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SPIRAL DRIVE FOOTSTEP POWER GENERATOR

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ABSTRACT

The increase in energy consumption of portable electronic devices and the concept of harvesting renewable energy in human surroundings arouse a renewed interest. Nowadays energy and power are one of the basic needs in this modern world. Energy demand is increasing day by day Non-conventional energy system is very essential at this time to our nation. On the other hand, the many energy resources are getting exhausted and wasted. This whole energy is wasted. If this energy is made possible for utilization it will be a great invention. In this project, we are converting non-conventional from just walking footstep into electrical energy. In this project, we are generating electrical power as a non-conventional method by simply walking or running in the footsteps. The project uses a spiral drive mechanism such as rack and pinion assembly. Where with the use of a plunger and twisted rod the linear motion is converted into rotary by the plunger to produce power using bevel gear. The generated energy can be stored in Batteries. Then the output of the battery is used to lighten the lamps in the room or can be used for various applications.

Keywords: Analysis, CAD, ANSYS, Twisted rod, Bevel Gear, Deflection.

I. INTRODUCTION

In daily life, electricity has a high demand for domestic as well as commercial purposes. It is used mainly in appliances like refrigerators, television, washing machine, air conditioning, computers, etc. This demand goes on increasing with population growth and economic development. The energy crisis is a major issue of the modern era. Some developing countries and newly-industrialized countries have several hours of daily power cuts in almost all cities and villages because the increase in demand for electricity exceeds the increase in electric power generation. People in these countries may use a power-inverter (rechargeable batteries) or a diesel/petrol-run electric generator at their homes during the power-cut.

Electricity is a non-renewable source of energy. Non-renewable or conventional sources of energy are limited and they cause pollution to the environment. So the most effective solution to this problem is generating electricity using renewable or non-conventional sources of energy. But the issue in using these sources is that they cause harm to the environment and these sources are non-renewable. So, the most effective solution to this problem is generating electricity using renewable sources of energy.

To reduce the electricity issue, we used the footsteps of humans to generate electricity using a spiral drive mechanism. We designed the parts and then with the help of the CAD Model performed structural analysis for some parts. Under structural analysis we comparisons based on Total Deformation, Shear Stress, Equivalent stress, Equivalent Elastic strain and compared the above-mentioned materials.

II. METHODOLOGY

To start with the design we will be completing the design of the parts of the arrangement and from the parameters obtained we created an assembled 2D drawing of the whole arrangement. Furthermore, we will be creating the CAD Model using NX10.0. Then we will be using static analysis for analyzing various parameters. Moreover, We intent to compare the analytical results obtained from ANSYS with theoretical results obtained from calculations.

Outline for static analysis:-

1. Build the model
2. Define engineering data

3. Material selection
4. Apply the meshing conditions
5. Apply the boundary conditions
6. Apply Load/Pressure
7. Obtain the solution
8. Review results

Flow of Project:-

1. Design calculations of the arrangement

i. Top Plate

ii. Spring

iii. Bevel Gear

2. Structural Analysis (static) of the mechanism

a. Normal Elastic Strain

b. Normal Stress

c. Total Deformation

d. Strain Energy

3. Theoretical Comparison of the results from Analytical analysis

III. MODELING AND ANALYSIS

Working Principle:

The design presented in this project is based on a spiral drive mechanism where the Force from the footsteps is expected to provide the motion to the rod and the bar so the motion of the bar interacts with the plunger and this linear motion of the rod is converted into rotary motion by the plunger. Now to produce power we intend to use bevel gear to rotate the motor present to generate the power. To transfer the power to the gears we used a wall-like element to take the rotary motion from the plunger and transfer it to the shaft which holds this wall and this shaft then will rotate the gear. Further on the gear will rotate the pinion and the power is generated from the motor. This power can be checked using a multi-meter, LCD or battery, etc.

Calculations:

(i) Spring

Material= Steel wire

Ultimate tensile strength= 1090 N/mm2

Modulus of rigidity= 81370 N/mm2

Permissible shear stress for spring wire should be 50% of ultimate tensile strength

Below table shows the parameters obtained for springs;

Table- 1. Spring Calculations

Parameters	Formula used	Values Obtained
Wire Diameter (d)	$T= k*(9*P*C)/(\pi*d^2)$	d= 5mm
Mean Coil diameter (D)	D= c×d	D= 30mm
No. of active coil (N)	⍰= $(8*P*D^3*N)/(G*d^4)$	N= 14
Total no of coils (N_1)	N1= N+2	N_1= 16
Solid length (L_1)	L_1 = (N1×d)	L_1= 80
Free length (L)	L= L_1+ axial gap+⍰	L= 135mm
Pitch of coil (P_1)	$P1 = \frac{L}{(N-1)}$	P_1= 8.66mm

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(ii) Bevel Gear

Assumptions used during calculations,

module m=2.5,

No. of teeth on gear= Z_g= 40,

No. of teeth on pinion= Z_p= 20,

Below table shows the parameters obtained for bevel gear;

Table- 2. Bevel gear Calculations

Parameters	Formula used	Values Obtained
Gear diameter (D_g)	$(D_g)= (Z_g)*(m)$	D_g= 100 mm
Pinion diameter (D_p)	$(D_p)= (Z_p)*(m)$	D_p= 50 mm
Speed Ratio (G)	$G= (Z_g)/(Z_p)$	G= 2
Pitch Cone Distance (A_o)	$Ao = \sqrt{((Dg^2/4) + (Dp^2/4))}$	A_o= 111.803 mm²
Face Width (b)	$b= (A_o)/3$	b= 55.9 mm
Pitch Cone Angle Gear (Υ_g)	$Tan(\Upsilon_g)= (Z_p)/(Z_g)$	$\Upsilon_{g\simeq}$ 26.56° = 27°
Pitch Cone Angle Pinion (Υ_p)	$Tan(\Upsilon_p)= (Z_g)/(Z_p)$	Υ_p = 63.43°
Formative no. of teeth pinion (Z_p')	$Z_p'= (Z_p)/cos(\Upsilon_p)$	Z_p'= 22.35
Formative no. of teeth gear (Z_g')	$Z_g'= (Z_g)/cos(\Upsilon_g)$	Z_g'= 89.27
Mean radius of gear (r_{mg})	$r_{mg} = (d_g/2)-((b/2)sin(\Upsilon_g)$	r_{mg} = 41.05mm
Mean radius of pinion (r_{mp})	$r_{mp} = (d_p/2)-((b/2)sin(\Upsilon_p)$	r_{mp} = 22.11mm

(iii) Top Plate

Assumptions:

Load P_1= 60Kg

Thickness of Plate= 10mm

Length= 300mm

Shear and Bending moment calculations for,

a. Point load

Below given is loading diagram used for calculations of Shear and Bending moment ,

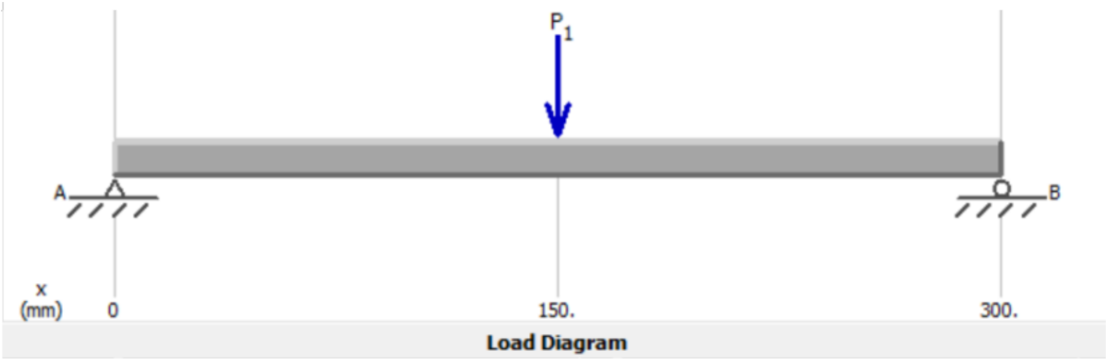

Figure 3.1 Loading Diagram for Point load

Observed results are given below,

Table- 3 Shear force and Bending moment for single load

Position	Point A (at x=0mm)	Point P_1 (at x=150mm)	Point B (at x=300mm)
Shear Force	294.3 N	-294.3 N	0 N
Bending Moment (Nmm)	0 Nmm	44.145 kNmm	0 Nmm

b. 2 Point load

Load here are P_1= 20Kg & P_2= 40Kg

Below given is loading diagram used for calculations of Shear and Bending moment ,

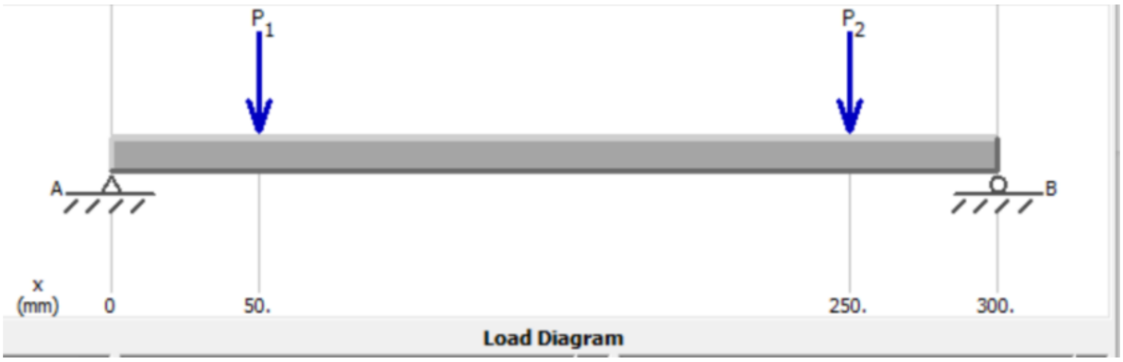

Figure 3.2 Loading Diagram for 2 Point load

Obtained results are as follows,

Table- 4 Shear force and Bending moment for 2 Point load

Position	Point A (at x=0mm)	Point P_1 (at x=50 mm)	Point P_2 (at x=250mm)	Point B (at x=300mm)
Shear Force	228.9 N	32.7 N	-359.7 N	0 N
Bending Moment (Nmm)	0 Nmm	11.445 kNmm	17.985 Nmm	0 Nmm

CAD Model & 2D Drawing

Based on the calculations and proper positioning of the parts we made a 2D draft of the assembled drawing representing the dimensions of the entire system,

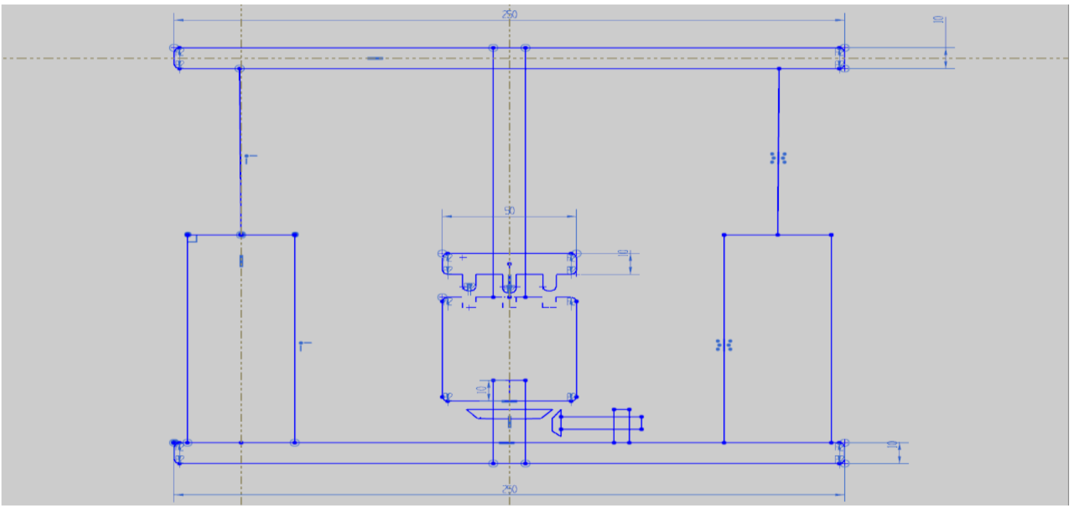

Figure 3.3 2D assembled drawing

The above given 2D drawings dimensions were used to construct the entire CAD model of the arrangement shown below is the total assembled CAD model prepared using NX 10.0 ,

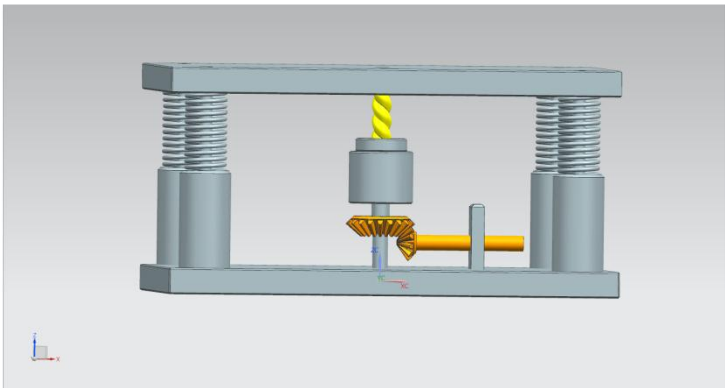

Figure 3.4 Assembled CAD Model

The assembled CAD model consists of the following components,

- Base & Top Plate
- Springs
- Side Support
- Twisted Rod
- Plunger (for Conversion of motion from linear to rotary)
- Wall (Transfer the motion from plunger to Gear)
- Bevel Gear

Below given is assembly of Base plate where the components which are mounted over the base plate are shown,

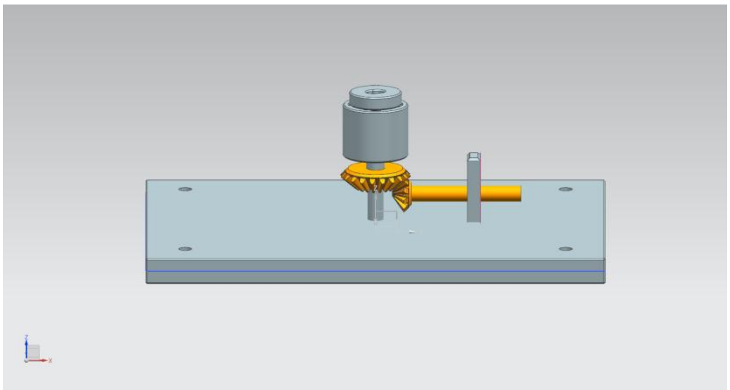

Figure 3.4 Bevel gear, Wall, Plunger and Base plate assembly

Analysis:

1. Top Plate:

Parameters used during analysis:

i. Mesh created using element size of 5mm

ii. Point Load of 60kg (588.6N) applied on the top surface

iii. Material used: Mild Steel

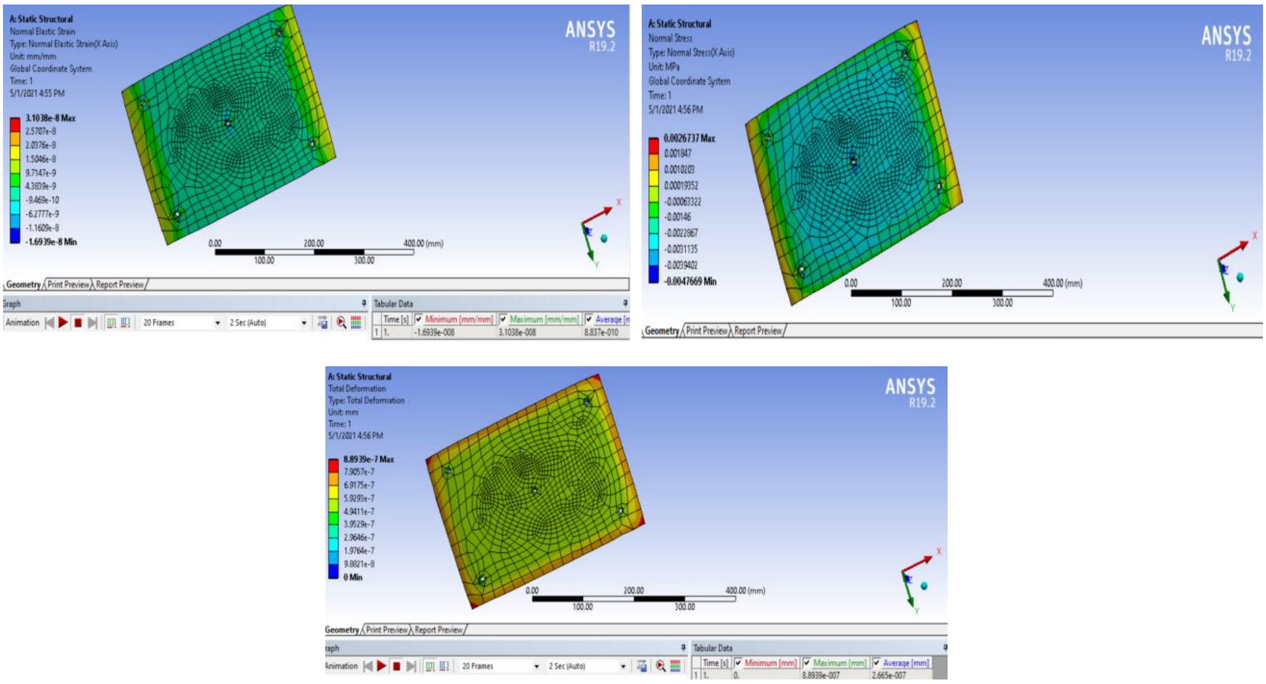

Figure 3.5 Normal elastic strain, Stress and Total Deformation of Top plate

Below given are the theoretical and analytical results obtained from ANSYS Workbench for top plate,

Table- 5 Analytical and Theoretical Results obtained for Top plate

Analyzed(Properties)	Minimum	Maximum	Average	Theoretical (Calculated)
Normal Elastic Strain	-1.6939e-008	3.1038e-003	8.837e-010	1.4988e-08
Normal Stress	-4.7669e-003Mpa	2.6737e-003Mpa	-2.6055e-003Mpa	3.1476e-003MPa
Total Deformation	0	8.8939e-7	2.665e-7	1.4988e-007

2. Support

Parameters used during analysis:

- Mesh created using element size of 4mm
- Point Load of 30.6kg (300N) applied on the top surface
- Material used: Mild Steel

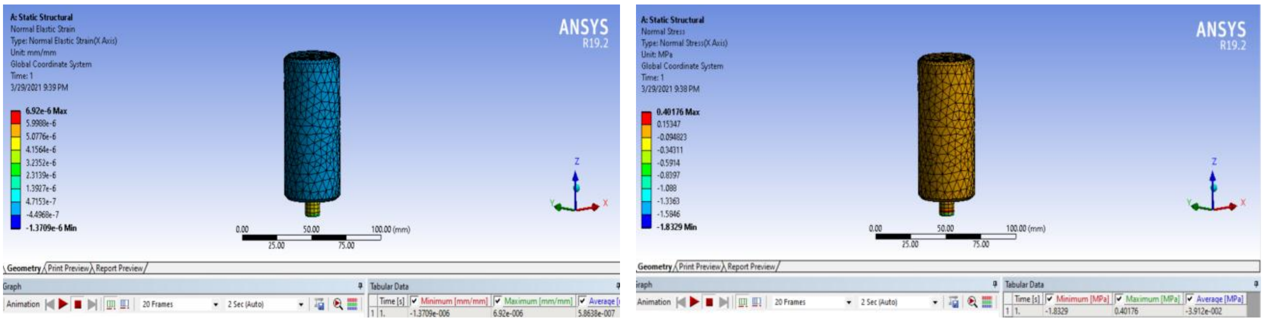

Figure 3.6 Normal elastic strain and Normal Stress of Support

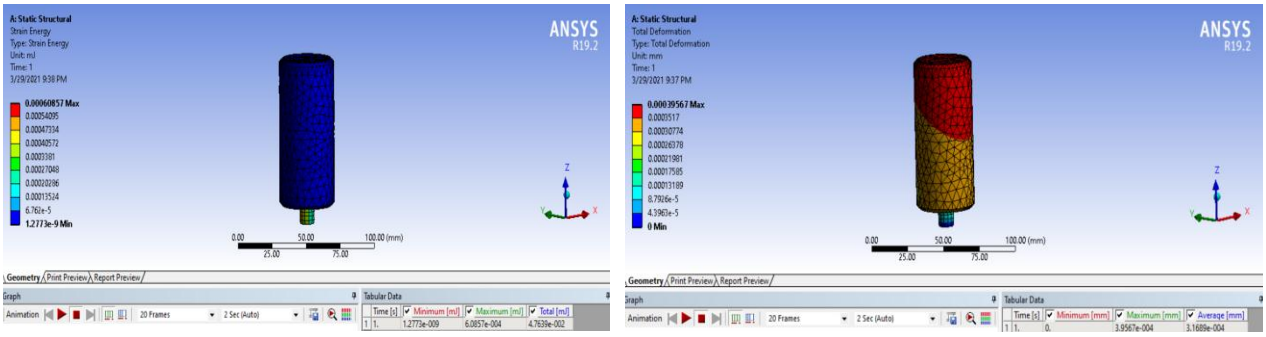

Figure 3.7 Strain Energy and Total Deformation of Support

Below given are the theoretical and analytical results obtained from ANSYS Workbench of support used below springs,

Table- 6 Analytical and Theoretical Results obtained for Supports

Analyzed(Properties)	Minimum	Maximum	Average	Theoretical (Calculated)
Normal Elastic Strain	-1.3709e-006	6.92e-006	5.8638e-007	1.1058e-004
Normal Stress	-1.8329Mpa	0.40176Mpa	-3.912e-002Mpa	0.023223MPa
Strain Energy	1.2773e-009mJ	6.0857e-004mJ	4.7639e-002mJ	4.4232e-003
Total Deformation	0	3.9567e-004mm	3.1689e-004mm	1.27e-008mJ

3. Wall

Parameters used during analysis:

- Mesh created using element size of 7mm
- Point Load of 30.6kg (300N) applied on the top surface
- Material used: Mild Steel

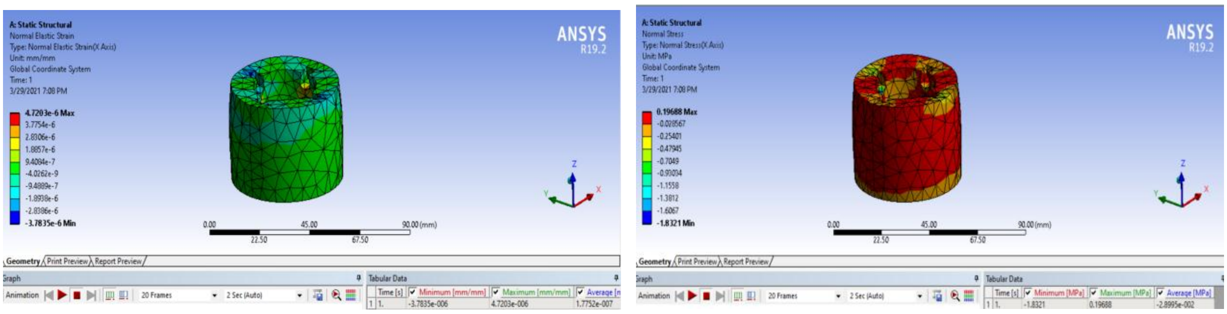

Figure 3.8 Normal elastic strain and Normal Stress of wall

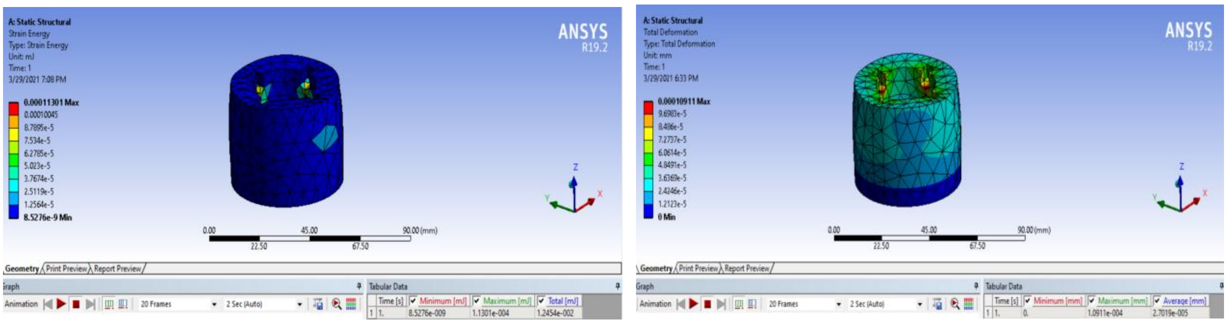

Figure 3.9 Strain Energy and Total Deformation of wall

Below given are the theoretical and analytical results obtained from ANSYS Workbench of support used below wall ,

Table- 7 Analytical and Theoretical Results obtained for wall

Analyzed(Properties)	Minimum	Maximum	Average	Theoretical (Calculated)
Normal Elastic Strain	-3.7835e-006	4.7203e-006	1.7752e-007	1.4735e-04
Normal Stress	-1.8321Mpa	0.1968Mpa	-2.8995e-002Mpa	3.094e-02
Strain Energy	8.5276e-009mJ	1.1301e-004mJ	1.2454e-002mJ	7.367e-03
Total Deformation	0	1.0911e-004mm	2.7019e-005mm	3.34484e-11

4. Twisted Rod

Parameters used during analysis:

- Mesh created using element size of 2mm
- Point Load of 40.77kg (400N) applied on the top surface
- Material used: Mild Steel

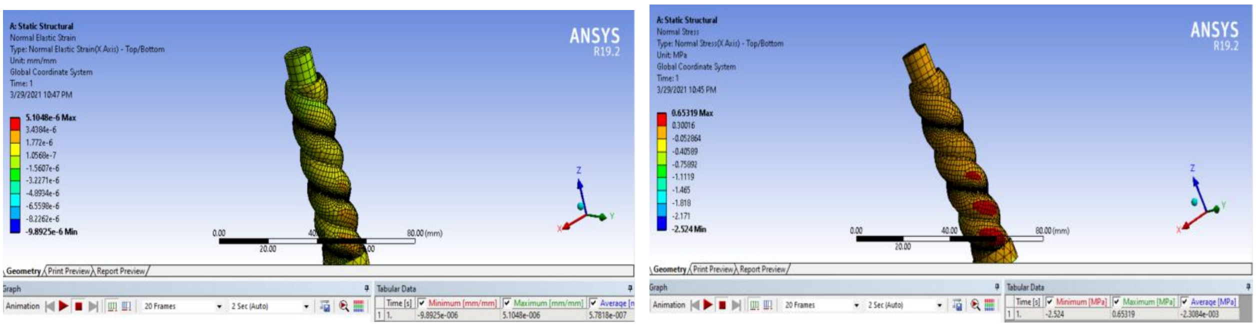

Figure 3.10 Normal elastic strain and Normal Stress of Twisted rod

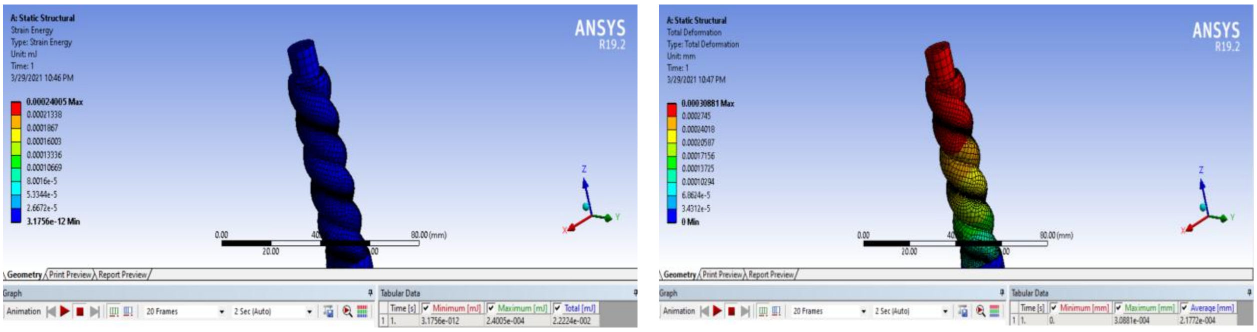

Figure 3.11 Strain Energy and Total Deformation of Twisted rod

Below given are the theoretical and analytical results obtained from ANSYS Workbench of support used below Twisted rod ,

Table - 8 Analytical and Theoretical Results obtained for Twisted rod

Analyzed(Properties)	**Minimum**	**Maximum**	**Average**	**Theoretical (Calculated)**
Normal Elastic Strain	-9.8925e-006	5.1048e-006	5.7818e-007	2.967e-04
Normal Stress	-2.524Mpa	0.65319Mpa	-2.3084e-003Mpa	0.0623
Strain Energy	3.1756e-012mJ	2.4005e-004mJ	2.2224e-002mJ	3.5604e-03
Total Deformation	0	3.0881e-004mm	2.1772e-004mm	5.066e-10mJ

IV. RESULTS AND DISCUSSION

The following results were obtained for the above results:

- Calculations of the parts were obtained and the calculations were verified.
- 2D Drawings of the assembled and the individual parts were obtained.
- CAD Model on was presented based on the dimensions from 2D drawings.
- Analysis based on the parts of the CAD Model was done and the results were compared with the theoretical results

V. CONCLUSION

Project work is based on the idea of electric power generation without polluting the environment. The waste energy in form of human walking is utilized in the system. A new design based on the spiral drive mechanism using a twisted rod is used in the above design. Where based on the drawings, CAD model, and Analysis the design was verified. This system is smothered and less noisy in operation and provides flexibility in working. This system plays an important role in producing electricity at places where there are no sources of electricity like village areas. This energy source is renewable and continuous.

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