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Design and Analysis of Stretcher with Portable Bed

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Abstract:
Stretchers trolley are mobility devices that are used to transport the patients from one place to other. In the old day's stretchers, the patient carries with help of two or more persons. So the human effort is much needed. It is also a risky method for handling the patient. In this project, the design of stretcher trolley is designed with portable beds. Only one person can be enough to operate. The longitudinal and transverse movement of the bed is controlled by using the simple mechanism. So the human effort can be reduced by this method. By this project, the patient can carry to anywhere and also safety. The design of the project is done with CREO. The stretcher trolley is fabricated with the material of steel. The load withstand capacity, stress and friction factors of the stretcher are analyzed with ANSYS. It is designed and fabricated in the standard norms so it can be used in hospital.

I. INTRODUCTION

A stretcher is an apparatus used for moving patient who require medical care. The stretcher must be carried by two or more people. A stretcher (known as a gurney, trolley, bed or cart) is often equipped with variable height frames, wheels, tracks, or skids. There are various stretchers are primarily used in acute out-of-hospital care situations by emergency medical services (EMS), military, and search and rescue personnel. A portable bed is specially designed for hospitalized patients or others need of form of health care. These beds have special features both for the comfort and well-being of patients and for the convenience of health care workers and best advantage for only one person can be enough to operate common features for include adjustable height for the entire bed. The portable bed is easy and safety way to carry the patient by shift the other bed. It didn't definitely injure the patient. In this portable bed controlled by lead screw and sliding mechanism. A lead screw, also known as a power screw or translation screw used as a linkage in a machine, to translate turning motion. Because of the large area of sliding contact between their male and female members, screw threads have a larger frictional energy losses compared to other Linkages. The lead screw is mainly used for raising and lowering the bed. Sliding mechanism is used for moving the bed from horizontal direction to lead screw is mainly used for raising and lowering the bed. Sliding mechanism is used for moving the bed from horizontal direction to pick up the patient bed.

II. LITERATURE REVIEW

The lead screw also called power screw used in machine to translate rotary motion into linear motion. The lead screw is compact, simple in design and having large load carrying capacity. Lead screw has wide application in industrial fixture so lead screw is selected for analysis purpose. During loading condition, the different stress acting on lead screw produces deflection. Where stress is concentrated at the point where thread is start stress is distributed in lead screw body gradually; mode shape gives the idea of different stresses and deformations produced in lead screw [1]. Lead-screw drives are often used in high-performance linear motion systems because they provide a transmission with a relatively high stiffness and an inherent drive reduction. Low-friction ball or roller screws provide acceptably smooth motion for many applications because of elastic averaging among many balls or rollers in simultaneous contact, and they are readily preloaded to have no backlash. Along with the important mechanical design parameters such as the lead and diameter of the screw, a controller of a given form can be parameterized with reasonable constraints [2]. Analysis of a simple aerial scissor lift Conventionally a scissor lift or jack is used for lifting a vehicle to change a tire, to gain access to go to the underside of the vehicle, to lift the body to appreciable height, and many other applications also such lifts can be used for various purposes like maintenance and many material handling operations. With such a design of an aerial scissor lift, the complexities in the design can be reduced. Also with such design parameters, the manufacturing time of an aerial scissor lift can Project relates to an Aerial Scissor lift working on the Lead Screw mechanism. An Aerial Scissor lift is basically an Aerial Work Platform used for the material handling as well as maintenance in Industries, Street Light repairing etc. It is a lifting mechanism, operated by Hydraulic, Pneumatic as well as by mechanical Means. Our research relates to the accessories that should be included in the design of an Aerial Scissor lift, which will increase its efficiency, Power, safety and ease of working [3].

III. LIST OF COMPONENTS

Table.1. List of Components

Components	Material	Size
Frame	Mild Steel	630*800
Base Plate & Lower Plate		2100*600*80
Link		1960*50*10
Nut		Ø40
Pin		Ø40
Lead Screw		Ø12
Portable Bed		1660*550*70

Design of Stretcher Trolley

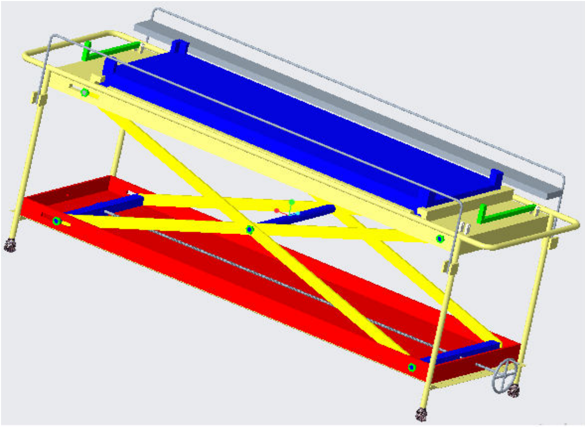

Figure.1. CAD Model of Stretcher Trolley

Stretcher Frame:

Moment of Inertia about XX axis

$$I_{XX} = \frac{bh^3}{12}+\frac{\pi}{64}(D^4 - d^4) - \frac{bh^3}{12} - \frac{\pi d^4}{64}$$

I_{XX} $=4.58752 \times 10^{10}+5438.1-33333.33$
-15707.96

$I_{XX} = 4.58751 \times 10^{10} mm^4$

Moment of Inertia about XY axis

$$I_{Xy} = \frac{bh^3}{12}+\frac{\pi}{64}(D^4 - d^4) - \frac{bh^3}{12} - \frac{\pi d^4}{64}$$

$=4.9392 \times 10^{11}+5438.1-52083.33$
-15707.96

I_{XY} $=4.93919 \times 10^{10} mm^4$

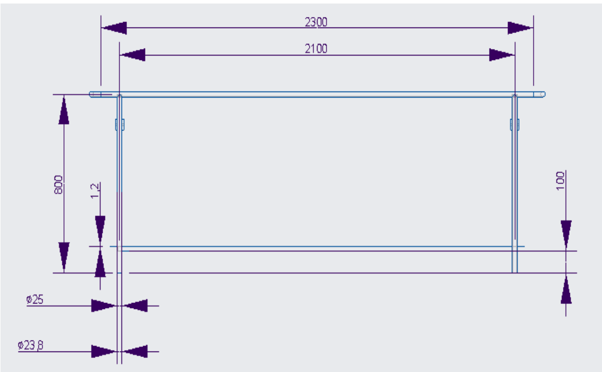

Figure.2. Layout of Stretcher

Base and Upper plate

[1] Rectangular Plate:

i. 2100×600×15 ⇒ volume
= 2100×600×15
Volume = $18.9\times 10^6\, mm^3$

ii. 2100 ×65× 20 ⇒ volume
$=2.73\times 10^6\, mm^3$ ×2Volume = $5.46 \times 10^6\, mm^3$

ii. 2100×65×20 ⇒ volume
$= 0.78 \times 10^6\, mm^3$ ×2
Volume = $1.56\times 10^6\, mm^3$

[2] Hollow Shaft:

i) $\phi 20 \times 20 \Longrightarrow$ Volume= $\frac{\pi}{4}(d)^2 \times$ l

$$= \frac{\pi}{4}(20)^2 \times 20 = 0.12566 \times 10^5 mm^3$$

ii) $\phi 12 \times 20 \Longrightarrow$ Volume= $\frac{\pi}{4}(d)^2 \times$ l

$$= \frac{\pi}{4}(12)^2 \times 20 = 0.04523 \times 10^5 mm^3$$

[3] Rectangular:

150×20×20⟹Volume= $0.6 \times 10^2 \times 2 = 1.20\times 10^5 mm^3$

Total volume = [(18.9×10^6) + (5.46×10^6) +
(1.56×10^6)]–[(0.12566×10^5)
+(0.04523×10^5)+(0.20×10^5)]
= [25.9×10^6] – [1.37089×10^5]

Total volume=$25.789 \times 10^6\, mm^3$

Weight = volume×density
= $25.789\times 10^6 \times 7.85\times 10^{-6}$

Weight = 202 kg × 9.81

Weight, W = 1985 N

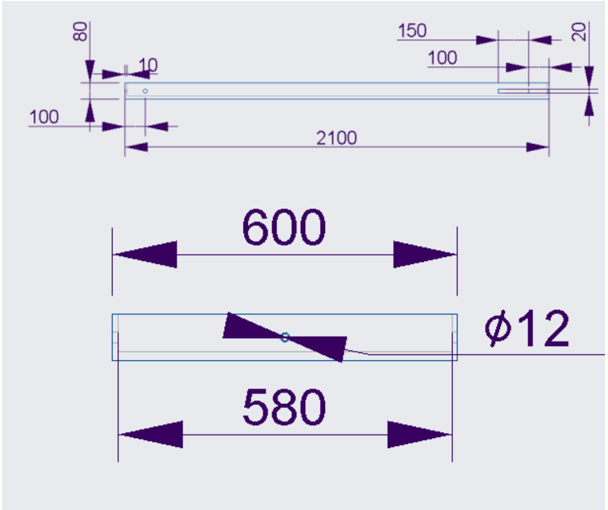

Figure.3. Layout of Base Plate

Lead Screw

Power screw is the ultimate component that takes up the load that is to be lifted or lowered by lift. It also delivers torque from the motor to the nut and also prevents falling of the lift due to its own weight.

Link length is assumed to be 385 mm.

In minimum position,

Therefore, $\cos\theta = \frac{1900}{1910} \Longrightarrow= \theta = 5.86°$

It can be seen from the above figure that maximum pull on the power screw occurs when lift is in lowermost position.

Considering force diagram,

$$\frac{W}{2} = P \times \sin 90^\circ$$

$$\Longrightarrow P = \frac{109.49}{2 \times \sin 5.86}$$

$$\approx 9721N$$

$$\Longrightarrow H = P \times \sin\frac{5.86}{9721} \times 536 \times \cos 5.86°$$

H≈ 9670N

∴ Magnitude of pull on square –threaded screw, F = 9670 N

Let d_c = Core diameter of the screw,

$$\therefore 1970 = \frac{\pi}{4} \times (d_c)^2 \times \sigma_t \frac{\pi}{4} \times (d_c)^2 \times \sigma_t$$

$d_c = 12mm$ [P.S.G Data book p.g.No. 5.69]∴ $d_c = 12mm$

But this diameter is too small to be achieved. That is why a standard diameter can be taken which is greater than the above value.

Assume d_c = 12 mm

Nominal Outer Diameter,

$d_o = d_c + p$ =12 + 2 = 14 mm

Mean Diameter,

$$d = d_\circ - \frac{P}{2} = 14 - 1 = 13mm$$

Let= α Helix angle

$$\tan\alpha = \frac{P}{\pi \times d} = \frac{2}{\pi \times 13} = 0.0489$$

Assume $\mu = \tan\phi = 0.20$

WKT effort required to rotate the screw while increasing height,

$$P = W + \tan(\alpha + \phi)$$
$$= W \times \left(\frac{\tan\alpha + \tan\phi}{1 - \tan\alpha \tan\phi}\right)$$
$$= 1970 \times \left(\frac{0.0489 + 0.20}{1 + 0.0489 + 0.20}\right)$$
$$= 9670 \times 0.2514$$
$$\text{P} = 2431N$$

Torque required in rotating the screw,

$$T = P \times \frac{d}{2} = 2431 \times \frac{13}{2} = 15801.5N - mm$$

Torsional Shear Stress,

$$\tau = \frac{16 \times 15801.5}{\pi \times 12^2} = 46\frac{N}{mm^2}$$

Direct Tensile Stress,

$$\sigma_t = \frac{W}{\frac{\pi}{4}(d_c)^2} = \frac{9670}{\frac{\pi}{4}(12)^2} = 85\frac{N}{mm^2}$$

Maximum Principal Stress,

$$\sigma_{t(\max)} = \frac{\sigma_t}{2} + \frac{1}{2} \times \sqrt{(\sigma_t)^2 + 4 \times \tau^2}$$
$$= \frac{85}{2} + \frac{1}{2} \times \sqrt{(85)^2 + 4 \times 46^2}$$
$$= 105\frac{N}{mm^2}$$

Maximum Shear Stress,

$$T_{max} = \frac{1}{2} \times \sqrt{(\sigma_t)^2 + 4 \times \tau^2}$$
$$= \frac{1}{2} \times \sqrt{(85)^2 + 4 \times 46^2}$$
$$= 62\frac{N}{mm^2}$$

Since the maximum stresses are in permissible limits, all the dimensions are correct. All the dimensions of the power screw are shown in the figure.

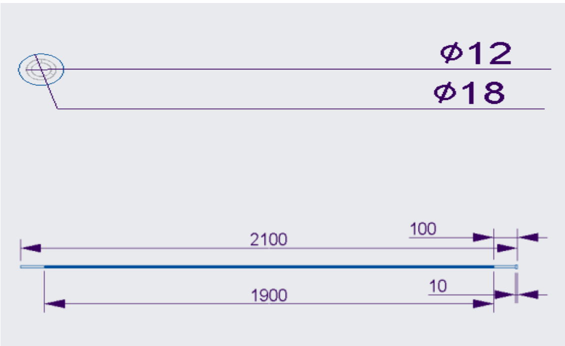

Figure.4. Layout of Lead Screw

Nut

Bearing Pressure for Mild Steel,

$$\text{P}_\text{b} = 20\frac{\text{N}}{\text{mm}^2}$$

Let n = number of threads in contact with screw

Assuming that the load W is distributed uniformly over the cross-sectional area of the nut, therefore bearing pressure between the threads,

$$\text{P}_\text{b} = \frac{\text{W}}{\frac{\pi}{4} \times [(\text{d}_\circ)^2 - (\text{d}_\text{c})^2] \times \text{n}}$$

$$\therefore 20 = \frac{9670}{\frac{\pi}{4} \times [18^2 - 12^2] \times \text{n}}$$
$$\Longrightarrow \text{n} = 11.83$$

$n = 2.5$ [P.S.G, Data book, pg. No.5.87]

In order to have good stability and also to prevent rocking of the screw in the nut, we shall provide n = 2.5 threads in the nut.

∴ Thickness of nut,

$$t = n \times p = 2.5 \times 6 = 15mm$$

∴ Width of the nut,

$$b = 1.5 \times d_\circ = 1.5 \times 18 = 27mm$$

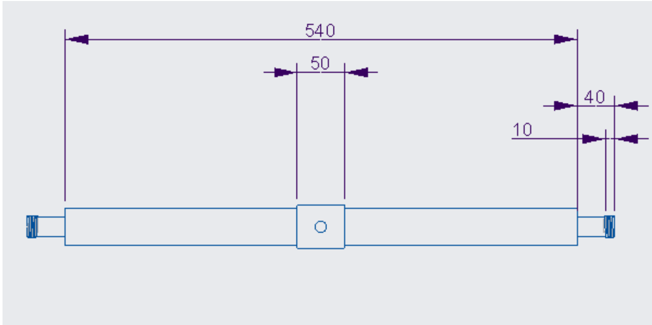

Figure.5. Layout of Nut

Link

Load on one link $= \frac{P}{2} = \frac{9670}{2} = 4835mm^3$

Assuming FOS=5, the links may be designed for a buckling load of

$$W_{cr} = 4835 \times 5 = 24{,}175N$$

Let, t_1= Thickness of the link

b_1= Width of the link

Assume $b_1 = 3 \times t_1 b_1 = 3 \times t_1$

Cross-Sectional Area of link= $3 \times {t_1}^2$

$$I = \frac{1}{12} \times t_1 \times (b_1)^2 = \frac{1}{12} \times t_1 \times (3 \times t_1)^4$$

Moment of Inertia,

$$k = \sqrt{\frac{1}{A}} = \sqrt{\frac{2.25 \times {t_1}^4}{3 \times {t_1}^2}} = 0.866t_1$$

Since for buckling of the link in the vertical plane, the ends are considered as hinged, therefore equivalent length of the link,

$$L = I = 1910mm$$

And Rankine's constant,

$$\alpha = \frac{1}{7500}$$

According to Rankin's formula bucking load

$$\therefore 24{,}175 = \frac{\sigma_c \times A}{1 + \alpha \times \left(\frac{L}{k}\right)^2} = \frac{247 \times 3 \times {t_1}^2}{1 + \frac{1}{7500} \times \left(\frac{1910}{0.866t_1}\right)^2}$$
$$\therefore 24{,}175 = \frac{714{t_1}^4}{{t_1}^2 + 648}$$
$$\therefore 741{\text{t}_1}^4 - 24{,}175{\text{t}_1}^2 - (15.6654 \times 10^6) = 0$$
$$\therefore {\text{t}_1}^2 = 162.62$$
$$\text{t}_1 \approx 13\text{mm}$$
$$\therefore \text{b}_1 = 13 \times 13 = 169\text{mm}$$

Radius of Gyration,

Since for buckling of the link in a plane perpendicular to the vertical plane, the ends are considered fixed, therefore Equivalent length of the link,

$$L = \frac{1}{2} = \frac{1910}{2} = 955mm$$

Again according to the Rankin’s formula,

$$W_{cr} = \frac{A}{1 + a + \left(\frac{L}{k}\right)^2} = \frac{247 \times 3 \times {t_1}^2}{1 + \frac{1}{7500} \times \left(\frac{955}{0.866 t_1}\right)^2}$$
$$= \frac{741 {t_1}^2}{1 + \frac{162.14}{{t_1}^2}}$$

Substituting the value of, $t_1 = 13mm$
We have

$$W_{cr} = \frac{300 \times 13^2}{1 + \frac{162.14}{13^2}} = 63{,}911N$$

Since the buckling load is less than the calculated value, therefore link is not safe for buckling in a plane perpendicular to the vertical plane.

$\therefore$ We may take $t_1 = 10mm$ and $b_1 = 50mm$

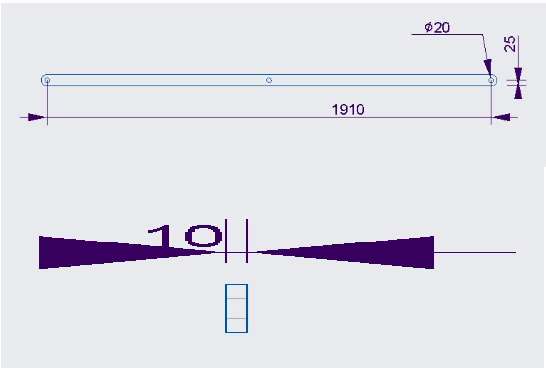

Figure.6. Layout of Link

Pin

Let d_1= Diameter of pins
Since the pins are in double shear, therefore load on the pins,

$$\therefore 9670 = 2 \times \frac{\pi}{4} \times (d_1)^2 \times \tau = 72.25 (d_1)^2$$
$$d_1 = 11.56mm$$

But to account for dimensions of other components let us take d_1= 20 mm

Design Analysis

1. Upper Plate:

Table.2. Dimension Details of Upper plate

Parameters	Length	Width	Thickness
Value	2100mm	600mm	80mm

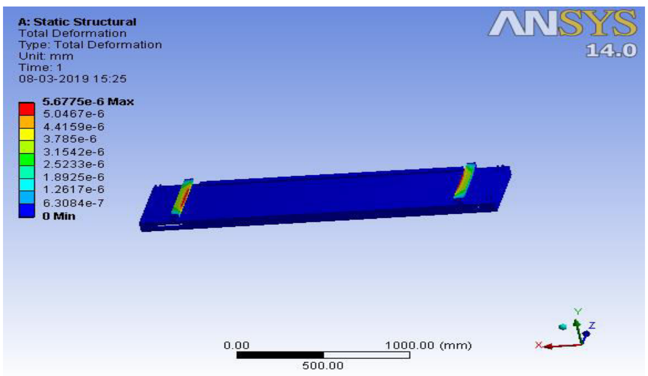

Figure.7. Total Deformation

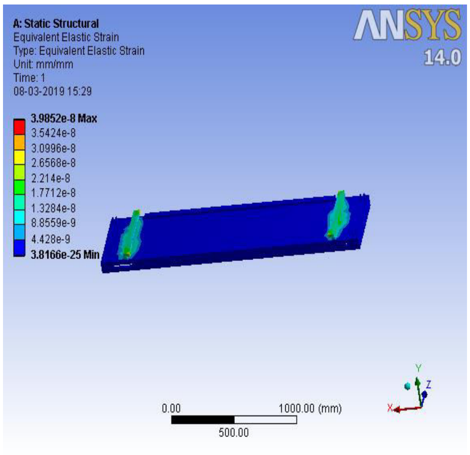

Figure.8. Equivalent Elastic Strain

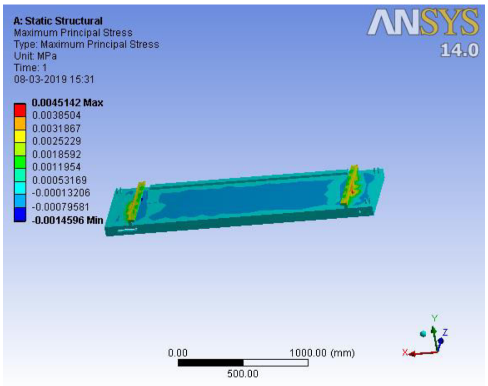

Figure.9. Maximum Principle Stress

Table.3. Analysis Details of Upper Plate

Type	Total Deformation	Equivalent Elastic Strain	Maximum Principle Stress
Minimum	0	3.8166e-025	-1.4596e-003MPa
Maximum	5.6775e-006mm	3.9852e-008	4.5142e-003MPa

2. Link

Table.4. Dimension Details of Link

Parameters	Length	Width	Thickness
Value	1910mm	50mm	10mm

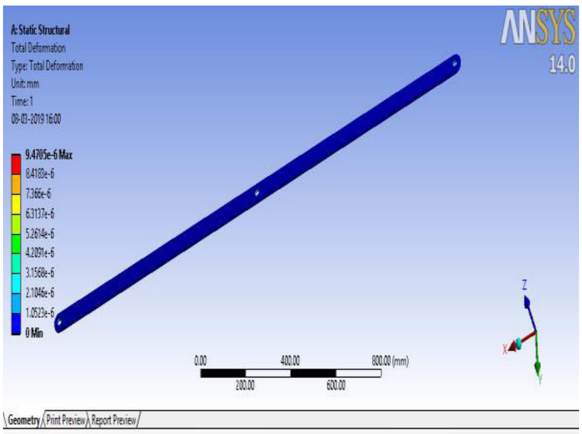

Figure.10. Total Deformation

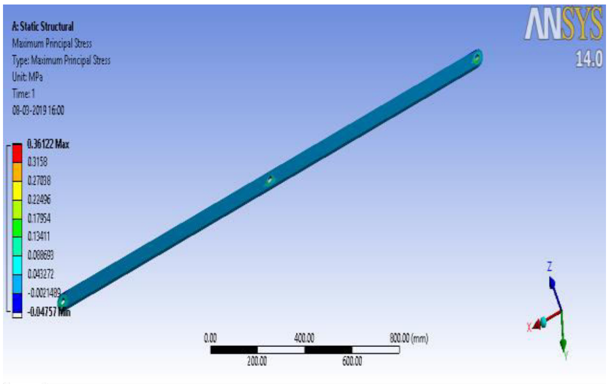

Figure.11. Maximum Principle Stress

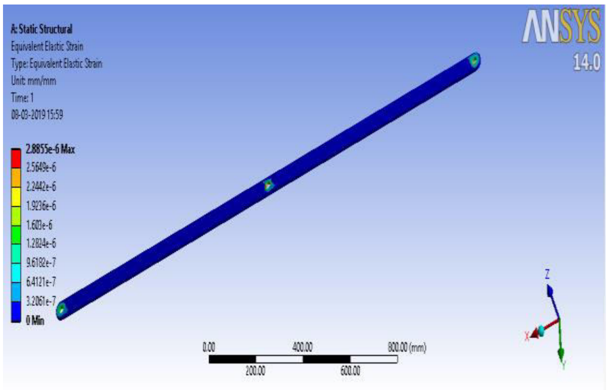

Figure.12. Equivalent Elastic Strain

Table.5. Analysis Details of Link

Type	Total Deformation	Equivalent Elastic Strain	Maximum Principle Stress
Minimum	0	0	-4.757e-002MPa
Maximum	9.4705e-006mm	2.8855e-006	0.36122MPa

3. Pin

Table.6. Dimension Details of Pin

Parameters	Length	Diameter
Value	600mm	20mm

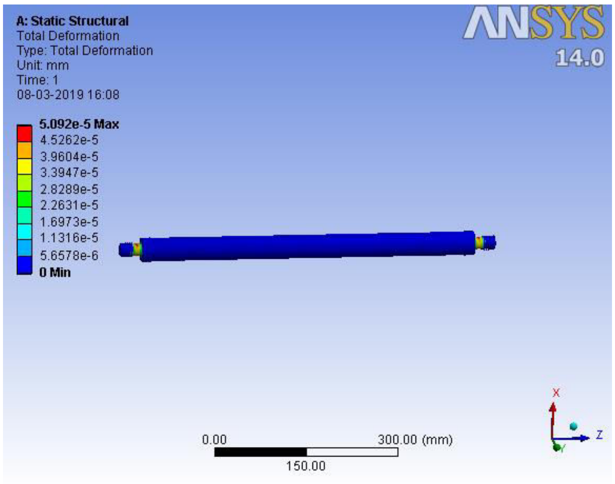

Figure.13. Total Deformation

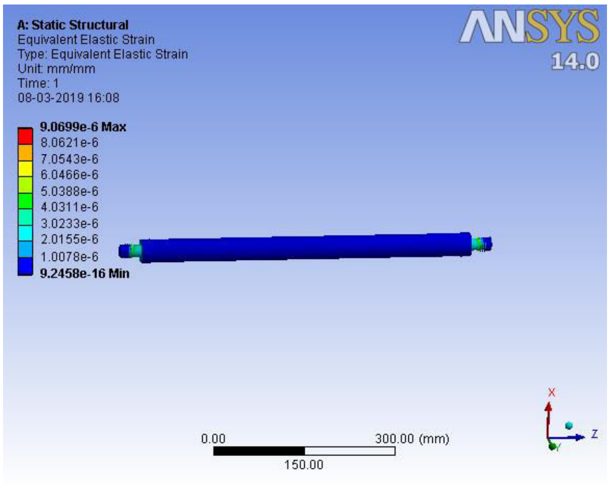

Figure.14. Equivalent Elastic Strain

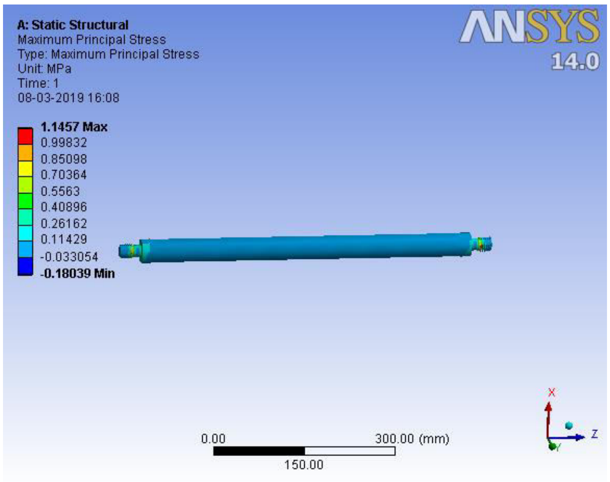

Figure.15. Maximum Principle Stress

Table.6. Analysis Details of Pin

Type	**Total Deformation**	**Equivalent Elastic Strain**	**Maximum Principle Stress**
Minimum	0	9.2458e-016	-0.1803MPa
Maximum	5.092e-005mm	9.0699e-006	1.1457MPaa

IV. CONCLUSION:

With the help of Current research, we briefed out the basic Design procedure of the Stretcher working on the Principle of Lead Screw and Sliding mechanism. The Design analysis on ANSYS has also shown that the design is safe under certain accepted parameters. Also modification can be implemented for optimizing the design and further analysis can carried out by finding other important parameters related to Stretcher Trolley.

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