Dynamic Analysis Of Passive Inclined Disc Opener

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ABSTRACT

Inclined disc opener are used in order to open the soil in a farm during the seed sowing operation. Disc openers are used where uniform seed depth is required. It is also observe that draft force required for furrow opening is also reduced as compared to conventional type of furrow opener. Disc is continuously runs in a soil and when it is stop it takes a load of frame. During turning of tractor it takes a maximum load upto 150 Kgs with some depth. Since the disc is running in a soil with a tractor speed of 3.5 – 4 km/hr. The dynamic analysis is carried out by taking into consideration that the disc is rotating at a speed of 3000 mm/sec and it hits on the rigid body or stone for a short period of time of 5 e -3 second. In this paper analysis of disc is carried out by using an ANSYS software. The analysis is based upon some fixed design consideration such as design parameters diameter of disc, thickness of disc, construction, etc. When disc hits on rigid body for a short period of time it deforms and carries different types of stresses. Thus calculation of these stresses is very important for the safe design of disc, hence analysis has been carried out for same in this research paper. Disc opener also helps in minimum soil opening in order to conserve the moisture in the soil thus it helps in to increase the germination rate of seed.Tetrahedral meshing is used for the analysis of disc in order to achieve finest results.

Keyword : - *Dynamic, draft force, meshing, germination, principal stresses, etc.*

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1. INTRODUCTION

Disc plays an important role in opening a furrow. It takes a different types of load during its operation. During the sowing process in agriculture field it is observe that the seed depth is non uniform. Result of which there is non uniform growth of plants. It may possible that one of the plant contains 100 numbers of fruits and second should have only 50 numbers of fruits. During the harvesting process this uneven growth of plants as well as uneven fruits of plants does not take into consideration. Thus result of which there is reduction in overall crop yield of farmer. It may possible that this uneven growth of plant is due to the germination of seed, quality of seed, etc. The one of the reason for this non uniform growth of plants is use of conventional type of tines. The Self Suspended Dispensing Coulter comprises consist of two disc which are inclined to each other and are symmetrically fitted. The function of these two disc is to open the furrow at required width in order to dispense the seed and fertilizer. The compression spring is used to give the load on the disc. Two passive double inclined disc are used for covering of seed and fertilizer in order to retain moisture in soil and increases the germination rate. It is also provided with `spring load for uniform covering of seed. The slight pressure on the seed results in firm contact of soil molecules with the seed which increases the germination rate as well as fast initial growth of plant. The draft force required for tractor is comparatively reduced as compared to the conventional type of tine and hence required tractor power is also reduced. Agricultural conservation systems are growing fastly in the world as well as India. Success of using and extending conservation tillage systems in particular, is depended on the performance of direct drilling machines. The suitable machine has to place seed in a proper depth at different field conditions including not plowing, high residue contents and sticky. Moreover the performance of such machine in those conditions is affected by its furrow openers. In this research different furrow openers including common double disc types were investigated with the goal of increasing performance of planting machines in the conservation systems. The treatments were : 1. Double disc type both with angles 2. Double disc type one vertical and one with angle. Double disc coulter type openers usually consist of two plain, flat disc coulters arranged so that the lower leading edges of the discs touch to cut and displace soil. As the discs roll forward, they cut residue and soil, and displace soil downwards and outwards to form a 'V'-shaped furrow. The seed delivery tube is fully enclosed by the discs and enables seed to be deposited into the furrow at a position slightly ahead of the point where the trailing edges of the discs leave the soil. In such s way disc have its vital role in opening the furrow and it work as one of the main component of sowing system. In dynamic analysis total deformation, von misses stress, maximum principal stress, maximum shear stress, equivalent elastic strain, maximum principal elastic strain, maximum shear elastic strain is carried out.

1.1 Disc furrow opener

Disc coulters have different parameters that will affect their performance and also their interaction with soil. Disc diameter, disc thickness, edge angle, disc angle, tilt angle and also depth of the cut are the parameters that can change the forces acting on the disc when cutting through the soil. Edge angle is the slope of the edge of the disc that defines its sharpness. Although it seems to be a negligible parameter among other parameters of the soil, it plays an important role in residue cutting ability of the disc. Also it can change the draft force required to pull the disc. Disc angle is the angle of rotation of the disc around vertical axis. It is the angle that horizontal axis of the disc makes with the direction of motion.

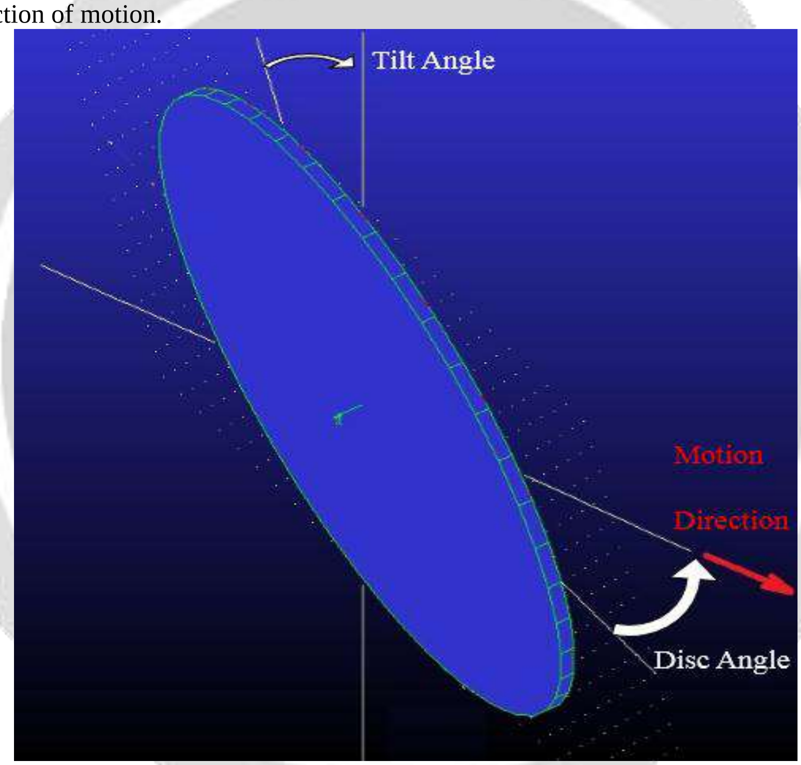

Fig. 1 : Schematic diagram of a disc coulter, showing disc angle (ɣ) and tilt angle (β)

And the tilt angle is the angle of the disc with the vertical plane, or the angle created by rotation of the disc around disc's horizontal axis. Having a disc angle of greater than zero, in a planter that uses disc coulter, is inevitable. Because the disc should open a furrow, wide enough that a seed can fit. But the tilt angle is optional. We call it a compound angle when a disc coulter is orientated using both disc and tilt angles. The effect of these angles and their combination had to be studied, to find the best combination that result in minimum draft force (the horizontal reaction force to the disc motion). Starting with the soil engagement tool, double discs with compound angle and installed at a staggered position. The disc angle and tilt angles of these discs are $\gamma=5^{\circ}$ and $\beta=7^{\circ}$, respectively. Diameter of disc selected as D= 305 mm.

2. DYNAMIC ANALYSIS OF DISC

Furrow opener disc is running in a soil continuously, hence it is necessary that the dynamic analysis of disc to be carry out. The dynamic analysis is based on the concept that when disc is running in a farm and a obstacle is come which is a rigid at that time the effect on disc is analyze. Fig. 2 shows the model imported from the catia.

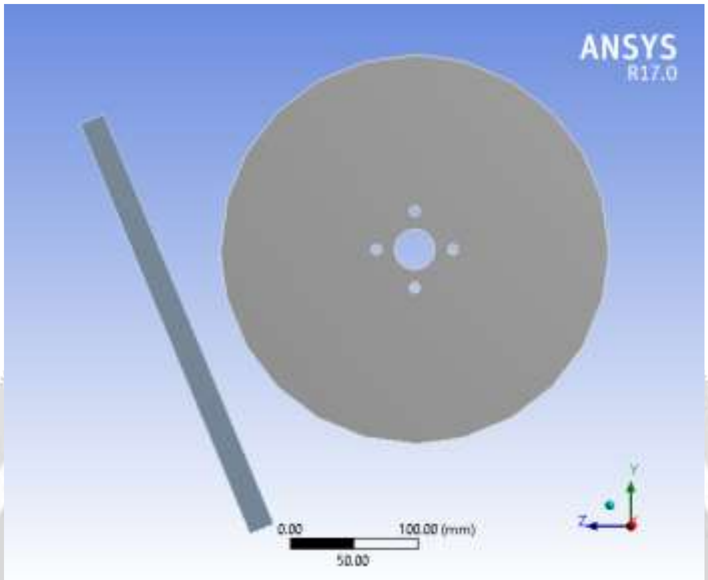

Fig. 2 : Ansys model for dynamic analysis

Meshing is one of the important part in dynamic analysis. Tetrahedal meshing is done for dynamic analysis of furrow opening disc and hexahedral meshing is done for a rigid component i.e. for obstacle. The nodes and elements in the meshing are 4937 numbers and 9015 numbers respectively.

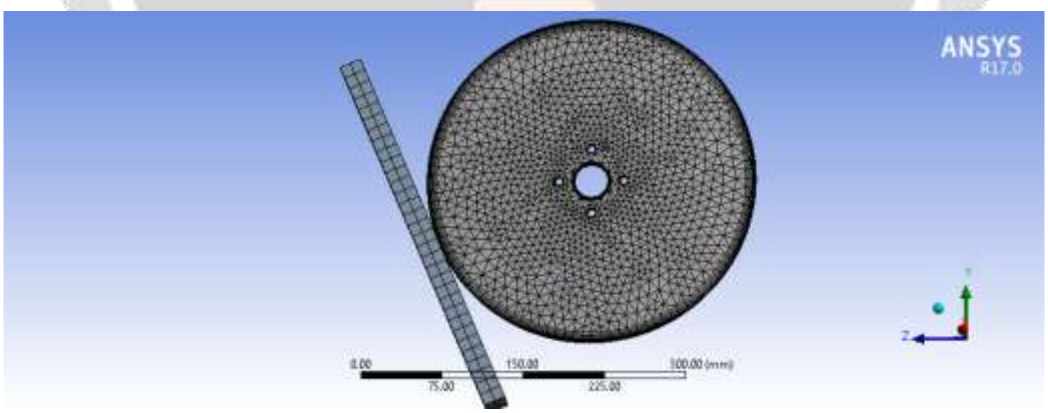

Fig. 3 : Meshing of disc and obstacle element

The maximum velocity of the disc is consider as 3000 mm / s. Since during the operation of disc for a very short period of time it obstacles with the rigid element. Fig. 4 shows the model of explicit dynamic initial condition of velocity.

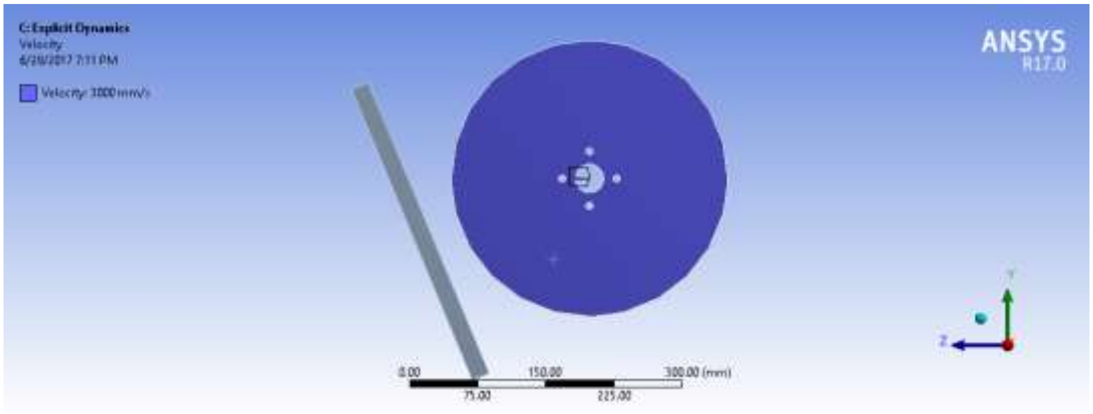

Fig. 4 : Explicit dynamic initial condition of velocity

Since the disc is running continuously in the field and it passes a obstacle for a very short period of time. This short period of time is taken as 5 e -003. Fig. 5 shows the explicit dynamics of for a short period of time. For this short period of time there will be no effect on the rigid component.

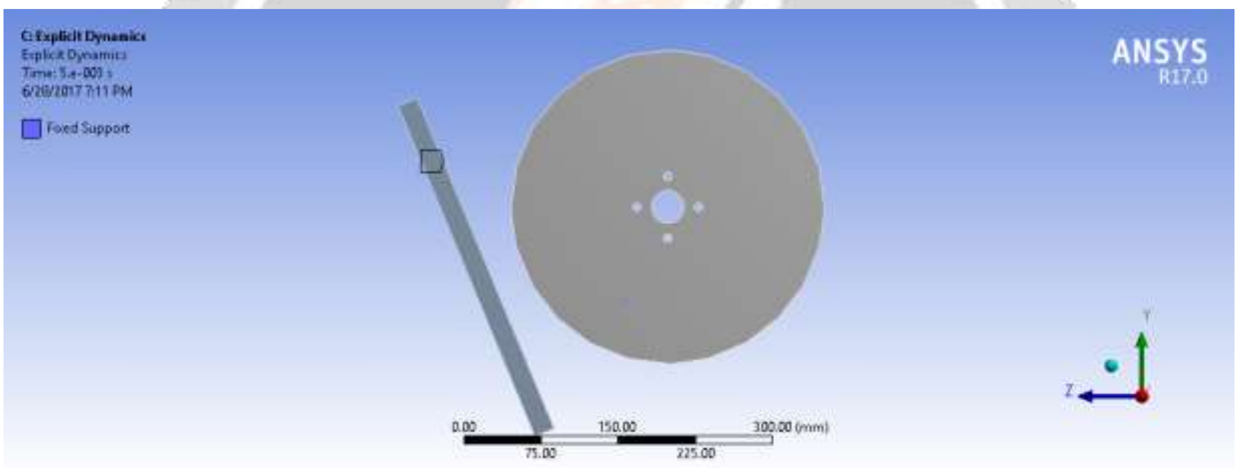

Fig. 5 : Ansys model showing time of obstacle

Disc is having a velocity of 3000 mm/s and it obstacles for a short period of time. For this short period of time the disc deforms which is shown in fig.6 for maximum value of 14.093 mm.

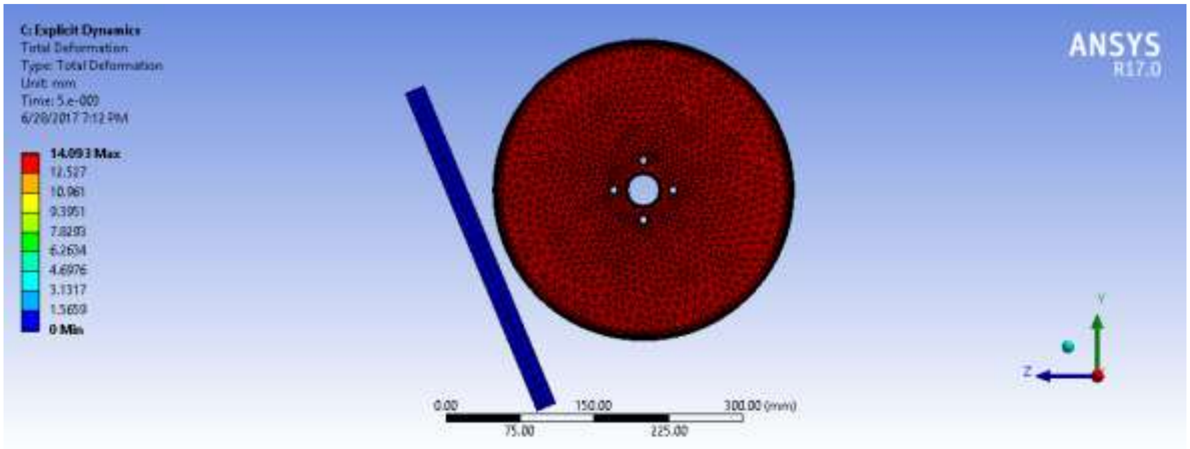

Fig. 6 : Total deformation of disc

Fig. 7 shows the total velocity of disc and the velocity effect on the meshing part. It is observed that effect is more pronounce at the portion which is deep in the soil whereas effect is not much more at the top surface. Fig. 8 shows the effect of acceleration vs time which is range in between 0 to 5 e-3 seconds.

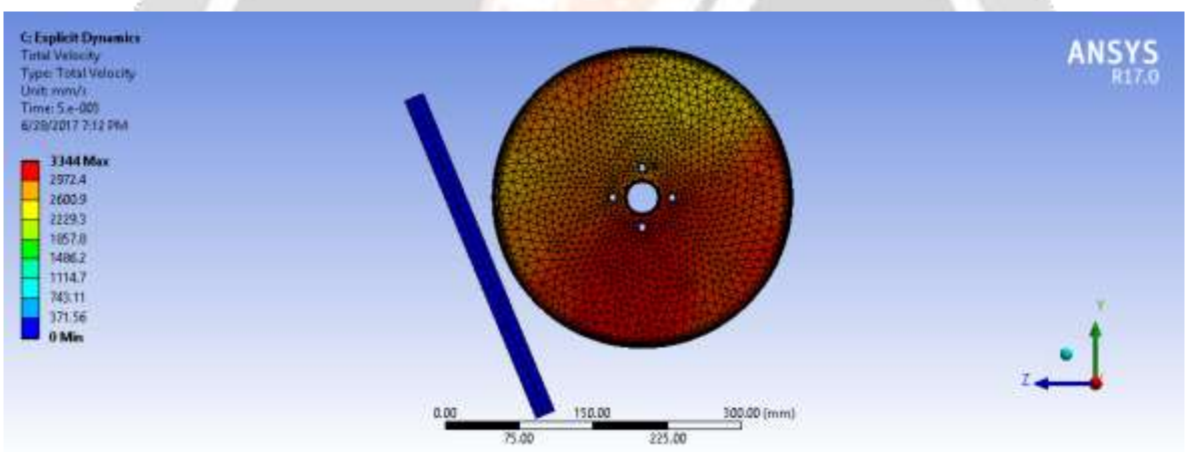

Fig. 7 : Total velocity

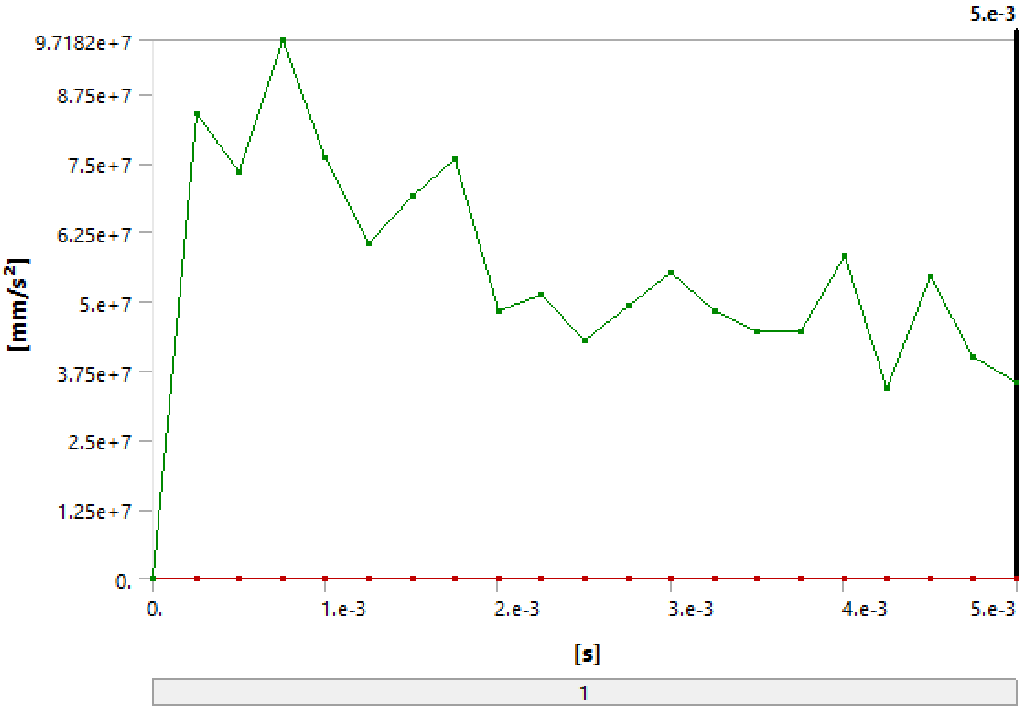

Fig. 8 : Relationship between acceleration and time

In dynamic analysis of disc it is necessary that to calculate the stresses coming on the disc when it is running in a soil. Fig.9 shows the graphical representation of equivalent stress vs time, for a nano second the equivalent stress becomes too much high and it is then stabilize for maximum value of 18.76 Mpa. Below table 1 shows the minimum and maximum values of equivalent stress for specific period of time.

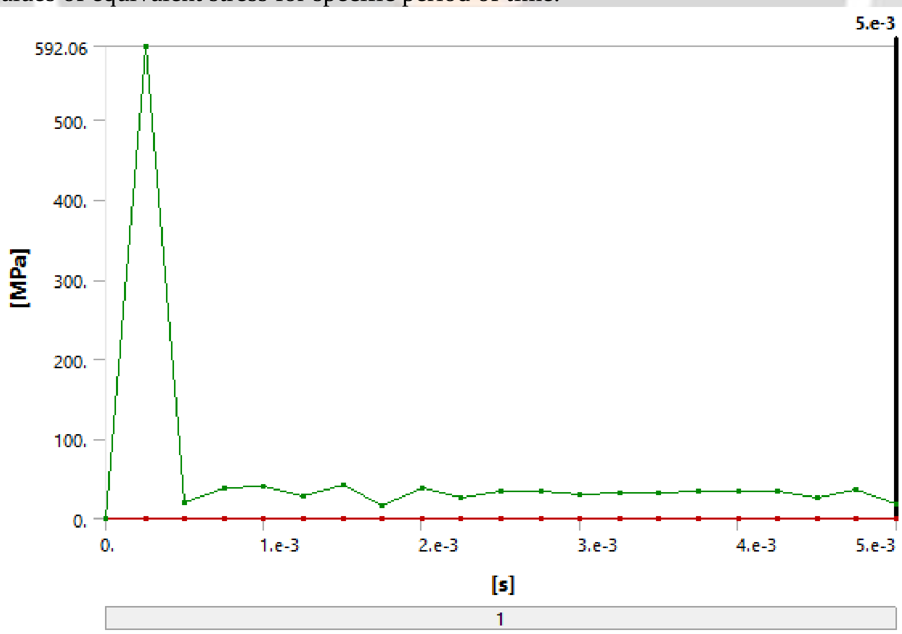

Fig. 9 : Graphical representation of equivalent stress and time

Table 1 : Minimum and maximum values of equivalent stress

Time [s]	Minimum [MPa]	Maximum [MPa]
1.1755e-038	0.	0.
2.5001e-004		592.06
5.0002e-004		21.002
7.5001e-004		37.499
1.e-003		40.172
1.25e-003		28.063
1.5e-003		42.444
1.75e-003		16.055
2.e-003		38.168
2.25e-003		25.972
2.5e-003		34.549
2.75e-003		35.122
3.e-003		30.441
6e-003		32.288
3.5e-003		32.437
3.75e-003		33.39
4.e-003		35.013
4.25e-003		33.652
4.5e-003		25.245
4.75e-003		36.893
5.e-003		18.76

Fig. 10 shows the equivalent stress when the disc is obstacles on a rigid component for a short period of time. It has been seen that stresses are more at the centre portion of disc and are moderate in the middle portion of disc and very less on the edges.

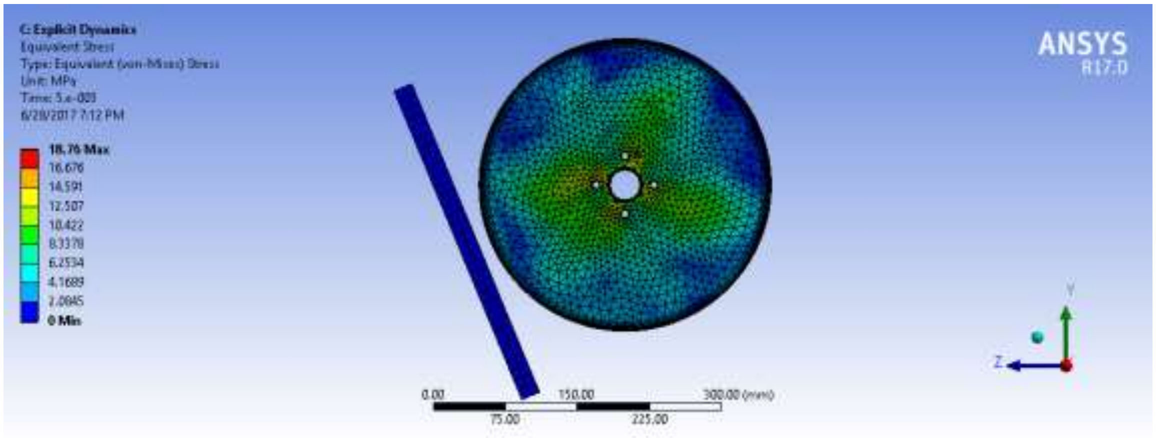

Fig. 10 : Analysis for equivalent stress of disc

Fig. 11 shows the graphical representation of the Maximum Principal Stress. Fig. 11 shows two values of stresses one is maximum and another is minimum. These values are related to the time, thus it has been found that for a very short period of time stress value is very high and then it is reduce since the time is pass.

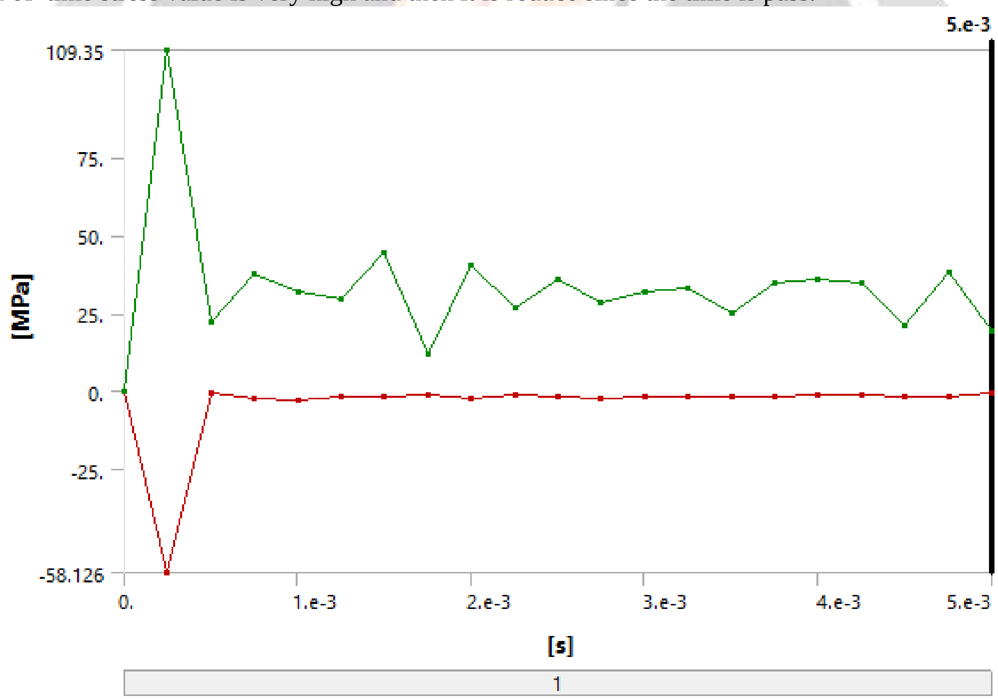

Fig. 11 : Graphical representation of Maximum Principal Stress

Table 2 shows the values of minimum and maximum Principal stress on disc with respect to time.

Table 2 : Minimum and maximum values of Principal Stress

Time [s]	Minimum [MPa]	Maximum [MPa]
1.1755e-038	0.	0.

2.5001e-004	-58.126	109.35
5.0002e-004	-0.6606	21.951
7.5001e-004	-2.4493	37.788
1.e-003	-2.6605	31.974
1.25e-003	-1.6703	29.755
1.5e-003	-1.8494	44.328
1.75e-003	-1.0084	11.98
2.e-003	-2.2963	40.694
2.25e-003	-1.3065	26.526
2.5e-003	-1.9323	36.076
2.75e-003	-2.3471	28.205
3.e-003	-1.7514	31.607
6e-003	-1.7209	33.145
3.5e-003	-1.8406	25.045
3.75e-003	-1.9467	34.964
4.e-003	-1.4429	36.125
4.25e-003	-1.4159	34.526
4.5e-003	-1.7251	21.132
4.75e-003	-1.6615	38.18
5.e-003	-0.86445	19.415

Fig. 12 shows the maximum principal stress on the disc furrow opener. Maximum principal stress observe is 19.415 MPa for a time interval of 5 e-003 seconds.

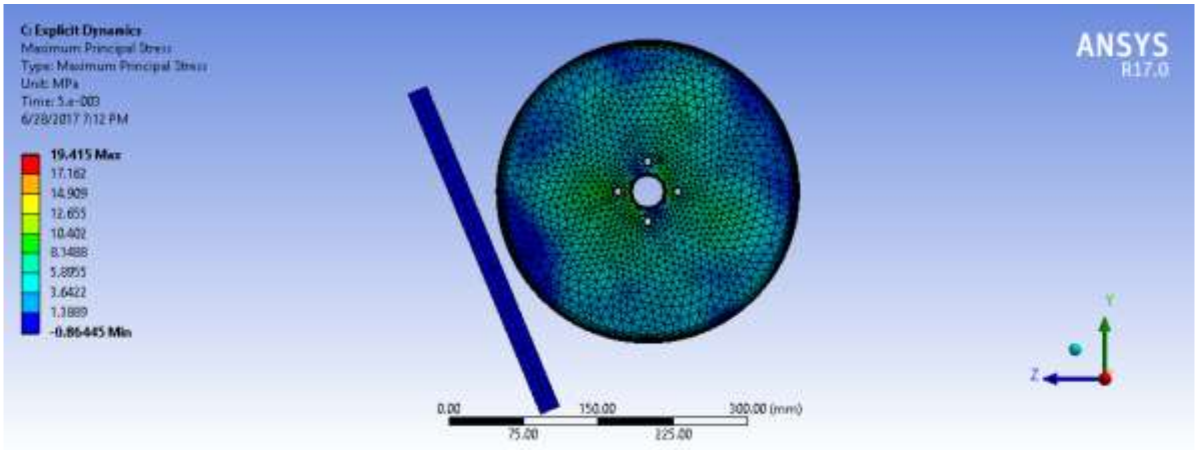

Fig. 12 : Ansys model for Maximum Principal Stress

Fig. 13 shows the maximum shear stress. It has been found that shear stress is maximum for a short period of time and then it is reduced for a time period of 5 e -003 upto 9.98 MPa.

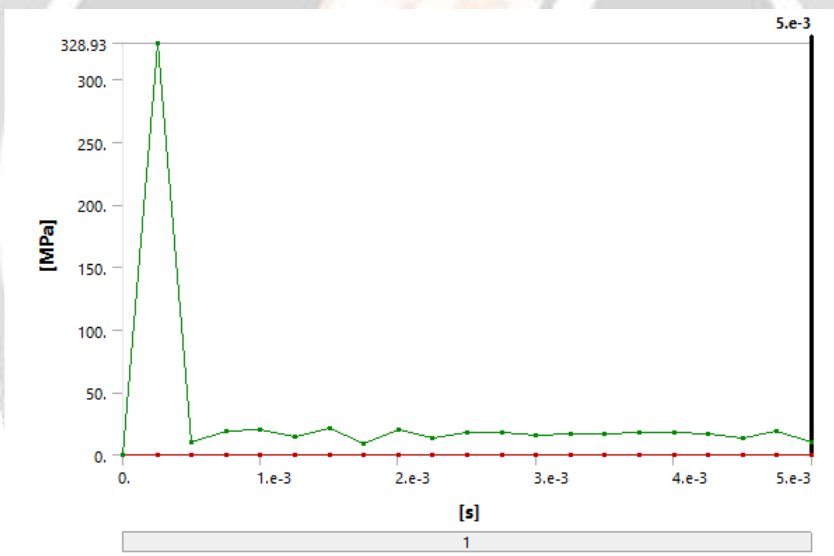

Fig. 13 : Graphical representation of Maximum shear stress

Table 3 : Maximum and minimum shear stress values

<table>
<tr><th>Time [s]</th><th>Minimum [MPa]</th><th>Maximum [MPa]</th></tr>
<tr><td>1.1755e-038</td><td rowspan="4">0.</td><td>0.</td></tr>
<tr><td>2.5001e-004</td><td>328.93</td></tr>
<tr><td>5.0002e-004</td><td>10.577</td></tr>
<tr><td>7.5001e-004</td><td>18.864</td></tr>
</table>

1.e-003		20.409
1.25e-003		14.065
1.5e-003		21.328
1.75e-003		8.6009
2.e-003		20.334
2.25e-003		13.46
2.5e-003		17.465
2.75e-003		17.953
3.e-003		15.599
6e-003		16.352
3.5e-003		16.848
3.75e-003		17.5
4.e-003		17.878
4.25e-003		17.098
4.5e-003		12.884
4.75e-003		18.816
5.e-003		9.9891

Fig. 14 shows the ansys model for maximum shear stress. The analysis is carried out for a very short period of time of 5 e-003 seconds. It has been found that maximum shear stress is observed at the pitch circle diameter holes which is very negligible. Shear stress is moderate at the middle portion of the disc and is very less at the edges of furrow opening disc.

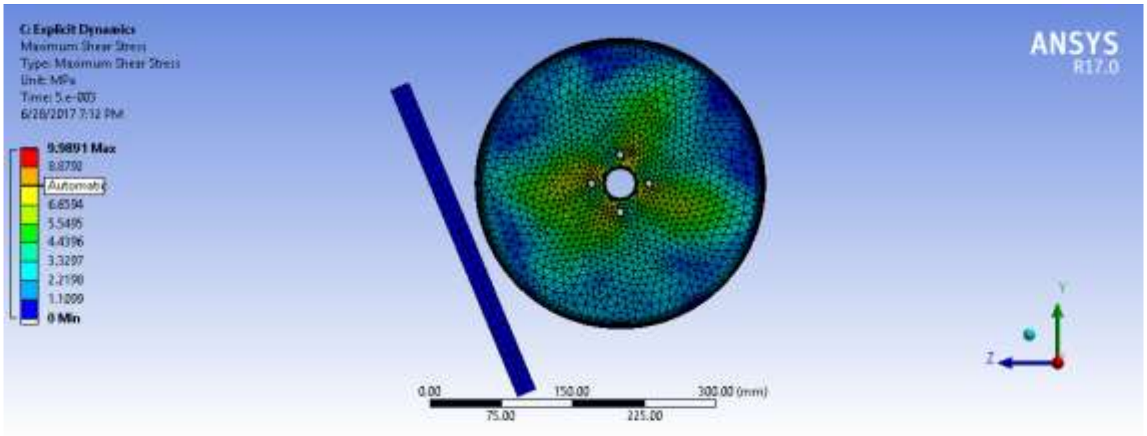

Fig. 14 : Maximum shear stress

During the dynamic analysis the disc is deform for a short period of time when it collides with the rigid body. Fig. 15 shows the graphical representation of equivalent elastic strain.

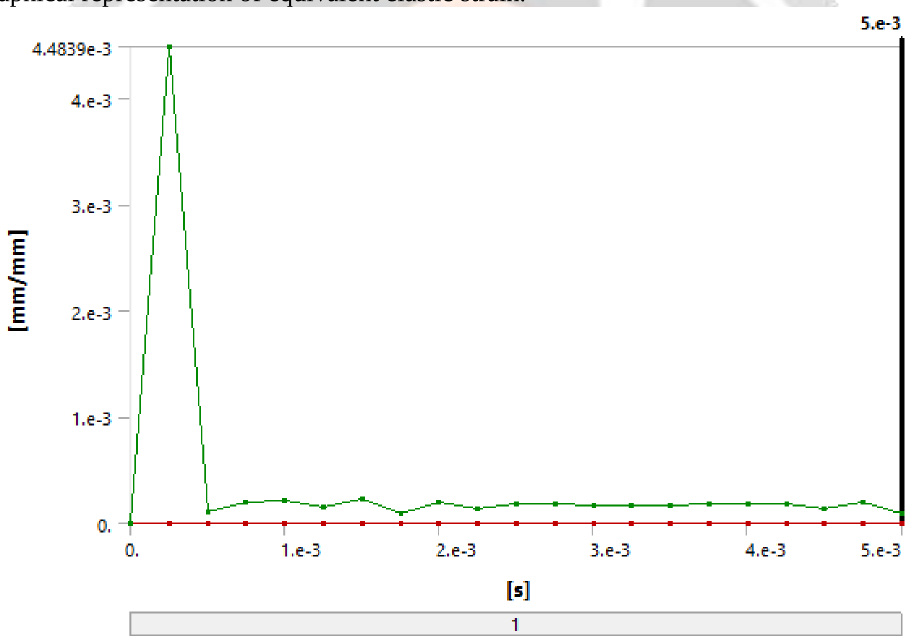

Fig. 15 : Graphical representation of equivalent elastic strain

Table 4 : Minimum and maximum values of equivalent elastic strain

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.1755e-038	0.	0.
2.5001e-004		4.4839e-003
5.0002e-004		1.1158e-004
7.5001e-004		2.016e-004

1.e-003		2.1086e-004
1.25e-003		1.4998e-004
1.5e-003		2.2244e-004
1.75e-003		9.0692e-005
2.e-003		2.0323e-004
2.25e-003		1.3864e-004
2.5e-003		1.8177e-004
2.75e-003		1.8601e-004
3.e-003		1.6187e-004
6e-003		1.6934e-004
3.5e-003		1.6983e-004
3.75e-003		1.7794e-004
4.e-003		1.8468e-004
4.25e-003		1.7578e-004
4.5e-003		1.3609e-004
4.75e-003		1.9468e-004
5.e-003		9.8638e-005

Fig. 16 shows the ansys model for equivalent elastic strain. It is found that equivalent elastic strain is very less on the disc furrow opener.

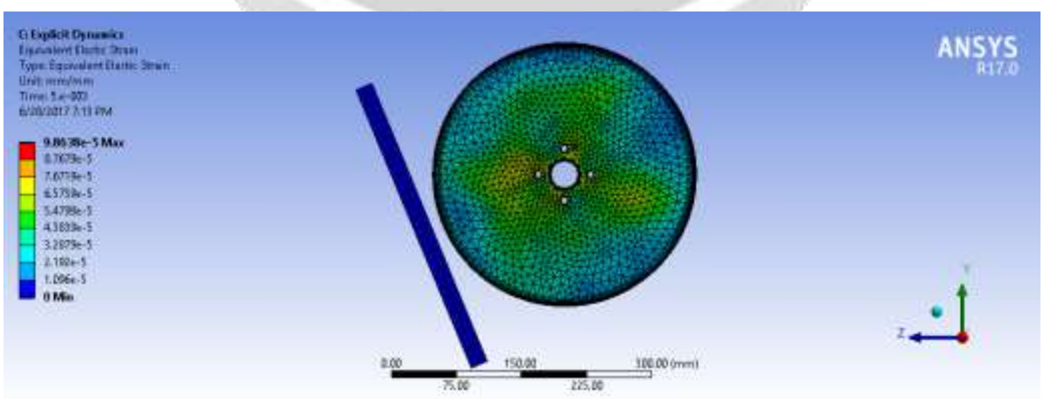

Fig. 16 : Ansys model of equivalent elastic strain

In dynamic analysis when disc strikes with obstacle it undergoes deformation which is elastic. 17 shows the peak value of principal elastic strain for a period of 0 to 5 e -3 seconds, which is maximum at the start point and reduce immediately and stable for some period of time.

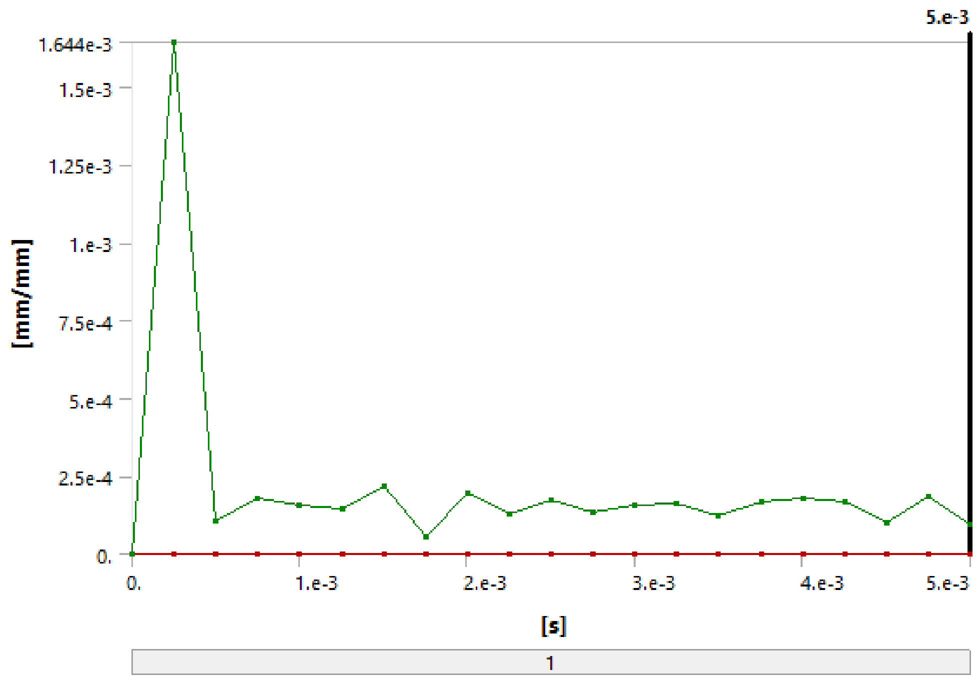

Fig. 17 : Graphical representation of maximum principal elastic strain

Table 5 : Minimum and maximum value of maximum elastic strain

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.1755e-038	0.	0.
2.5001e-004		1.644e-003
5.0002e-004		1.069e-004
7.5001e-004		1.8168e-004
1.e-003		1.5422e-004
1.25e-003		1.437e-004
1.5e-003		2.1598e-004
1.75e-003		5.8244e-005
2.e-003		1.9571e-004
2.25e-003		1.3079e-004

2.5e-003		1.7363e-004
2.75e-003		1.364e-004
3.e-003		1.5407e-004
6e-003		1.6293e-004
3.5e-003		1.2522e-004
3.75e-003		1.7005e-004
4.e-003		1.7721e-004
4.25e-003		1.6997e-004
4.5e-003		1.0252e-004
4.75e-003		1.8697e-004
5.e-003		9.5085e-005

In dynamic analysis of disc it has been found that the maximum principal elastic strain is having negligible effect on the disc when we consider a time period of 5 e -3 seconds.

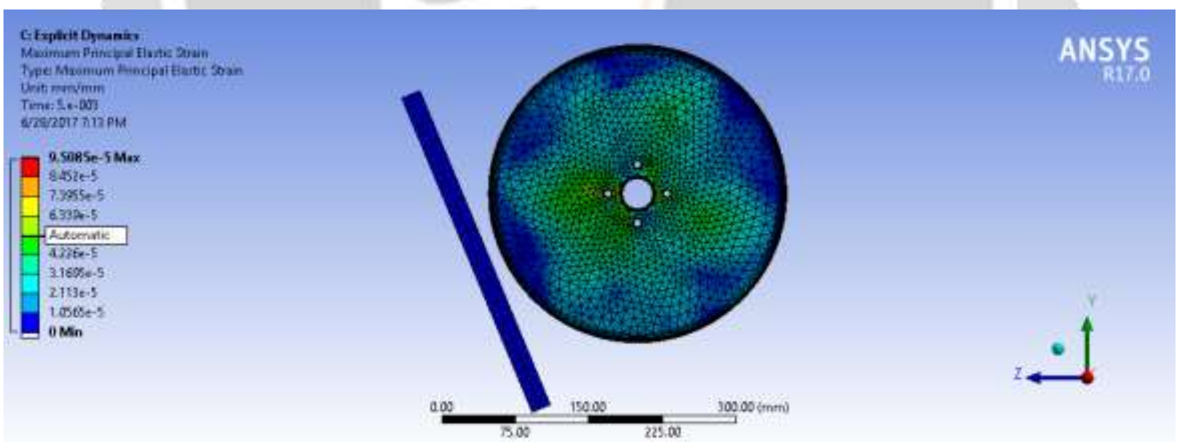

Fig. 18 : Ansys model of maximum principal elastic strain

Maximum shear strain is having more pronounce effect as compared to maximum principal elastic strain on the furrow opener disc. Fig. 19 shows the graphical representation of the maximum shear elastic strain w.r.t. time.

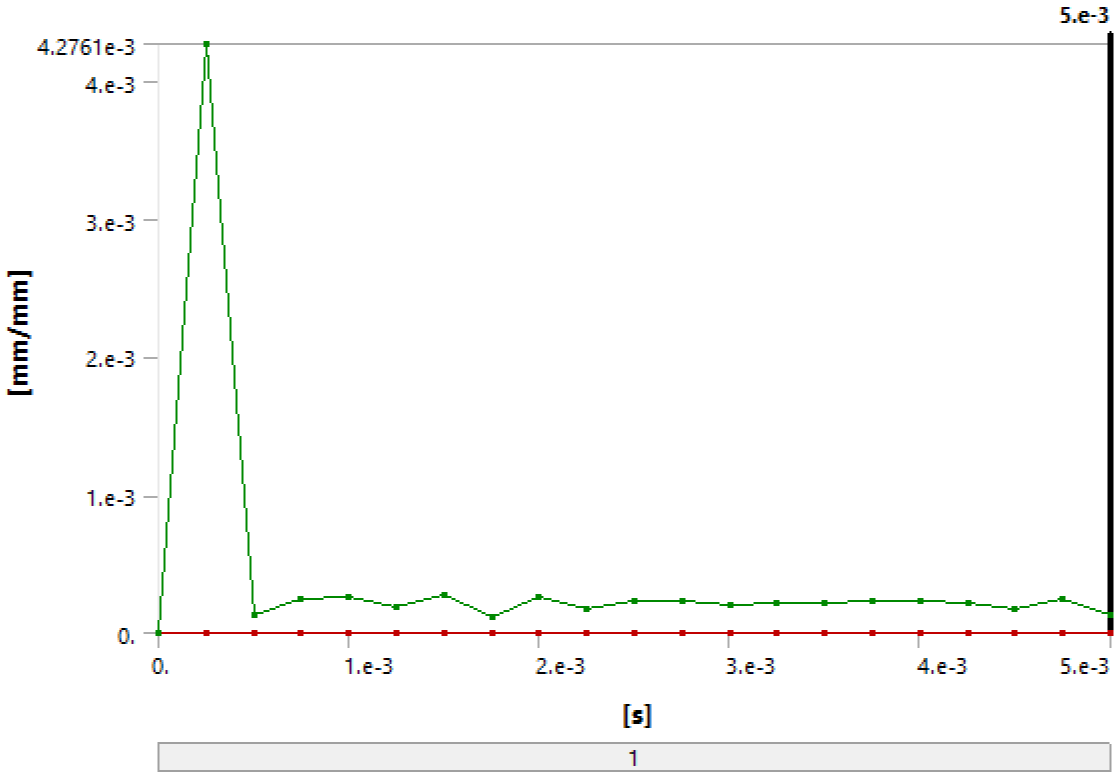

Fig. 19 : Graphical representation of maximum shear elastic strain

Table 6 : Minimum and maximum values of shear elastic strain

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.1755e-038	0.	0.
2.5001e-004		4.2761e-003
5.0002e-004		1.375e-004
7.5001e-004		2.4524e-004
1.e-003		2.6532e-004
1.25e-003		1.8284e-004
1.5e-003		2.7727e-004
1.75e-003		1.1181e-004
2.e-003		2.6434e-004
2.25e-003		1.7499e-004

2.5e-003		2.2704e-004
2.75e-003		2.3338e-004
3.e-003		2.0279e-004
6e-003		2.1257e-004
3.5e-003		2.1902e-004
3.75e-003		2.275e-004
4.e-003		2.3241e-004
4.25e-003		2.2228e-004
4.5e-003		1.6749e-004
4.75e-003		2.4461e-004
5.e-003		1.2986e-004

Fig. 20 shows the maximum shear elastic strain when disc is collides with the rigid component at a velocity of 3000 mm/s for a short period of time. It has been observed that maximum shear elastic strain has very less effect on the disc opener and found most effect at the holes provided on the disc and it is modearte at the middle portion.

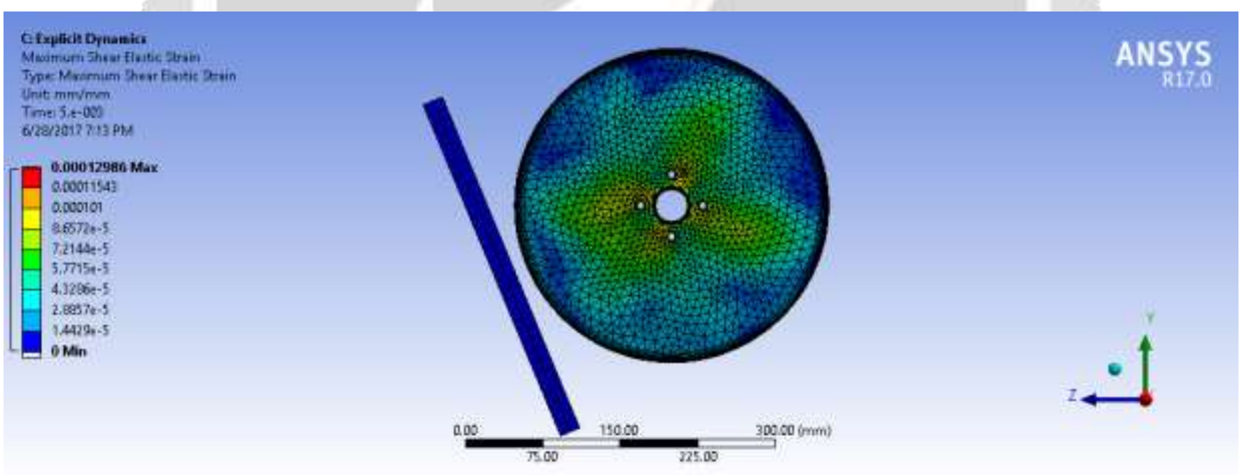

Fig. 20 : Ansys model of maximum shear elastic strain

4. CONCLUSIONS

In dynamic analysis it is observed that deformation is maximum at short period of time where as stresses on disc are very less. Thus in order to reduce the deformation it is necessary to provide sharp edges to disc so that area of impact will reduce. All stresses found in limit thus design of disc is safe.

6. REFERENCES

[1]Ali Khosravani Goshtasb, Jack Desbiolles1 and John Fielke,(2014) Circular Disc Blade Considerations in Soil Force Prediction Modelling, *Journal of Agricultural Science and Technology* pp 371-383

[2]E. Seidi, Effects of Geometry of Disk Openers on Seed Slot Properties,(2012) *World Academy of Science, Engineering and Technology. International Journal of Biological, Biomolecular, Agricultural, Food and Biotechnological Engineering* 12-20.

[3]Md. Monjurul Alam,(1989) Soil reaction forces on agricultural disc implements, *The University of NewcastIe,* 1, pp 62-68.

[4]E. Seidi, S.H. Abdollahpour, A. Javadi and M. Moghaddam,(2010) Effects of Novel Disk-type Furrow Opener Used in No-Tillage System on Micro Environment of Seed, *American Journal of Agricultural and Biological Sciences*, pp1-6.