DESIGN AND STATIC STRUCTURAL ANALYSIS OF INDUSTRIAL HAND TRUCK CHASSIS

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ABSTRACT:

Creating better quality, decreasing the assembling cost and conveying the item rapidly, have now become the significant focuses for manufacturing industries. Hand-truck chassis is a skeleton for mounting points for different segments and giving structural strength. Finite element stress analysis of a hand-truck chassis assumes a significant role in design stages. The chassis serves as a supporting the body and various parts of the hand-truck. Its principle function is to convey the most extreme load for all designed working condition securely that ought to be inside an utmost. In this work, chassis is modelled with the help of Creo software tool. FEA on the modelled chassis is done utilizing the ANSYS Workbench and its static conduct was examined taking four unique kinds of material as structural steel, mild steel, aluminium alloy and titanium alloy.

Keywords: Creo software tool, ANSYS, FEA, hand truck Chassis, structural steel, mild steel, aluminium alloy and titanium alloy

INTRODUCTION

The utilization of fuelled and non-fuelled industrial hand-trucks is exposed to specific risks that can't be totally wiped out by mechanical methods. Therefore it is basic to have able and cautious operators, genuinely and intellectually fit, and completely prepared in the safe activity of the equipment and the handling of the loads. Over-burdening, poor support, load flimsiness, impact with different items or obstacles are a portion of the genuine perils for the model.

1.1 Need of improvement in industrial workplace

Due to manual handling of the container, it might extrude labourers to several bodily problems (e.g., power, cumbersome stances, and redundant movements) that can prompt major as well as minor wounds, burned through vitality and sat around idly. To stay away from these issues, the coming demand of work errands and the labourer's capacities can be improved coming from the organization [1]. To put it plainly, changing working environment by improvement in advantage work environment by:

i. Decreasing or forestalling injuries.

ii. Minimising the labourer's endeavours by diminishing powers in lifting, handling, pushing and pulling materials.

iii. Expanding efficiency, item and administration quality and labourer confidence.

iv. Bringing down expenses by decreasing or wiping out production bottlenecks, mistake rates or dismissals, utilization of therapeutic services due to musculoskeletal disarranges labourer's pay claims and retraining [2].

1.2 Need of hand truck

A hand truck is an L-shaped moving handcart which is generally used for moving the box container in commercial sector as well. It is also known as box cart, sack truck, trolley or a bag borrows. It is having the wheels on the base of the cart, handles at one endand a flat ledge for holding or loading the objects which is to be transported. Some hand trucks are set with stair climber wheels. These stair climbers are used to transport objects from downstairs to upstairs and vice versa.The hand trucks are fabricated from several materials which generally include aluminium extrusion, steel tubs or high impact plastics [3].

The hand trucks are of various types and can be classified according to be use and structures. Some are according to wheel types, some according to stair climber, some with handle type or some with wheel size. Other separates to be taken into account by the shape of load compared with the shape of backrest, e.g., cylindrical loads should sit on curved backrest.

Hand trucks are sometimes used as luggage carts by porters in railway stations and skycaps at airports.

1.3 Significance of Material handling system in Industry

Material handling is an important segment of any beneficial movement in industry. In the ongoing time of rivalry, this has procured more noteworthy greatness because of developing requirement for lessening the cost of manufacturing. Material handling is important when the proportion of handling cost to the processing cost is huge. A straight consistent progression of material is normally generally proficient [4]. The utilization of mechanical equipment instead of people is as a rule, however not constantly, alluring—contingent on the span of the activity, recurrence of excursions, load components, and qualities of the material. The best possible material handling equipment chosen by examining the material, the course it must take from purpose of beginning to goal, and comprehending what equipment is accessible [5].

1.4 Problem identification and objective of project:

- Hand trucks intended for transporting heavy load and more particularly, to an improved and streamlined hand-truck which is received to move substantial loads effectively here and there from the stair; with the assistance of this truck we can lift the load effectively all over from stairs. The new "stinger" stabilizer arm cannot handle the large amount of force that stresses it.
- In industry 1200 pound weighing hand truck is not available.
- In inclined road region, the hand truck not easily possible to carry forward movement.
- For different shaped, there are not available different fixture for holding

Therefore the objectives of current project are

- Analysis of present system.
- Suggest the best possible design for the existing system
- Cost reduction

Materials and Methods:

2.1 Computer aided modelling of novel hand truck:

The hand truck is modelled with the help of Creo software tool. Figure 1 shows the Isometric view of novel motorised hand truck.

Fig. 1 Isometric view of novel motorised hand truck

Figure 2 shows the detailed views with dimensions of novel motorised hand truck.

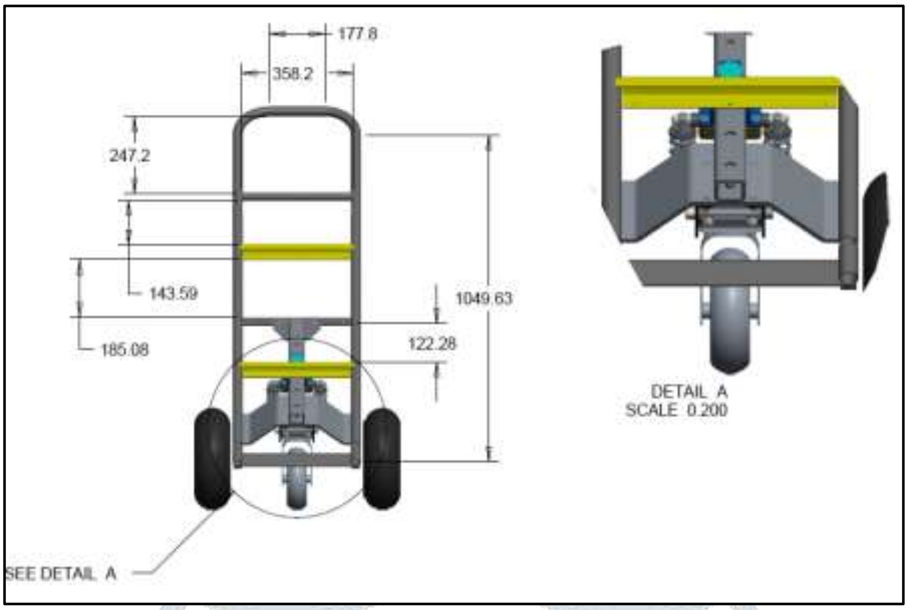


Fig. 2 Detailed view of novel motorised hand truck

2.2 DESIGN CALCULATION

Table No. 1: Truck Specification

S.N	Particulars	Unit	Details
1	Truck Weight	kg	40
2	Material Weight	kg	110
3	Total Weight	kg	150
4	Total Weight in Newton	N	1491

Table No. 2: Helical compression spring design and Specification [6], [7]

S.N	Particulars	Unit	Details
1	Deflection of the spring(μ)	mm	50
2	Resultant shear stress(Ꚍ)	N/mm^2	350
3	Modulus of rigidity (G)	kg	84000
4	Stiffness of the spring(K)	N/mm	30
5	Mean diameter of coil (D)	mm	80
6	Wire diameter (d)	mm	10
7	No. of active coil(n)	-----	5
8	Total no. of active coil(n)	-----	7
9	Solid length (L_s)	mm	42
10	Free length (L_f)	mm	99.5
11	Pitch of the coil (P)	mm	16

Design of Shaft

Considering the shafts to be made of SAE 1030 [8]

Power provided by the motor, p = 1 HP = HP = 746 watts = 0.746KW

SHAFT

Speed of the shaft, N1 =495 RPM.

Design Torque:-

$T_d = (p\times 60)\times K_1/(2\times \pi \quad N_1) = 25.1978$ N-m

Considering c only:-

$(T_1 / T_2)_A = e^{\mu\times\theta}$

Since μ= 0.1 for C.I. – C.I. Material pair and included angle is θ= 180°$or\pi$

Thus , $(T_1)_A = 1.37(T_2)_A$ ------------------------(i)

and $T_d = (T_1 - T_2)_A\times r_A$, T_2=220.8957 N, T_1=565.4932 N

Also, T_1+T_2=786.3889 N

Considering D only :-

$(T_1 / T_2)_A = e^{\mu\times\theta}$

Since μ= 0.1 for C.I. – C.I. Material pair and included angle is θ= 180°$or\pi$

Thus , $(T_1)_A = 1.37(T_2)_A$ ------------------------(i)

and $T_d = (T_1 - T_2)_A\times r_A$, T_2=2530 N, T_1=3476 N

Also, T_1+T_2=6006 N

Considering vertical forces only for vertical moment diagram:-

$R_{AV}+R_{BV}$ =25.05+8.377N ----------------------(iii)

R_{BV} =7.335 N, R_{AV}= 26.091 N

Moment at points

M_{CV} **= 0,** M_{AV} **= -625.25,** M_{BV} **= -209.85,** M_{DV} **= 0**

Shear force diagram

F AT C = -25.05N, F AT A = 1.041N, F AT B = 8.376N, F AT D = 0 N

Considering vertical forces only for horizontal moment diagram :-

$R_{AH}+R_{BH}$ =786.3889+6006N ----------------------(iv)

R_{BH} =6332.2256 N, R_{AH}= 460.1632 N

Moment at points

M_{CH} **= 0,** M_{AH}**= -19659.7225,** M_{BH} **=-147750.0025,** M_{DH} **= 0**

Shear force diagram

F AT C = -786.3889N, F AT A = -326.2257N, F AT B = 6005.99N, F AT D = 0 N

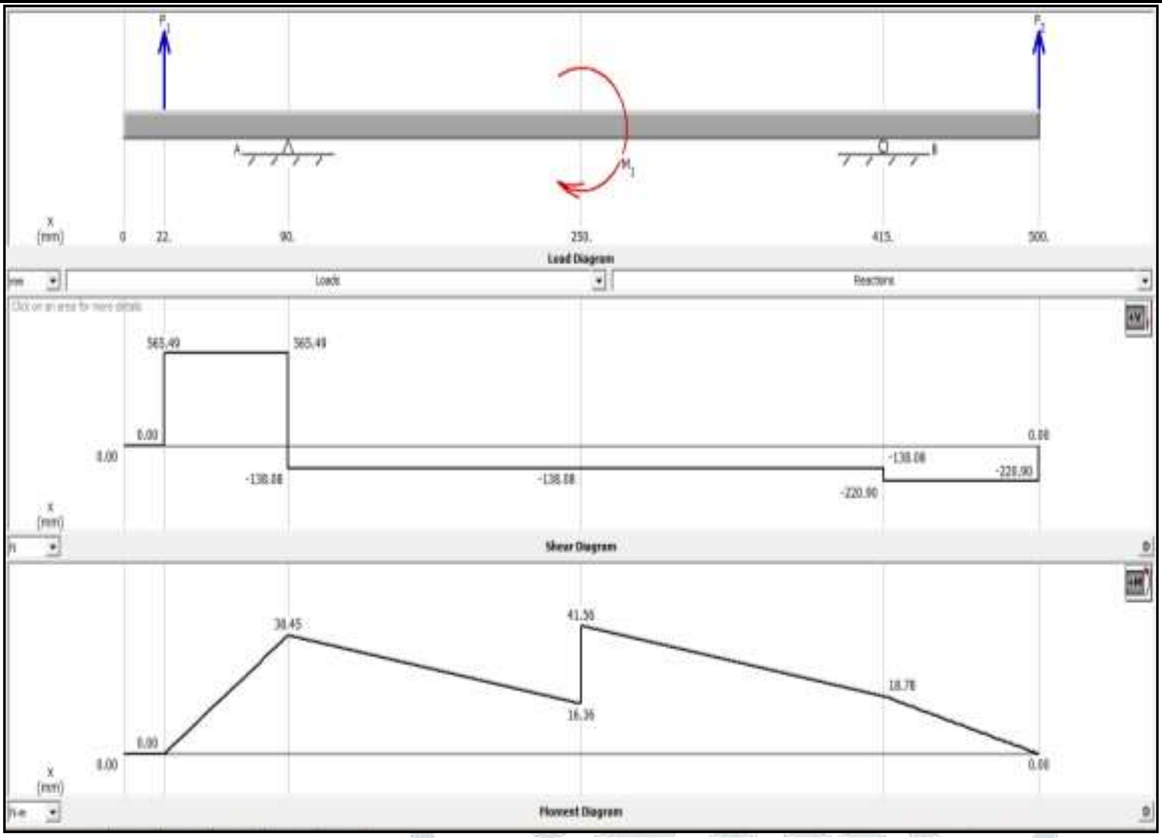


Fig. 3: Load, Shear and Bending moment diagram for Shaft

2.3 STRUCTRAL ANALYSIS OF A CHASSIS

The preprocessing step is, quite generally, described as defining the models as in figure 5 [9], [10]

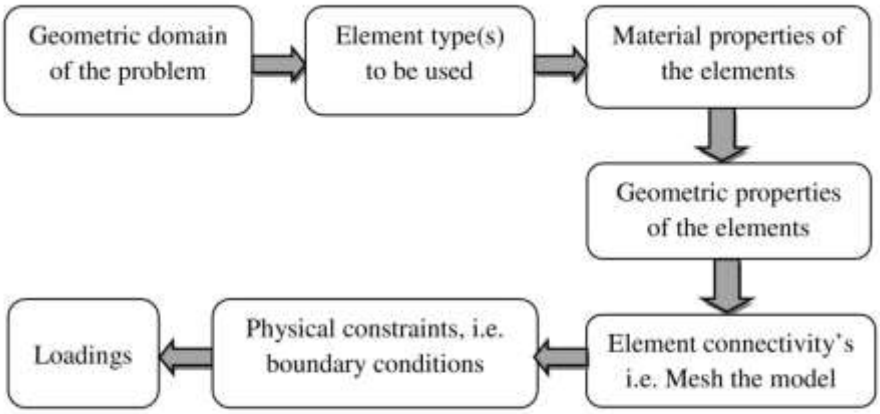


Fig. 4: Defining the models in preprocessing

Post processing is an analysing and evaluation of the solution results. Postprocessor procedure of finite element solution as given in fig 6, [11], [12]

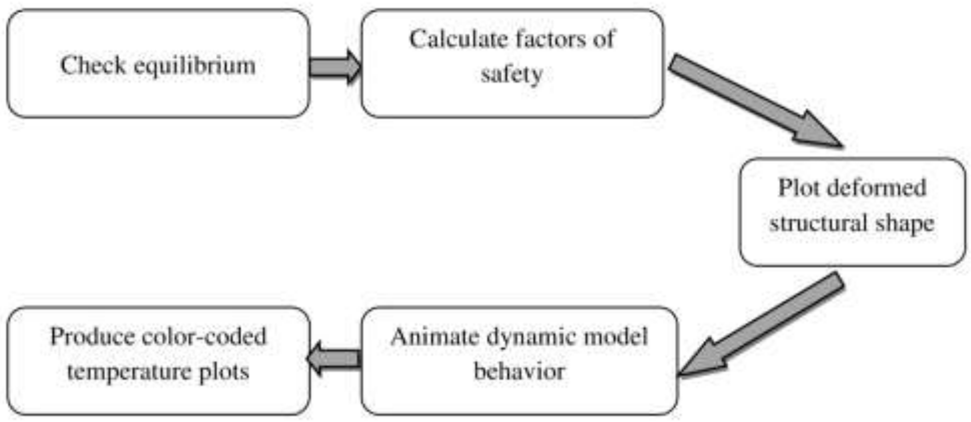


Fig. 5 Post processing

RESULTS AND DISCUSSION

PROPERTIES OF DIFFERENT COMPONENT

- Below table consists of

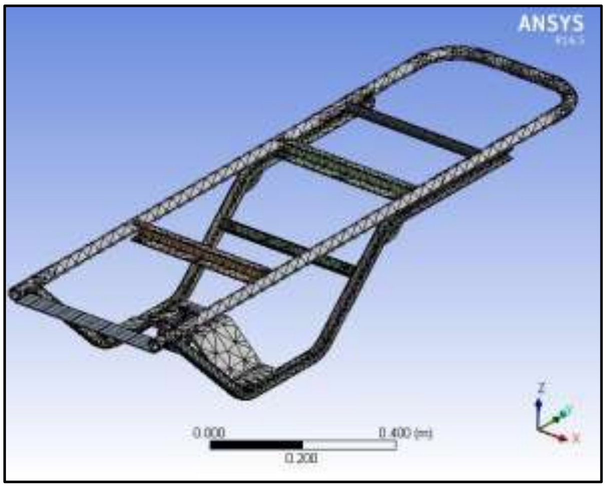
1. Parts wise volume
2. Mass properties
3. Moment of inertia
4. Centroid of the parts

- Details of node and elemets part wise

Table 3 Mass Properties of Structural Steel

Object Name	MSBR	MSBR	MSBR	MSBR	MSBR
State	Meshed				
Bounding Box					
Length X	0.3937 m	0.381 m	0.3683 m		1.27e-002 m
Length Y	0.127 m	8.6721e-002 m	4.1707e-002 m		8.7491e-002 m
Length Z	0.10058 m	3.9289e-002 m	3.3186e-002 m		3.6247e-002 m
Properties					
Volume	5.5236e-004 m³	1.8022e-004 m³	9.4681e-005 m³		7.9206e-006 m³
Mass	4.336 kg	1.4147 kg	0.6817 kg		5.7029e-002 kg
Centroid X	-6.727e-009 m	-7.0471e-008 m	6.8803e-007 m	7.4957e-007 m	-0.1905 m
Centroid Y	-0.34026 m	-0.66396 m	0.2079 m	-0.3001 m	0.12302 m
Centroid Z	-0.19701 m	-2.7089e-002 m	-1.7525e-003 m		-6.4925e-002 m
Moment of Inertia Ip1	1.1069e-002 kg·m²	1.0472e-003 kg·m²	1.8877e-004 kg·m²		3.4779e-005 kg·m²
Moment of Inertia Ip2	5.7013e-002 kg·m²	1.7152e-002 kg·m²	7.1392e-003 kg·m²		1.9773e-006 kg·m²
Moment of Inertia Ip3	5.7747e-002 kg·m²	1.8109e-002 kg·m²	7.0236e-003 kg·m²		3.3931e-005 kg·m²
Statistics					
Nodes	4013	728	2293	2307	622

Elements	1960	90	1072	1083	110



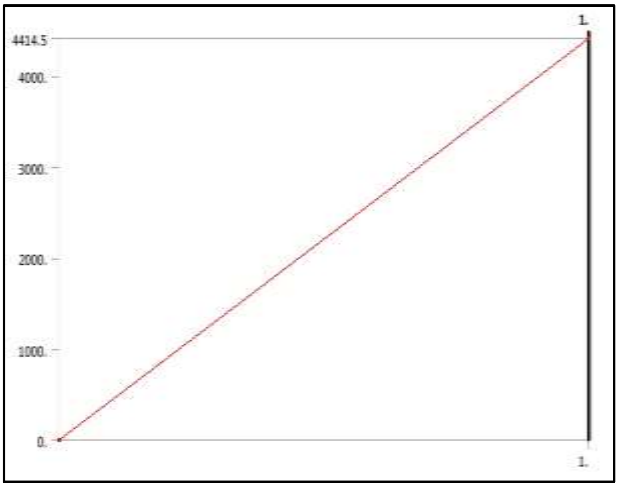


Fig 6: (a) Meshing of Chassis (b) Loading Value

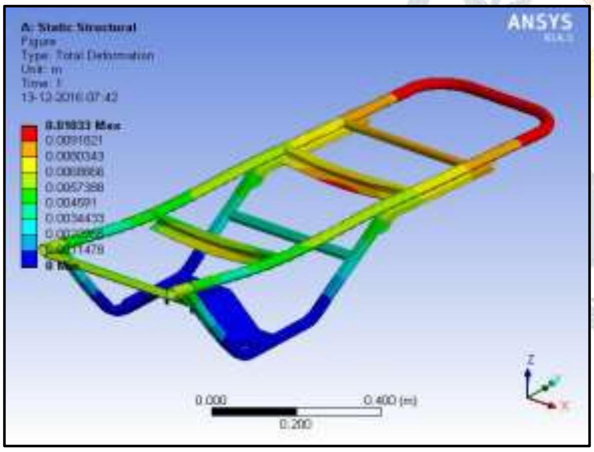
RESULTS OBTAINED

Table 4 Result

Type	Total Deformation	Equivalent (von-Mises) Stress
Minimum	0. m	215.52 Pa
Maximum	1.033e-002 m	9.5434e+008 Pa

DEFORMATION IN CHASSIS

- AFTER APPLYING LOAD, THE VALUES OBTAIED FOR DEFORMATION IS VERY LESS.



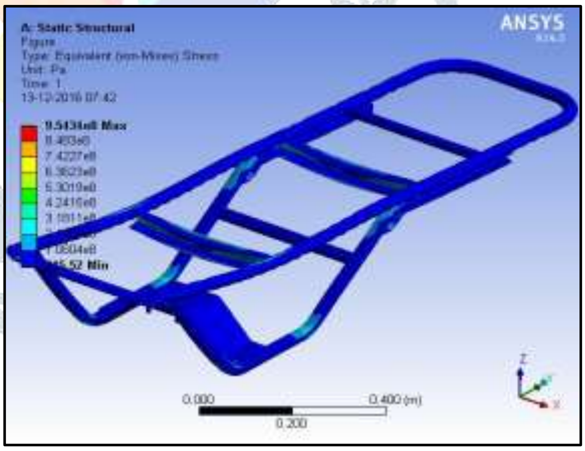


Fig 7 (a) : Total Deformations in Chassis (b) Stress Produced at different points

CHASSIS ANALYSIS FOR Mild Steel

Static Structural (A5)

Table 5 Mass Properties of Mild Steel

Density	**7200 kg m^-3**
Thermal Expansion Coefficient	1.1e-005 C^-1
Specific Heat	447 J kg^-1 C^-1
Thermal Conductivity	52 W m^-1 C^-1
Resistivity	9.6e-008 ohm m

Fig: 8 (a) Total Deformation in Chassis (b) Stress Produced

CHASSIS ANALYSIS FOR ALUMINUM ALLOY

Table 6 Mass Properties of Aluminum Alloy

Density	**2770 kg m^-3**
Thermal Expansion Coefficient	2.3e-005 C^-1
Specific Heat	875 J kg^-1 C^-1

For aluminum alloy

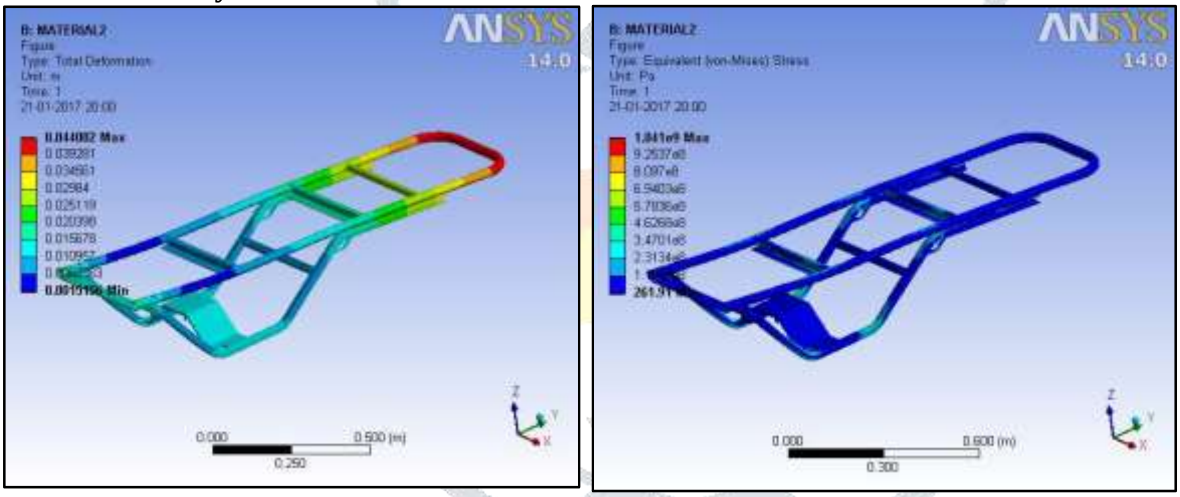


Fig: 9 (a) Total Deformation of Chassis (b) Stress Produced

CHASSIS ANALYSIS *Titanium Alloy*

Table 7 Mass Properties of Titanium Alloy

Density	**4620 kg m^-3**
Thermal Expansion Coefficient	9.4e-006 C^-1
Specific Heat	522 J kg^-1 C^-1
Thermal Conductivity	21.9 W m^-1 C^-1
Resistivity	1.7e-006 ohm m

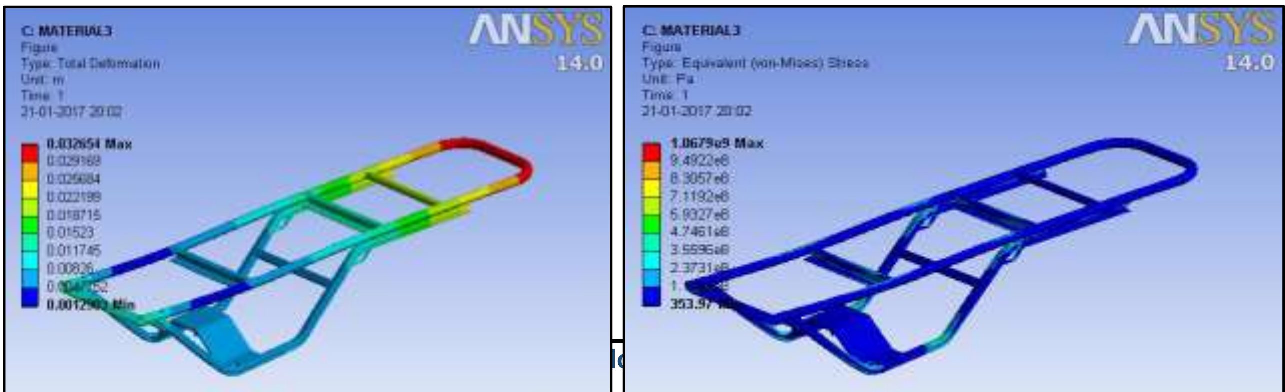


Fig: 10 (a) Total Deformation in Chassis (b) Stress Produced

CONCLUSION:

In this present work, computer aided modelling, design and static structural analysis of hand truck chassis was carried out by utilizing finite element method. Finite element methods with the help of ANSYS stand apart as the most precise and broadly utilized techniques.

Based on the analysis following conclusion can be done.

1) The produced Von-mises stresses are smaller than allowable value; therefore design is safe for all four materials.

2) Von mises stress was discovered least in aluminum alloy and most extreme in titanium alloy under provided boundary conditions.

3) Shear stress was discovered least in aluminium alloy and most extreme in mild steel under given boundary conditions.

4) The analysis provides most extreme equivalent stress and total deformation which are in the desired limit.

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