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Design and Analysis of Sowing Robot

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Abstract: Robots are widely being used in farming. This paper will focus in designing a seed sowing robot using Strandbeest. The project aims at finalizing the robot with economical, light weight and efficient design. It is important to design a light weight assembly in order to increase the overall performance. Also, lot of forces act during bump conditions which require high torque in driving the robot. The torsional equation has been used to find the torque required to drive the model. So, this paper deals with calculation of various loads and their simulation. The Finite Element Analysis result indicates that the material used in the model is safe.
Keywords: Sowing, Theo Jansen, Strandbeest, prototype, farming

I. INTRODUCTION

Most of the farmers use draught animals in ploughing or harvesting. But the main problem occurs in rain-fed areas where the animals are not healthy and have less efficiency for farming activities. Most of the farmers use labor-intensive techniques for operations like ploughing etc. Low productivity is one of the major problems faced by Indian agriculture as compared to other countries. As manpower is involved, the productivity rate is low. In some cases, aged farmers cannot put physical effort which in turn affects productivity. Moreover, in developing nations, there is a problem of affordability for hi-tech equipments. A lot of farmers are poor or middle class and cannot afford advanced robots for farming. Therefore, these farming activities viz. harvesting, ploughing, and sowing have to be done manually, involving huge labor cost. Hence a robot that is effective, easy to use and yet, inexpensive is needed to solve this problem.

Robotics is one of the rapidly growing engineering fields. Robots are designed to eliminate the human factor from labor-intensive work. A cost-effective robot can be used to pacify the physical element required in farming. Seed sowing is a process that is done in hot, sunny conditions and is taxing. Agricultural robots have started performing better at daunting agricultural activities due to the efforts put by several researchers. Applications in agricultural applications have not reached on a commercial scale, except for milking robots. An increase in production cost and reduced availability of labor has brought attention from several researchers in recent years. However, The fastest prototypes are also nowhere close to competing with human labor. The main issue for generalized robotics systems is trying to increase the speed and accuracy in farming applications. However, lots of fundings and budget is declared in this process.

Travelling on gravelly soil or much is difficult for any kind of wheels. It has been observed that the legs of animals viz. A spider can easily travel on uneven land. The mechanism which uses biolegged mechanisms has become popular in robotics due to their unique ability over wheels. Theo Jansen mechanism is a four-legged complex mechanism that has 1 degree of freedom. This popular mechanism has been used for many applications in the past because of its insect-like characteristic. This paper will mainly focus on how the Theo Jansen mechanism can be used to make the process of seed sowing fully automatic. It helps to convert rotary energy into the progression of the robot.

II. PROBLEM STATEMENT

A. Agriculture involves various activities wherein farmers have to do lot of manual work in hot and sunny days. Among these is the process of seed sowing.

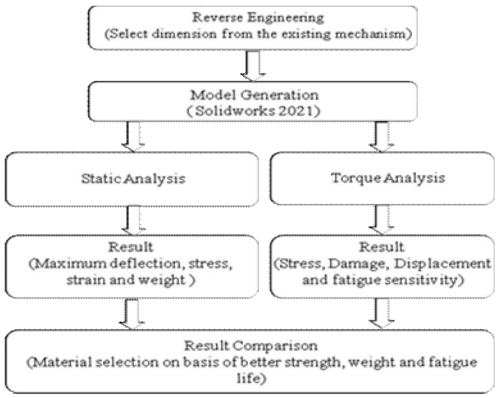
B. Generally robots or automobiles with wheels are used in agricultural processes. Wheels cannot drive over obstacles. Small or large obstacles have to be passed in uneven terrains for the robot to pass. It is difficult for a wheel because then the robot has to be at least twice as tall of the vertical obstacle. Driving in a farm has always been the job automobiles or robot with wheels. Wheels dig in and get stuck because of their circular surface area and inability. To get out of muck in a farm, high torque is required which consumes more fuel or electricity.

III.OBJECTIVES

A. Designing a robot which is can be used in seed sowing.

B. Using Theo Jansen Mechanism instead of wheels to attain motion over uneven terrain.

IV. METHODOLOGY



V. PROPOSED SYSTEM

A. Components of the Assembly

1) *Arm:* Forward propulsion is managed by keeping the leg on the ground for as long as possible. As the crankshaft the leg stays perfectly leveled throughout the stride. This is a drastic improvement from the bipedal gait, wherein each hip-tilting costs more energy when lifts and drops the body. It is made up of polucarbonate and hence is strong as well as light in weight.
2) *Frame:* The main rotating shaft and the chain drive are mounted on the frame. Aluminium alloy 6061 is used for this frame.

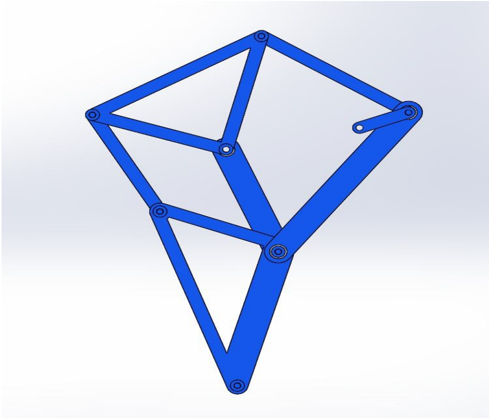


Fig. 1 Arm

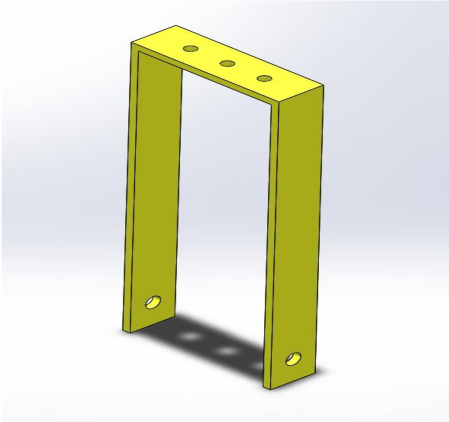


Fig. 2 Frame

3) *Mounting Support:* It is used to mounting and supporting legs at a fixed distance. Aluminium alloy 6061 is used for this.
4) *Silo: It is used to store seeds which will be used for sowing. This is made of hardwood. The tube connected to the container is guided towards the rotor.*

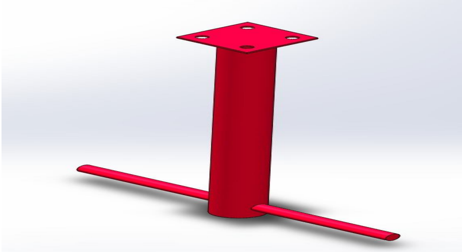


Fig. 3 Mounting support

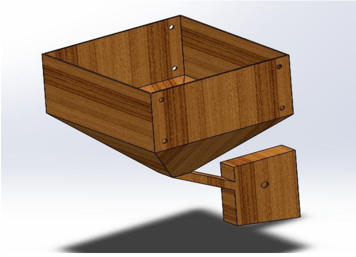


Fig. 4 Silo

5) *Chain Drive*: It transmits the power from the motor to the linkage. The chain is mounted on the sprockets which are attached to the shaft.
6) *Rotor*: This part helps in the systematic and uniform diffusion of seeds. Its diameter can be changed to attain different time intervals of diffusion which will in turn change sowing distance.

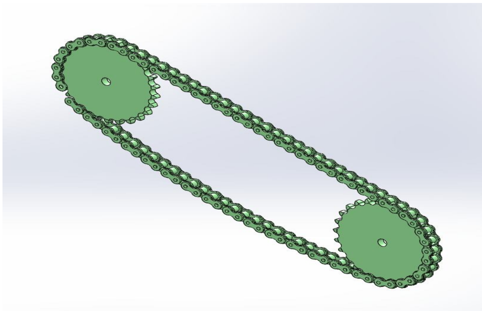


Fig. 5 Chain Drive

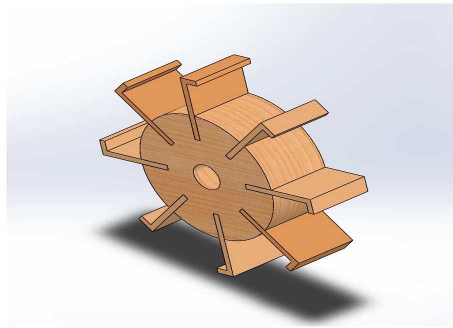


Fig. 6 Rotor

VI. WORKING PRINCIPLE

Like spiders, this mechanism has 11 links that are connected. The walking motion of complete linkage is the resultant of the rotational motion of a singular link. The synchronization of the links traces an elliptic trajectory. The front and rear linkage is connected by a shaft which helps in the rotation of the entire link. The forward and backward motion of the linkage depends on the rotational direction of the axle. Linkages are connected on both sides of a rotating axle and the shaft rotates by 90 degrees per stride. The fore link and rear link move at antiphase which helps in cooperative movement of the entire mechanism. It consists of a motor that drives the model. When the motor gets started, the shaft connected to the motor rotates which in turn rotates the sprocket attached to it. This driving sprocket is connected to the driven sprocket through a chain drive which rotates when the motor is started. When the driven sprocket gets rotated a shaft on them, attached to the legs of the linkage which gets a movement. When all this process is going on, on the other hand, the seeds from the container get sown into the field. A small motor is been attached to ensure uniform diffusion of seeds. Because of this, one seed is sown at a time and also at a specific distance.

VII. CALCULATIONS

First determine the sizes of the chain drive

Assumptions:

Distance between two sprockets $(x) = 337mm$

Teeth on driving sprocket $(t_1) = 26$ teeth

Teeth on driven sprocket $(t_2) = 26rpm$ of driven

RPM of driven sprocket $(N_2) = 25rpm$

Diameter of driving sprocket $(d_1) = 113mm$

Diameter of driving sprocket $(d_2) = 113mm$

To find:

Pitch to the chain $(P) = ?$

Length of the chain $(L_{chain}) = ?$

The relation between PCD and pitch is given by,

$$d_1 = P\,\mathrm{cosec}\left(\frac{180}{t_1}\right)$$

$$113 = P\,\mathrm{cosec}\left(\frac{180}{26}\right)$$

$$113 = P\,\mathrm{cosec}(6.92)$$

$$113 = P \times 8.22$$

$$P = \frac{113}{8.22}$$

$P = 13.74 \cdots$ (pitch)

$L_{chain} = P \cdot k$

where,

$$k = \left(\frac{t_1 + t_2}{2}\right) + 2m + \frac{\left[\operatorname{cosec}\left(\frac{180}{t_1}\right) - \operatorname{cosec}\left(\frac{180}{t_2}\right)\right]^2}{4m}$$

$\because x = m \cdot P$

$$m = \frac{x}{P}$$

$$m = \frac{360}{13.74}$$

$m = 24.52$

$$k = \left(\frac{26 + 26}{2}\right) + (2 \times 24.52) + \frac{\left[\operatorname{cosec}\left(\frac{180}{26}\right) - \operatorname{cosec}\left(\frac{180}{20}\right)\right]^2}{4 \times 24.52}$$

$$k = 26 + 49.04 + \frac{[8.22 - 8.22]^2}{98.08}$$

$$k = 26 + 49.04 + \frac{0}{98.08}$$

$k = 75.04$

$L_{chain} = P \cdot k$

$L_{chain} - 13.74 \times 75.04$

$L_{chain} = 1031.04mm$

$L_{chain} = 1.03m$

Therefore, by using torque, rpm we can find power required

$$\therefore P = \frac{2\pi N_1 T_1}{60}$$

$$P = \frac{2 \times \pi \times 25 \times 1.03}{60}$$

$P - 4.78kN$

VIII. FINAL MODEL

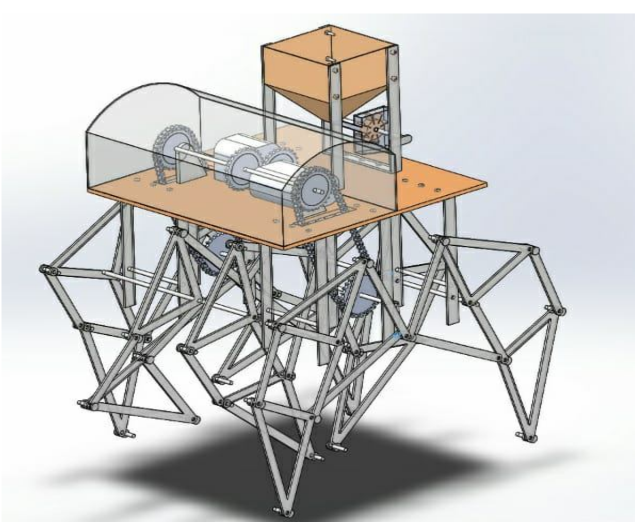


Fig.7 Model View

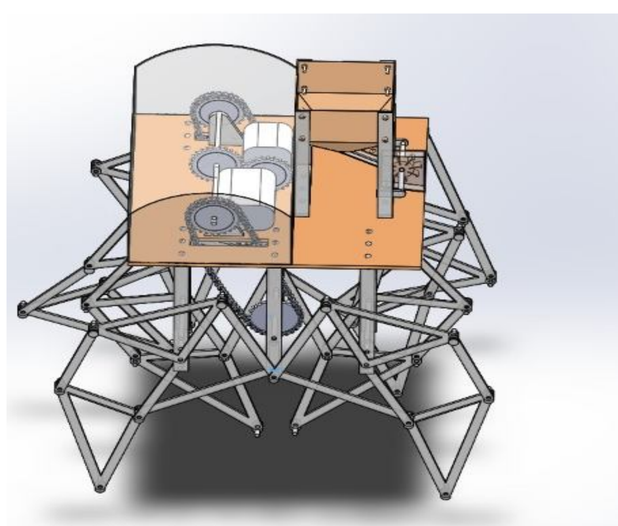


Fig. 8 Model View

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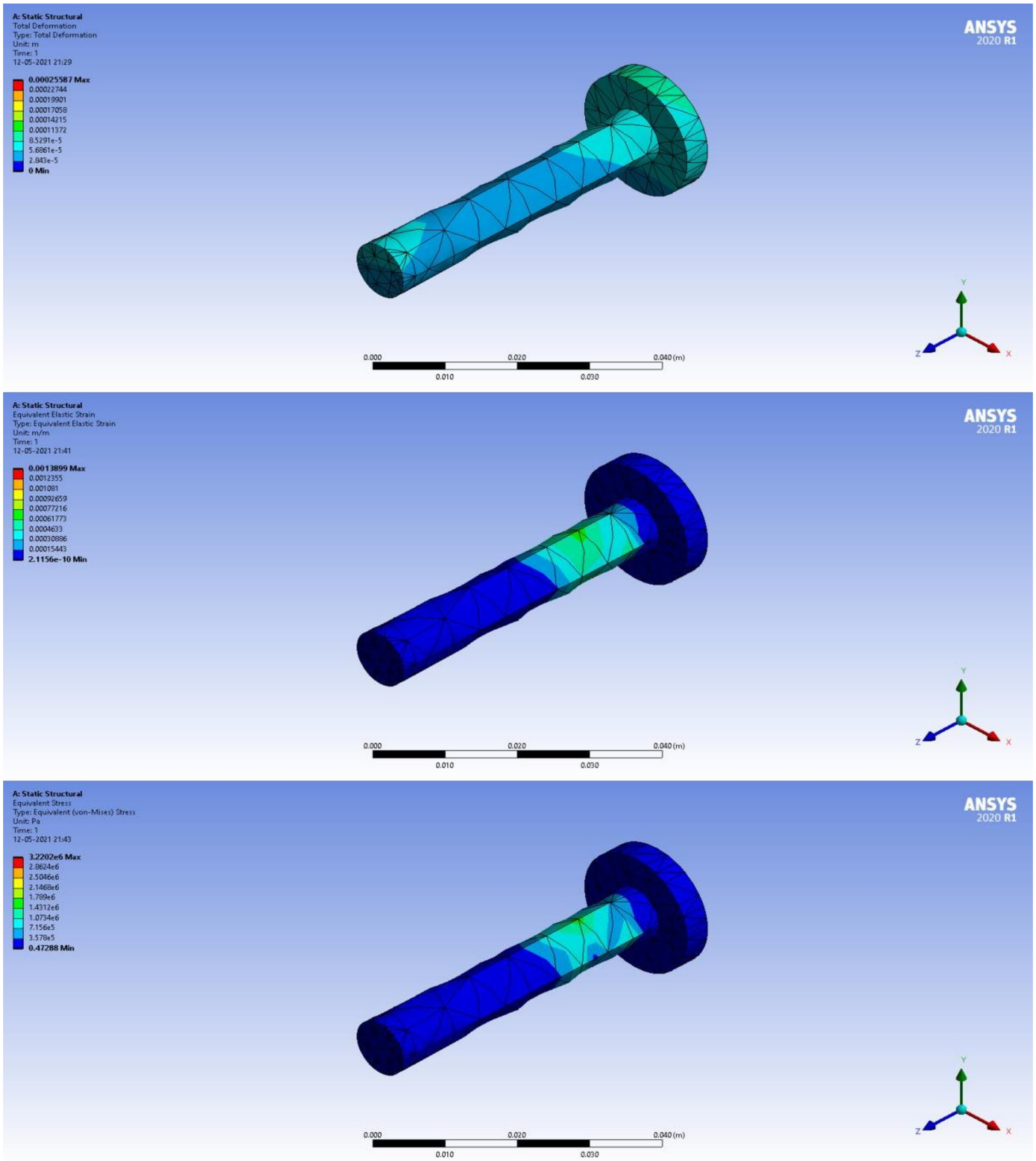
IX. ANALYSIS

The analysis of the model has been done on ANSYS 2020.

1) *Pin:* It holds the linkage together by acting as support between every link. The material used for the pin is Polycarbonate. Force of 50N is applied on the pin.



Results	Minimum	Maximum	Units	Time (s)
Total Deformation	0.	1.4127e-004	m	1.
Equivalent Elastic Strain	1.5199e-010	7.0863e-004	m/m	1.
Equivalent Stress	0.33958	1.6397e+006	Pa	1.

Fig.9 Pin Analysis

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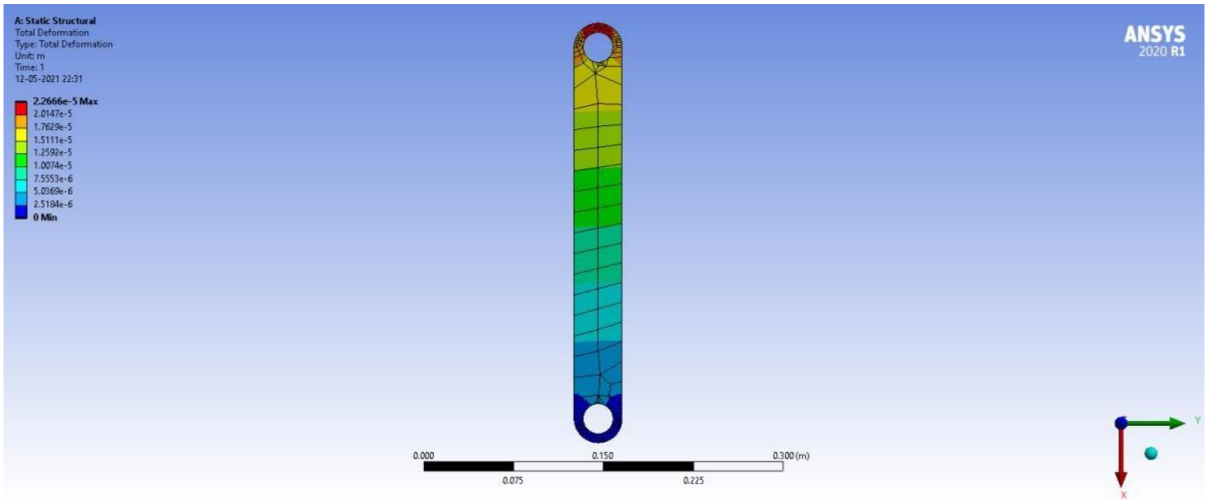
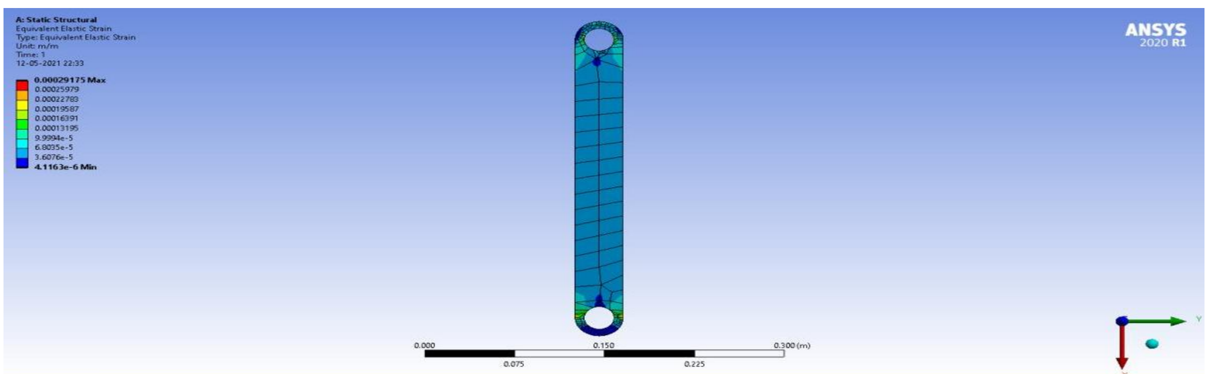
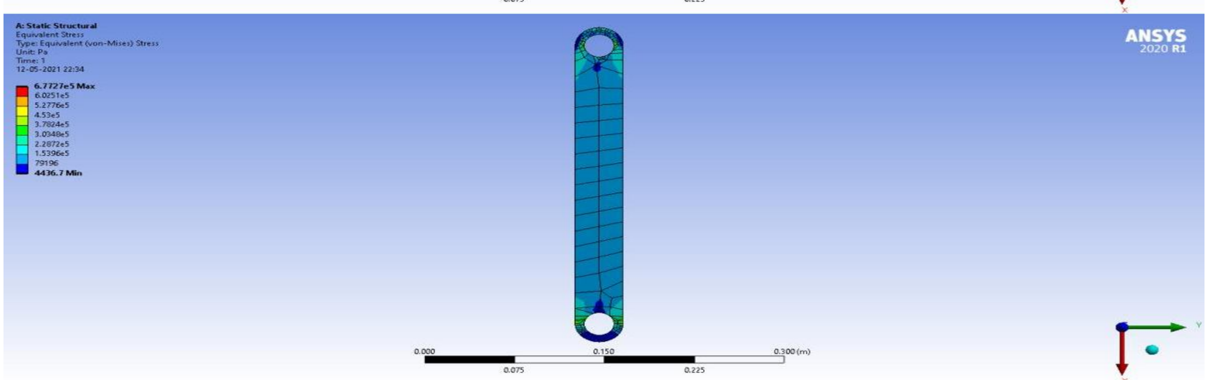
2) *Link:* It is the pith of the mechanism as more than half of the model's body comprises links. It is made up of Polycarbonate. Force applied on the link is 25N.







Results	Minimum	Maximum	Units	Time (s)
Total Deformation	0.	1.137e-005	m	1.
Equivalent Elastic Strain	4.6006e-006	3.8278e-004	m/m	1.
Equivalent Stress	7846.8	8.4061e+005	Pa	1.

Fig.10 Link Analysis

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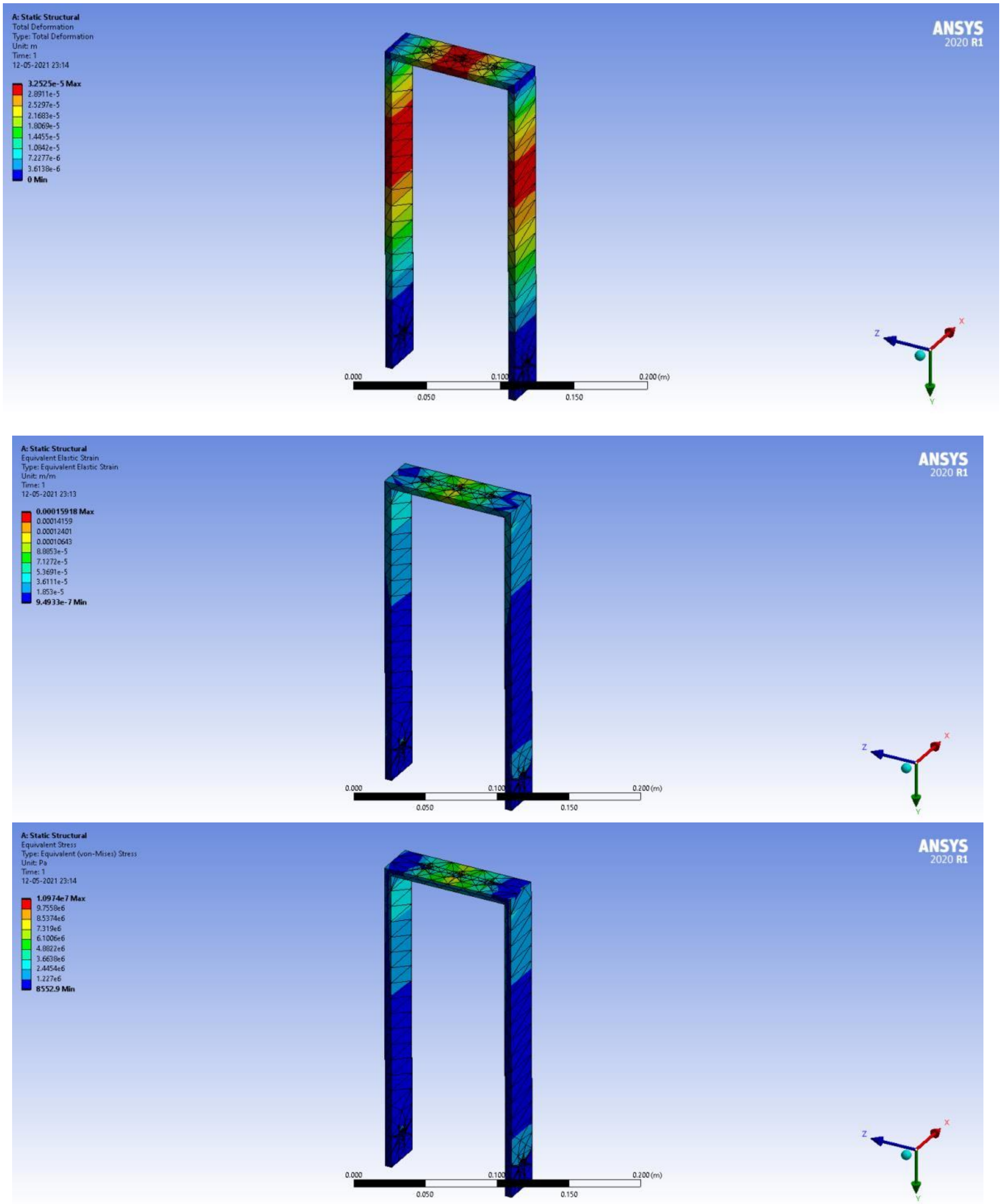
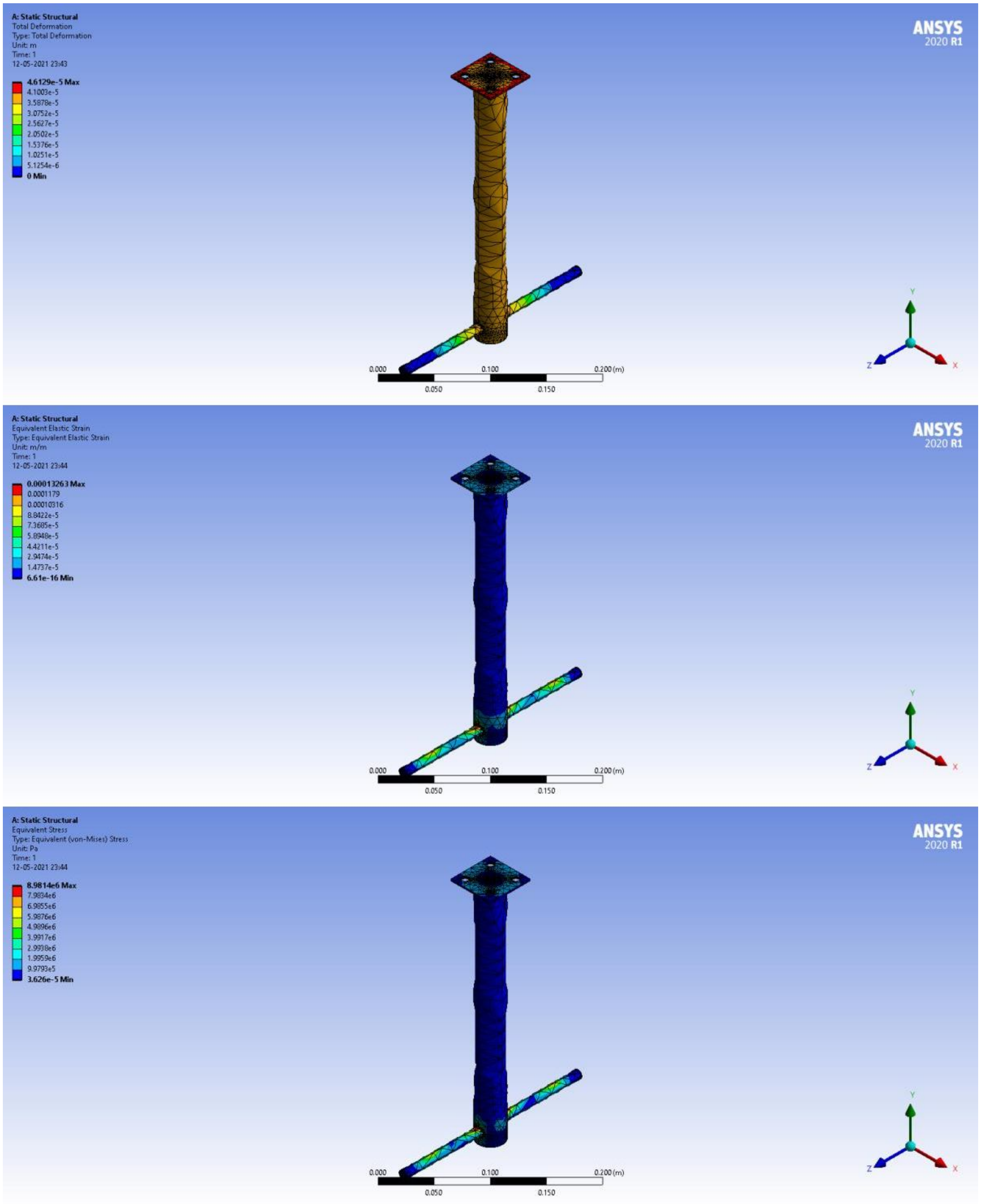
3) *Middle Frame:* It supports the main rotating shaft. It is made up of Aluminium alloy 6061 T6. The force applied to it is 100N.



Results	Min[illegible]	[illegible]	Units	Time (s)
Equivalent Elastic Strain	9.4[illegible]	[illegible]	m/m	1.
Equivalent Stress	8552.9	1.0974e+007	Pa	1.
Total Deformation	0.	3.2525e-005	m	1.

Fig.11 Middle Frame Analysis

4) *Mounting Support:* It is used as a fixed support for front and back linkages of the mechanism. Polycarbonate is used for this and a force of 50N is applied to it.



Results	Minimum	Maximum	Units	Time (s)
Equivalent Elastic Strain	6.61e-016	1.3263e-004	m/m	1.
Equivalent Stress	3.626e-005	8.9814e+006	Pa	1.
Total Deformation	0.	4.6129e-005	m	1.

Fig.12 Mounting Support Analysis

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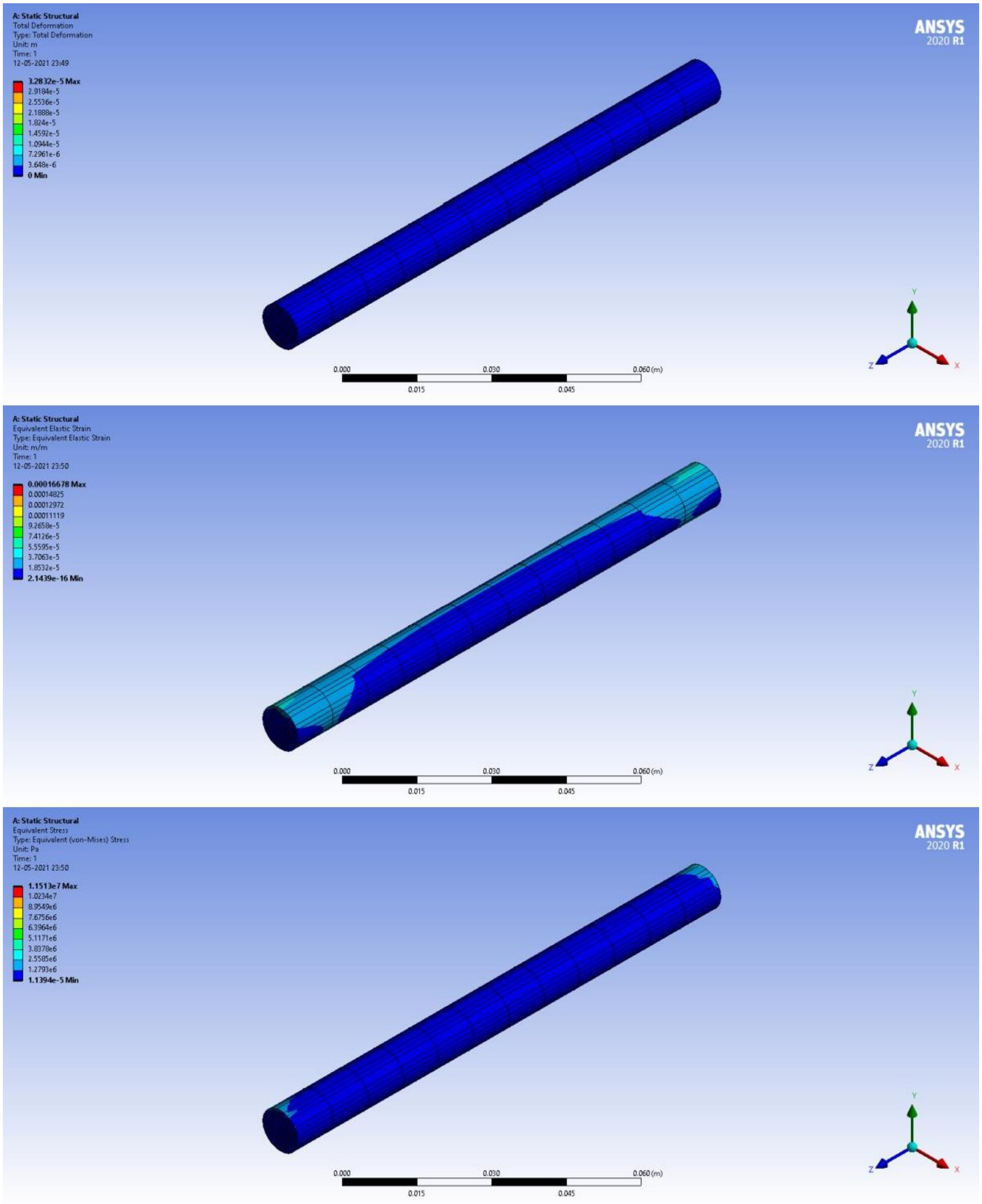
5) *Middle Shaft:* This shaft is responsible for the motion of the complete linkage of the mechanism. The chain drive is mounted on it which is attached to the motor.



Results	Minimum	Maximum	Units	Time (s)
Equivalent Elastic Strain	2.1439e-016	1.6678e-004	m/m	1.
Equivalent Stress	1.1394e-005	1.1513e+007	Pa	1.
Total Deformation	0.	3.2832e-005	m	1.

Fig.13 Middle Shaft Analysis

A. Static Structural Analysis of the Assembly

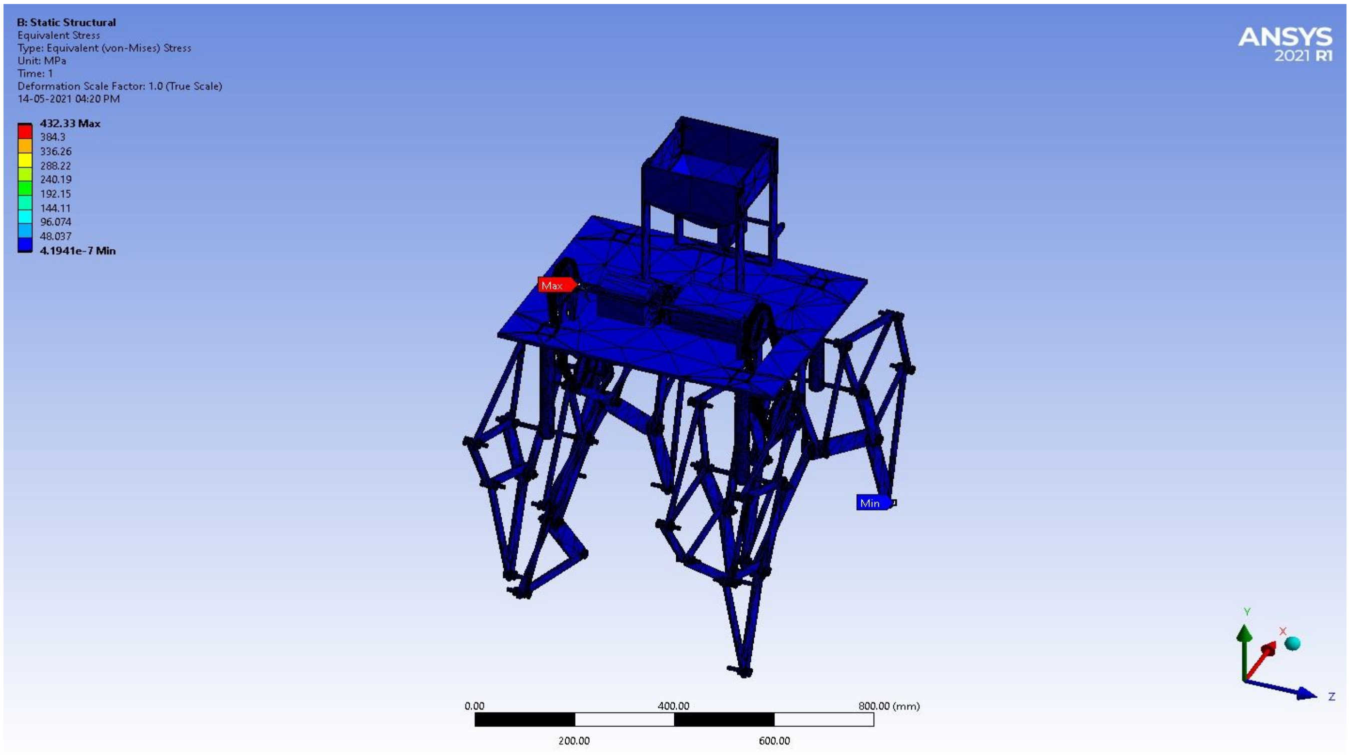


Fig.14 Assembly - Equivalent Stress

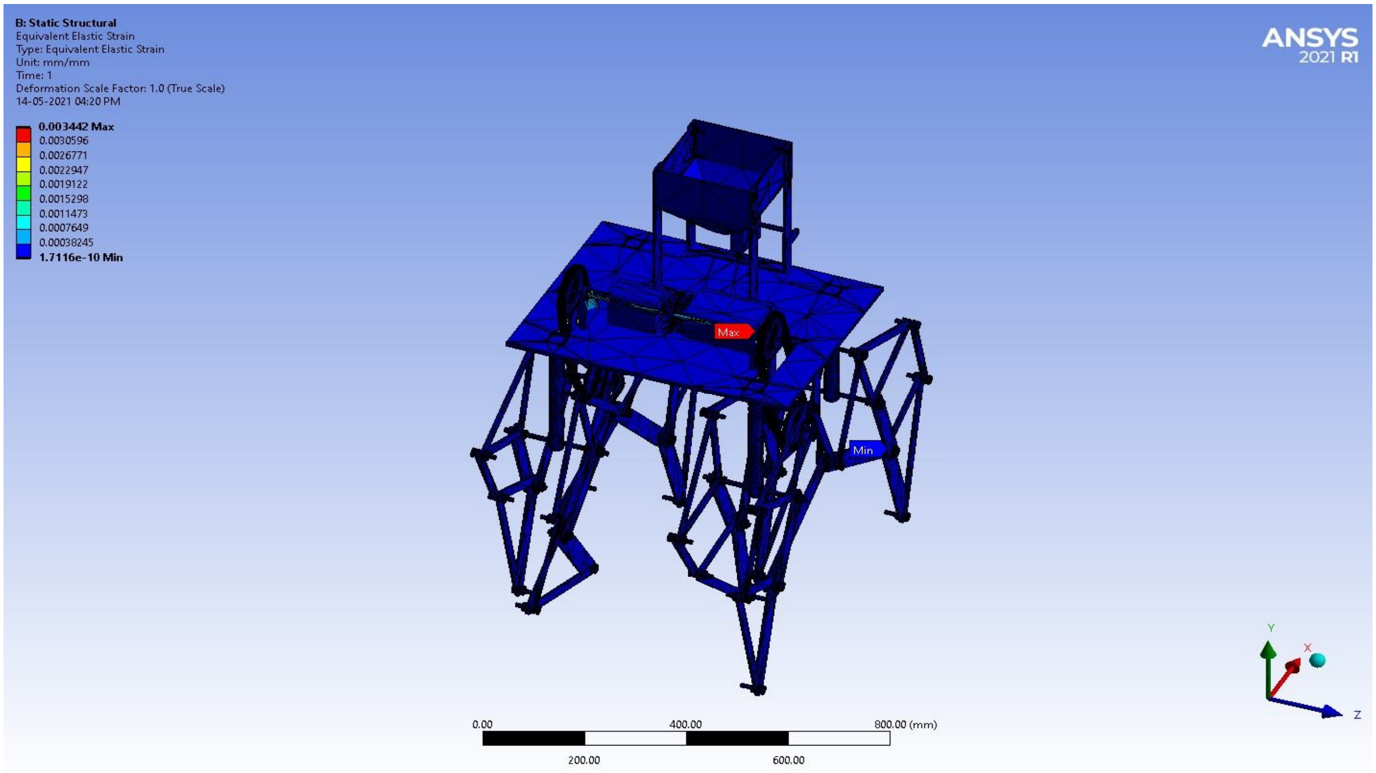


Fig.15 Assembly – Equivalent Elastic Strain

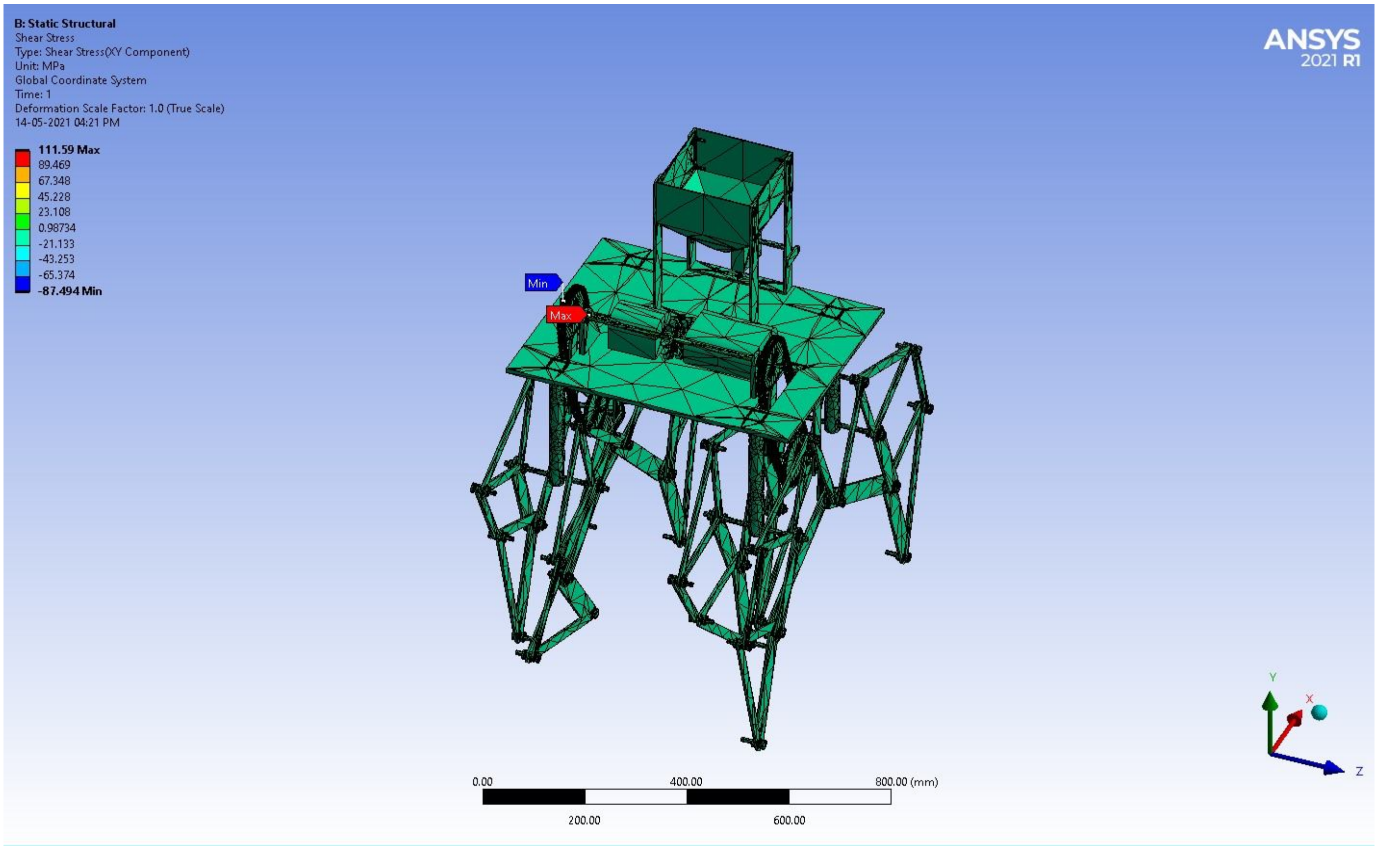


Fig.16 Assembly – Shear Stress

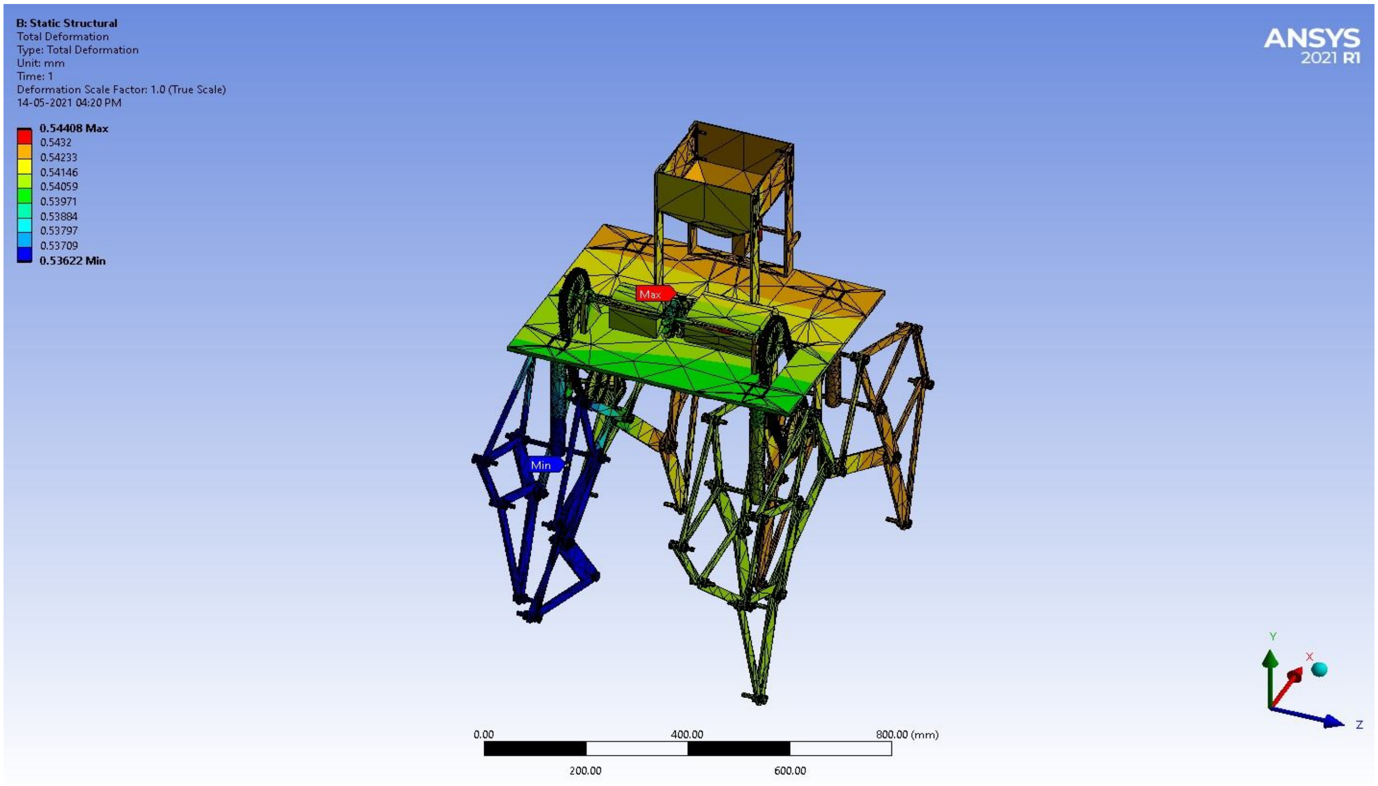


Fig.17 Assembly Total Deformation

X. RESULTS

Results	Minimum	Maximum	Units	Time (s)
Total Deformation	0.53622	0.54408	mm	1.
Shear Stress	-87.494	111.59	MPa	1.
Equivalent Stress	4.1941e-007	432.33	MPa	1.
Equivalent Elastic Strain	1.7116e-010	3.442e-003	mm/mm	1.

XI. CONCLUSION

The seed sowing robot using Theo Jansen mechanism robot Design and Analysis is done. The design is prepared in SolidWorks 2020 version and simulation and assembly in SolidWorks Simulation. It can carry the load of 1 kg of seeds and travel at a speed of 0.25 m/s to 0.55 m/s. This project has great capability to be developed as a product for the agriculture sector. By solving the problems in implementation, it will be beneficial in assisting the farmers.

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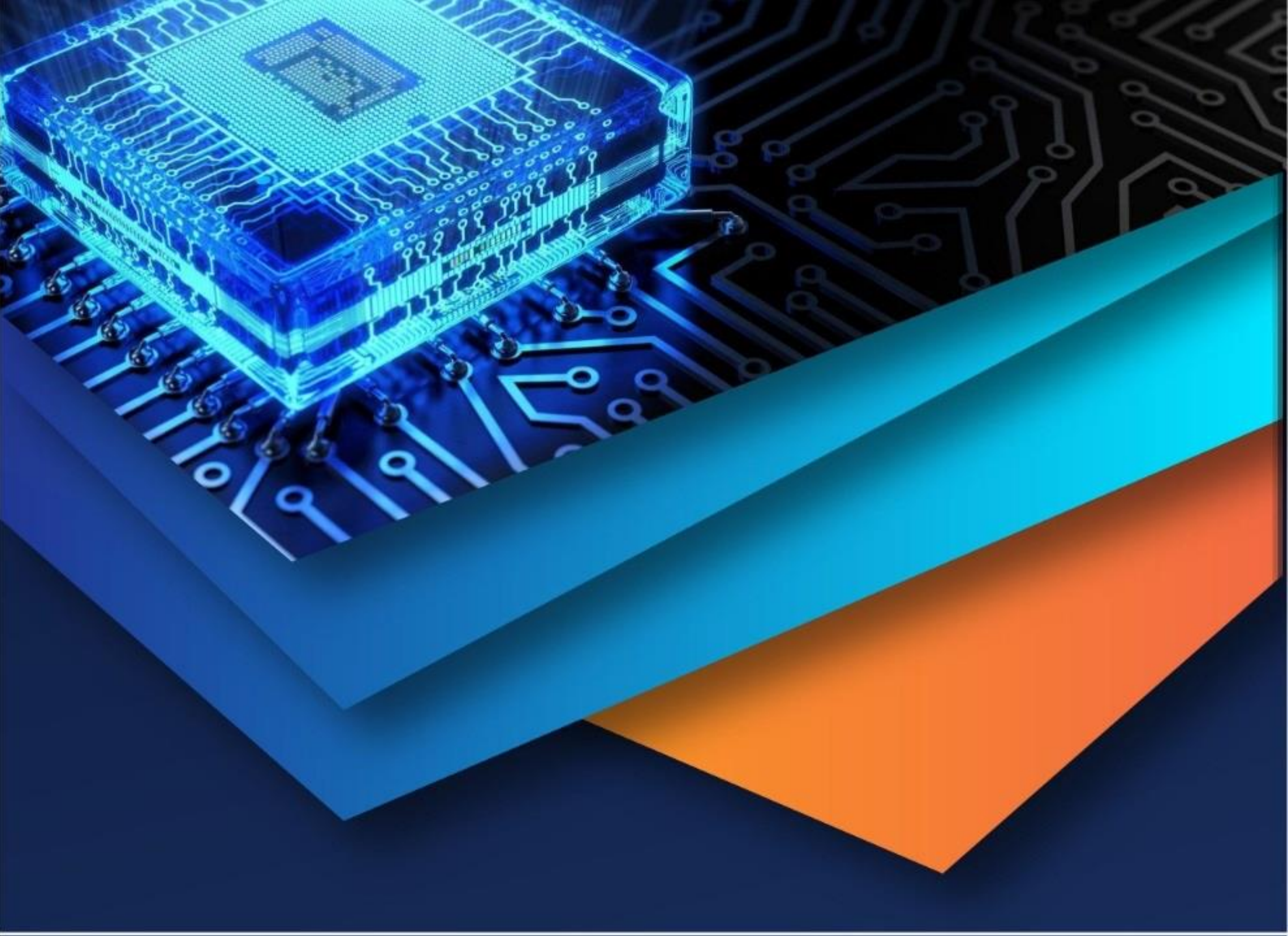

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