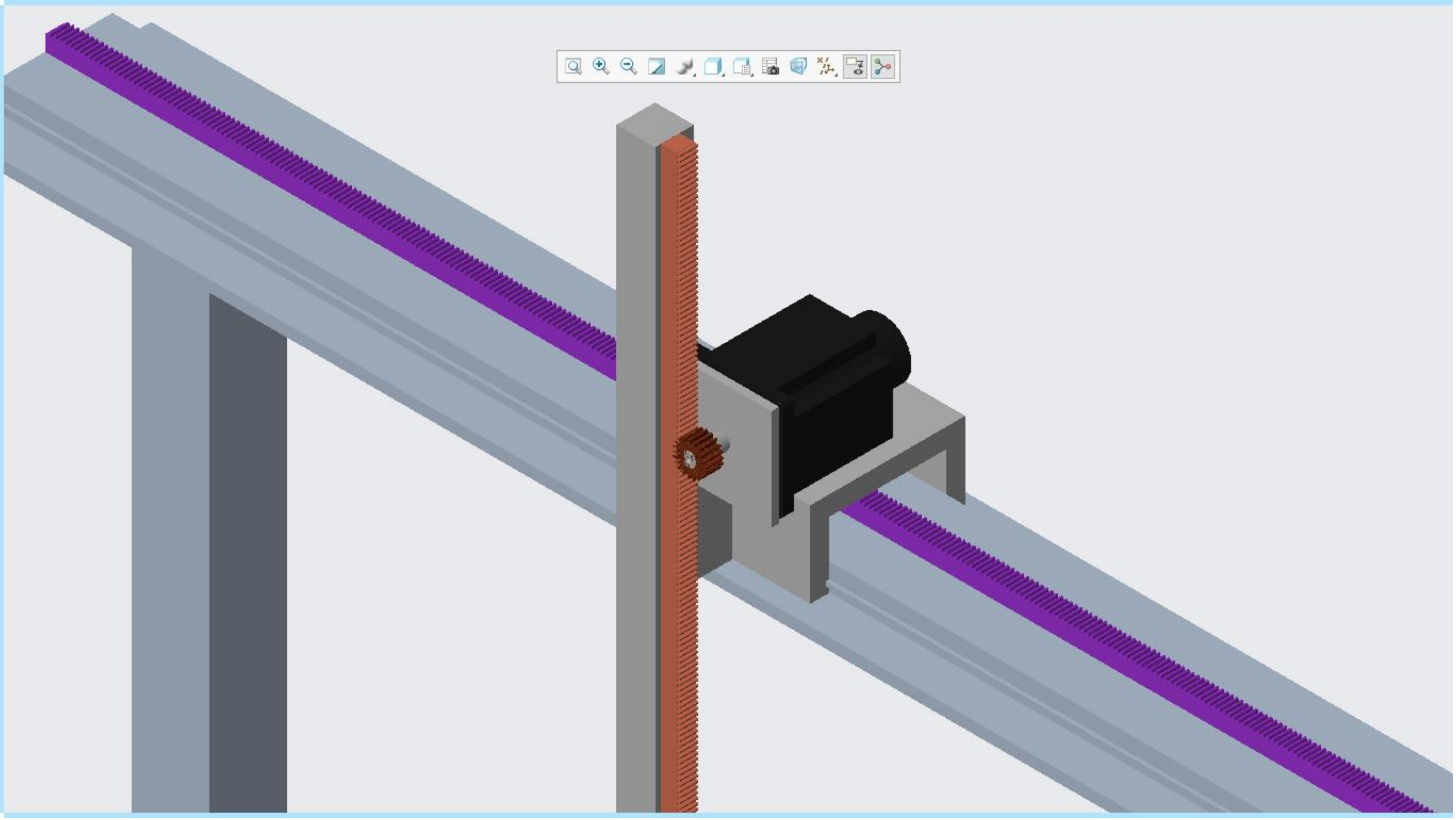


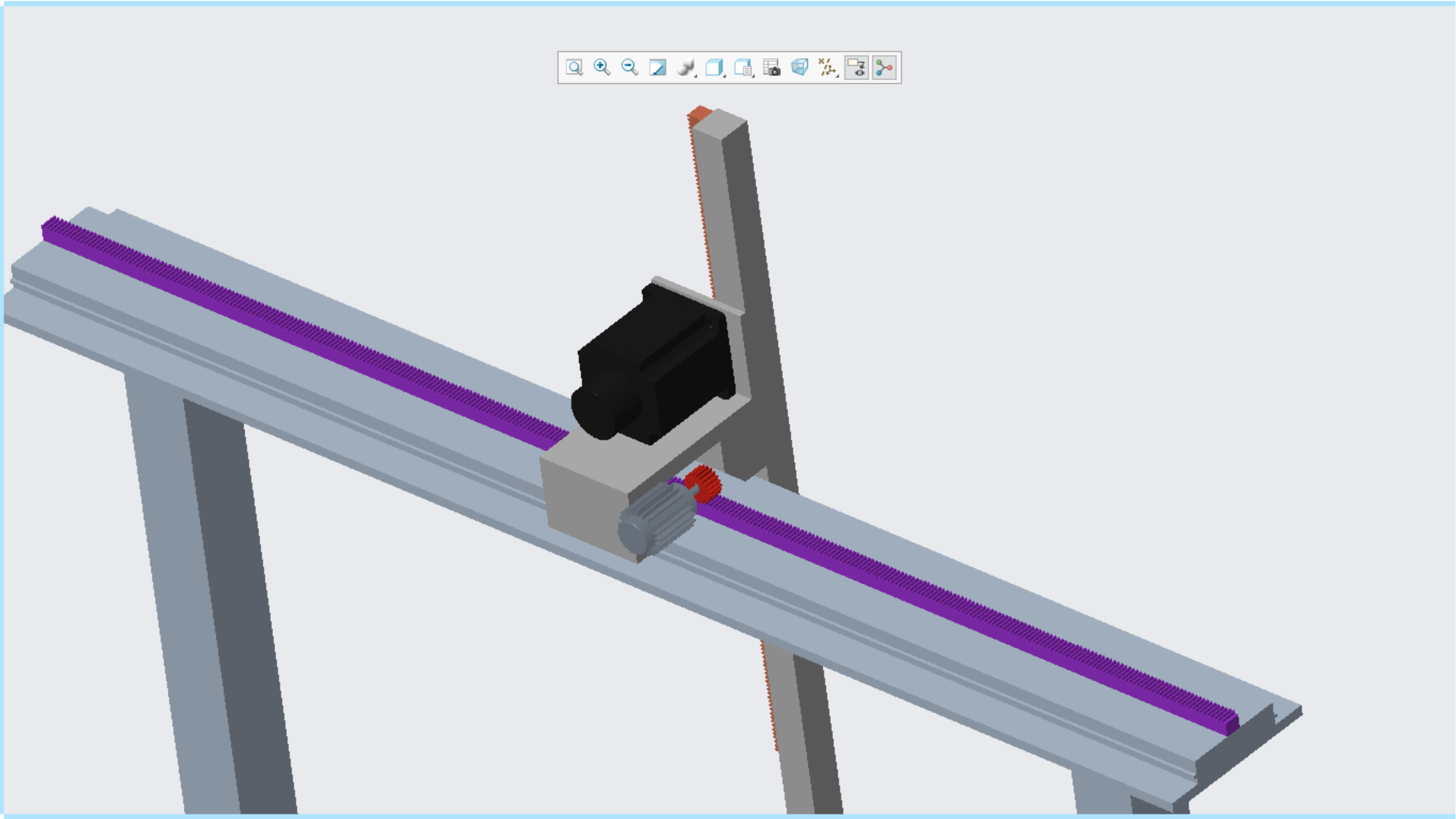
6.7 CAD Design of vertical component.



6.8 CAD 3D Assembly .







SYSTEM DESIGN PROJECT

Sensors

- A proximity sensor is a no-touch method to provide either simple “there/not there” logic or precise and accurate measurement of the exact distance to an object. The term proximity sensor is quite overarching as they can range widely in both size and detection distance.
- These technologies include ultrasonic, photoelectric, laser rangefinder and inductive sensors, which are ideally suited for moderate ranges of detection from a few inches up to tens of feet.
- We have chosen proximity sensor for horizontal movement, vertical movement and object detection.
- Since it is low cost, has higher refresh rate and fits in small place.

Model: ATO-PSC-12AAZ
Detection range: 12 mm±10%
Response frequency : DC: 0.5kHz, AC: 25Hz
Supply voltage : DC type: DC 12-24V (6-36V), impulse (p-p) 10% below; AC type: AC 110-220V (90-250V) 50/60Hz

Motor

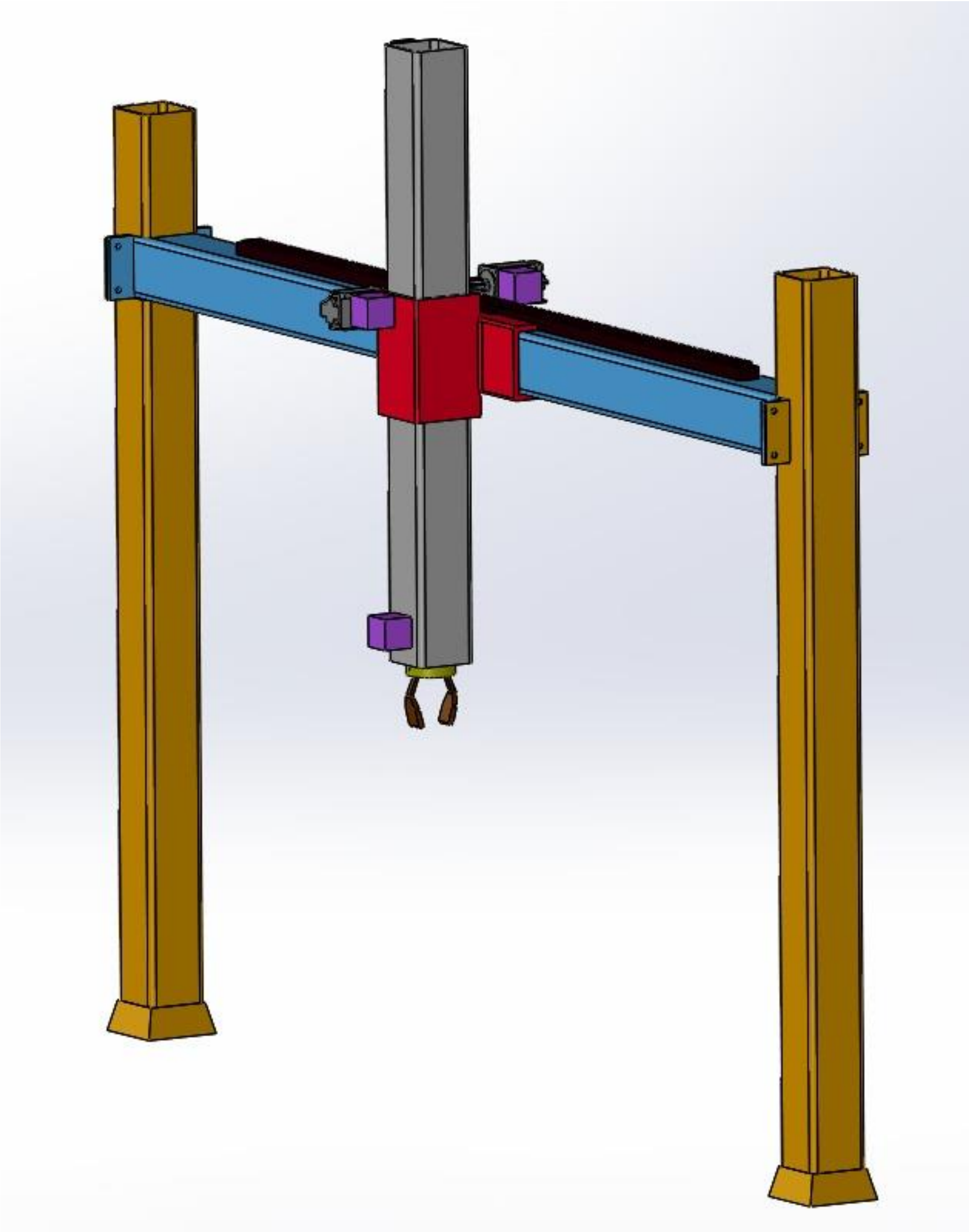
- For motor we have chosen servo motor because it can move very accurately and the speed can be also varied as compared to stepper and dc motor.

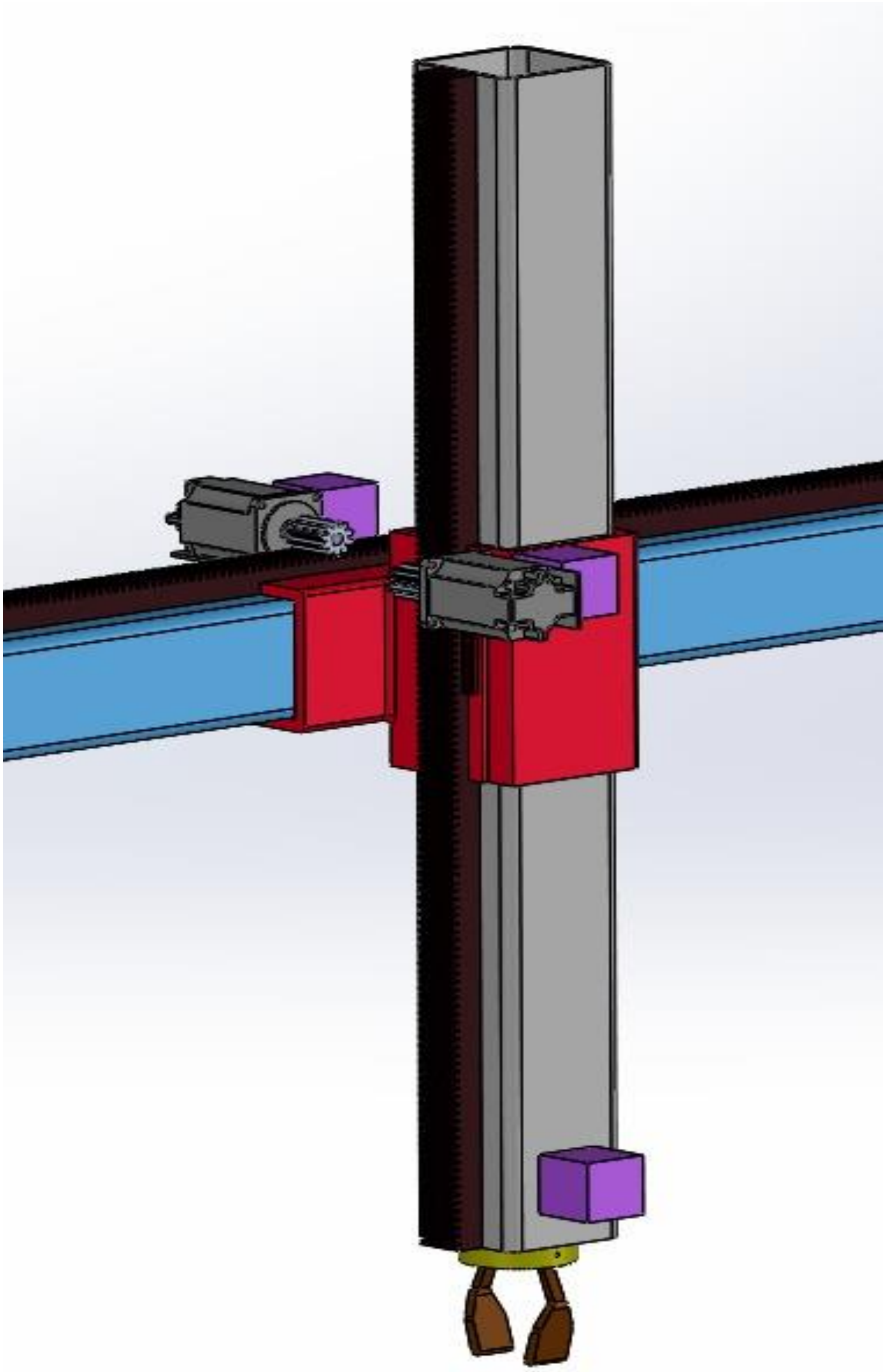
*motor specification are mentioned in the motor selection section.

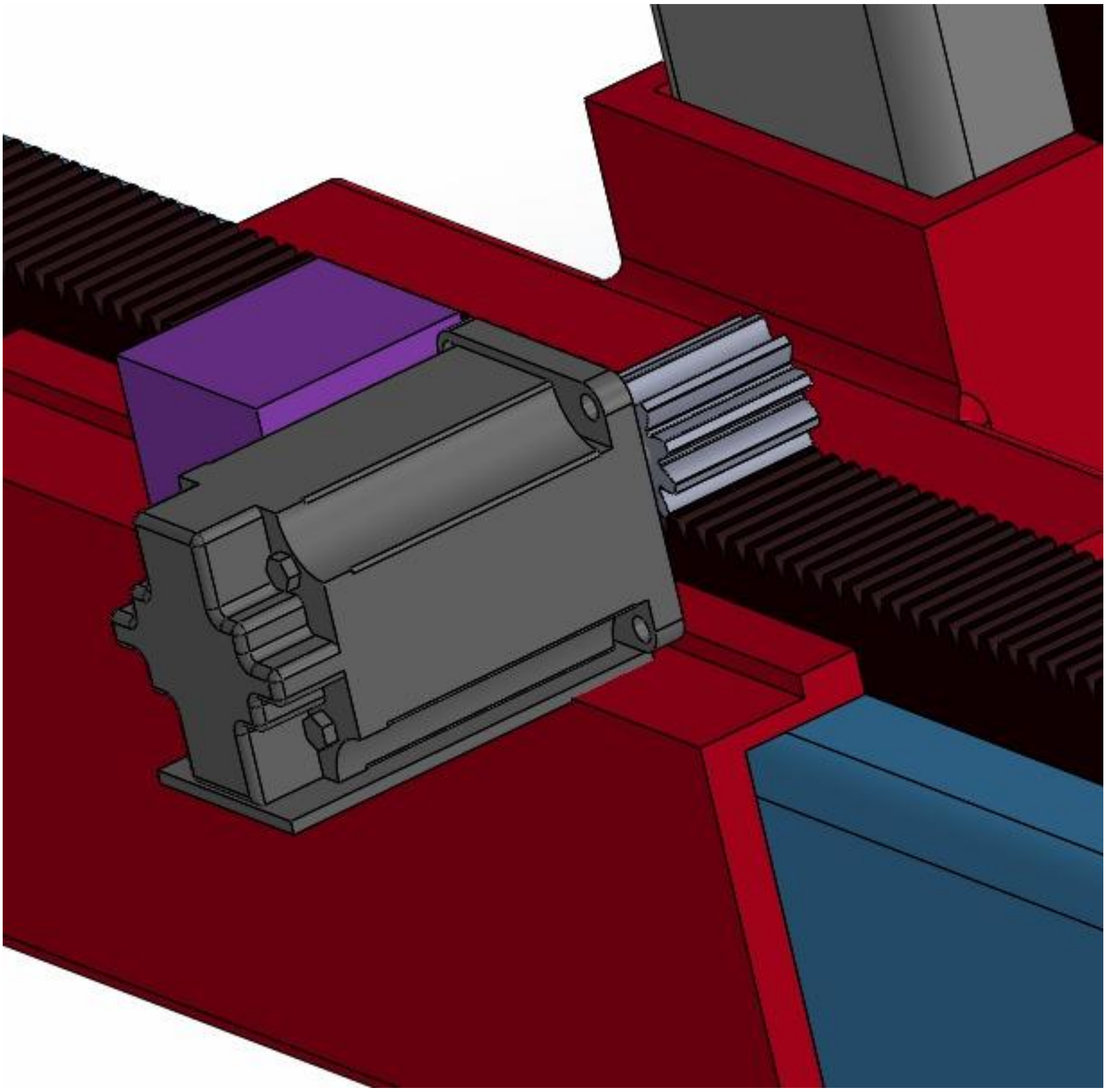
For controller part we have chosen PLC as controller.

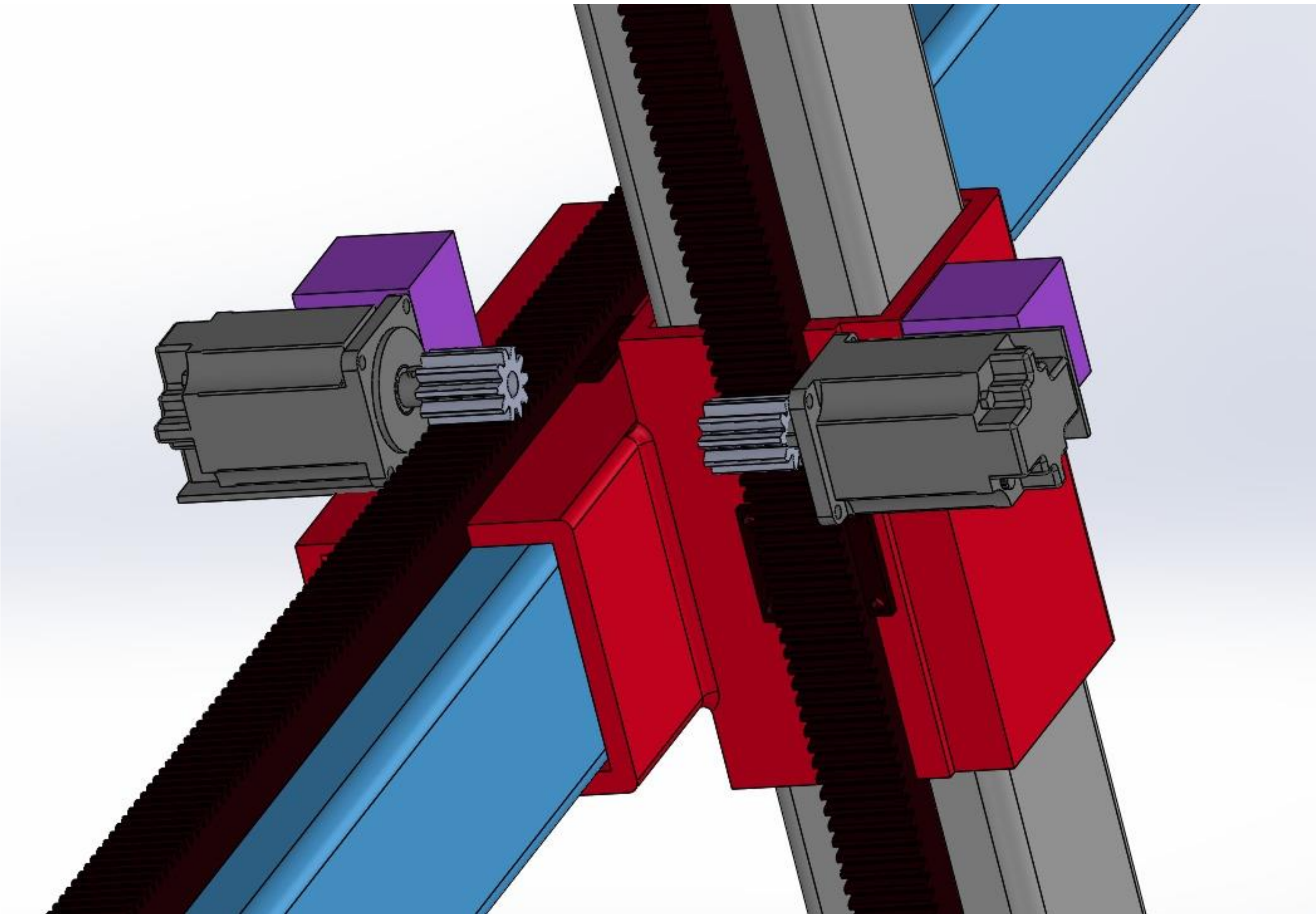
Each MicroLogix 1400 controller includes 20 digital inputs and 12 digital outputs. In addition,
several models include 4 embedded analog inputs and 2 embedded analog outputs.
Each controller has 2 serial ports with DF1/DH485/Modbus RTU/DNP3/ASCII protocol support and a built-in Ethernet port, which supports EtherNet/IP, Modbus TCP/IP and DNP3
over IP.
An embedded LCD screen lets you monitor controller and I/O status, as well as make changes to bit and integer data.

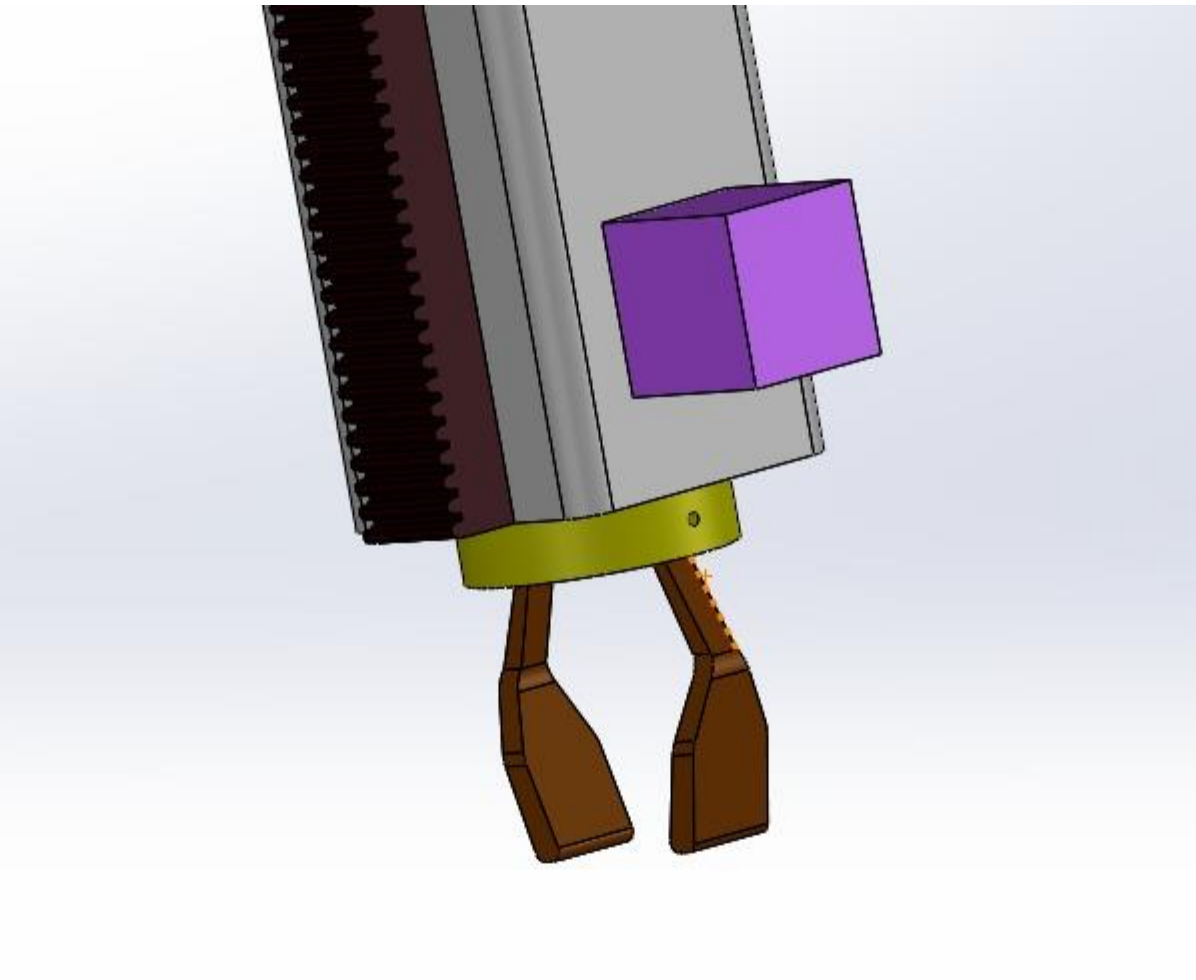
Modification of CAD drawings after adding sensors and actuators.











FLOW CHART

1. Switch on the machine.
2. The sensor near the gripper sends signal to the gripper and activates the actuator, then the gripper holds the work piece.
3. Once the gripper holds the workpiece the sensor again senses and gives the signal to the vertical motor.
4. The motor starts rotating and after taking pre-defined rotation cycles (as guided by the sensor) it stops.
5. As it stops the horizontal motor get signal and starts to run.
6. After rotating for the pre-defined rotation cycles it also stops.
7. Now, towards the workpiece holder the vertical motor rotates and stops after the pre-defined number of rotation.
8. The sensor in the vertical component near the gripper senses the surfaces where the workpiece needs to be dropped .
9. The actuator releases the gripper, the workpiece is placed on the holder.

10. The cycle continues until stopped manually or by fault detection system.

7. Conclusion

Thus, the part magazine to hold the cubes and conveyor loader mechanism for transferring one cube from the bottom of the part magazine at a time onto the conveyor is designed based on the given dimensions, which clearly provide the mechanism implemented, design calculations for strength/dimensions for each link/component and selection of bolts, bearings is justified.

8. References

[1] https://www.azom.com/article.aspx?ArticleID=2867

[2] https://en.wikipedia.org/wiki/2024_aluminium_alloy

[3] https://www.pennstainless.com/resources/product-information/stainless-grades/300-series/304l-stainless-steel/

[4] http://www.matweb.com/search/datasheet_print.aspx?matguid=67d8cd7c00a04ba29b618484f7ff7524

[5] https://www.onlinemetals.com/en/product-guide/alloy/2024