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ATICS

DESIGN EVALUATION OF FLYWHEEL USED IN PETROL ENGINE

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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 excess energy is developed during power stroke is absorbed by the flywheel and releases its to the crank shaft during the other strokes in which no energy is developed, thus rotating the crankshaft at a uniform speed.

The flywheelis located on one end of the crankshaft and serves two purposes. First, through its inertia, it reduces vibration by smoothing out the power stroke as each cylinder fires. Second, it is the mounting surface used to bolt the engine up to its load.

The aim of the project is to design a flywheel for a multi cylinder petrol engine flywheel using the empirical formulas. A 2D drawing is drafted using the calculations. A parametric model of the flywheel is designed using 3D modeling software Pro/Engineer.

The forces acting on the flywheel are also calculated. The strength of the flywheel is validated by applying the forces on the flywheel in analysis software ANSYS.

Structural analysis, modal analysis and fatigue analysis are done on the flywheel. Structural analysis is used to determine whether flywheel withstands under working conditions. Fatigue analysis is done for finding the life of the component. Modal analysis is done to determine the number of mode shapes for flywheel.

Analysis is done for two materials Cast Iron and Aluminum Alloy A360 to compare the results.
Pro/ENGINEER is the standard in 3D product design, featuring industry-leading productivity tools that promote best practices in design.

ANSYS is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user-designated size) called elements.

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INTRODUCTION TO IC ENGINES

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. This force moves the component over a distance, generating useful mechanical energy.
The term internal combustion engine usually refers to an engine in which combustion is intermittent, such as the more familiar four-stroke and two-stroke piston engines, along with variants, such as the Wankel rotary engine. A second class of internal combustion engines use continuous combustion: gas turbines, jet engines and most rocket engines, each of which are internal combustion engines on the same principle as previously described.[1][2][3][4]
The internal combustion engine (or ICE) is quite different from external combustion engines, such as steam or Stirling engines, in which the energy is delivered to a working fluid not consisting of, mixed with, or contaminated by combustion products.

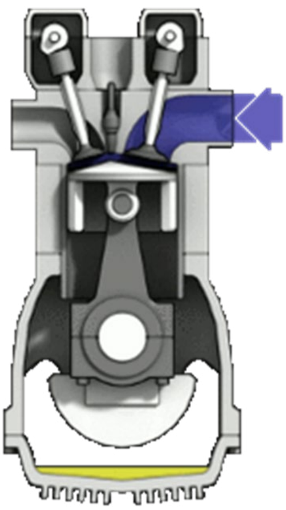
Working fluids can be air, hot water, pressurized water or even liquid sodium, heated in some kind of boiler.

A large number of different designs for ICEs have been developed and built, with a variety of different strengths and weaknesses. Powered by an energy-dense fuel (which is very frequently gasoline, a liquid derived from fossil fuels). While there have been and still are many stationary applications, the real strength of internal combustion engines is in mobile applications and they dominate as a power supply for cars, aircraft, and boats, from the smallest to the largest.

Applications

Internal combustion engines are most commonly used for mobile propulsion in vehicles and portable machinery. In mobile equipment, internal combustion is advantageous since it can provide high power-to-weight ratios together with excellent fuel energy density. Generally using fossil fuel (mainly petroleum), these engines have appeared in transport in almost all vehicles (automobiles, trucks, motorcycles, boats, and in a wide variety of aircraft and locomotives).

Where very high power-to-weight ratios are required, internal combustion engines appear in the form of gas turbines. These applications include jet aircraft, helicopters, large ships and electric generators.



Four-stroke cycle (or Otto cycle)
1. Intake
2.Compression
3.Power
4. Exhaust

As their name implies, operation of four stroke internal combustion engines have four basic steps that repeat with every two revolutions of the engine:

Intake
o Combustible mixtures are emplaced in the combustion chamber

Compression
o The mixtures are placed under pressure

Combustion (Power)

o The mixture is burnt, almost invariably a deflagration, although a few systems involve detonation. The hot mixture is expanded, pressing on and moving parts of the engine and performing useful work.

Exhaust

o The cooled combustion products are exhausted into the atmosphere
Many engines overlap these steps in time; jet engines do all steps simultaneously at different parts of the engines.

Many engines overlap these steps in time; jet engines do all steps simultaneously at different parts of the engines.

Introduction To Flywheel

A flywheel is a mechanical device with a significant moment of inertia used as a storage device for rotational energy. Flywheels resist changes in their rotational speed, which helps steady the rotation of the shaft when a fluctuating torque is exerted on it by its power source such as a piston-based (reciprocating) engine, or when an intermittent load, such as a piston pump, is placed on it.
Flywheels can be used to produce very high power pulses for experiments, where drawing the power from the public network would produce unacceptable spikes. A small motor can accelerate the flywheel between the pulses.

Recently, flywheels have become the subject of extensive research as power storage devices for uses in vehicles and power plants.

Physics

A flywheel is a spinning wheel or disc with a fixed axle so that rotation is only about one axis. Energy is stored in the rotor as kinetic energy, or more specifically, rotational energy:

$$E_k = \frac{1}{2} I \omega^2$$

Where:
•ω is the angular velocity, and
•$I$is the moment of inertia of the mass about the center of rotation. The moment of inertia is the measure of resistance to torque applied on a spin-

ning object (i.e. the higher the moment of inertia, the slower it will spin after being applied a given force).

Application Of Flywheel Used In Ic Engines

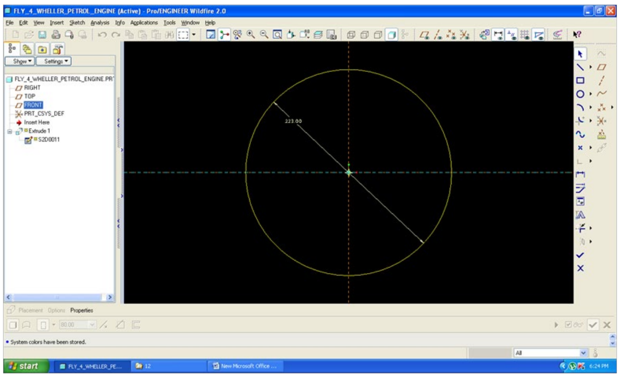
A 4 cylinder engine produces a power stroke every half crankshaft revolution, an 8 cylinder, every quarter revolution. This means that a V8 will be smother running than a 4. To keep the combustion pulses from generating a vibration, a flywheel is attached to the back of the crankshaft. The flywheel is a disk that is about 12 to 15 inches in diameter. On a standard transmission car, the flywheel is a heavy iron disk that doubles as part of the clutch system. On automatic equipped vehicles, the flywheel is a stamped steel plate that mounts the heavy torque converter. The flywheel uses inertia to smooth out the normal engine pulses.

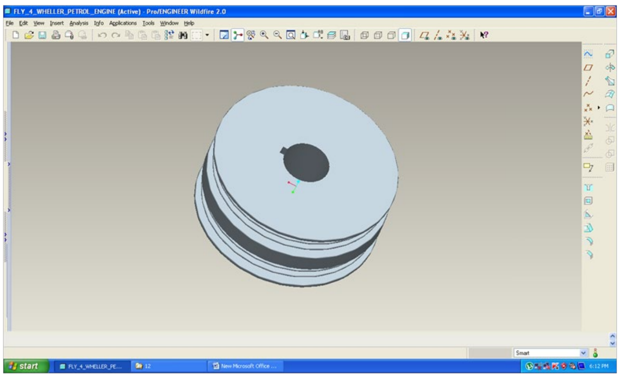
Introduction To Pro/Engineer

Pro/ENGINEER Wildfire is the standard in 3D product design, featuring industry-leading productivity tools that promote best practices in design while ensuring compliance with your industry and company standards. Integrated Pro/ENGINEER CAD/CAM/CAE solutions allow you to design faster than ever, while maximizing innovation and quality to ultimately create exceptional products.

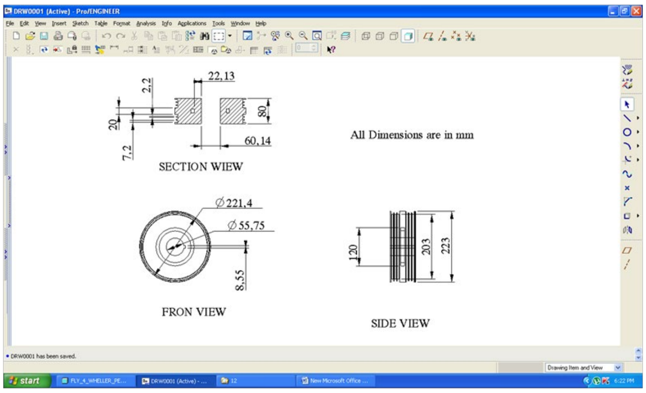
Customer requirements may change and time pressures may continue to mount, but your product design needs remain the same - regardless of your project's scope, you need the powerful, easy-to-use, affordable solution that Pro/ENGINEER provides.

Model Of Flywheel





2D Drawing



Introduction To Fea

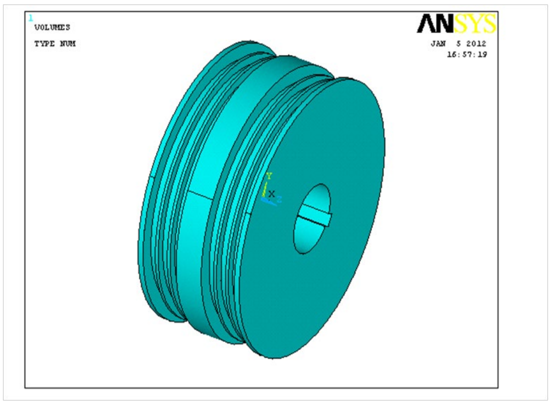
FEA consists of a computer model of a material or design that is stressed and analyzed for specific results. It is used in new product design, and existing product refinement. A company is able to verify a proposed design will be able to perform to the client's specifications prior to manufacturing or construction. Modifying an existing product or structure is utilized to qualify the product or structure for a new service condition.In case of structural failure, FEA may be used to help determine the design modifications to meet the new condition.

FEA uses a complex system of points called nodes which make a grid called a mesh. This mesh is programmed to contain the material and structural properties which define how the structure will react to certain loading conditions. Nodes are assigned at a certain density throughout the material depending on the anticipated stress levels of a particular area. Regions which will receive large amounts of stress usually have a higher node density than those which experience little or no stress. Points of interest may consist of: fracture point of previously tested material, fillets, corners, complex detail, and high stress areas. The mesh acts like a spider web in that from each node, there extends a mesh element to each of the adjacent nodes. This web of vectors is what carries the material properties to the object, creating many elements.

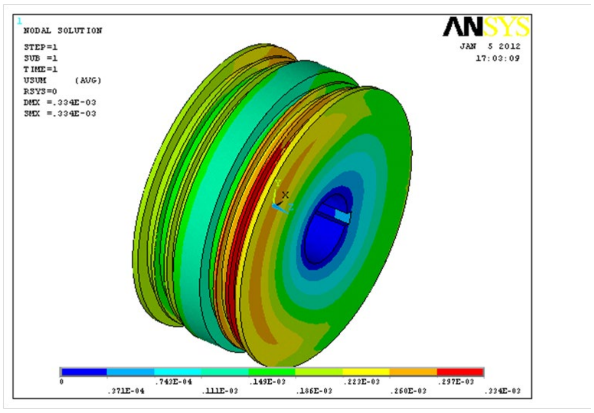
Introduction To Ansys

ANSYS is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user-designated size) called elements. The software implements equations that govern the behaviour of these elements and solves them all; creating a comprehensive explanation of how the system acts as a whole. These results then can be presented in tabulated, or graphical forms. This type of analysis is typically used for the design and optimization of a system far too complex to analyze by hand. Systems that may fit into this category are too complex due to their geometry, scale, or governing equations.

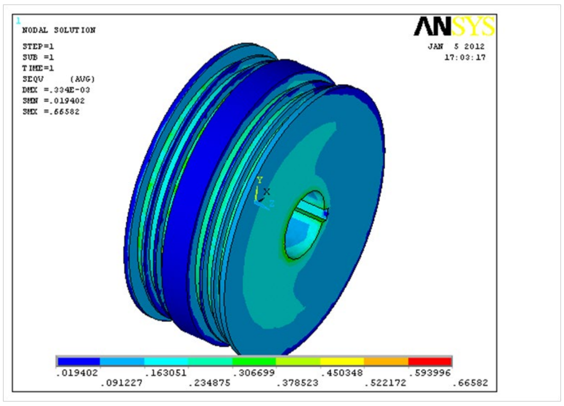
Structural Analysis of Flywheel



Imported Model from Pro/Engineer

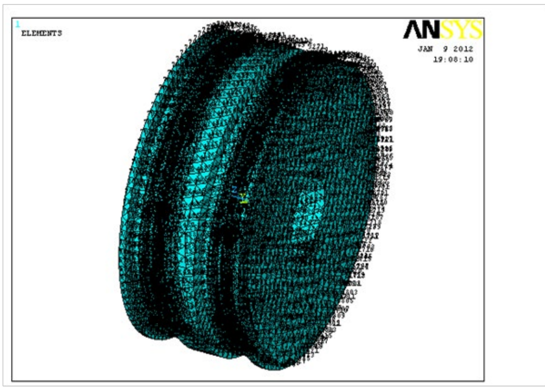


Displacement Vector Sum



Von Mises Stress

Fatigue Analysis



Location: 1Node 12536 at the constrained area. The combination of event 2, load 1 and event 2, load 2 produces an alternating stress intensity of 0.64398e-01 N/mm². The flywheel was subjected to 5000 cycles while from the S-N Table, the maximum number of cycles allowed at that stress intensity is 1,000,000.

The partial usage value, 0.005, is the ratio of cycles used/cycles allowed.

The combination of event 1, load 1 and event 1, load 2 produces an alternating stress intensity of 0.86604e-01 N/mm². The flywheel was subjected to 500,000 cycles while from the S-N Table, the maximum number of cycles allowed at that stress intensity is 1,000,000. The partial usage value, 0.5, is the ratio of cycles used/cycles allowed.

The Cumulative Fatigue Usage value is 0.505, is the sum of the partial usage factors (Miner's rule).

Results

Cast iron		
	RESULTS	PERMISSIBLE
DISPLACEMENT	0.334e-3	
VONMISES STRESS	0.66582	620
	Frequency	Displacement
MODE 01	45.254	0.111115
MODE 02	63.595	0.20176
MODE 03	54.501	0.181312
MODE 04	69.819	0.159127
MODE 05	93.227	0.266552

	Cast iron	A360 Alloy
Constrained area Event 1 Load1, Event 1 500000cycles Load 2 Event 2 Load1, Event 2 50000cycles Load 2	0.10417/mm² 0.77463e-01 N/mm2	0.86604e-010.64398e-01
Pressure area Event 1 Load1, Event 1 500000Cycles Load 2 Event 2 Load1, Event 2 50000cyclesLoad 2	0.17499 N/mm² 0.13012 N/mm²	0.25849 0.19221
Open area Event 1 Load1, Event 1 500000cycles Load 2 Event 2 Load1, Event 2 50000cyclesLoad 2	0.17018 N/mm² 0.12654 N/mm²	0.6954e-01 0.51714e-01

CONCLUSION

In our project we have designed a four wheeler flywheel used in a petrol engine using theoretical calculations. 2d drawing is created and modeling of flywheel is done using Pro/Engineer.

We have done structural and modal analysis on flywheel using two materials Aluminum Alloy A360 and Cast Iron to validate our design.

By observing the results, for all the materials the stress values are less than their respective permissible yield stress values. So our design is safe.

We have also done modal analysis for number of modes to see the displacement of flywheel for number of frequencies.

By comparing the results for two materials, the stress value for Aluminum Alloy A360 is less than that of Cast Iron.

So we conclude that for our design, Aluminum A360 is better material for flywheel. By using Aluminum A360 we can reduce Weight. Also it is rust free.

Fatigue analysis is also done on flywheel to verify the stress values at the selected nodes. The nodes are selected at constrained area, pressure area and open area.
In this project its having some disadvantages is by replacing with Aluminum A360 energy storage is reduced. In this project mainly we done material optimization.
For both the materials the number of cycles allowed for flywheel is 500000 cycles.

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