Vol-08 Issue 05, May -2024 ISSN: 2456-9348
Impact Factor: 7.936

IJETRM
International Journal of Engineering Technology Research & Management

MODELLING AND ANALYSIS OF FLYWHEEL

P. Shekar reddy[1]
[1]Associate Professor, Department of Mechanical Engineering, GNITC, Hyderabad, Telangana
K. Ajay[2], **V. Jayakrishna**[3], **S. Mohanakrishna**[4], **P. Kailash***[5]
[2,3,4,5]UG Scholars, Department of Mechanical Engineering, GNITC, Hyderabad, Telangana

---

ABSTRACT

Flywheels serve as kinetic energy storage and retrieval devices with the ability to deliver high output power at high rotational speeds as being one of the Emerging energy storage system available today in various stages of Development, especially in advanced spacecrafts. Today, most of the research efforts are being spent on improving energy storage capability of flywheels to deliver high power at transfer times, lasting longer than conventional battery-powered technologies. Mainly, the Performance of a flywheel can be attributed to three factors i.e., material strength, geometry (cross-section) and rotational speed. While material Strength directly determines kinetic energy level that could be produced safely combined (coupled) with rotor speed, this study solely focuses on exploring the effects of flywheel geometry on its energy storage to the deliver capability per unit mass, further defined as Specific Energy. To determine the model analysis of models with variation of tooth for Flywheel to obtain procedural results show that smart design of flywheel geometry could both have a significant effect on the Specific Energy Performance.

---

1. INTRODUCTION

A flywheel is a mechanical device particularly intended to effectively store rotational vitality. The measure of vitality put away in a flywheel is relative to the square of its rotational speed. The best approach to change a flywheel's put away vitality is by expanding or diminishing its rotational speed applying a torque lined up with its hub of symmetry.

Basic employments of a flywheel include:

- Smoothing the power yield of a vitality source. For instance flywheels are utilized as a part of responding motors in light of the fact that the dynamic torque from the individual cylinders is irregular.
- Energy stockpiling frameworks Flywheel vitality stockpiling.
- Flywheels are used to store energy and release it when needed, such as in uninterruptable power supplies during outages.
- Delivering vitality at rates past the capacity of a vitality source. This is accomplished by gathering vitality in a flywheel after some time and afterward discharging it rapidly, at rates that surpass the capacities of the vitality source.
- Controlling the introduction of a mechanical framework, spinner and response wheel
- Flywheels are normally made of steel and turn on customary orientation; these are by and large constrained to a greatest upheaval rate of a couple of thousand RPM. High vitality thickness flywheels can be made of carbon fiber composites and utilize attractive course, empowering them to rotate at speeds up to 60,000 RPM (1 kHz).

Figure 1. Flywheel to even out the power of its Single Cylinder.

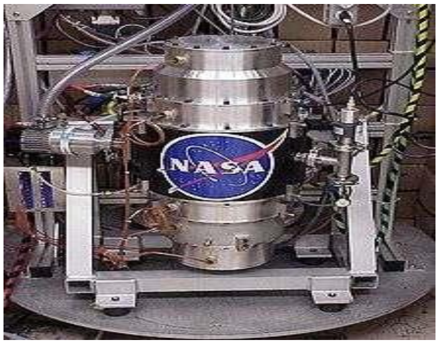


Figure 2. G2 flywheel, NASA

2. LITERATURE REVIEW

In 2005 **JohnA.Akpobi and Imafidon A.Lawani** [1] have proposed, a PC supported plans of programming for flywheels utilizing object-arranged programming methodology of Visual Basic. The different setups of flywheels (rimmed or strong) framed the reason for the improvement of the product. The product's graphical highlights were utilized to give a visual understanding of the arrangements. The product's viability was tried on various numerical illustrations, some of which are sketched out in this work.

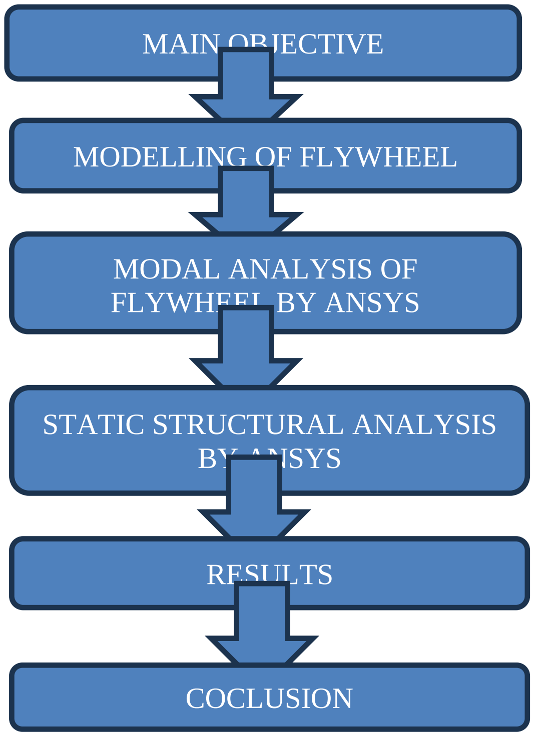
In 2012 Sushama G Bawane, A P Ninewa and S K Choudhary had proposed [2] flywheel outline, and investigation the material determination process. The FEA demonstrate is depicted to accomplish a superior comprehension of the work sort, work size and limit conditions connected to finish a viable FEA show.

Saeed Shojaei , Seyyed Mostafa Hossein Ali Pour Mehdi Tajdari Hamid Reza Chamani [3] have proposed calculations in view of dynamic examination of wrench shaft for planning flywheel for I.C. engine , torsional vibration investigation result by AVL\EXCITE is contrasted and the rakish relocation of a want free had of wrench shaft ,likewise thought of exhaustion for weariness examination of flywheel are given.

Sudipta Saha, Abhik Bose, G. SaiTejesh, S.P. Srikanth have propose [4] the significance of the flywheel geometry outline choice and its commitment in the vitality stockpiling execution. This commitment is exhibited on illustration cross-areas utilizing PC helped investigation and enhancement system. Proposed Computer supported examination and advancement methodology comes about demonstrate that keen outline of flywheel geometry could both significantly affect the Specific Energy execution and decrease the operational burdens applied on the pole/course because of lessened mass at high rotational velocities.

Bedier B. EL-Naggar and Ismail A. Kholeif [5] had is proposed the plate edge flywheel for light weight. The mass of the flywheel is limited subject to limitations of required snapshot of inactivity and permissible burdens. The hypothesis of the turning circles of uniform thickness and thickness is connected to each the plate and the edge autonomously with reasonable coordinating condition at the intersection. Appropriate limit conditions on the radiating burdens are connected and the dimensional proportions are gotten for least weight. It is demonstrated that the required outline is near the circle with uniform thickness.

3.METHODOLOGY



4. MODELLING OF FLYWHEEL BY SOLIDWORKS

Solid works is a 3d solid modeling bundle which permits users to broaden complete solid fashions in a simulated surroundings for each layout and analysis. In strong works; you caricature thoughts and experiment with distinctive designs to create 3-d models. Strong works is used by college students, designers, engineers, and other experts to supply simple and complex elements, assemblies, and drawings.

4.1. Solid Works components - parts

Before we begin looking at the software, it is important to understand the different components that make up a solid works model.

1. Part:
2. Assembly:
3. Drawing

4.2. Solid Works – Let's begin

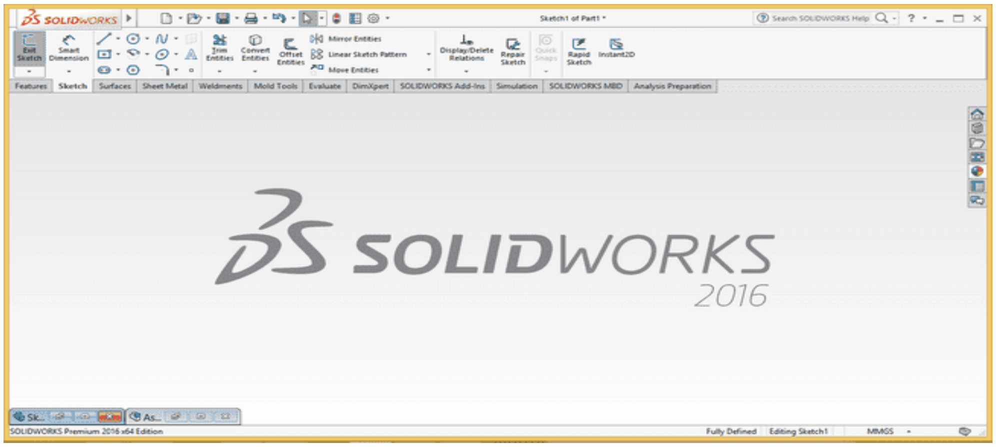


Figure 3. Solid works default page

4.3. Modelling of Flywheel by Solidworks

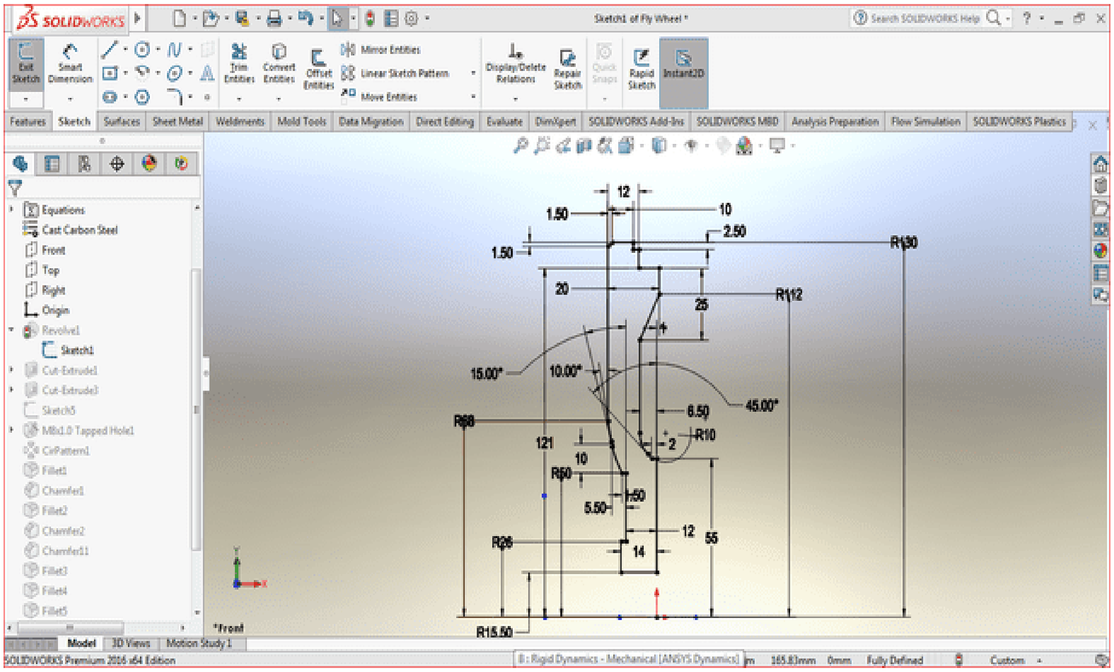
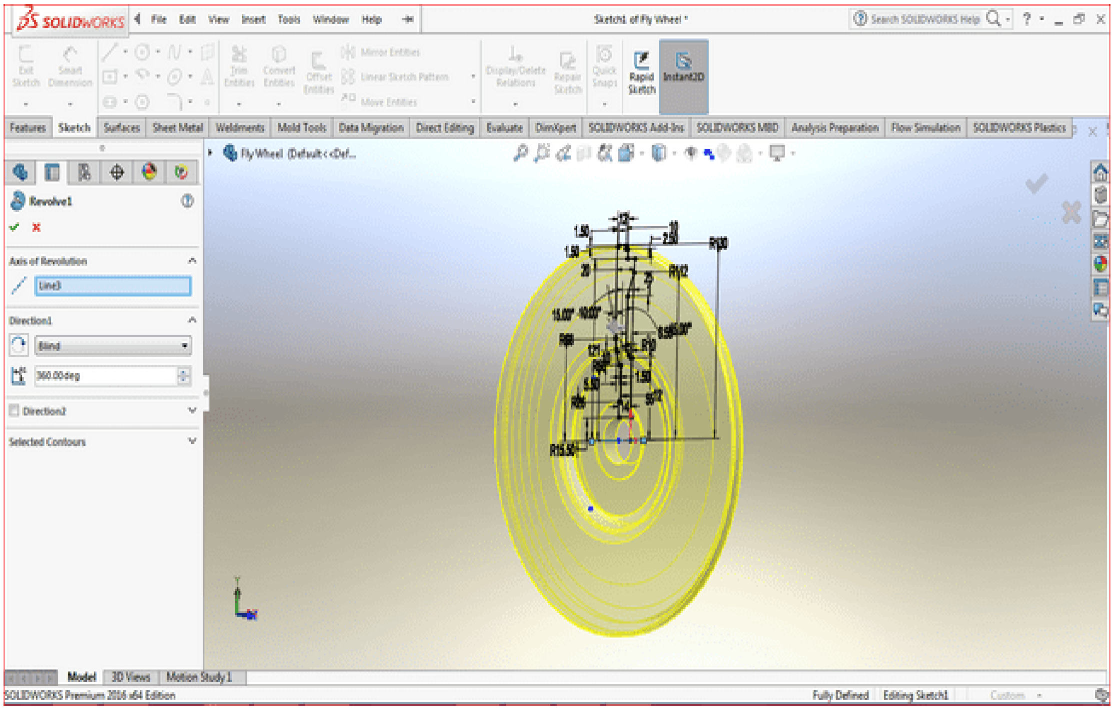


Figure 4. Sketch for the flywheel



Axis of Revolution: Line3

Direction1: Blind

360.00deg

Direction2

Selected Contours

Figure 5. Revolve

- ➢ On part module go to sketch. And select sketch, then create sketch as shown in figure in below.
- ➢ Later select on exit sketcher.

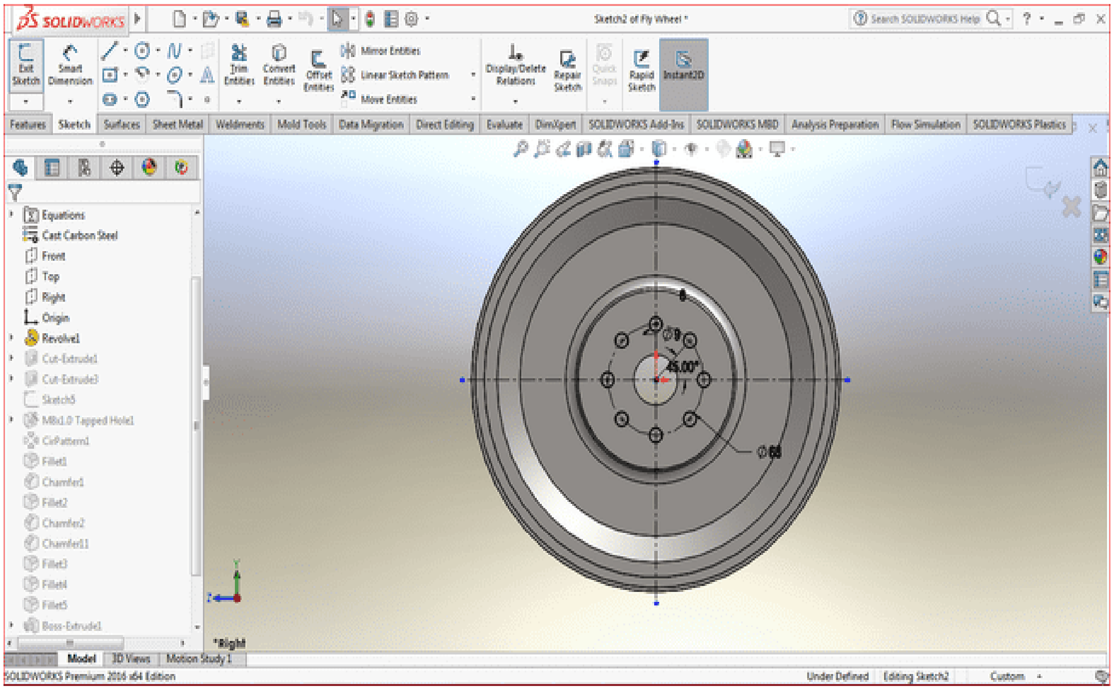
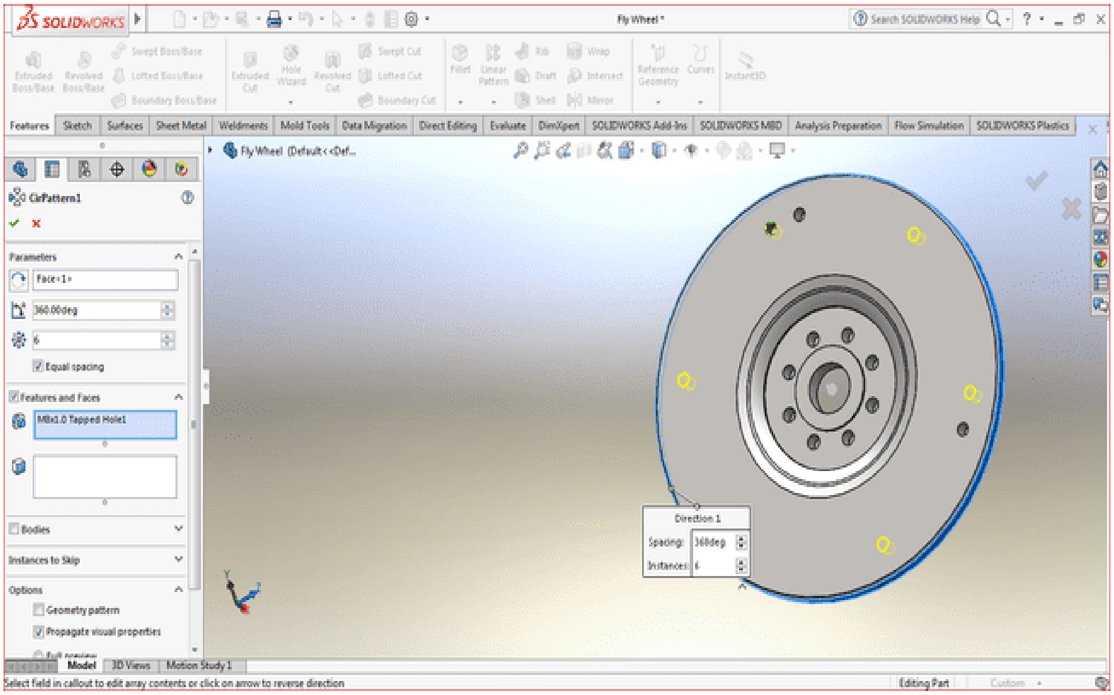


Figure 6. Extrude cut.



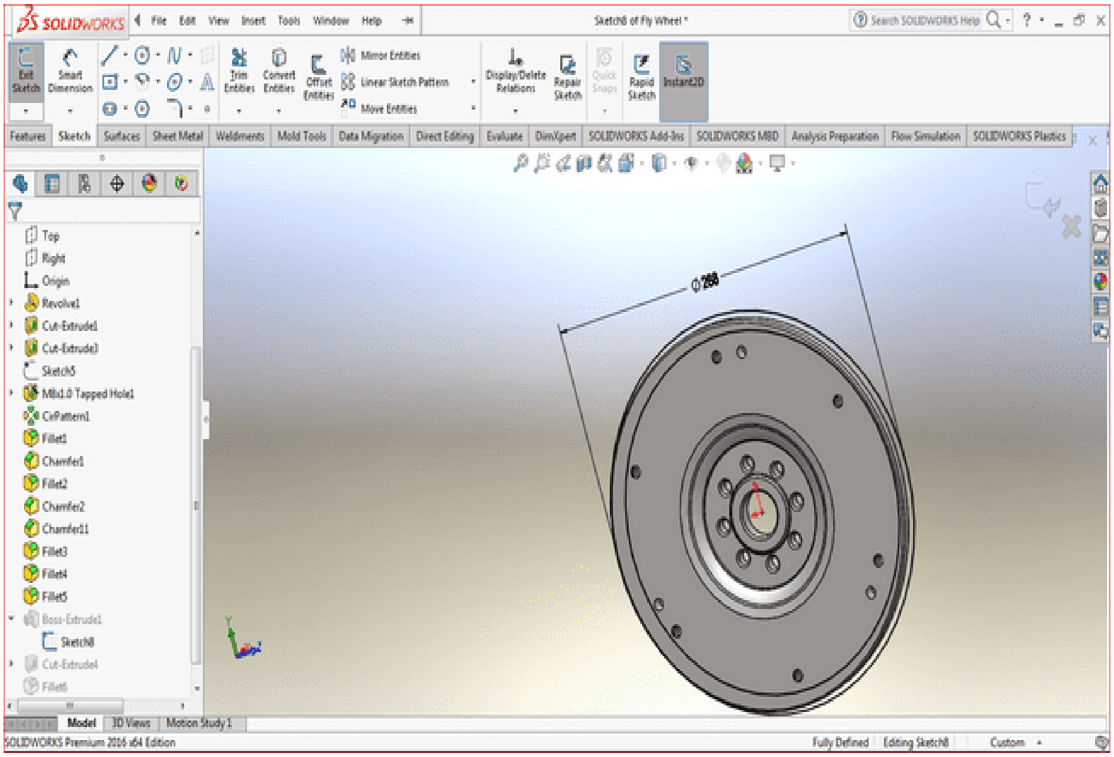
Face<1>
360.00deg
6
☑ Equal spacing
M8x1.0 Tapped Hole1
☐ Geometry pattern
☑ Propagate visual properties

Direction 1
Spacing: 360deg
Instances: 6

Select field in callout to edit array contents or click on arrow to reverse direction

Figure 7. Extrude cut and circular pattern

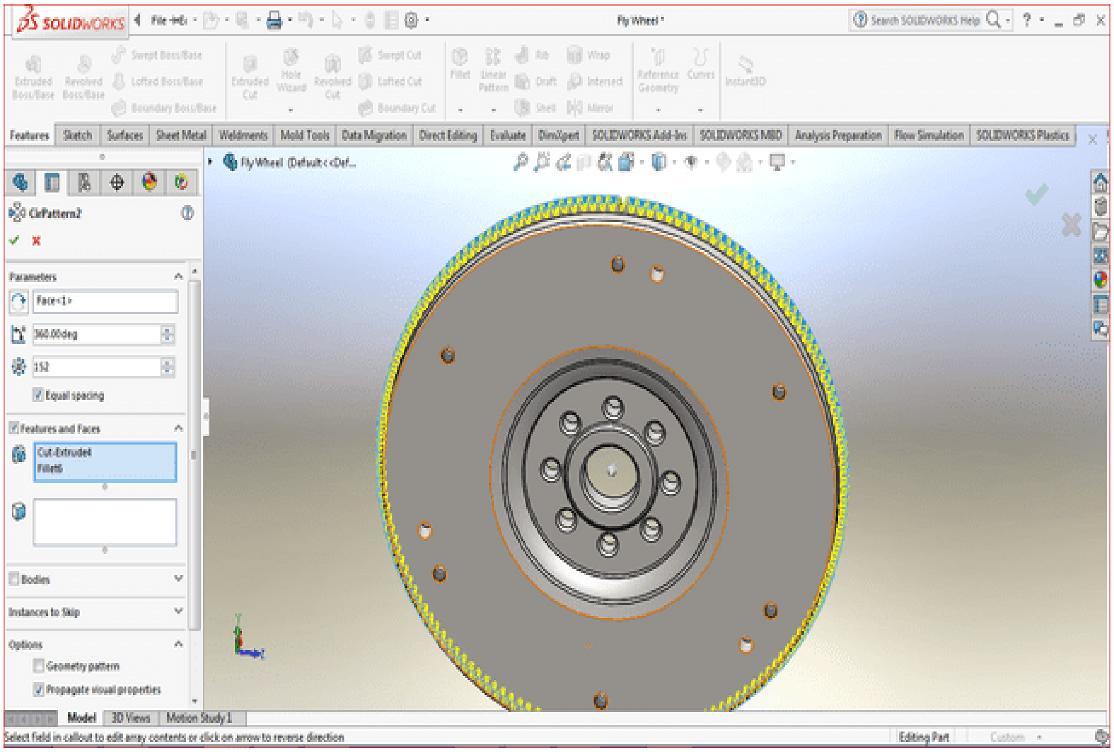
- After extrude cut, go to plane in reference and select front plane as a reference and specify offset distance 0.45 meter.



SOLIDWORKS Premium 2016 x64 Edition
Fully Defined
Editing Sketch8

Figure 8. Sketch for teethes

Final modal with 152 teethes

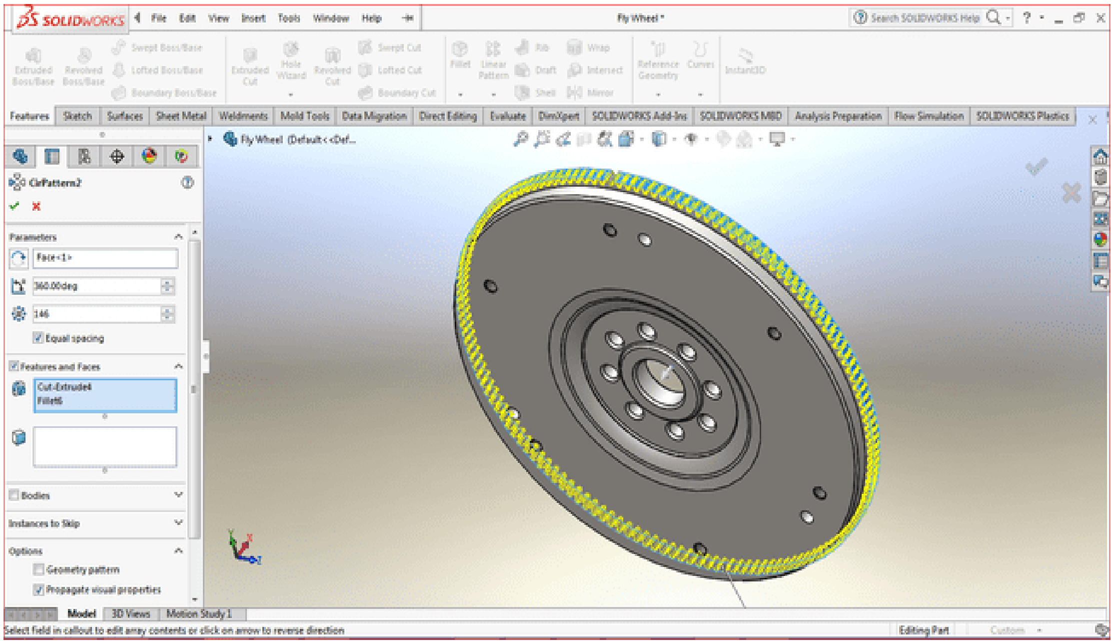


Face<1>
360.00deg
152
☑ Equal spacing
☑ Features and Faces: Cut-Extrude4, Fillet6
☐ Geometry pattern
☑ Propagate visual properties

Select field in callout to edit array contents or click on arrow to reverse direction

Figure 10. Modal 1 With 152 Teeth

Similarly 146 teeth Fly wheel created (Final modal)



Face<1>
360.00deg
146
☑ Equal spacing
☑ Features and Faces: Cut-Extrude4, Fillet6
☐ Geometry pattern
☑ Propagate visual properties

Select field in callout to edit array contents or click on arrow to reverse direction

Figure 11. Modal 2 with 146 Teeth

IJETRM
International Journal of Engineering Technology Research & Management

5. MODAL ANALYSIS OF FLYWHEEL BY ANSYS

5.1. Generating the mesh for the model

Now, you need to generate the mesh of the model.

1. Double click on model cell will enter into mechanical window. Also, you will notice that in the outline window, the mesh node is displayed in the tree outline with a yellow thunderbolt attached to it.
2. Click on mesh in the tree outline; the details of "mesh" window is displayed.

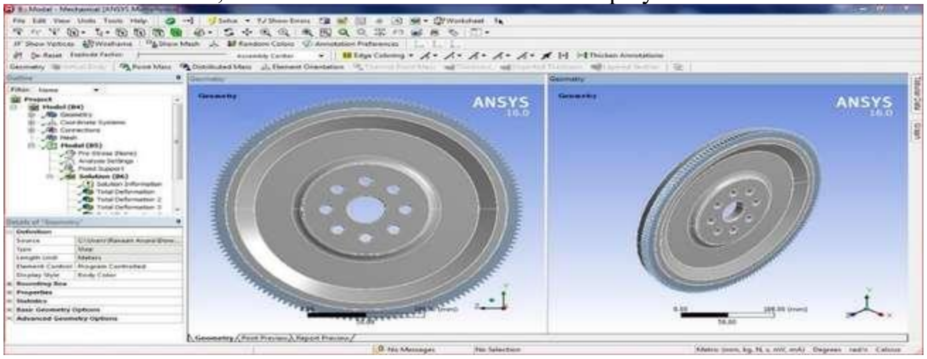
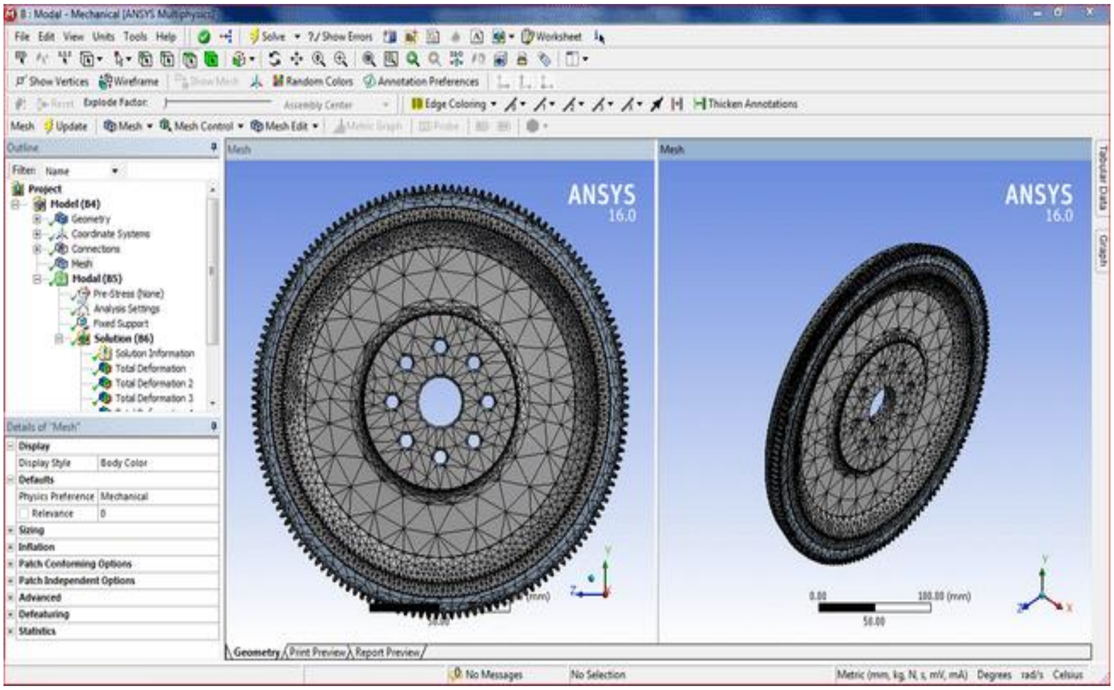


Figure 12. Mechanical window with the modal

3. In the details of "mesh" window, expand the sizing node, if not already expanded.
4. In the sizing node in the details of "mesh" window, (inter 2-5 in the element size edit box.
5. Right-click on mesh in the tree outline and then choose the preview > surface mesh from the shortcut menu displayed; the preview of the mesh for the model is displayed.

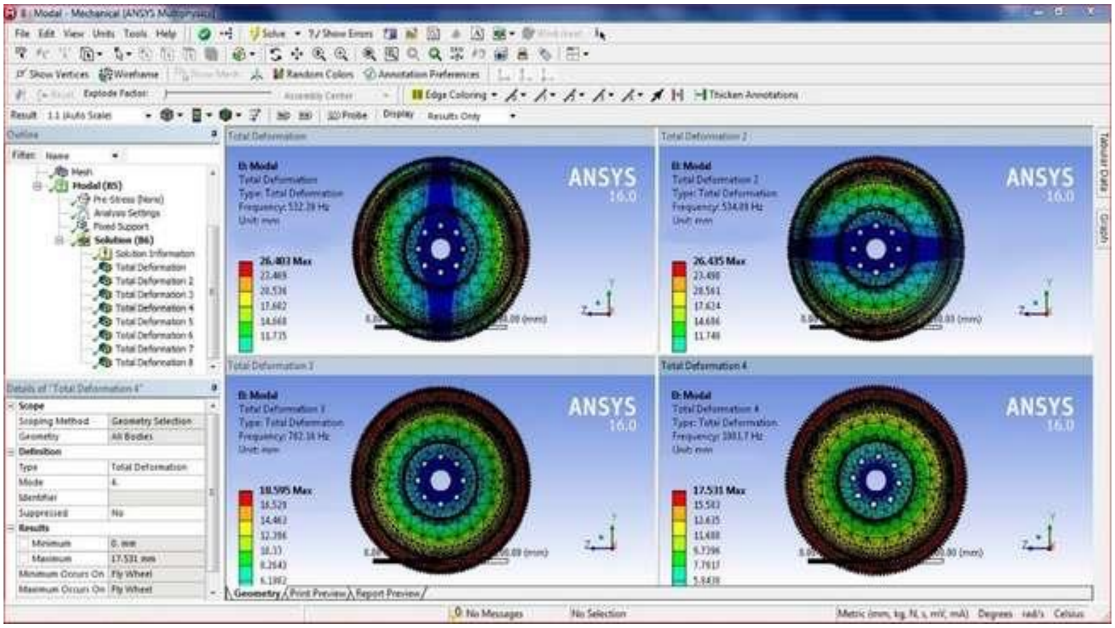


Details of "Mesh"

Display	
Display Style	Body Color
Defaults	
Physics Preference	Mechanical
☐ Relevance	0
Sizing	
Inflation	
Patch Conforming Options	
Patch Independent Options	
Advanced	
Defeaturing	
Statistics	

Figure 13. Generate mesh

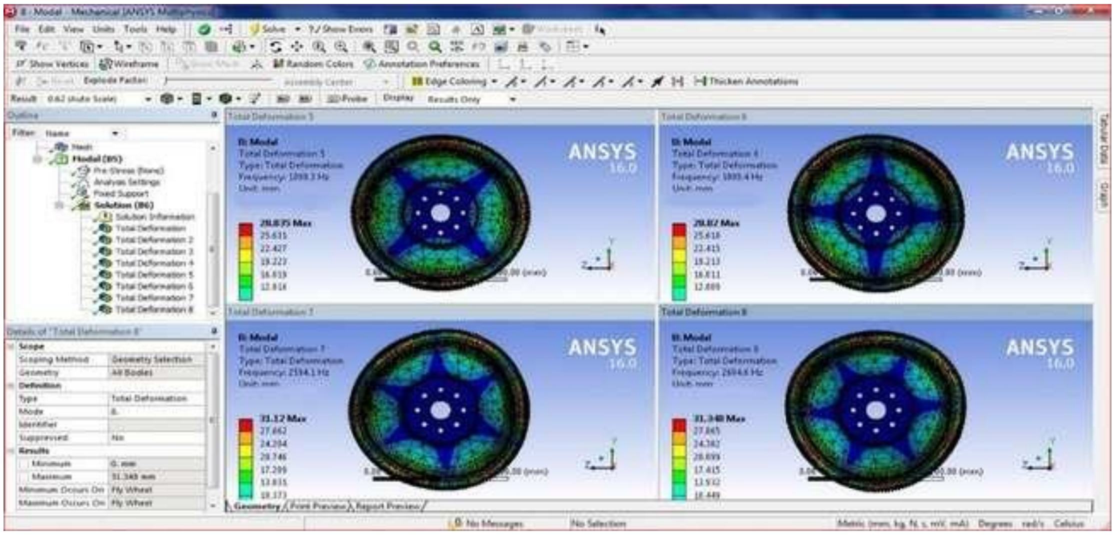
5.2. Modal 1 with 152 teeth



Details of "Total Deformation 4"

Scope
Scoping Method: Geometry Selection
Geometry: All Bodies
Definition
Type: Total Deformation
Mode: 4.
Identifier:
Suppressed: No
Results
Minimum: 0. mm
Maximum: 17.531 mm
Minimum Occurs On: Fly Wheel
Maximum Occurs On: Fly Wheel

Figure 15. Total deformation 1st, 2nd, 3rd and 4th



Details of "Total Deformation 8"

Scope
Scoping Method: Geometry Selection
Geometry: All Bodies
Definition
Type: Total Deformation
Mode: 8.
Identifier:
Suppressed: No
Results
Minimum: 0. mm
Maximum: 31.348 mm
Minimum Occurs On: Fly Wheel
Maximum Occurs On: Fly Wheel

Figure 16. Total deformation 5th, 6th, 7th and 8th

Table 1. Resultant summary from workbench for modal 1 with 152 teeth

Results	Minimum	Maximum	Units	Reported Frequency (Hz)
Total Deformation1	0.	26.403	mm	532.39
Total Deformation2	0.	26.435	mm	534.09
Total Deformation3	0.	18.595	mm	782.16
Total Deformation4	0.	17.531	mm	1081.7
Total Deformation5	0.	28.835	mm	1099.3
Total Deformation6	0.	28.82	mm	1099.4
Total Deformation7	0.	31.12	mm	2594.1
Total Deformation8	0.	31.348	mm	2604.6

5.3. Modal 2 with 146 teeth

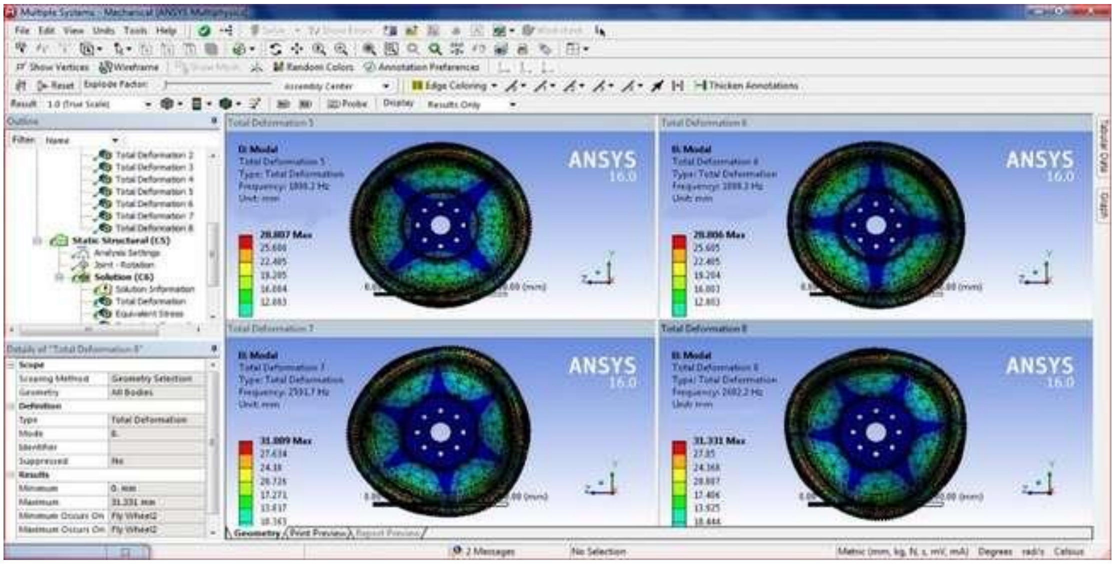


Figure 17. Total deformation 1st, 2nd, 3rd and 4th

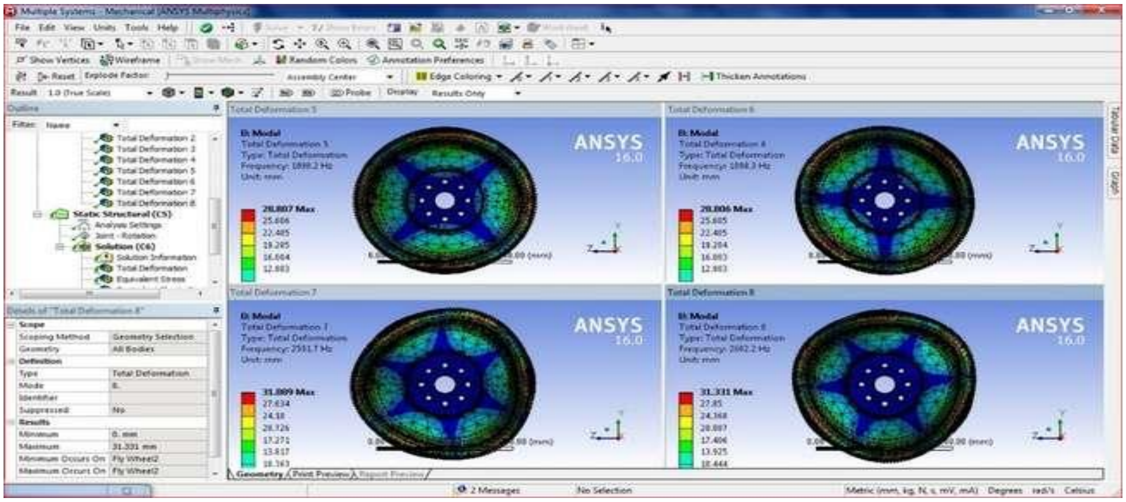


Figure 18. Total deformation 5th, 6th, 7th and 8th

Table 2. Resultant summary from workbench for modal 2 with 146 teeth

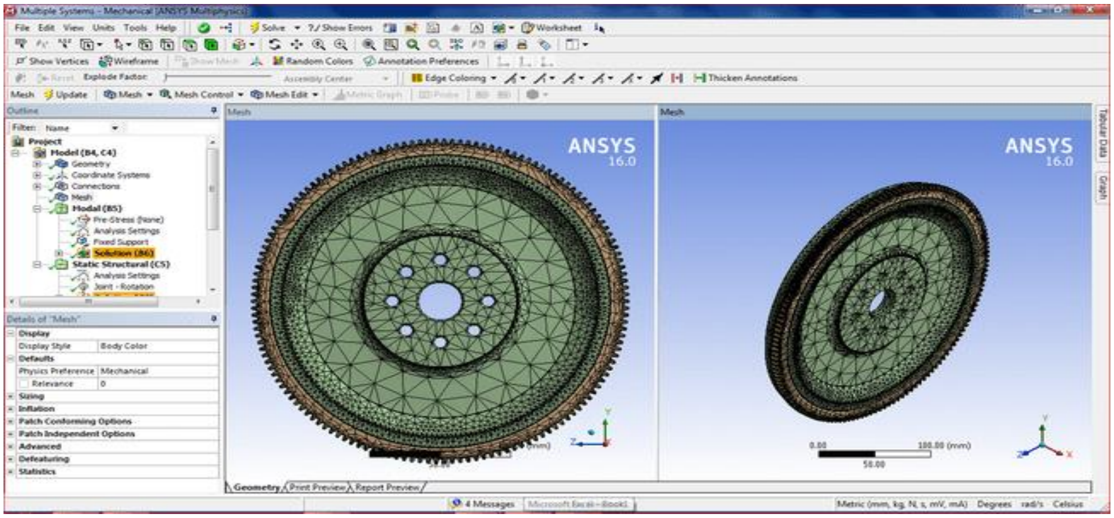
Results	Minimum	Maximum	Units	Reported Frequency (Hz)
Total Deformation1	0.	26.37	mm	531.78
Total Deformation2	0.	26.412	mm	533.09
Total Deformation3	0.	18.568	mm	781.42
Total Deformation4	0.	17.519	mm	1081
Total Deformation5	0.	28.807	mm	1098.2
Total Deformation6	0.	28.806	mm	1098.3
Total Deformation7	0.	31.089	mm	2591.7
Total Deformation8	0.	31.331	mm	2602.2

6. STATIC STRUCTURAL ANALYSIS

6.1. Generating the mesh

After the model is created in the design modeler window, you need to generate the mesh for the model in the mechanical window.

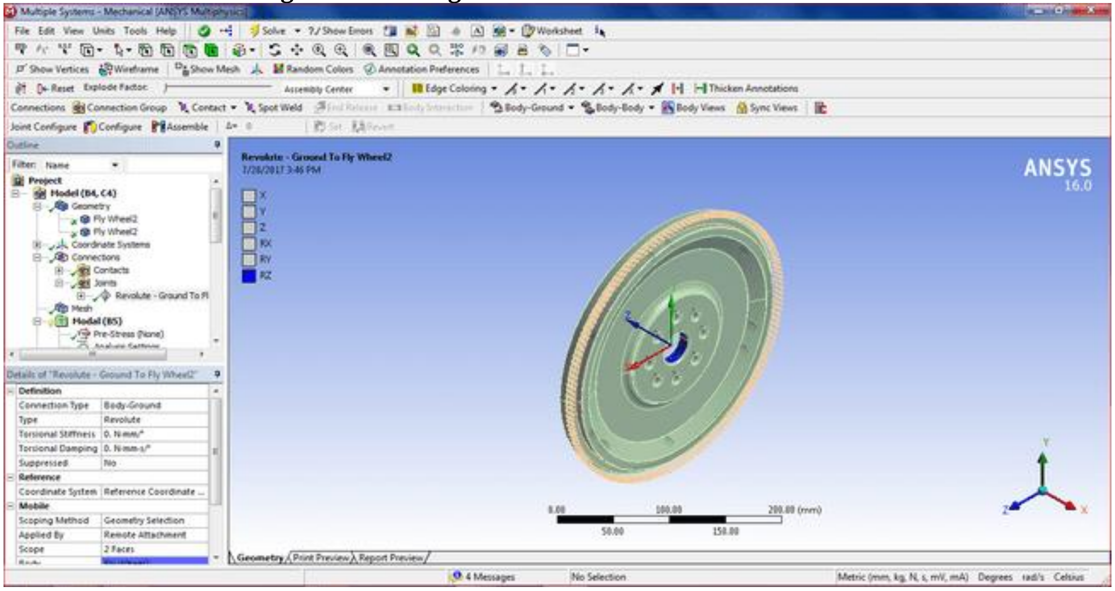
1. In the project schematic window, double-click on the model cell in the static structural analysis system; the mechanical window is displayed.
2. Select mesh in the tree outline to display the details of "mesh" window.
3. In the details of "mesh" window, expand the sizing node, if it is not already expanded. Also, notice that default is displayed in the element size edit box.



Details of "Mesh"

Display	
Display Style	Body Color
Defaults	
Physics Preference	Mechanical
Relevance	0
Sizing	
Inflation	
Patch Conforming Options	
Patch Independent Options	
Advanced	
Defeaturing	
Statistics	

Figure 19. Mesh generated with default mesh control

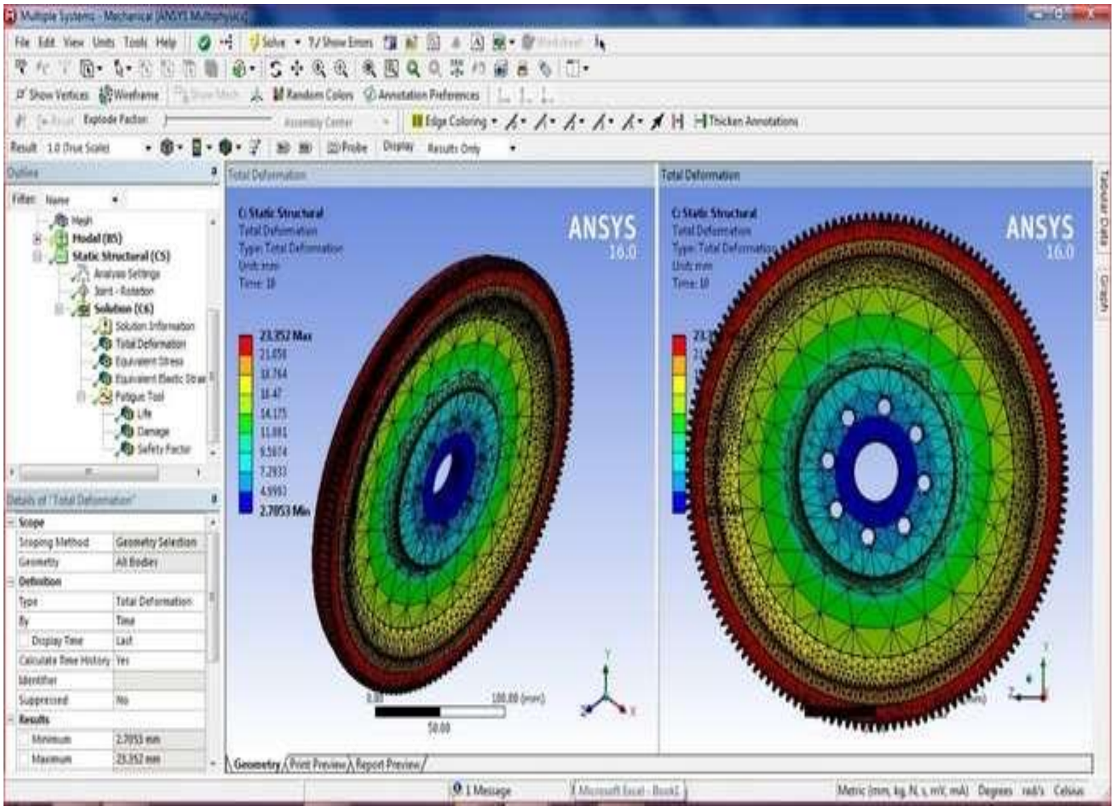


Details of "Revolute - Ground To Fly Wheel2"

Definition	
Connection Type	Body-Ground
Type	Revolute
Torsional Stiffness	0. N·mm/°
Torsional Damping	0. N·mm·s/°
Suppressed	No
Reference	
Coordinate System	Reference Coordinate ...
Mobile	
Scoping Method	Geometry Selection
Applied By	Remote Attachment
Scope	2 Faces

Figure 20. Connections

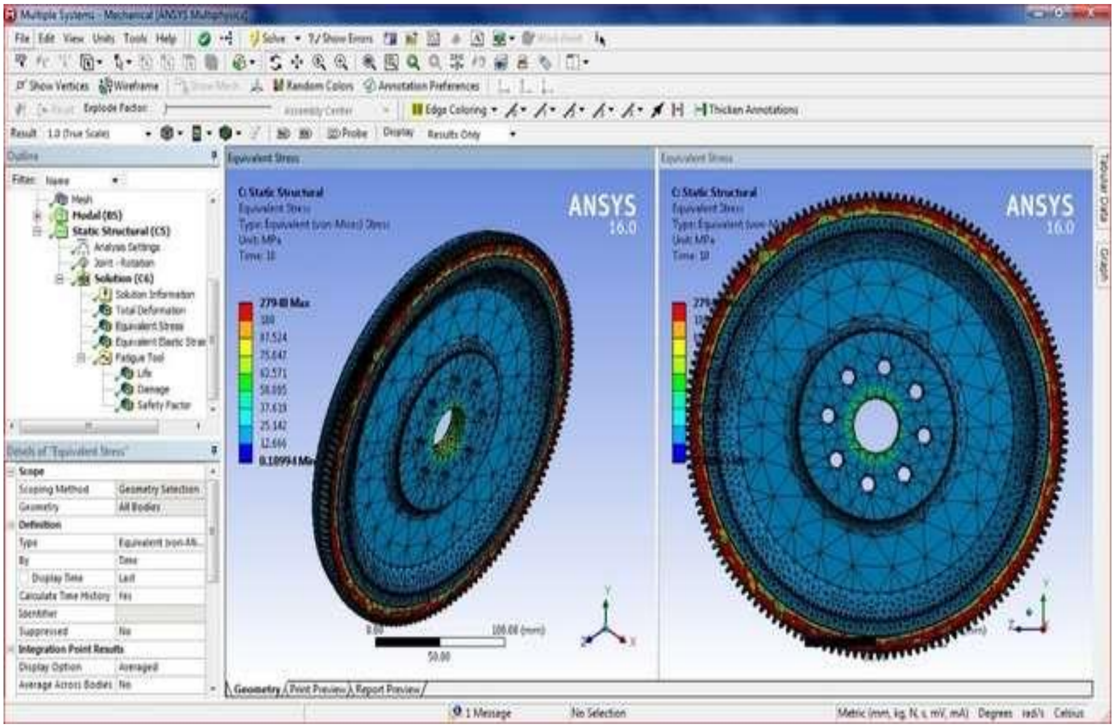
6.2. For modal 1 with 152 teeth



Details of "Total Deformation"

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Total Deformation
By	Time
Display Time	Last
Calculate Time History	Yes
Identifier	
Suppressed	No
Results	
Minimum	2.7053 mm
Maximum	23.352 mm

Figure 21. The maxi and mini values of total deformation.

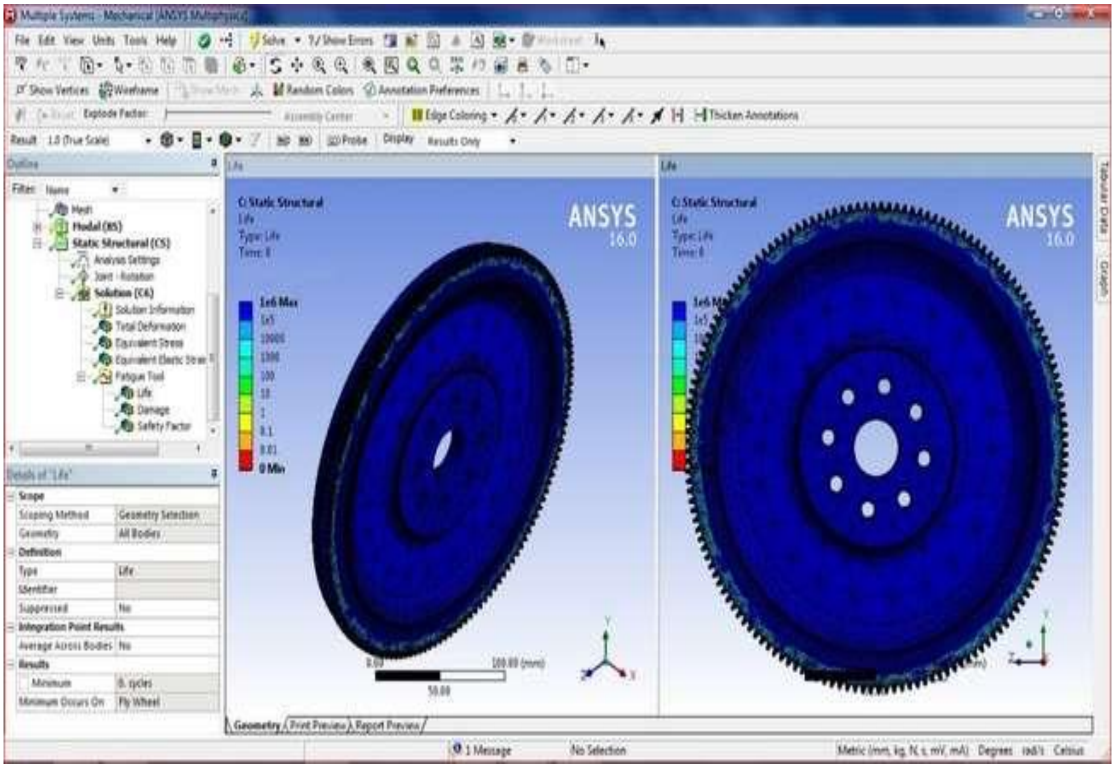


Details of "Equivalent Stress"

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Equivalent (von-Mi...
By	Time
Display Time	Last
Calculate Time History	Yes
Identifier	
Suppressed	No
Integration Point Results	
Display Option	Averaged
Average Across Bodies	No

Figure 22. The maxi and mini values of equivalent stress.

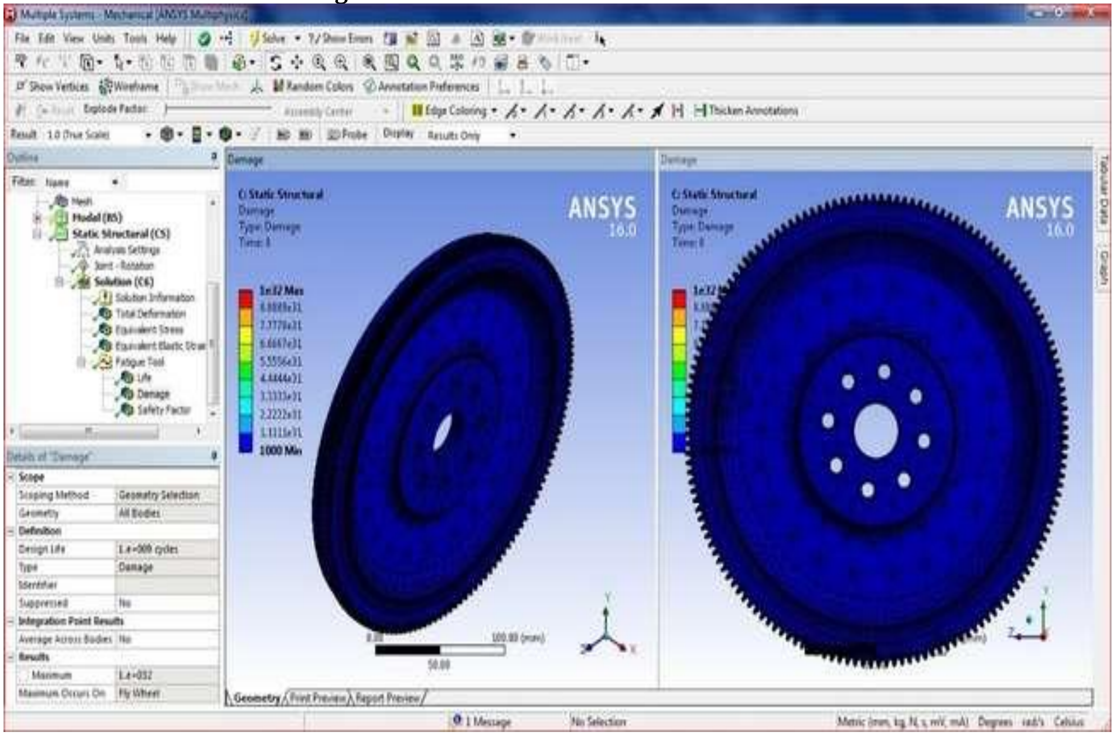
iJETRM
International Journal of Engineering Technology Research & Management



Details of "Life"

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Life
Identifier	
Suppressed	No
Integration Point Results	
Average Across Bodies	No
Results	
Minimum	0. cycles
Minimum Occurs On	Fly Wheel

Figure 23. The maxi and mini values of life.



Details of "Damage"

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Design Life	1.e+009 cycles
Type	Damage
Identifier	
Suppressed	No
Integration Point Results	
Average Across Bodies	No
Results	
Maximum	1.e+032
Maximum Occurs On	Fly Wheel

Figure 24. The maxi and mini values of damages

iJETRM
International Journal of Engineering Technology Research & Management

Table 3. Summary from workbench for modal 1 with 152 teeth

Results	Minimum	Maximum	Units	Time (s)
Total Deformation	2.7053	23.352	mm	10.
Equivalent Stress	0.18994	27948	MPa	10.
Equivalent Elastic Strain	1.8089e-006	0.14823	mm/mm	10.
Life	0.	1.e+006	Units Unavailable	0.
Total Deformation5	1000.	1.e+032	Units Unavailable	0.
Safety Factor	3.0843e-003	15.	Units Unavailable	0.

6.3. For modal 2 with 146 teeth

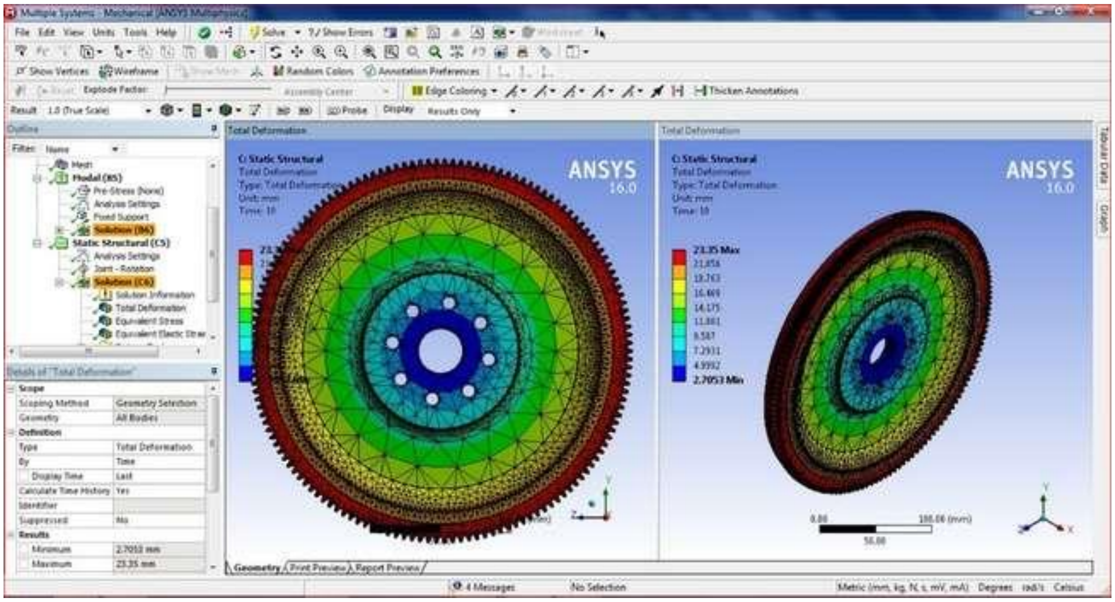


Figure 25. The maxi and mini values of total deformation.

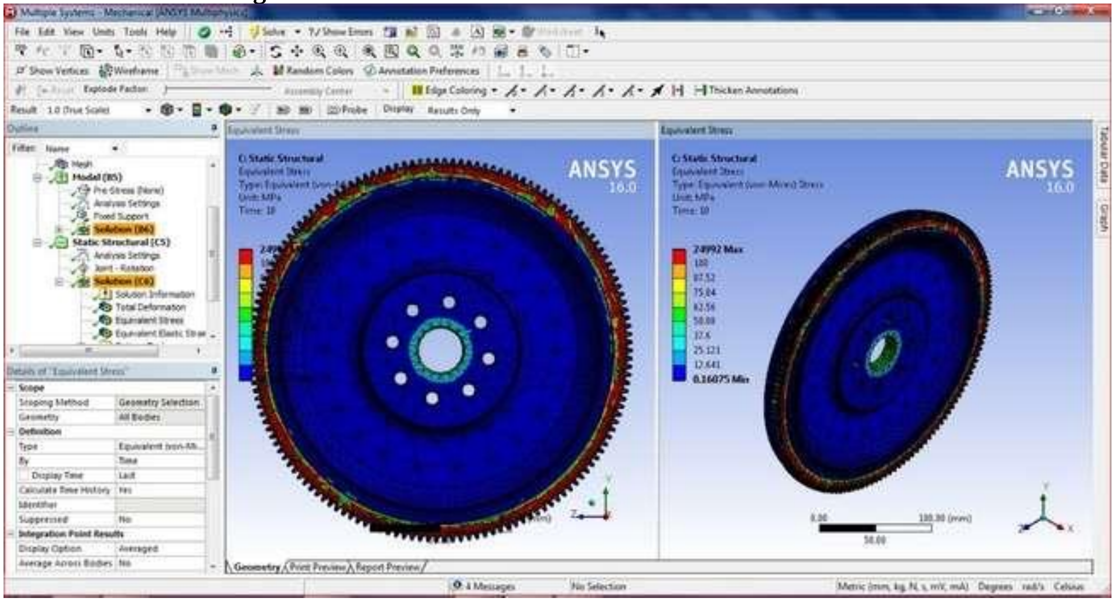


Figure 26. The maxi and mini values of equivalent stresses

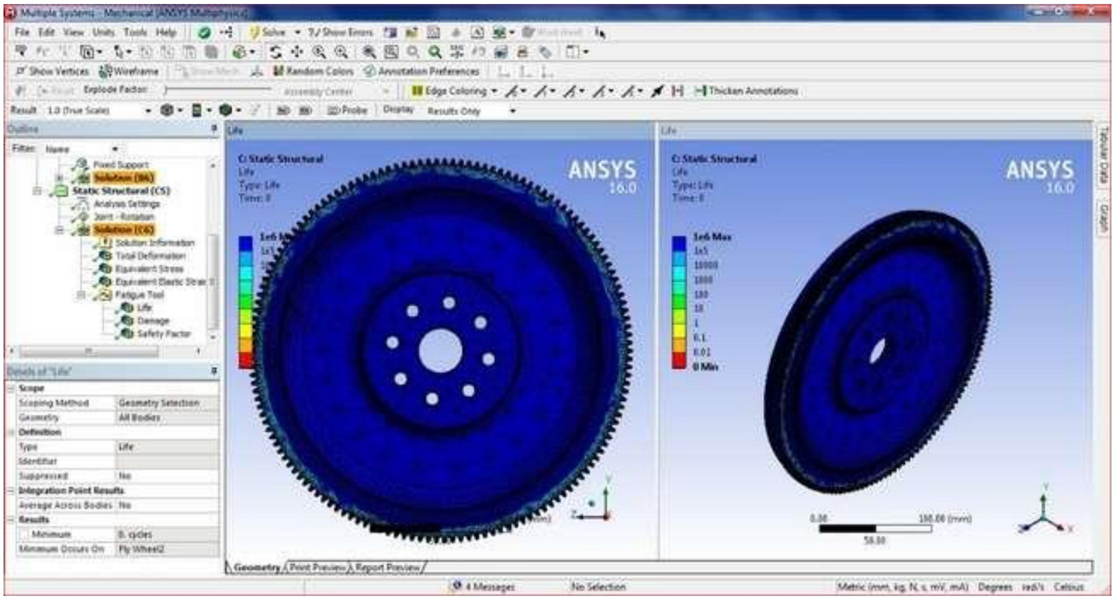


Figure 27. The maxi and mini values of life.

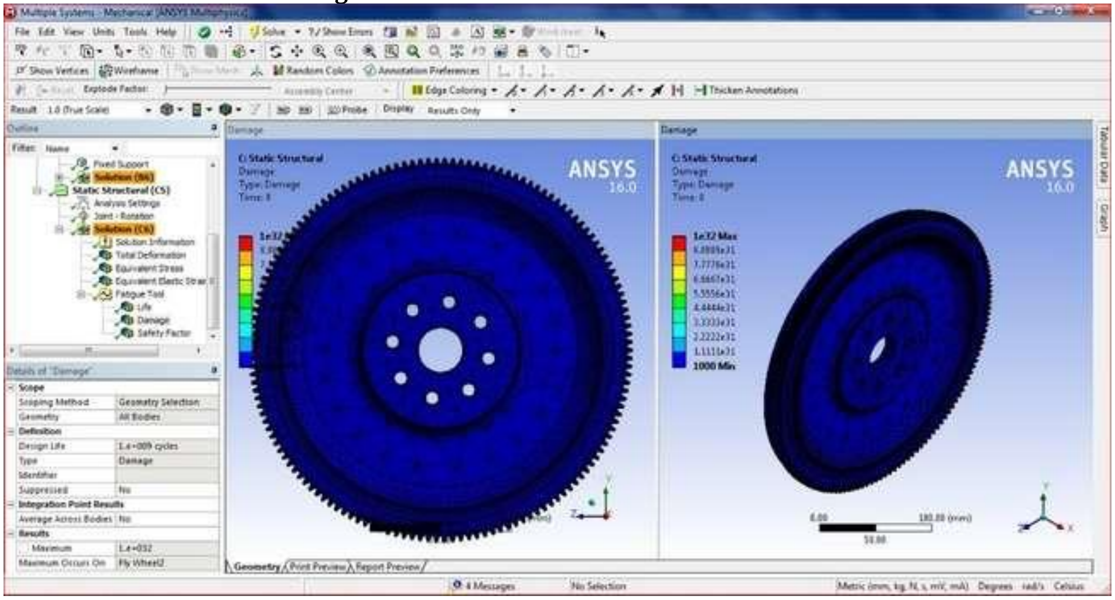


Figure 28. The maxi and mini values of damages

Table 4. Summary from workbench

Results	Minimum	Maximum	Units	Time (s)
Total Deformation	2.7053	23.352	mm	10.
Equivalent Stress	0.18994	27948	MPa	10.
Equivalent Elastic Strain	1.8089e-006	0.14823	mm/mm	10.
Life	0.	1.e+006	Units Unavailable	0.
Total Deformation5	1000.	1.e+032	Units Unavailable	0.
Safety Factor	3.0843e-003	15.	Units Unavailable	0.

7. RESULTS

After the designing of new flywheel modal with 146 teeth is constructed by solid works in contrary to existing flywheel with 152 teeth. This two modals are set to analyzed by ANSYS software for Modal analysis and Static structural analysis.

In modal analysis both models are analyzed for vibrations at various frequencies and loads, after the analysis the results for both models are obtained and shown in below table 4. As the results clearly shown in the below table are deformations and vibrations are lower in newly designed modal with 146 teeth compared to existing 152 teeth flywheel.

7.1. Total Deformation for MODAL ANALYSIS

	Model 1		Model 2	
Modes	Total Deformations Mm	Frequency Hz	Total Deformations Mm	Frequency Hz
1	26.403	532.39	26.37	531.78
2	26.435	534.09	26.412	533.09
3	18.595	782.16	18.568	781.42
4	17.531	1081.7	17.519	1081
5	28.835	1099.3	28.807	1098.2
6	28.82	1099.4	28.806	1098.3
7	21.12	2594.1	31.089	2591.7
8	31.348	2604.6	31.331	2602.2

Table 5. Resultant Deformations

In static structural analysis the both models are analyzed for von-misses stresses and deformations at various loads so the results are obtained after the analysis are shown in below table 5. As the results clearly shown in the table that von-misses stresses and deformations are lower for newly designed 146 teeth flywheel compared to existing flywheel with 152 teeth. So the overall damage for new flywheel is low compared to existing flywheel it indicates the life increment of flywheel.

7.2. TOTAL DEFROMATION OF STATIC STRUCTURAL

Modal 1		
Types	Units	Maximum
Total Deformation	Mm	23.352
Equivalent Stress	MPa	27948
Equivalent Strain	Mm/Mm	0.14823
Life	Hours	1000000
Damage	Positions	1000
Safety Factor	No nits	0.0003084

Modal 2		
Types	Units	Maximum
Total Deformation	Mm	23.35
Equivalent Stress	MPa	24992
Equivalent Strain	Mm/Mm	0.1322
Life	Hours	1000000
Damage	Positions	1000
Safety Factor		0.0003449

Table 6. Total Deformation and Stress a Moment 10

8. COCLUSION

It is here considered in this project to discover the change made in fly wheel by variation of teeth. In this project here consider a fly wheel of 152 teeth and later re designed to 146 teeth and stresses, vibrations and deformations are compared in both modals. In this process ANSYS is used to compare stresses, vibrations and deformations as the observation made during the structural analysis is that when teeth of flywheel are reduced results in less red color area. Change of flywheel teeth also results in stress, vibrations and deformations hence this change increases the life of flywheel.

Static structural analysis and Modal analysis are done through ANSYS software for low head FLY WHEEL sprinter. Von-misses stresses created at the sprinter cutting edges are greatest at joints between the center point and sprinter sharp edge. So the von misses stresses and deformations are reduced it is being recorded in results tables by performing the static structural analysis for 146 teeth flywheel compared to existing 152 teeth flywheel. The modal analysis demonstrates no reverberation(vibrations) in any of the four mode shapes. The regular recurrence of all mode shape does not coordinate with the common recurrence of the sprinter sharp edge. Hence vibrations and distortions are slightly reduced it is found by performing modal analysis for 146 teeth flywheel compared to existing 152 teeth flywheel.

ACKNOWLEDGEMENT

We wish to express our sincere thanks to **Dr. H.S SAINI**, Managing Director, GuruNanak Institutions and **Dr. KODUGANTI VENKATA RAO**, Director, Guru Nanak Institutions Technical Campus, School of Engineering and Technology, for providing us with all the necessaryfacilities and their support.

We place on record, our sincere thanks to **Dr. A. RAJ KUMAR,** Professor and Head of the Department, Mechanical Engineering for their wholehearted co-operation, providing excellent lab facility, constant encouragement and unfailing inspiration.

We would like to say sincere thanks to **MR.V.SHYAMU,** Assistant Professor, Department of Mechanical Engineering for coordinating Projects.

We would like to say sincere thanks to our guide **Mr.P.SHEKAR REDDY** , Associate Professor, Department of Mechanical Engineering for Coordinating Projects for the suggestions and constant guidance in every stage of the project, we also like to thank all our lecturers helping us in every possible way. On a more personal note, we thank our beloved parents and friends for their moral support during our project.

9. REFERENCES

1. "Flywheels move from steam age technology to Formula 1"; Jon Stewart | 1 July 2012, retrieved 2012-07-03
2. "Breakthrough in Ricardo Kinergy 'second generation' high-speed flywheel technology"; Press release date: 22 August 2011. retrieved 2012-07-03
3. http://www.popularmechanics.com/technology/engineering/news/10-tech-concepts-you-need-to-know-for-2012-2
4. Lynn White, Jr., "Theophilus Redivivus", Technology and Culture, Vol. 5, No. 2. (Spring, 1964), Review, pp. 224–233 (233)
5. Lynn White, Jr., "Medieval Engineering and the Sociology of Knowledge", The Pacific Historical Review, Vol. 44, No. 1. (Feb., 1975), pp. 1–21 (6) (page 10, accessed 1 Dec 2011, Moment of inertia tutorial
6. "Flywheels: Iron vs. Steel vs. Aluminum". *Fidanza Performance*. Retrieved 6 October2016.
7. *Ashby, Michael (2011). Materials Selection in Mechanical Design (4th ed.). Burlington, MA: Butterworth-Heinemann. pp. 142–146.* ISBN 978-0-08-095223-9.
8. *Totten, George E.; Xie, Lin; Funatani, Kiyoshi (2004). Handbook of Mechanical Alloy Design. New York: Marcel Dekker*. ISBN 0-8247-4308-3.
9. *Kumar, Mouleeswaran Senthil; Kumar, Yogesh (2012).* "Optimization of Flywheel Materials Using Genetic Algorithm" *(PDF). Acta technical Corviniensis-Bulletin of Engineering*. Retrieved 1 November 2015.
10. https://www.calnetix.com/vdc-kinetic-energy-storage-systems

11. "Flywheel Energy Calculator". *Botlanta.org.2004-01-07*. Retrieved 2010-11-30."energy buffers". *Home.hccnet.nl*.Retrieved 2010-11-30.
12. "Message from the Chair | Department of Physics | University of Prince Edward Island". *Upei.ca*. Retrieved 2010-11-30.
13. "Density of Steel". *Hypertextbook.com. 1998-01-20*. Retrieved 2010-11-30.
14. Flywheel Rotor and Containment Technology Development, FY83. Livermore, Calif: Lawrence Livermore National Laboratory, 1983.p.