STRAIGHT KICKER

Straight kicker consists of solenoid and plunger. Plunger is the one that hits the ball.

Solenoid:

The frame of solenoid is made of 6061-Aluminium alloy and is cylindrical in shape with an inner diameter of 11.4mm and an outer diameter of12.5mm. Its length is 44mm and thickness is 0.55mm. The wires wound around it are 24 AWG wires and the number of turns is approximately 400. We assume that a constant current of 40 A flows in it throughout its application time.

Plunger:

Straight kicker consists of a custom made plunger with magnetic material (pure iron) in the middle and aluminium upon the remaining length. The length of the iron part is 45mm.The diameter of plunger is 11mm.

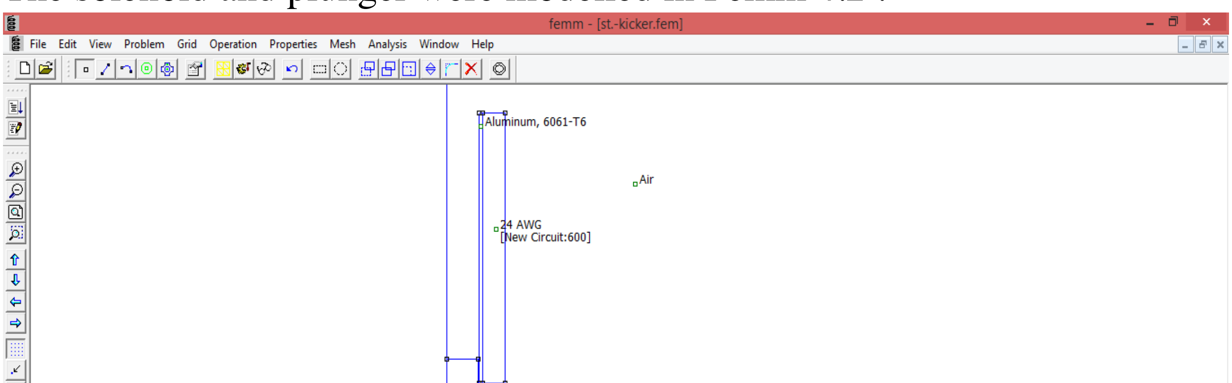
The Dynamic Analysis of a solenoid which when fed by constant current was done using MATLAB 2013a, FEMM 4.2 and ADAMS software's.

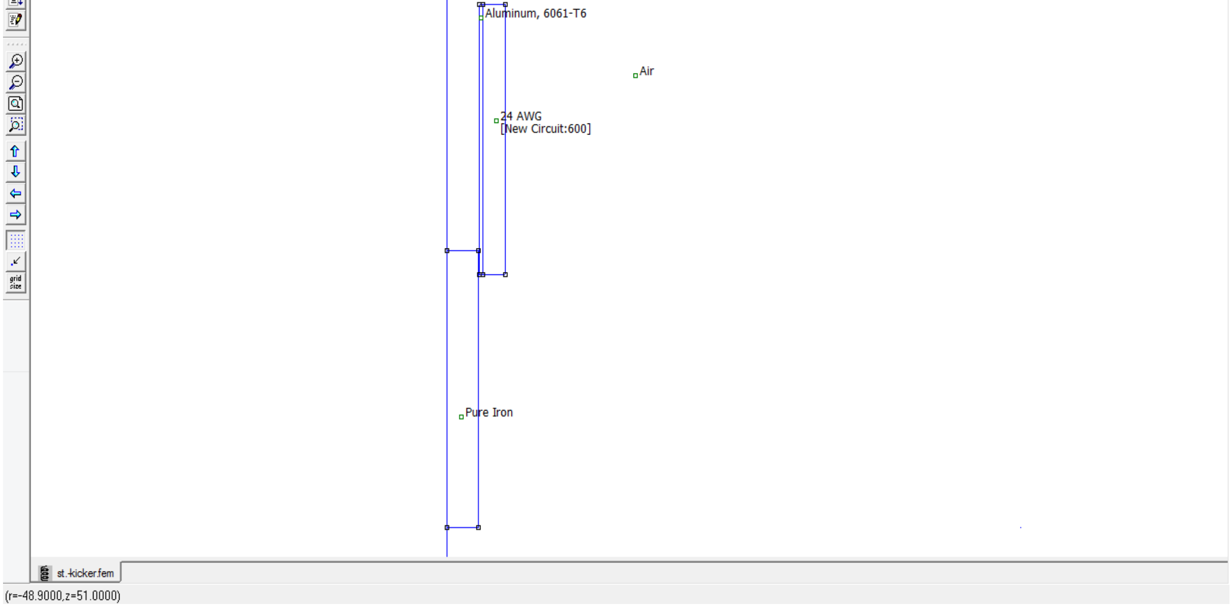
Approach:

Using FEMM 4.2 software we created the image initial position of plunger in the solenoid across the two cross sections. Then using a code in MATLAB the plunger was made to move a little distance (about 1 mm) into the solenoid in each iteration. In each iteration the force was calculated in the plunger and stored in an array f while its distance from its initial position was stored in x. The iterations were carried on till the plunger reached its final position (here after 40 iterations). The force was calculated in each iteration. Finally the plot of force vs distance was generated. The area of the enclosed in the graph gave us the energy supplied by the solenoid to the plunger.

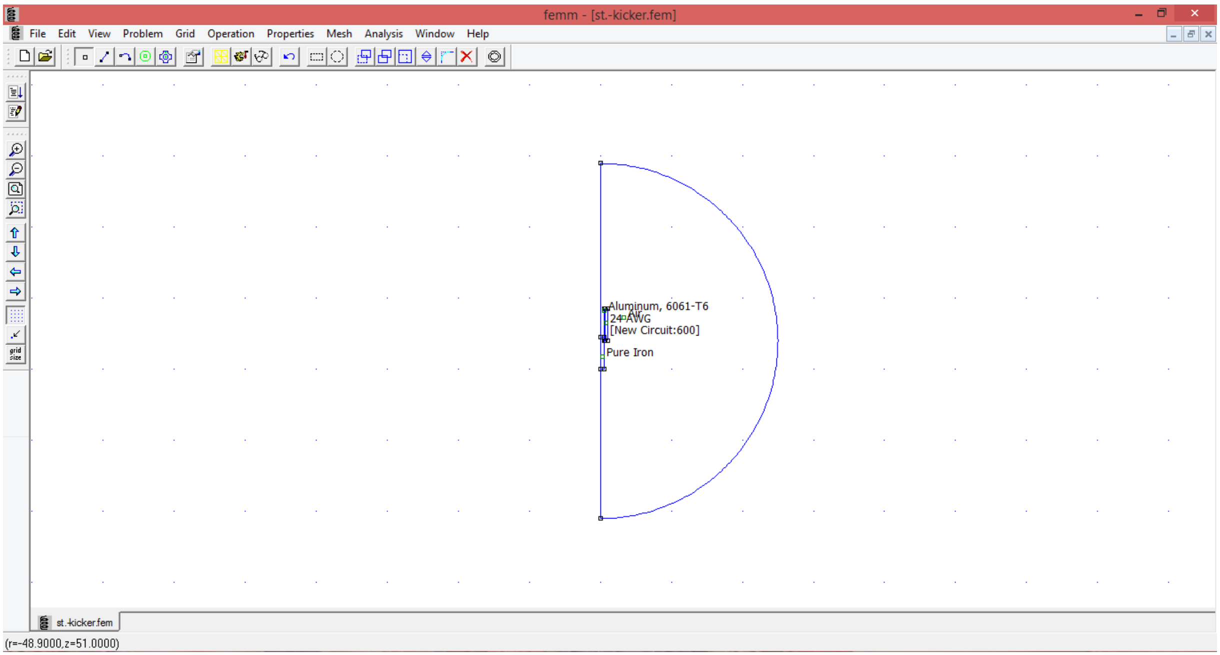
Analysis:

The solenoid and plunger were modelled in Femm 4.2 .





The boundary in FEMM simulation is kept sufficiently large in comparison with the solenoid dimensions (here a semi-circle of 210 mm radius).



The following Matlab code was used to generate the graph force vs. displacement of the plunger.

```
openfemm

opendocument('st.-kicker.fem');
mi_saveas('temp.fem');
n=40;
y=zeros(n,1);
f=zeros(n,1);

for k=1:n
    disp(sprintf('iteration %i of %i',k,n));
    mi_analyze;
    mi_loadsolution;
    mo_groupselectblock(1);
    y(k)=(k-1);
    f(k)= mo_blockintegral(19);
    disp(sprintf('  force = %f',f(k)));
```

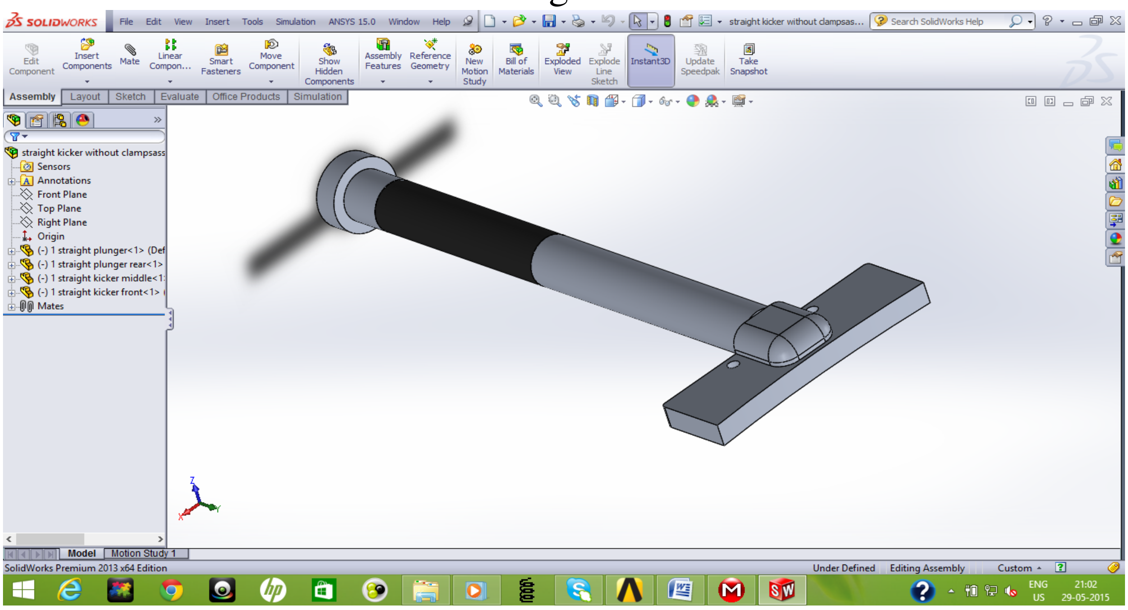
```
    mi_analyze;
    mi_loadsolution;
    mo_groupselectblock(1);
    y(k)=(k-1);
    f(k)= mo_blockintegral(19);
    disp(sprintf('  force = %f',f(k)));
    mi_modifycircprop('New Circuit',1,40);
    mi_selectgroup(1);
    mi_movetranslate(0,1);
    mi_clearselected;
end

plot(y,f)
xlabel('Displacement, mm');
ylabel('Force, N');
title('Plunger Force vs. Displacement');
a = trapz(y,f);

disp(sprintf('Area = %f',a));
closefemm
```

The following graph is generated. The area is calculated by trapz () function which uses trapezoidal method to find the area under the curve. The graph gives us relation between force and displacement of plunger.

Static Structural Analysis of straight kicker

We used ADAMS software to estimate the force while the static structural analysis as done using ANSYS software. Initially a solid works model was created of the straight kicker. The material used was aluminum alloy and cast iron. This model was then used in ADAMS and ANSYS.

The solid works model of the straight kicker :



Estimation of maximum Force on straight kicker:

For the estimation of the maximum force on the kicker during the collision with the ball, ADAMS simulation was used. We got the maximum deceleration of the front part of the kicker and multiplying it with the mass of kicker we got the required force.

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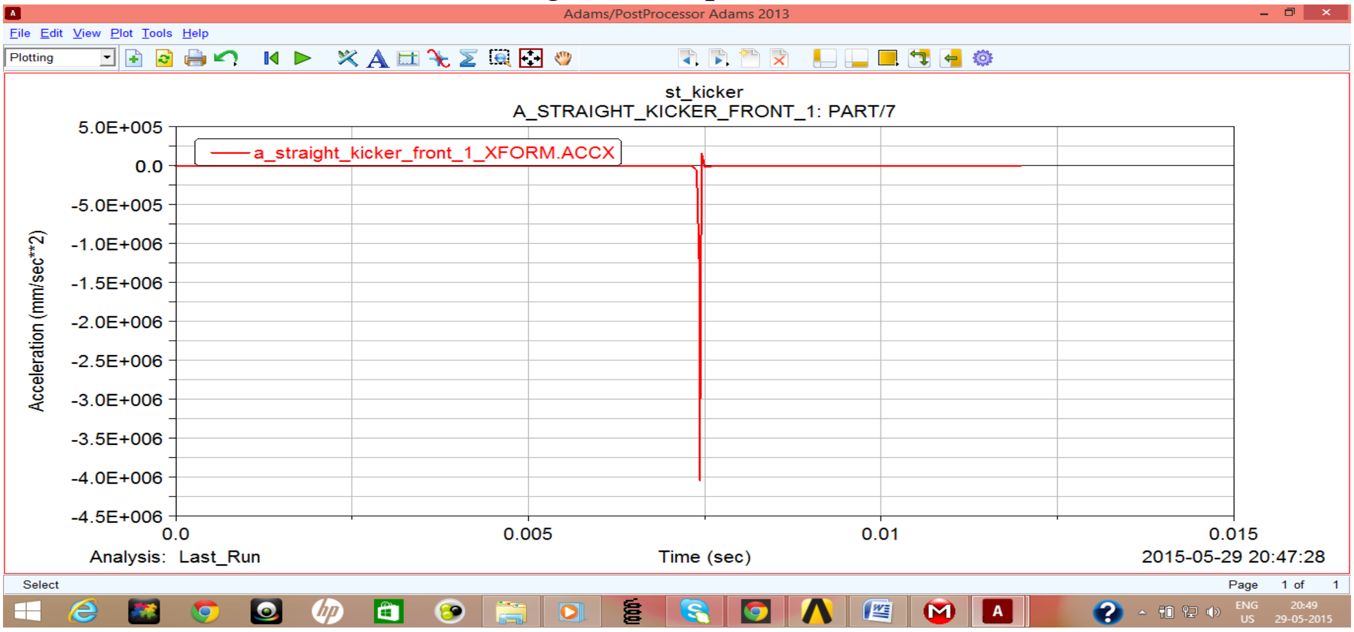


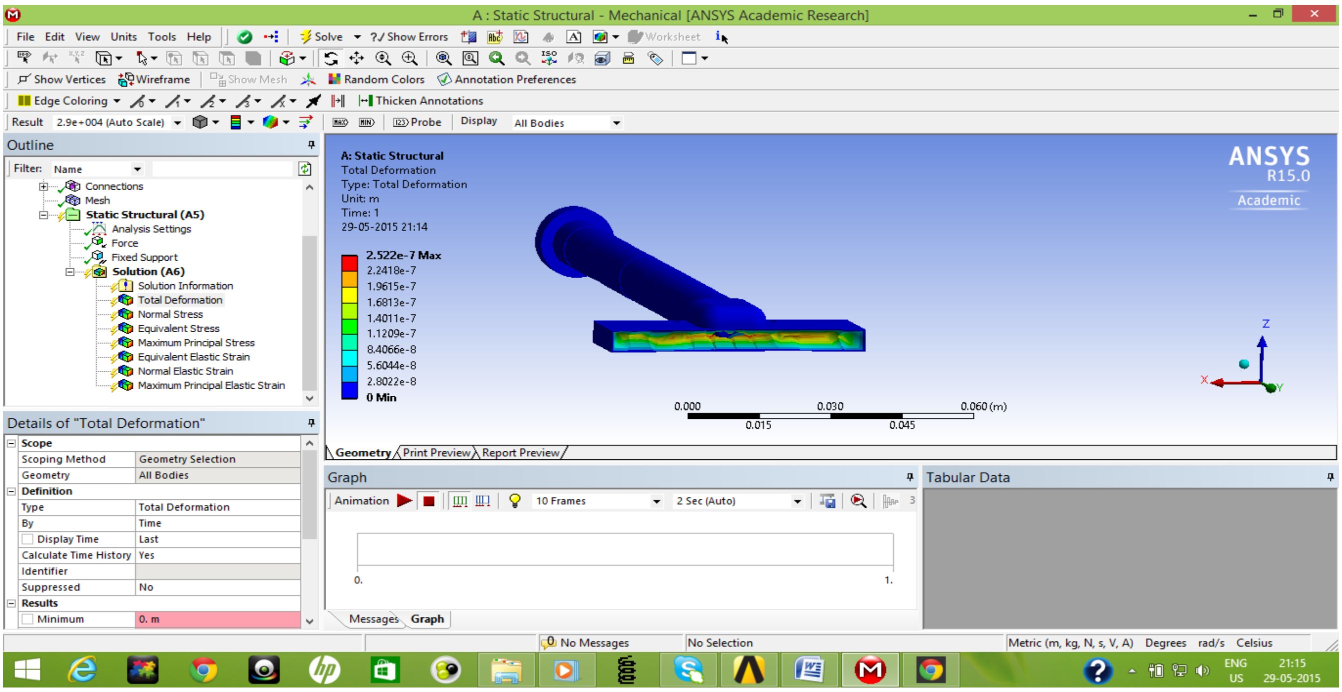
Maximum deceleration = 4.1×10^6 ms^{-2} (approx)

Mass of the kicker = 64.35 gm

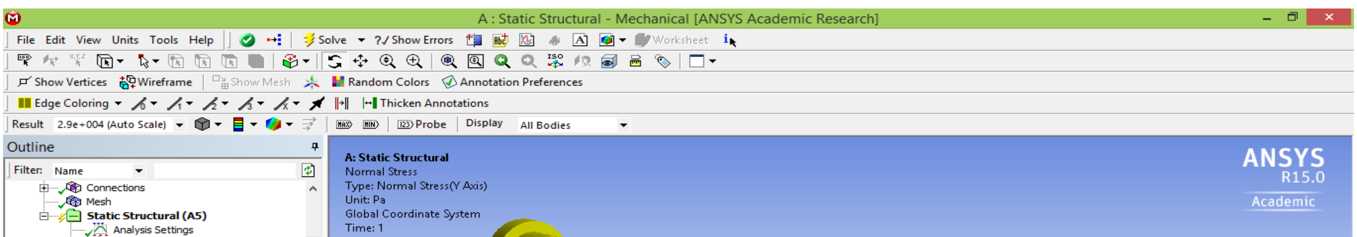
Maximum force = 263835 N

Analysis using ANSYS: In the analysis we are looking at the worst possible case. So we assumed that the entire force is acting on the front face of the kicker while all the side faces are acting as fixed supports. The results of the analysis are as follows:

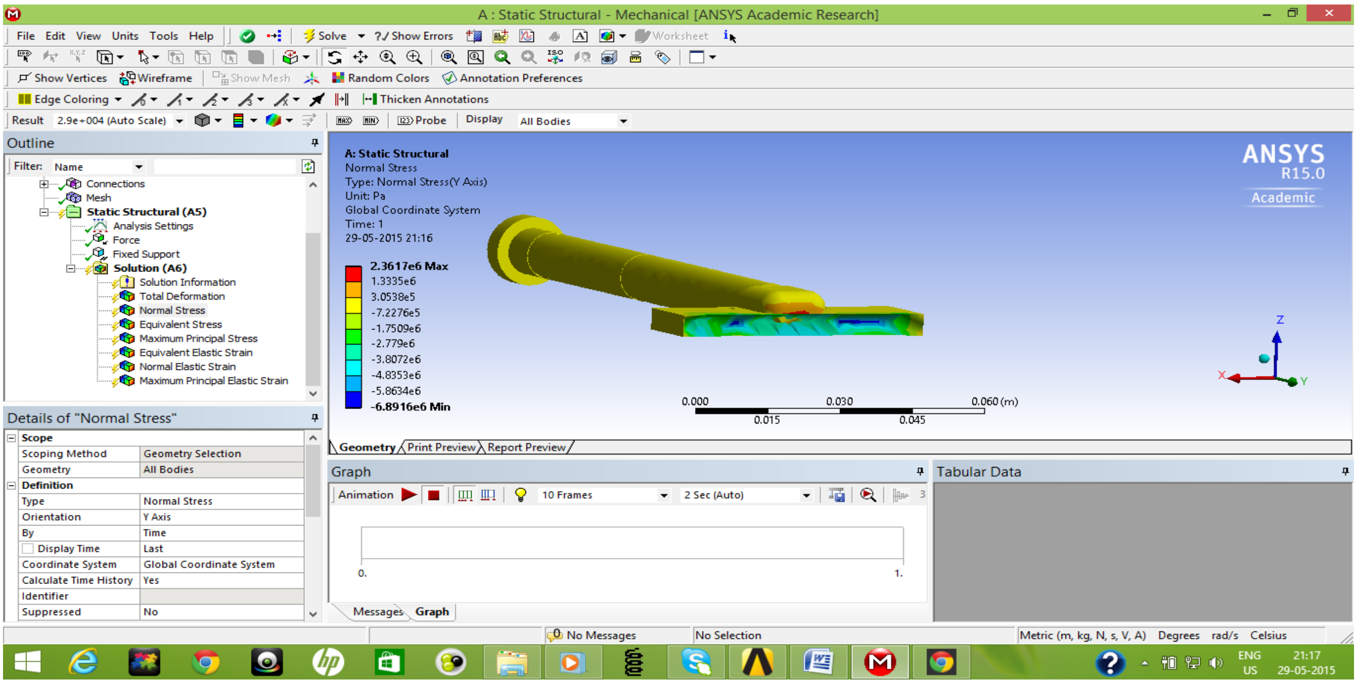
Total deformation :



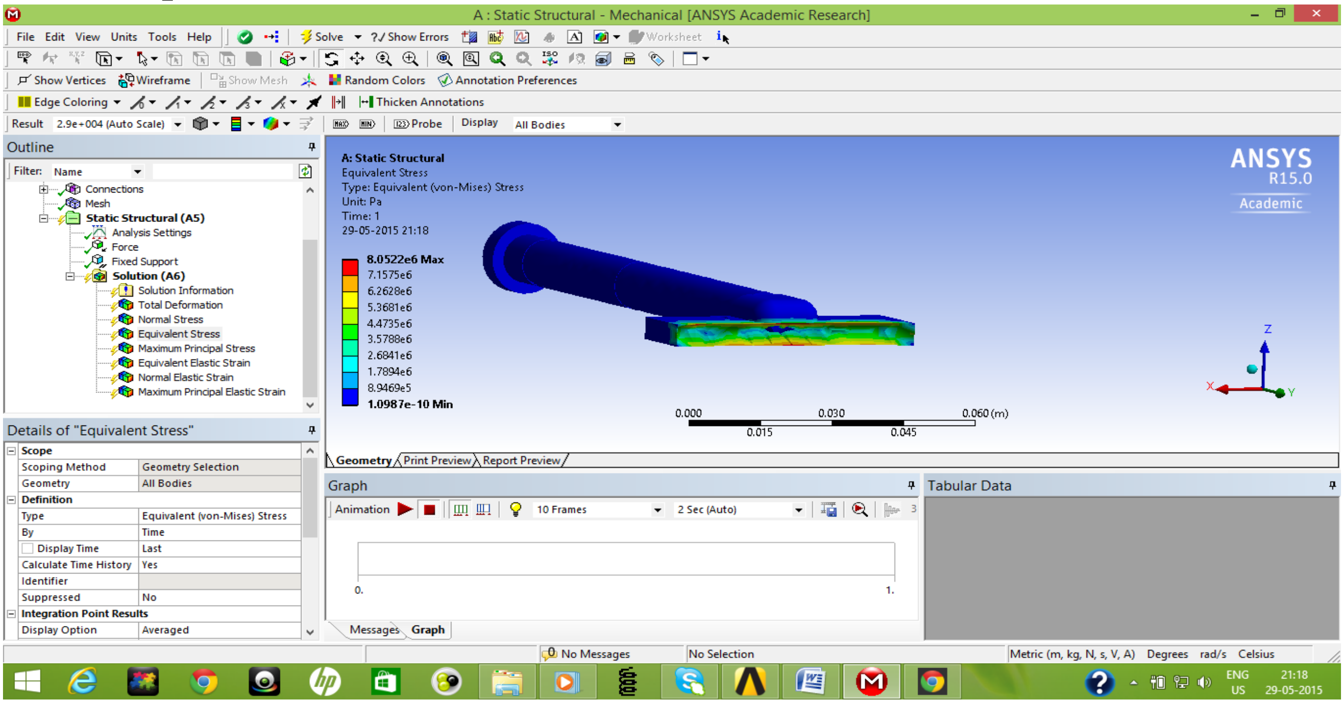
Normal Stress :



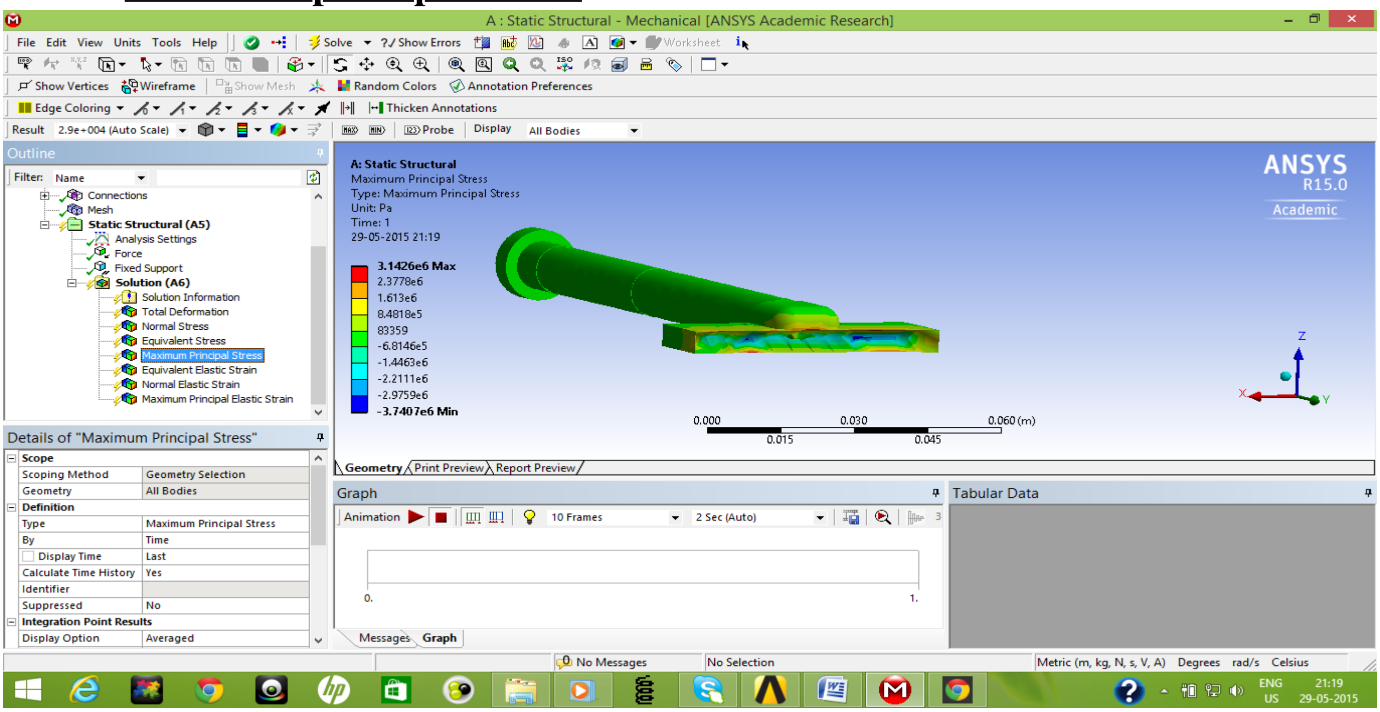
Normal Stress :

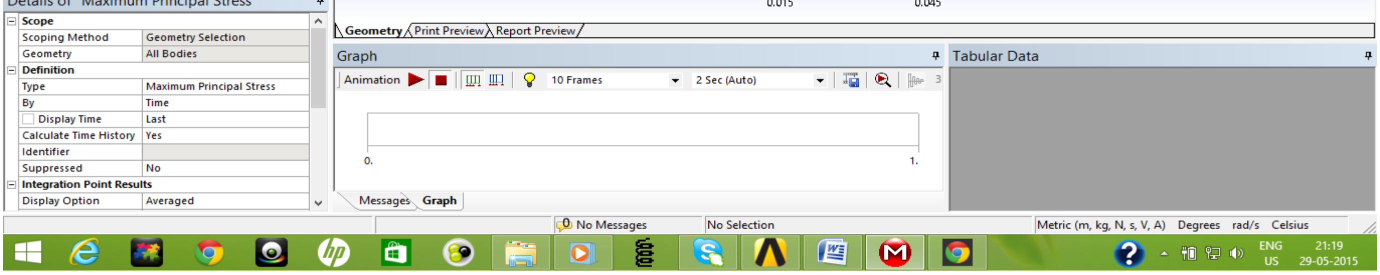


Equivalent stress :

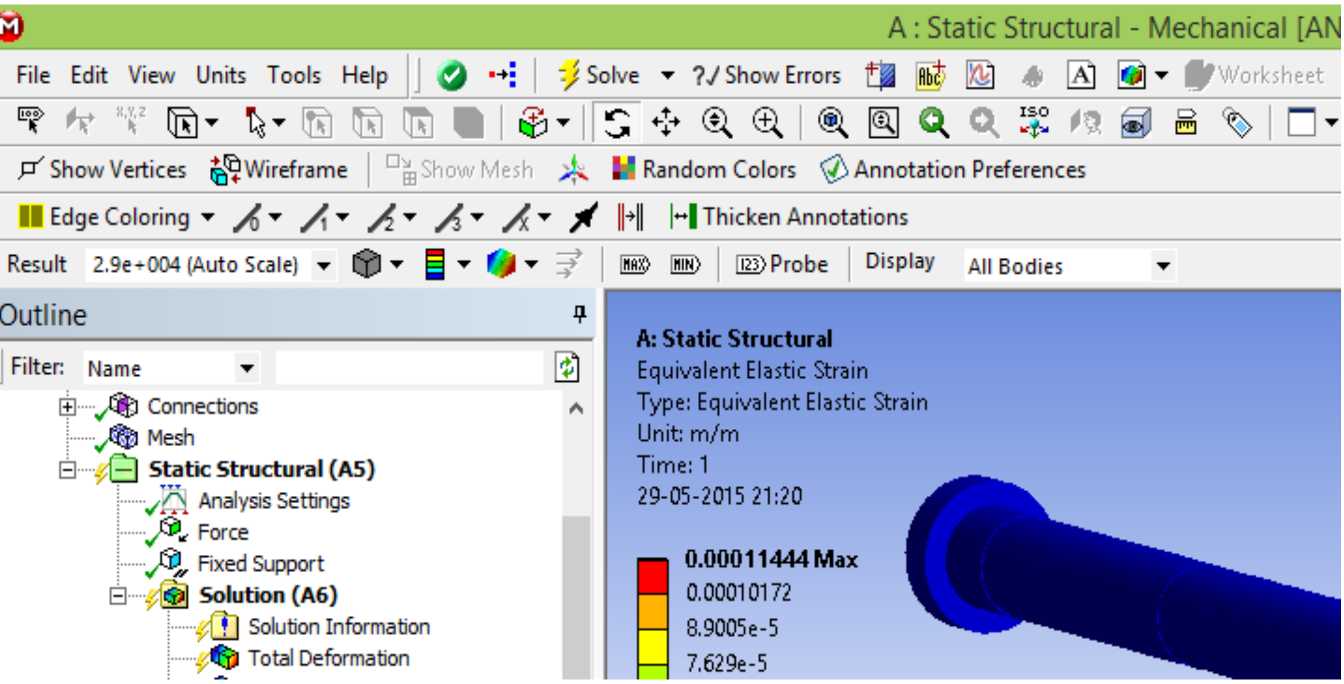


Maximum principle stress:

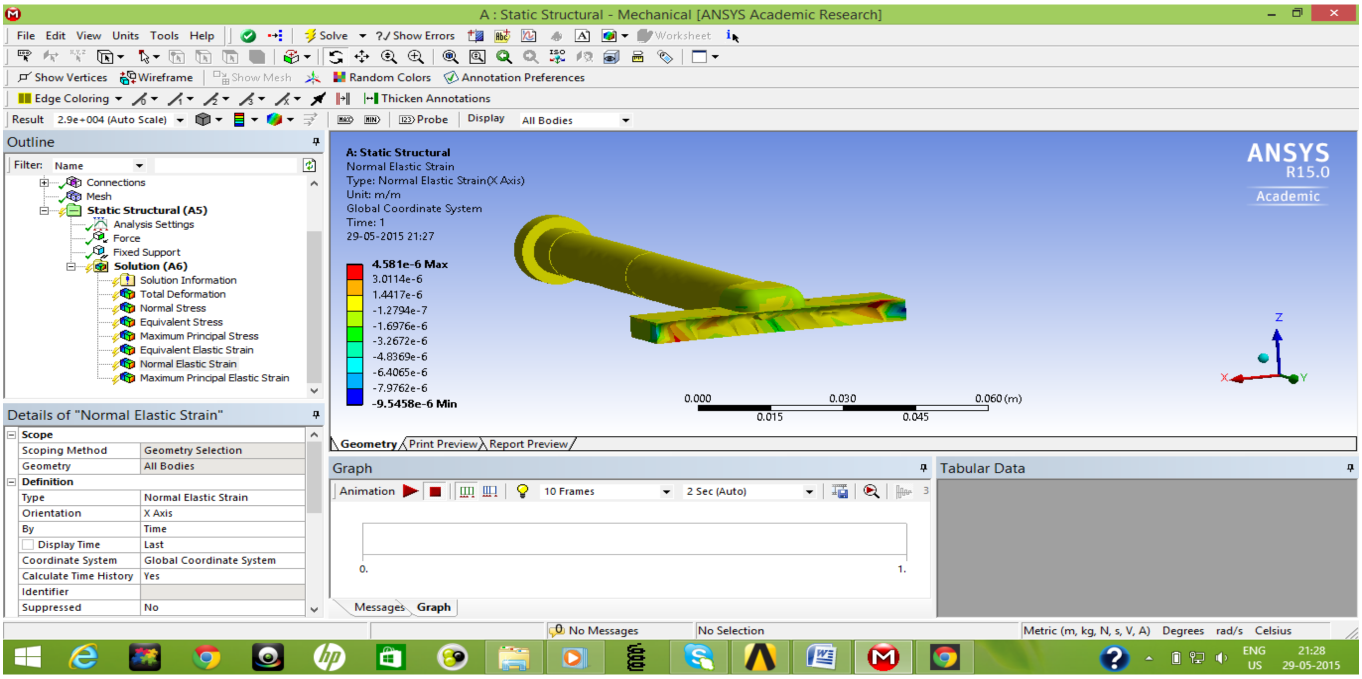




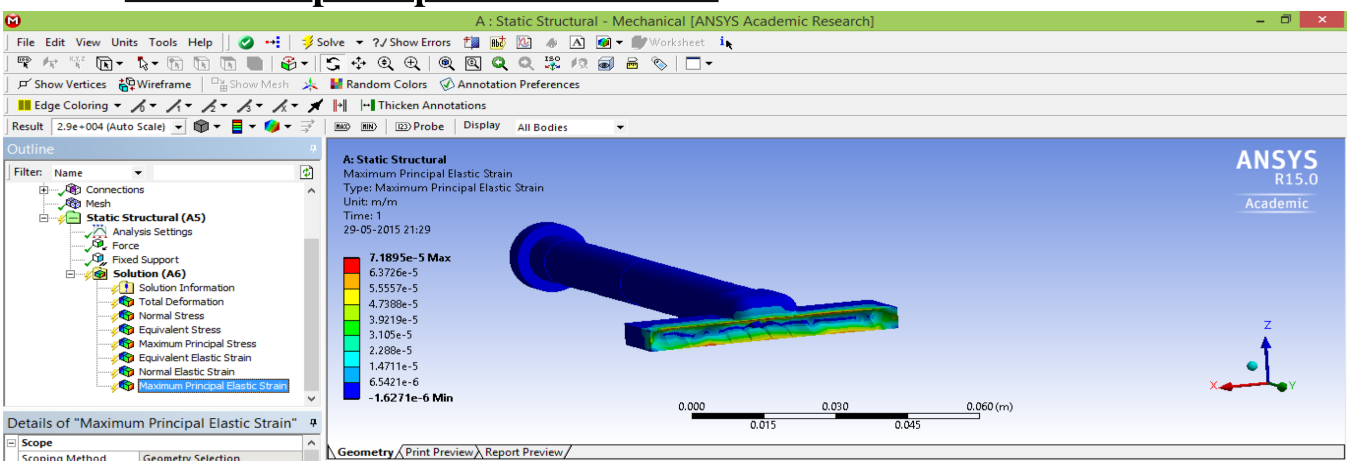
Equivalent Elastic Strain:

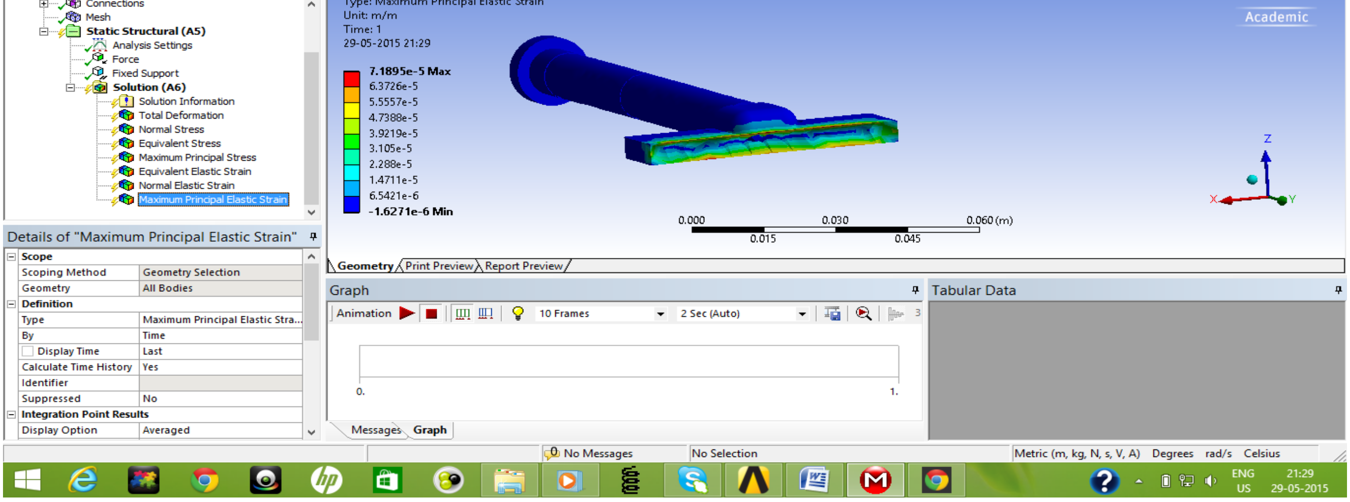


Normal Elastic Strain :

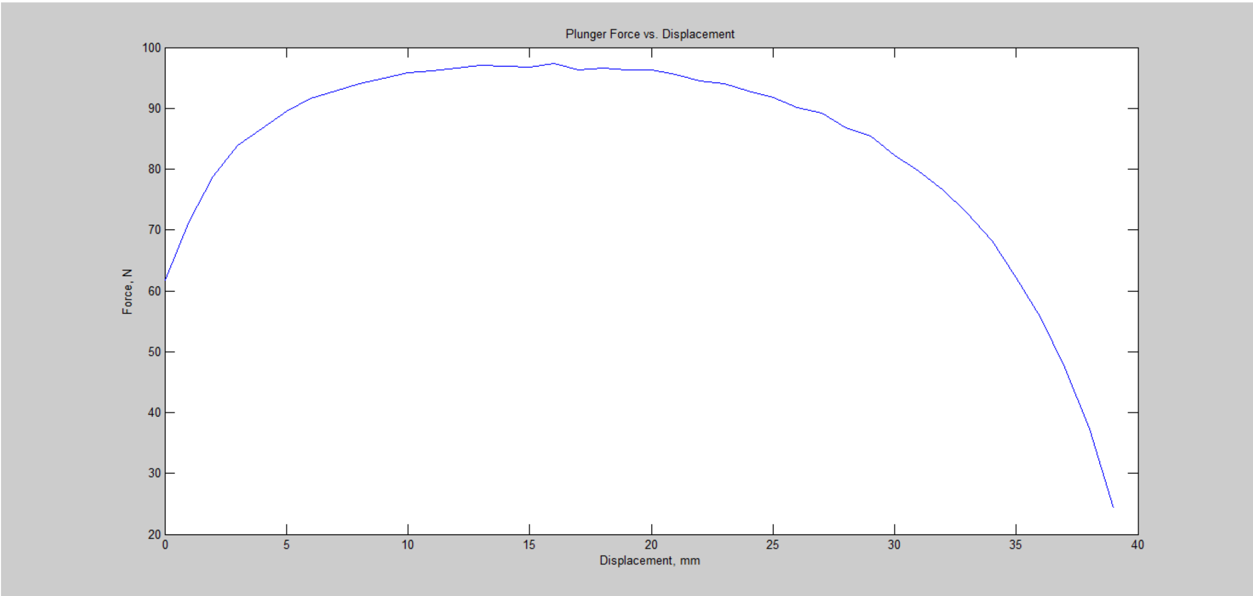


Maximum principle Elastic Strain:





Conclusion : As expected the front portion of the kicker bears the brunt of the collision.



The area enclosed by the graph = 3290.940units
Thus Energy = 3.290 Joules (approx.).
The approx. polynomial of this function is:

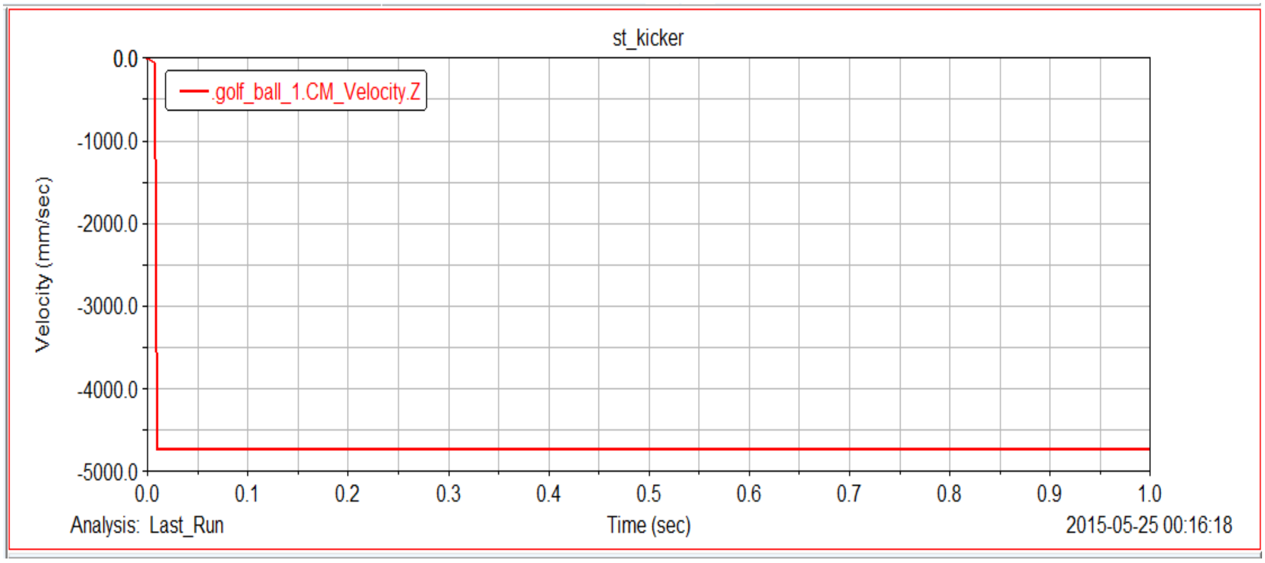
y = p1*x^10 + p2*x^9 +
p3*x^8 + p4*x^7 +
p5*x^6 + p6*x^5 +
p7*x^4 + p8*x^3 +
p9*x^2 + p10*x +
p11

Coefficients:
p1 = -2.676e-12
p2 = 5.7409e-10
p3 = -5.3736e-08
p4 = 2.87e-06
p5 = -9.6523e-05
p6 = 0.0021383
p7 = -0.031974
p8 = 0.32827
p9 = -2.372
p10 = -12.159

p4 = 2.87e-06
p5 = -9.6523e-05
p6 = 0.0021383
p7 = -0.031974
p8 = 0.32827
p9 = -2.372
p10 = 12.159
p11 = 61.585

Later, the polynomial function was feeded in Adams-View software and simulation was done by applying force as obtained in matlab on the plunger.

The graph of speed of ball is :-



The simulation gave a speed of ball is about 5m/s.