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Design and Analysis of Flywheel for Different Material using Ansys

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Abstract: A flywheel used in machines serves as a reservoir which stores energy during the period when the supply of energy is more than the requirement and releases it during the period when the requirement of energy is more than supply. For example, in I.C. engines, the energy is developed only in the power stroke which is much more than engine load, and no energy is being developed during the suction, compression and exhaust strokes in case of four stroke engines. The aim of the project is to design a flywheel for a multi cylinder petrol engine flywheel using the empirical formulas. A parametric model of the flywheel is designed using 3D modeling software CATIA V5R20. The strength of the flywheel is validated for alloy materials (Silicon carbide) by applying the rotational velocity on the flywheel in analysis software ANSYS. Structural analysis is used to determine whether flywheel withstands under working conditions.

Keywords: Flywheel, Ansys, Design,

I. INTRODUCTION

In this chapter, basic introduction of flywheel, their role in machines to get desired outputs like moment of inertia, energy fluctuations, torque, etc.., with respect to corresponding inputs will explained. Based on the dynamic functions, specifications of the system the main features of the flywheel is initially determined, the detail design study of flywheel is done .Then more and more designs in diverse areas of engineering are being analyzed through the software. FEA provides the ability to analyze the stresses and displacements of a part or assembly, as well as the reaction forces to other elements are imposed. This thesis guides the path through flywheel design and analysis to the material selection process. The FEA model is described to achieve a better understanding of the mesh type, mesh size and boundary conditions applied to complete an effective FEA model. At last the design objective could be simply to minimize cost of flywheel by reducing material or control the fluctuations of flywheel.

The internal combustion engine is an engine in which the combustion of a fuel (normally a fossil fuel) occurs with an oxidizer (usually air) in a combustion chamber. In an internal combustion engine the expansion of the high-temperature and –pressure gases produced by combustion applies direct force to some component of the engine, such as pistons, turbine blades, or a nozzle.

II. OBJECTIVE

- To study the stress induced in the engine flywheel..
- FEM Modeling of Flywheel
- Perform static structural Analysis using ANSYS.
- Consideration of flywheel model for shape optimization.
- Material replacement

III. ABOUT FLYWHEEL

A **flywheel** is a mechanical device specifically designed to efficiently store rotational energy. Flywheels resist changes in rotational speed by their moment of inertia. The amount of energy stored in a flywheel is proportional to the square of its rotational speed. The way to change a flywheel's stored energy is by increasing or decreasing its rotational speed by applying a torque aligned with its axis of symmetry,

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Common uses of a flywheel include:

Smoothing the power output of an energy source. For example, flywheels are used in reciprocating engines because the active torque from the individual pistons is intermittent.

Energy storage systems

Delivering energy at rates beyond the ability of an energy source. This is achieved by collecting energy in a flywheel over time and then releasing it quickly, at rates that exceed the abilities of the energy source.

Controlling the orientation of a mechanical system, gyroscope and reaction wheel

Flywheels are typically made of steel and rotate on conventional bearings; these are generally limited to a maximum revolution rate of a few thousand RPM.[1] High energy density flywheels can be made of carbon fiber composites and employ magnetic bearings, enabling them to revolve at speeds up to 60,000 RPM (1 kHz).[2]

Carbon-composite flywheel batteries have recently been manufactured and are proving to be viable in real-world tests on mainstream cars. Additionally, their disposal is more eco-friendly than traditional lithium ion batteries.

IV. APPLICATION

Flywheels are often used to provide continuous power output in systems where the energy source is not continuous. For example, a flywheel is used to smooth fast angular velocity fluctuations of the crankshaft in a reciprocating engine. In this case, a crankshaft flywheel stores energy when torque is exerted on it by a firing piston, and returns it to the piston to compress a fresh charge of air and fuel. Another example is the friction motor which powers devices such as toy cars. In unstressed and inexpensive cases, to save on cost, the bulk of the mass of the flywheel is toward the rim of the wheel. Pushing the mass away from the axis of rotation heightens rotational inertia for a given total mass.

Modern automobile engine flywheel

A flywheel may also be used to supply intermittent pulses of energy at power levels that exceed the abilities of its energy source. This is achieved by accumulating energy in the flywheel over a period of time, at a rate that is compatible with the energy source, and then releasing energy at a much higher rate over a relatively short time when it is needed. For example, flywheels are used in power hammers and riveting machines.

Flywheels can be used to control direction and oppose unwanted motions, see gyroscope. Flywheels in this context have a wide range of applications from gyroscopes for instrumentation to ship stability and satellite stabilization (reaction wheel), to keep a toy spin spinning (friction motor), to stabilize magnetically levitated objects (Spin-stabilized magnetic levitation)

V. MATERIAL SELECTION

Flywheels are made from many different materials; the application determines the choice of material. Small flywheels made of lead are found in children's toys. Cast iron flywheels are used in old steam engines. Flywheels used in car engines are made of cast or nodular iron, steel or aluminum.[7] Flywheels made from high-strength steel or composites have been proposed for use in vehicle energy storage and braking systems.

The efficiency of a flywheel is determined by the maximum amount of energy it can store per unit weight. As the flywheel's rotational speed or angular velocity is increased, the stored energy increases; however, the stresses also

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increase. If the hoop stress surpass the tensile strength of the material, the flywheel will break apart. Thus, the tensile strength limits the amount of energy that a flywheel can store.

In this context, using lead for a flywheel in a child's toy is not efficient; however, the flywheel velocity never approaches its burst velocity because the limit in this case is the pulling-power of the child. In other applications, such as an automobile, the flywheel operates at a specified angular velocity and is constrained by the space it must fit in, so the goal is to maximize the stored energy per unit volume. The material selection therefore depends on the application.[8]

The table below contains calculated values for materials and comments on their viability for flywheel applications. CFRP stands for carbon-fiber-reinforced polymer, and GFRP stands for glass-fiber reinforced polymer.

VI. TABLE

1	Molecular formula	AL
2	Atomic Number	13
3	Element category	other metal sometimes considered a metalloid
4	Odor	Odourless
5	Standard atomic weight	26.9815385
6	Density	2.70 g•cm−3
7	Melting point	933.47 K, 660.32 ° C,
8	Boiling point	2743 K, 2470 ° C, 4478 ° F
9	Solubility in water	Insoluble
10	Solubility	insoluble in diethyl ether, practically insoluble in ethano
11	Thermal conductivity	237 W • m -1 • K-1
12	Young's modulus	70 GPa
13	Shear modulus	26 GPa
14	Bulk modulus	76 GPa
15	Micron size	200 mesh (74µm)
16	Poisson ratio	0.35

item	SiC	Fe2O3	F.C	proportion
I	≥97%	≤1.2%	≤0.3%	3.2g/cm3
II	≥90%	≤1.5%	≤0.5%	

VII. DESIGN OF FLYWHEEL

INTRODUCTION TO CATIA

CATIA is a robust application that enables you to create rich and complex designs. The goals of the CATIA course are to teach you how to build parts and assemblies in CATIA, and how to make simple drawings of those parts and assemblies. This course focuses on the fundamental skills and concepts that enable you to create a solid foundation for your designs

WHAT IS CATIA

CATIA is mechanical design software. It is a *feature-based*, *parametric solid modeling* design tool that takes advantage of the easy-to-learn Windows graphical user interface. You can create *fully associative* 3-D solid models with or without *constraints* while utilizing automatic or user-defined relations to capture *design intent*. To further clarify this definition, the *italic* terms above will be further defined:

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Feature-based

Like an assembly is made up of a number of individual parts, a CATIA document is made up of individual elements. These elements are called features.

When creating a document, you can add features such as pads, pockets, holes, ribs, fillets, chamfers, and drafts. As the features are created, they are applied directly to the work piece.

Features can be classified as sketched-based or dress-up

Sketched-based features are based on a 2D sketch. Generally, the sketch is transformed into a 3D solid by extruding, rotating, sweeping, or lofting.

Dress-up features are features that are created directly on the solid model. Fillets and chamfers are examples of this type of feature.

Solid Modeling:-

A solid model is the most complete type of geometric model used in CAD systems. It contains all the wireframe and surface geometry necessary to fully describe the edges and faces of the model. In addition to geometric information, solid models also convey their ―topology‖, which relates the geometry together. For example, topology might include identifying which faces (surfaces) meet at which edges (curves). This intelligence makes adding features easier. For example, if a model requires a fillet, you simply select an edge and specify a radius to create it.

Fully Associative:-

A CATIA model is fully associative with the drawings and parts or assemblies that reference it. Changes to the model are automatically reflected in the associated drawings, parts, and/or assemblies. Likewise, changes in the context of the drawing or assembly are reflected back in the model.

Constraints:-

Geometric constraints (such as parallel, perpendicular, horizontal, vertical, concentric, and coincident) establish relationships between features in your model by fixing their positions with respect to one another. In addition, equations can be used to establish mathematical relationships between parameters. By using constraints and equations, you can guarantee that design concepts such as through holes and equal radii are captured and maintained.

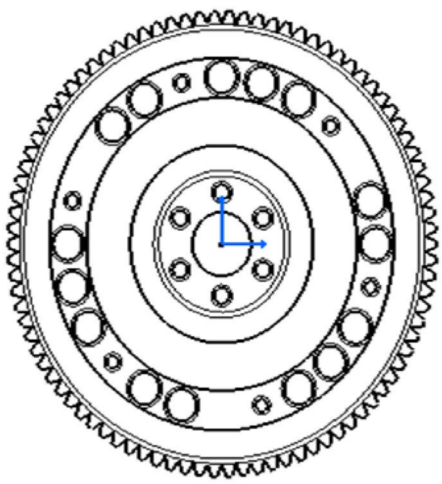

Figure 1

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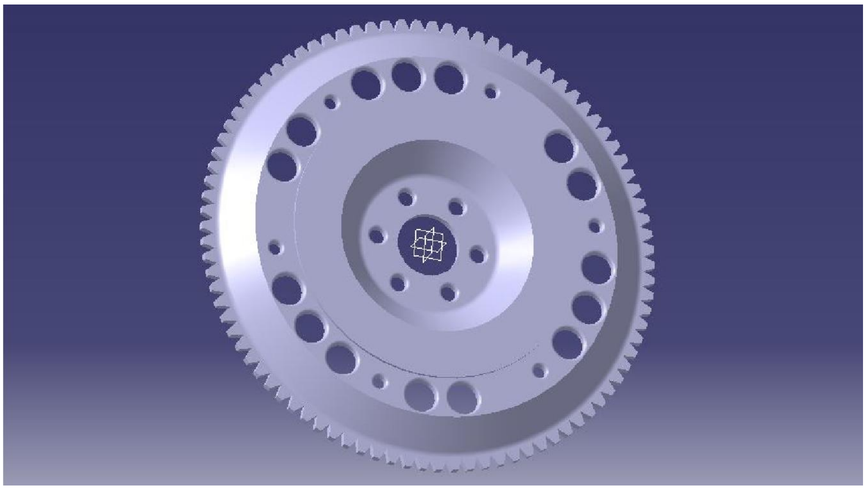

Figure 2

VII. RESULT

Steel

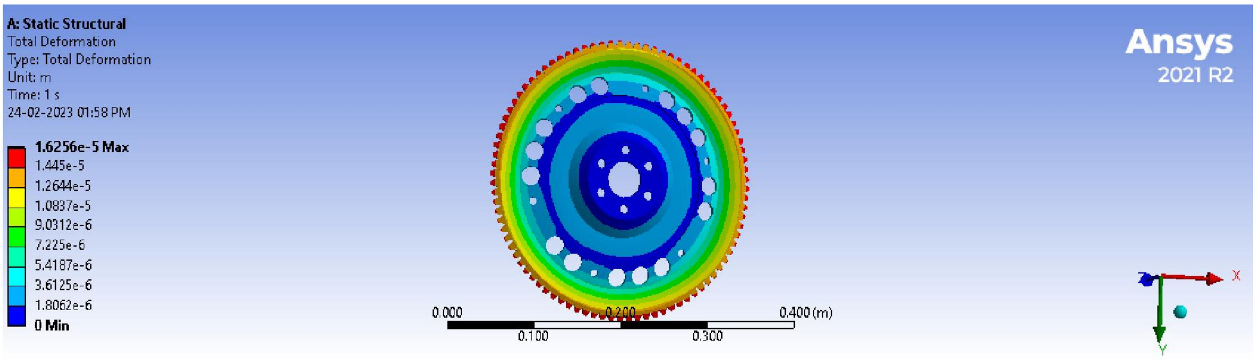

Fig. Total deformation of steel flywheel

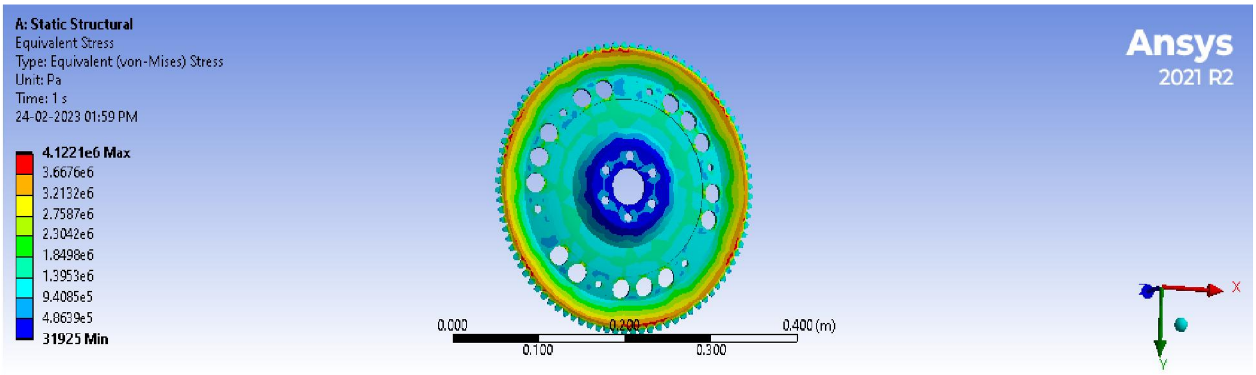

Fig. Equivalent stress of steel flywheel

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Aluminium

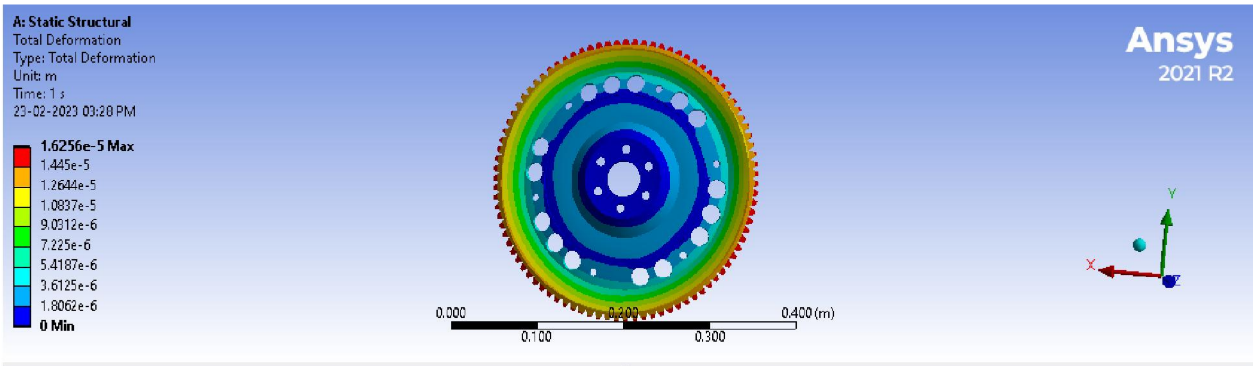


Fig. Total deformation of alumunium sic flywheel

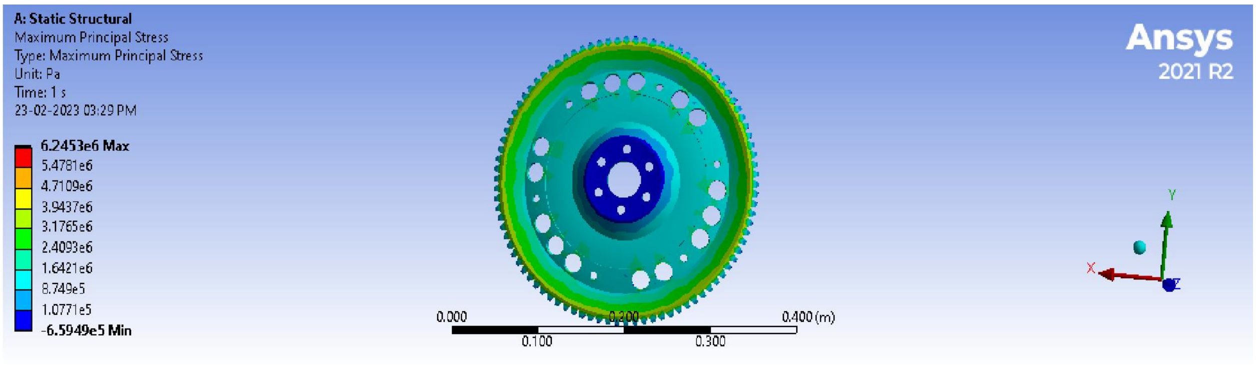
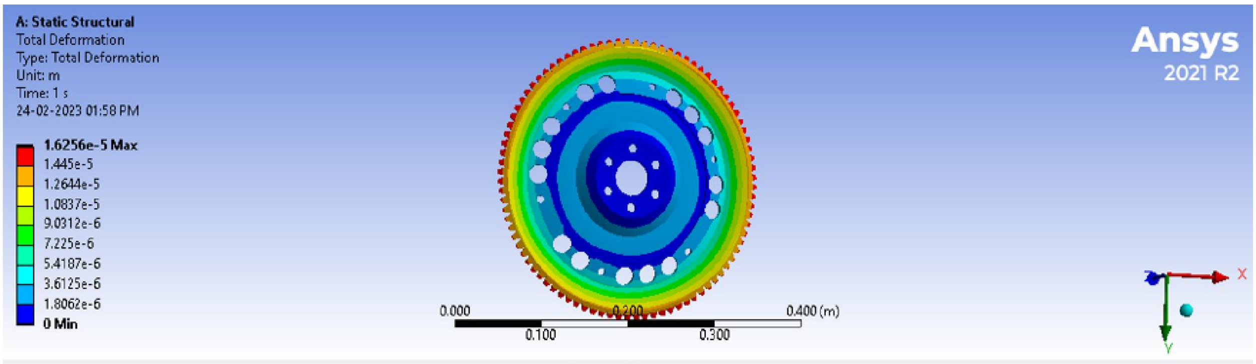
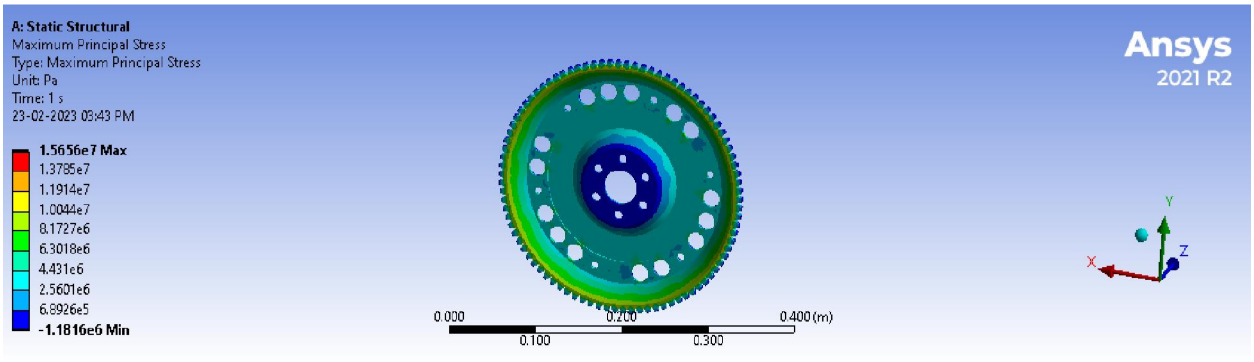


Fig. Maximum principal stress of alumunium sic flywheel

Cast iron



Total deformation of cast iron flywheel



Max principal stress of cast iron flywheel

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S. NO.	RESULTS	STEEL		ALUMINIM SILICON CARBIDE		GREY CAST IRON	
		MAX	MIN	MAX	MIN	MAX	MIN
1.	TOTAL DEFORMATION	1.6369E-5	0	7.2109E-6	0	2.70434E-5	0
2.	MAX PRINCIPAL STRESS	1.7302E7	-1.4963E6	6.0416E6	-2.7459E5	1.5656E7	-1.1816E6
3.	NORMAL STRESS	7.1727E6	-3.6623E6	2.399E6	-1.2078E6	6.4131E6	-3.2745E6
4.	EQUIVALENT STRESS	1.1845E7	86726	4.5406E6	25593	1.0963E7	75032

IV. CONCLUSION

Our project is about material replacement of existing flywheel which is performed using ANSYS workbench 18.1 and analyzed with application of various important factors with change of material (structural steel).

From the above results it is clear from the lower values of deformation and stress values, structural steel material is best suitable for our flywheel design

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