IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

DESIGN AND OPTIMIZATION OF PETROL ENGINE FLYWHEEL FOR VARIABLE SPEEDS

Dr. K. Mothilal [1], Mr. Korra Lokesh [2]
[1] Head & Associate Professor, [2] M.Tech Student, Dept. of Mechanical Engineering,
Ellenki College of Engineering and Technology (Autonomous), Patelguda(V), Ameenpur (M),
Sanga Reddy, Telangana, India

Abstract: *The flywheel in a machine function as a reservoir, storing energy and releasing it when the supply of energy is insufficient to meet the demand. Four-stroke engines do not produce any energy during the suction, compression, or exhaust strokes, whereas I.C. engines only produce energy during the power stroke, which is far more than the engine load. When no energy is produced during the other strokes, the crankshaft rotates at a steady speed because the flywheel absorbs the excess energy produced during the power stroke and transfers it to the crankshaft. The two-purpose flywheel is situated on one end of the crankshaft. First, the inertia of each cylinder reduces vibration by smoothing out the power stroke as it fires. Secondly, the engine is fastened to the mounting surface in order to sustain its weight. A multi-cylinder gasoline engine's flywheel will be developed using the different speeds, and the results will be analysed to make improvements. The computations are then used to draft a 2D drawing. Catia is a 3D modelling program used to create a parametric model of the flywheel. Additionally, the forces operating on the flywheel are computed. Using the analysis program Ansys to apply forces to the flywheel validates its strength. Cast iron and aluminum alloy are the two materials examined in order to compare the outcomes. Catia is the industry standard for 3D product design. A complex system can be numerically broken down into extremely tiny units, known as elements, of a user-specified size using finite element analysis. Ansys is a general-purpose software program for finite element analysis (FEA).*

I- INTRODUCTION

Flywheel

The engine's inertia is provided by the flywheel, a disc composed of cast iron, aluminium, or zinc that is mounted at one end of the crankshaft. An object is considered to have inertia if it stays in its state of rest or uniform motion until it is acted upon by an external force. Inertia is a property of matter, not a force.

Fig 1.1: Flywheel

At specific points throughout a reciprocating engine's operation, combustion takes place. In order to keep the engine from losing speed and possibly stopping its rotation between combustion intervals, the flywheel provides the necessary inertia. Variations in force and speed in an internal combustion engine impact the crankshaft, flywheel, and other engine parts with each stroke. In a four-stroke engine, the piston and connecting rod assembly suddenly move during the power event, swiftly accelerating the crankshaft. The flywheel's resistance to acceleration helps to even out some of the force and rpm variations. The engine as a whole is dampened by the flywheel's inertia, which balances off radial acceleration forces and rpm variations generated by the engine.

1.1 What does a flywheel do?

The torque converter or flywheel (harmonic balancer). The crank throw for a given cylinder accelerates as it fires. A twist is created when the remainder of the crankshaft starts to lag a little. This results in torsional vibrations, which the vibration damper either dampens or partially absorbs. cause comparable changes in its speed; the flywheel's function is to lessen these variations by holding onto energy while the crankshaft speeds up and releasing it when the shaft slows down. The flywheel resists any sudden change in crankshaft (engine) speed. Consequently, when a power impulse starts (with its first high pressure), the crankshaft gets a quick, strong push (via the connecting rod and crankshaft). The flywheel, however, opposes the crankshaft's propensity to advance. The engine runs smoothly by counteracting the short power surges.

Things continue to move smoothly thanks to the fly wheel. It also helps with the engine's power characteristics. The engine can "rev" more freely with a lightweight fly wheel, but it will tick over lumpily at low rpm.

1.2 Physics of Flywheels

The flywheel is always dynamically connected to the piston rod, as far as I'm aware. However, in electrical setups, the flywheel is on the rotor shaft to maintain momentum, therefore there is no piston. For instance, I had an ancient three-phase electrical generator with a large fly wheel that helped to maintain it and stabilize the rpm when the load changed. As far as I'm aware, the flywheel should always be as close to the crankshaft pistons or the dynamic load as possible, even in odd and creative circumstances, to minimize the impacts of independent gyroscopic masses, particularly in an automobile.

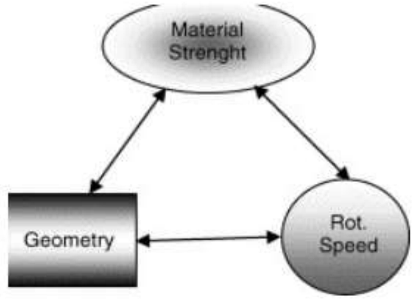
II - LITERATURE SURVEY

A literature review is an assignment of earlier work by certain writers and the gathering of data or information from research papers published in journals in order to further our goal. It enables us to pick up fresh notions and ideas. When determining the project's concept, some of the numerous previous works on the same topic are taken into consideration. Using flywheels to store energy more effectively than rechargeable chemical batteries while also offering some control advantages has been the aim of mission important technology projects in recent years. Since ancient times, flywheels have been acknowledged as a basic method for storing energy in a revolving mass.

2.1. Detail History

Imafidon A. Lawani and John A. Akpobi presented computer-aided design of flywheel software in 2005. They made use of object-oriented programming in Visual Basic. The software was developed using the various flywheel designs (rimmed or solid). Using the software's graphical features, the solutions were displayed. This study outlines some of the numerical examples that were used to evaluate the software's effectiveness. Dr. A. Stodola's 1917 English translation of his thesis is one of the first modern dissertations on the theoretical stress limitations of spinning discs. The development of improved flywheels began in the 1970s. Revolving wheels have been used for energy storage and delivery since prehistoric times. With a 4,000-year history, the potter's wheel may have been the first device that resembled a flywheel. The word "flywheel" was first used in 1784, during the industrial revolution.

S. H. Salter emphasized in this piece how simple it is to construct a machine that will react forcefully to the movement of ocean waves. Making one that won't is actually very difficult. Slow, unpredictable, reversing energy flows with extremely high extreme values are more difficult to transform into phase-locked synchronous electricity with a power quality that a utility network can withstand. This research outlines potential conversion equipment for high-pressure water and oil and low-pressure air after a variety of control systems with different levels of complexity. If waves were to be employed on underdeveloped island networks, they would benefit from some form of energy storage, just as many other renewable energy sources.



- **Material strength:**

Stronger materials can essentially withstand high operational loads and, as a result, can be rotated at high speeds, which increases their energy storage capacity.

- **Rotational speed:**

Directly regulates the amount of energy retained; higher speeds result in greater energy savings; however, high speeds during shaft design place undue stress on the flywheel and bearings.

- **Geometry:**

regulates the flywheel's specific energy, or kinetic energy storage capacity. In any optimization section, the overall shaft/bearing loads and the likelihood of material failure can be decreased by significantly increasing the kinetic energy storage capacity.

III - OBJECTIVES AND METHODOLOGY

This project's goal is to successfully build a flywheel design for a gasoline engine with variable speeds. This technique must be practical, straightforward, and dependable. Giving the car engine a design for unbanked bends is the goal of this flywheel mechanism project. Because a direct gearbox system experiences substantially less side force on the flywheel at varied speeds than an engine occupying a position, this technology is also expected to improve engine comfort. Instead of designing every component from scratch, the technique opted to utilise existing and standard components. The benefit of this approach is that since each component has already demonstrated its value in practical situations, you don't need to waste excessive amounts of time testing its integrity. The design was first taken from an existing flywheel and modified somewhat to fit our needs. The mechanism was initially developed based on the engine's ability to lift and lower each wheel of the vehicle.

3.1 Summary of capabilities

It is always evolving to include new features, just like any other software. The information below aims to provide an overview of the product's capabilities rather than providing detailed information on each feature. The three primary categories of engineering design, analysis, and manufacturing can be used to categorise the product's capabilities. Following that, this data is recorded in either the ASME Y14.41-2003 3D drawing standard or a normal 2D production drawing.

3.2 Engineering Design

To make it easier to create a thorough digital model of the object being designed, Catia Elements offers a range of tools. In addition to the generic geometry tools, geometry can be generated for other integrated design disciplines, such as comprehensive wiring definitions and standard and industrial pipe work. There are also resources available to support cooperative development. With the help of several idea design tools that provide Industrial Design concepts up front, the product can subsequently be engineered downstream. Detailed freeform surface tools, point cloud-based reverse engineering, and imaginative industrial design sketches are a few examples.

3.3 Analysis

Thermal, static, dynamic, and fatigue FEA analysis are among the many analytical techniques offered by Ansys Elements, which are all intended to aid in product development. These tools include design optimisation, mould flow, manufacturing tolerance, and human factors. To determine the ideal design dimensions, the design optimization can be used at the geometry level in tandem with the FEA analysis.

IV - DESIGN TERMINOLOGY OF FLYWHEEL

A flywheel is one device that can be used to store inertial energy. In addition to collecting mechanical energy, this device serves as a reservoir, releasing energy when demand outpaces supply and storing it when supply does.

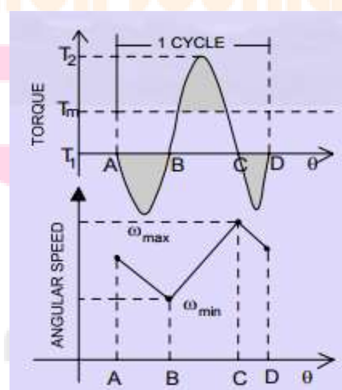


Fig 4.1: Flywheels-Function

The torque time function varies during the cycle in many machines due to load patterns. One or two cylinder internal combustion engines are a common example. Other systems with fly wheels include rock crushers, punch presses, and piston compressors.

4.1 Design Approach

A flywheel is designed in two steps. It is necessary to first establish the energy needed to achieve the desired level of smoothing and the (mass) moment of inertia required to absorb that energy.

4.2 Design Parameters

The required flywheel inertia (size) is closely correlated with the permissible speed variations.

4.3 Equation of energy stored in a flywheel

The mass's moment of inertia and angular velocity determine how much kinetic energy a flywheel can store.

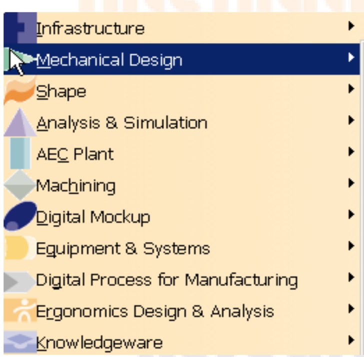
Below is the relationship.
The angular velocity is ω.
About the centre of rotation, I is the mass's moment of inertia.
Regarding a solid cylinder
For an empty, thin-walled cylinder
For an empty, thick-walled cylinder
r = radius and m = flywheel mass

V - DESIGN METHODLOGY OF PETROL ENGINE FLYWHEEL

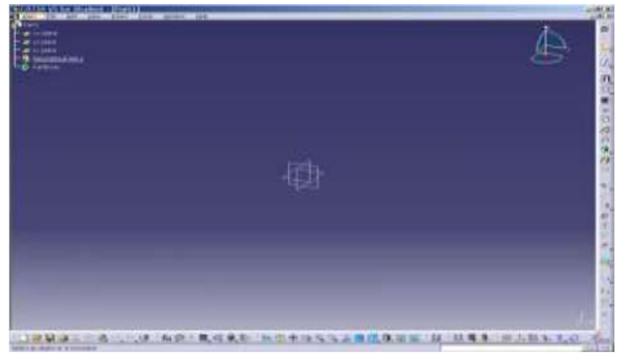
5.1 Introduction to CATIA

A French company called Dassault Systems developed the multi-platform commercial software suite called CATIA (Computer Aided Three-dimensional Interactive Application) for CAD, CAM, and CAE. Dassault Systems' C++ programming language is used to create CATIA, the core of their product lifecycle management software suite.

.

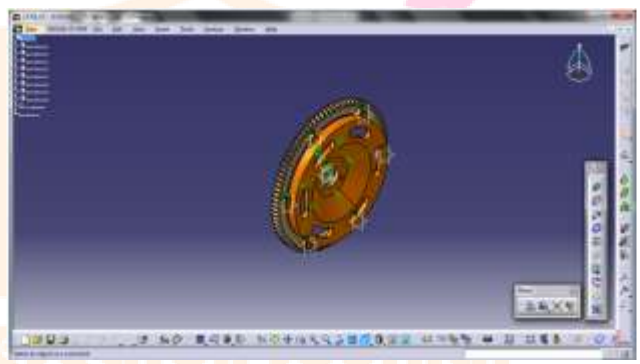


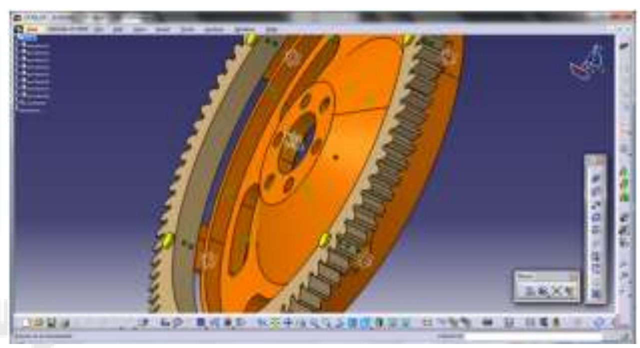
Workbench sets can be assembled based on user preferences. Consequently, three distinct software installation versions are available from Dassault Systems. When less functionality is required or for training sessions, the platform P1 is utilised. It has the bare minimum of functionalities. P2 is the right platform for work that is process-oriented. In addition to basic design features, it facilitates analysis tools and production-related operations. The incorporation of external software packages is one of the special advanced scopes that P3 includes.



5.4 Modeling of Petrol Engine Flywheel in CATIA V5

Using CATIA V5, this gasoline engine flywheel was made. Several industries, including consumer goods, automotive, aerospace, and heavy engineering, use this program. It is a very powerful program for CATIA Version 5 applications, including part and assembly design, and for making complex 3D models. Below are the exact same CATIA V5 R20 2D sketch model and 3D model for reference. Dimensions are derived from. The following software is used for testing, while CATIA V5 is utilised to create the 3D model.





5.5.3 Assembly Modeling of Petrol Engine

Flywheel

Using restrictions, coincidence, contact, offset, angle, fix component, flexible, manipulation, etc., all of the components are put together in this modelling.

Manipulate: With the use of this command, the component can be turned, rotated, or otherwise manipulated in any direction that is necessary or appropriate constraints can be applied.

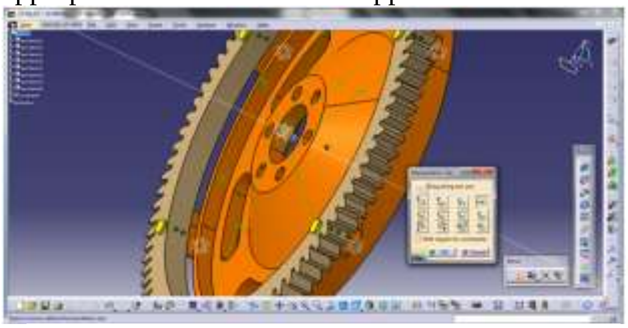


Fig: 5.16: Using Manipulate Command

Multi View: This command allows all of the component or model views to be shown on the screen simultaneously and allows editing of them under the workbench.

Fig: 5.17: Using Multi View Command

VI - ANALYSIS OF PETROL ENGINE FLYWHEEL FOR VARIABLE SPEEDS

6.1 Procedure for FE Analysis Using ANSYS:

ANSYS is used for the flywheel analysis. In order to compete, assembly is not necessary; instead, moments must be applied at the rotational location along the axis that we must specify. The bottom legs are the fixation place.

6.2 Preprocessor:

The following actions were taken at this stage:
File import in the ANSYS window
File Menu > Import> STEP > Click "OK" to open the dialogue window. Select the file saved from CATIAV5R20 by clicking "Browse." To import the file, click "OK."

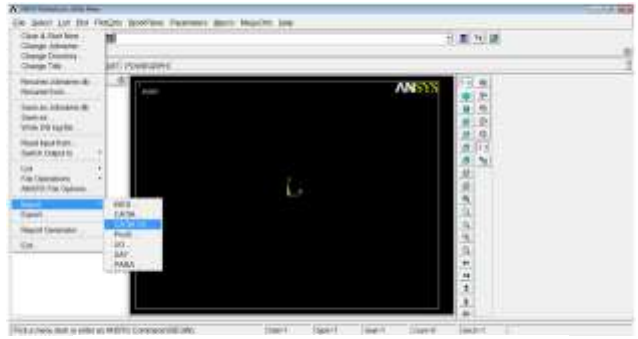


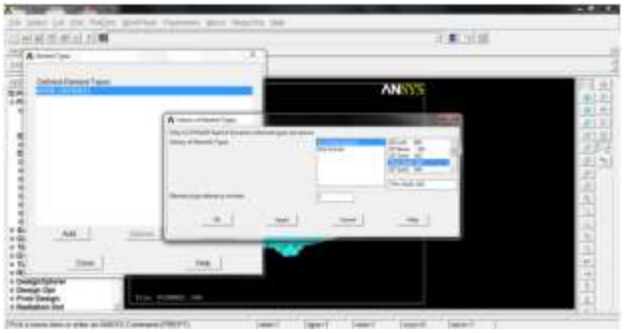
Fig.6.1: Import panel in Ansys

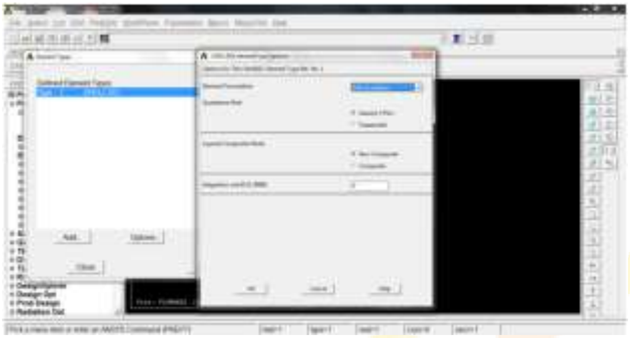
6.2.1 Meshing:

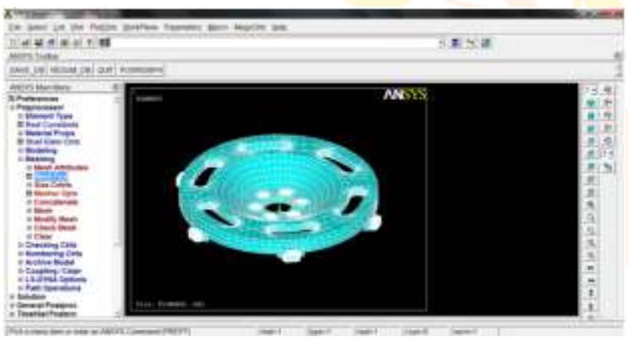
Common applications include computational fluid dynamics and finite element analysis, which are rendered to a computer screen. Although the input model form can take many different forms, CAD, NURBS, B-rep, and STL (file format) are frequent sources. With contributions from computer science, engineering, and mathematics, the topic is extremely interdisciplinary. For finite element analysis, three-dimensional meshes must be made out of tetrahedra, pyramids, prisms, or hexahedra. They can be any polyhedral and are utilised for the finite volume approach. Finite difference approaches often require multi-block structured meshes, which are piecewise organised arrays of hexahedra. Its meshing tools cover almost every aspect of physics.

6.3 Analysis Procedure of Flywheel:

The tetrahedral element's quadratic displacement behavior makes it ideal for representing irregular meshes, such as those created by various CAD/CAM applications.







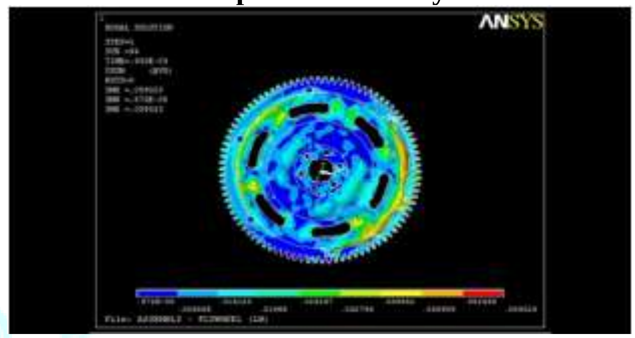
6.4 Meshed View of Flywheel:

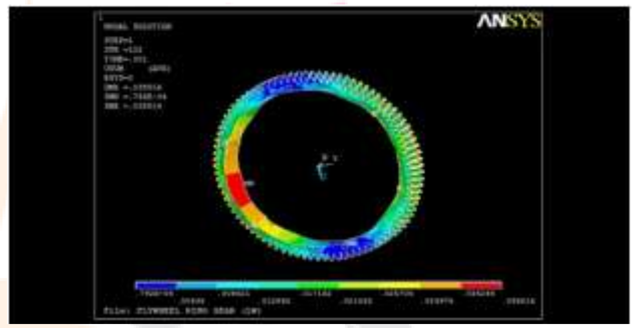
As seen above, flywheels are assembled with neighboring components after being modelled using an element. Rotational force analysis is used to check the stress and displacements during rotation in a few components. Following the completion of meshing each assembly component, analysis based on OEM (Original Equipment of Manufacturer) application is conducted.

VII - DISCUSSION ON ANALYSYS RESULT

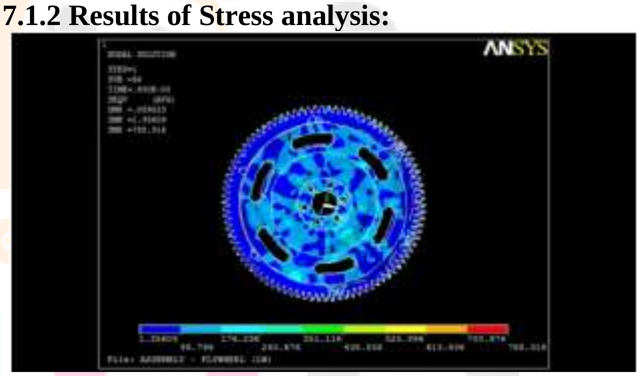
7.1 Structural Analysis Results for Flywheel:

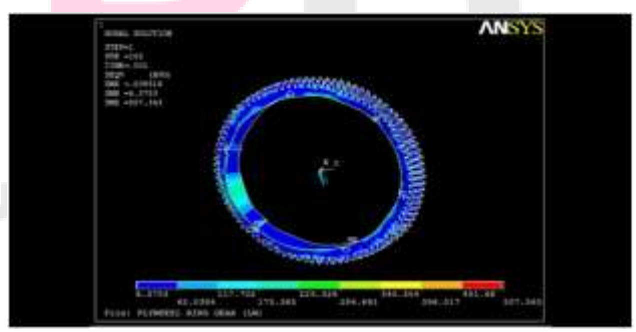
7.1.1 Results of Displacement Analysis:



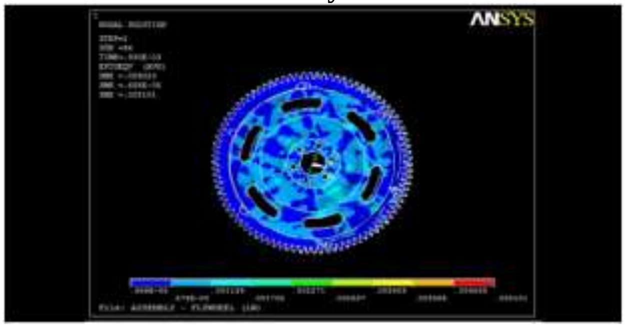


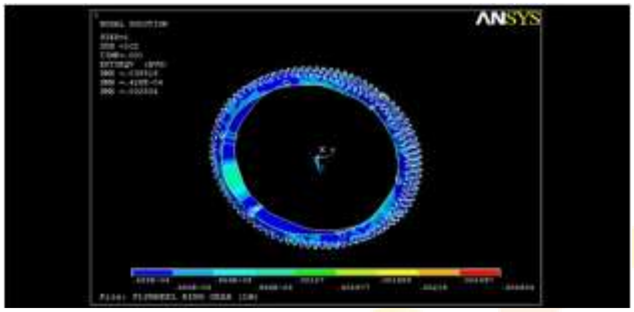
7.1.2 Results of Stress analysis:





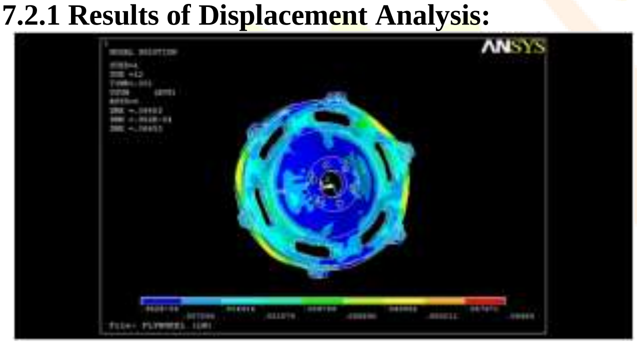
7.1.3 Results of Strain analysis:

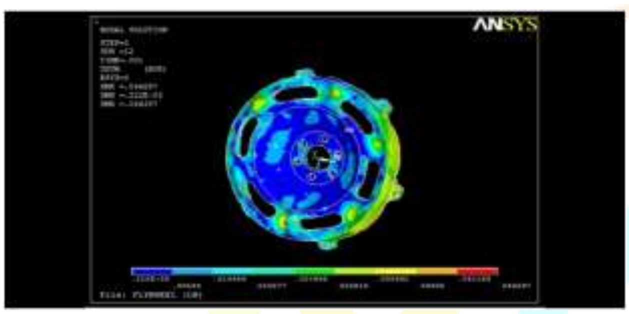


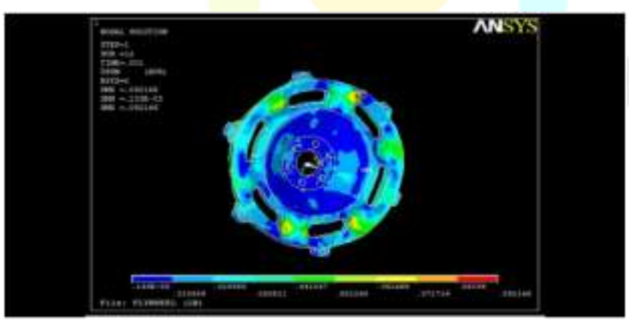


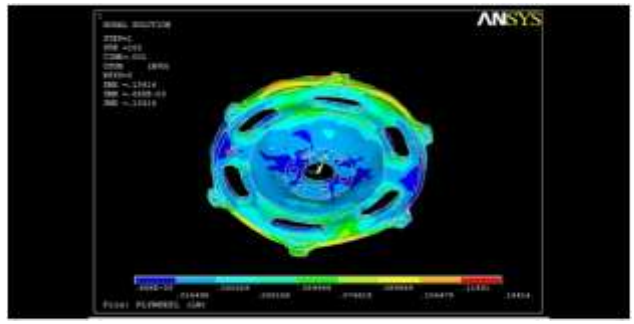
7.2 Dynamic Analysis Results for Flywheel:

7.2.1 Results of Displacement Analysis:

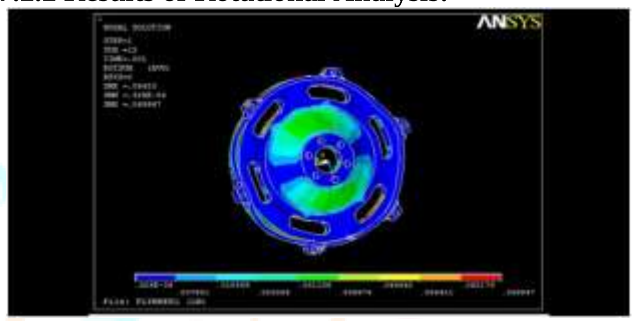


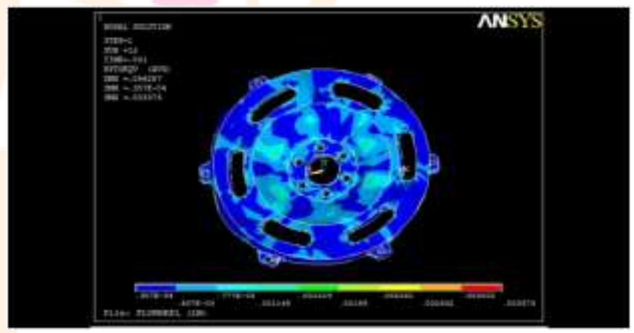


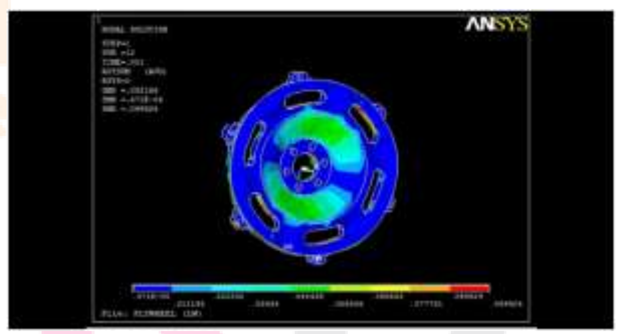


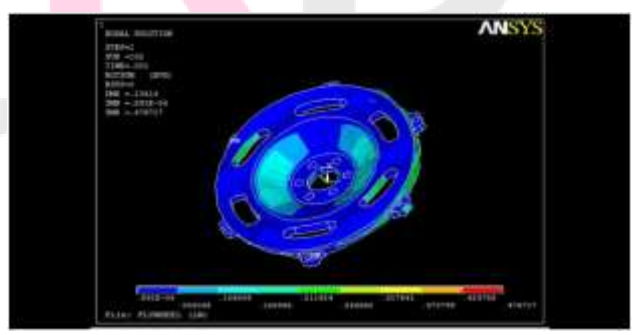


7.2.2 Results of Rotational Analysis:

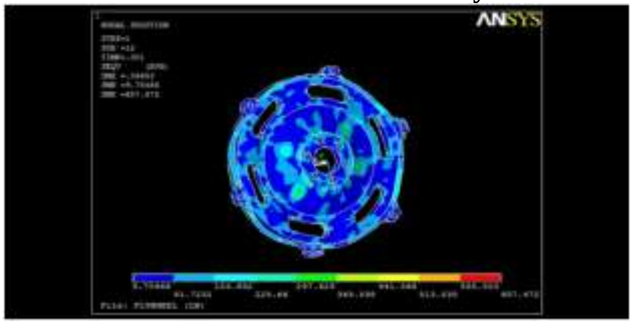


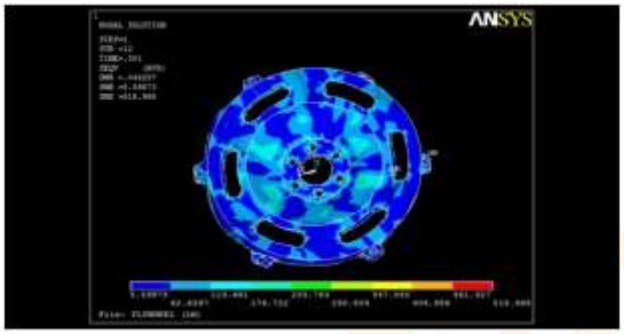


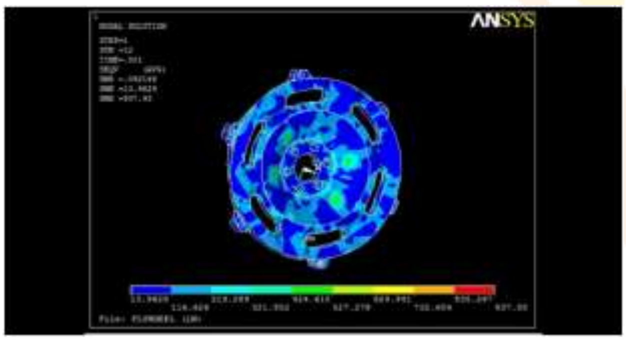


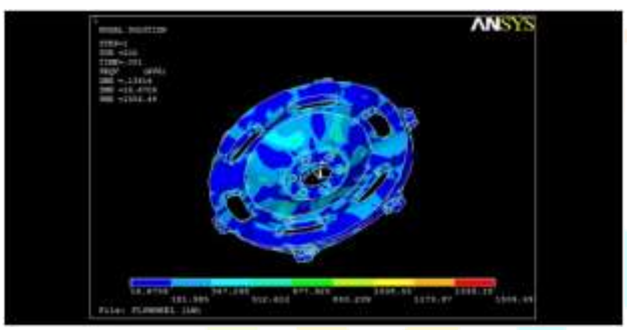


7.2.3 Results of Von Mises Stress Analysis:

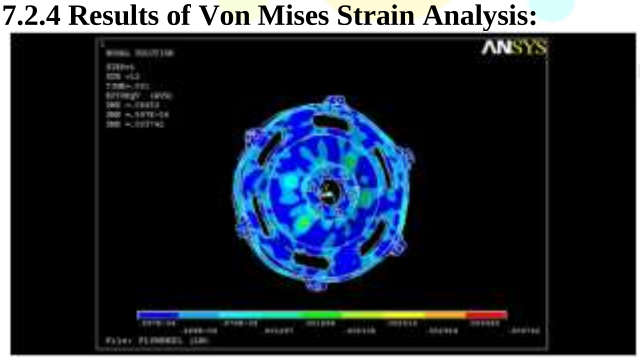


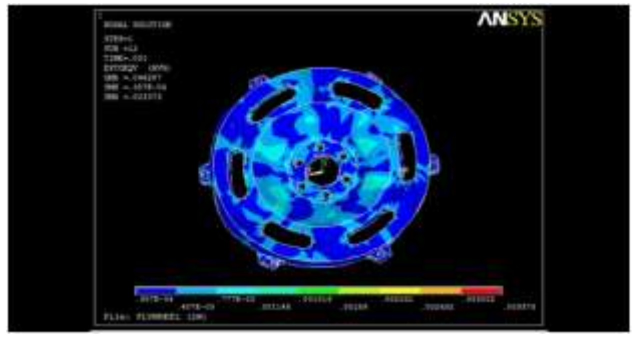


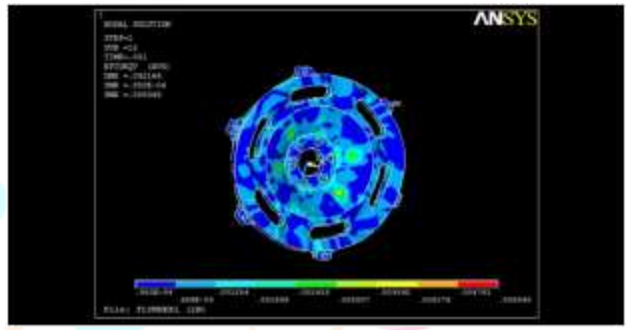


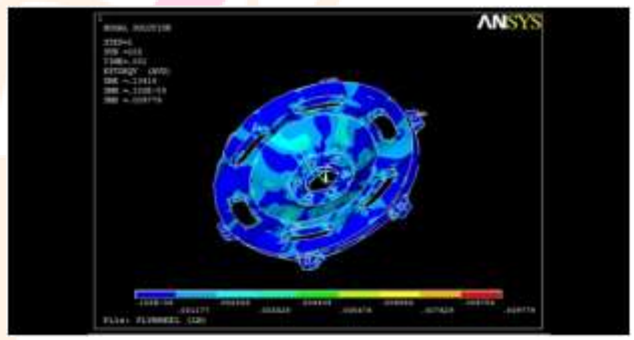


7.2.4 Results of Von Mises Strain Analysis:









VIII - CONCLUSION

The result above shows that our goal was to determine what happened to the flywheel of a gasoline engine with variable speed when loads fell on it. The design has worked well.

Structural Analysis

S. No	Results	Flywheel Assembly	Flywheel Ring Gear
01	Displacement (mm)	0.59023	0.38516
02	Stress (MPa)	788.316	507.343
03	Strain (MPa)	0.005101	0.002804

The flywheel assembly and ring gear displacements are relatively small, as can be seen in the above pictures, which demonstrate how the flywheel's whole assembly design is meshed and solved using Ansys. These demonstrate to us the obvious slight displacement of every component in the assembly. There is stress where it should be (minimum stress that is tolerable). Below the yield point, the values are extremely low in relation to the yield values. The fixed position is where the designed model's strain is located.

Dynamic Analysis

Results	**CI – 3500**	**Al – 3500**	**CI – 10000**	**Al – 10000**
Displacement (mm)	0.06453	0.04628	0.09216	0.1341
Displacement Rot. (mm)	0.069947	0.00337	0.09992	0.4767
Von Misses Stress (MPa)	657.472	518.968	937.93	1504.4
Von Misses Strain (MPa)	0.003742	0.00337	0.00534	0.0097

In analysis as well, the flywheel design in the gasoline engine with variable speed mechanism operated flawlessly. All of these facts strongly suggest that we have achieved our goal.

REFERENCES

- Janse van Rensburg, P.J. "Energy storage in composite flywheel rotors". University of Stellenbosch.
- Jump up rosseta Technik GmbH, Flywheel Energy Storage, German, retrieved February 4, 2010.
- Zhang Da-lun, Mechanics of Materials, Tongji University Press, Shanghai, 1993
- Huang Xi-kai, Machine Design, Higher Education Press, Beijing, 1995
- Engineering Fundamentals of the Internal Combustion Engine by Willard W. Pulkrabek
- MARK'S Calculations for mechanical design by Thomas H. Brown
- K. Lingaiah, Machine Design Data Handbook, McGraw-Hill Inc, New York, 1994
- R. S. Khurmi, J. K. Gupta, Machine Design, Eurasia Publishing House, New Delhi, 1993
- ANSYS User's Manual, Swanson Analysis Systems, Inc., Houston
- N.K. Giri-Automobile Mechanics. Khanna publications
- Design Data Handbook by Jalaludeen, Anuradha Publications, 2004, ISBN 8187721626, 9788187721628.
- Ritesh Krishna Kumar, Toms Philip, "Analysis ofan Arm Type Rotating Flywheel", International Conference on Advanced Technology and Science (ICAT'14).
- M. Dhengle, Dr. D. V. Bhope, S. D. Khamankar," Investigation of Stresses in Arm Type Rotating Flywheels". International Journal of Engineering Science and Technology (IJEST).
- Sudipta Saha, Abhik Bose, G. Sai Tejesh, S.P. Srikanth, "Computer Aided Design & Analysis on Flywheel for Greater Efficiency". International Journal of Advanced Engineering Research and Studies. E-ISSN2249–8974
- S.M. Choudhary, D.Y. Shahare, "Design Optimization of Flywheel of Thresher Using FEM", International Journal of Emerging Technology and Advanced Engineering, IJETAE, ISSN 2250-2459, volume 3, issue 2, February 2013.
- Engineering mechanics Statics by R.C. Hibbler.
- Akshay P. Punde, G.K. Gattani." Analysis of Flywheel", International Journal of Modern Engineering Research (IJMER), ISSN: 2249-6645, Vol.3, Issue.2, March-April 2013
- Automotive Production Systems and Standardization by WERNER.
- Jump up, "Breakthrough in Ricardo Kinergy 'second generation' high-speed flywheel technology"; Press release date: 22 August 2011. retrieved 2012-07-03
- Mechanical Engineering Design by Budynas – Nisbett.
- Rajamani R Vehicle Dynamics and control
- Robert L. Norton, Design of Machinery, McGraw-Hill Inc, New York, 1992
- Automotive Engineering by Patric GRANT.
- "Flywheels move from steam age technology to Formula 1"; Jon Stewart 1 July 2012, retrieved 2012-07- 03
- Sushama G Bawane1, A P Ninawe1 and S K Choudhary, "Analysis and Optimization of Flywheel", International Journal of Mechanical Engineering and Robotic Research, ISSN 2278 – 0149, Vol. 1, No. 2, July 2012.