ISSN (ONLINE): 2321-3051

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING

INNOVATIVE MATERIAL SELECTION AND OPTIMIZATION OF CONVENTIONAL SPRINGS

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Abstract

A spring is an elastic object used to store mechanical energy. Springs are typically made out of spring_steel. Small springs can be cut from pre-hardened stock, while bigger ones are made from annealed steel and hardened after fabrication. Whenever a spring is compressed or stretched, it exerts some force which is proportional to its change in length. The rate of a spring is the change in the force it exerts, divided by the change in deflection of the spring. In evaluating the stresses and strain in the part, modeling and simulation are used. The modeling of the spring is modeled using 3D software. Here we will be using Pro E for modeling. The simulation part will be carried out using the Analysis software i.e ANSYS.

The created model is exported to ANSYS by converting it to IGES format. The imported model is meshed in ANSYS and boundary constrains are defined. With the Boundary constrains, the stresses and strain of the bone can be determined and the values are tabulated. And again by changing the material of the model the analyzing of the optimized model is done. Thus the investigation of stress and strain is carried out using ANSYS and better design is achieved. This project will also help to learn Pro E and also ANSYS.

Keywords: ANSYS; Conventional springs; IGES, PRO-E; Composites

1. Introduction

A spring is an elastic object used to store mechanical energy. Generally springs made of hardened steel are used. Small springs can be wound from pre-hardened stock while larger ones are made from annealed steel and hardened after fabrication. Non-ferrous metals are also used such phosphor bronze and titanium for parts requiring corrosion resistance and beryllium copper for springs carrying electrical current because of its low electrical resistance.

The rate of spring is called the change in the force it exerts, to the change in deflection of the spring. That means, it is the gradient of the force versus deflection curve. An extension of compression spring has units of force divided by distance, for example N/m. Torsion springs have units of force multiplied by distance divided by angle, such as N-m/rad . The inverse of spring rate in compliance that is if a spring has a rate of 10 N/mm, it has a fulfillment of spring in series.

On the basis of design and required operating environment, any material can be used to construct a spring, so long as the material has the required combination of rigidity and elasticity: technically, a wooden bow is a form of spring.

In the present scenario the automobile industry is regularly trying to reduce the fuel consumption of the automobile vehicles. Fuel efficiency of automobiles can be maximized by lowering the weight of the vehicle. The suspension system of an automobile is one of the important segments of the automobile vehicle. The use of steel helical coil spring in suspension system is generally used by the automobile manufacturers. We know that, the spring of the suspension system plays an important role for a smooth and easy ride. So it required to design the springs very exactly. The use of conventional steel in spring increases the weight and with the current scenario the automobile manufacturers are interested in replacing steel springs with light weight composite materials.

1.1 Composite

Composites are usually man-made materials but can also be sometimes natural such as wood. The properties of a composite as a whole are enhanced as compared to the properties of its components. They are generally formed by the combination of two different materials separated by a different interface. The two phases that make up a composite are known as reinforcing phase and matrix phase. The reinforcing phase is enclosed in the matrix phase and mainly provides strength to the matrix. The reinforcing phases commonly found in composites are fibers, particles or sheets and the matrix materials can be in the form of ceramics, polymers, or metals.

1.2 Why to use composite

The most important advantage associated with composites is their high strength and stiffness together with low weight. This high strength to weight ratio make able to the greater usage of composites in space applications where being light and strong is given more importance. And also in composites the fibers present share the load applied and prevents the rapid propagation of cracks as in metals. Another advantage of composites is their flexibility associated with their designing method. It is because they can be moulded to form various shapes may be it easy or complex.

Composites with proper composition and manufacturing can withstand high temperature environments and corrosive. With all these advantages it is liable to think why the composites have not replaced with metals. One of the major drawback linked with the composites is its high cost which is often due to the use of expensive raw materials and not due to the manufacturing processes.

In this paper, we discussed about the existing system or material used in the manufacturing of spring and the proposed material MMC's benefit is discussed. And the remaining section of this paper is organized as follows. In the II section, Metal Matrix Composites is discussed. Section III will describe the ANSYS Software. Section IV will describe the Modelling software PRO-E.Conclusion will be drawn in section V.

2 METAL MATRIX COMPOSITES

A **metal matrix composite** (**MMC**) is composite material with at least two constituent parts, one is a metal. And the other material may be a different metal or any another material, such as organic compound or ceramics. When there is at least three materials are present, it is called a hybrid composite. The MMC is complementary to a cermet.

2.1Composition

MMCs are made by dispersing a reinforcing material into a metal matrix. Reinforcement surface can be coated to prevent a chemical reaction with the matrix. Most generall example for that is, carbon fibers are commonly used in aluminum matrix to synthesize composites showing low density and high strength. But sometimes, carbon reacts with aluminum to generate a brittle and water-soluble compound Al_4C_3 on the surface of the fiber. In order to stop this reaction, the carbon fibers are coated with titanium boride or nickel.

2.2 Matrix

The matrix is the monolithic material into which the reinforcement is enclosed, and is completely continuous. This means that there is a path through the matrix to any point in the material, the two different materials are sandwiched together. In structural applications, the matrix is generally a lighter metal such as magnesium, aluminium or titanium, and provides a perfect support for the reinforcement. In high-temperature applications, cobalt-nickel alloy and cobalt matrices are widely found.

2.3 Reinforcement

We know that the reinforcement material is embedded into the matrix. The reinforcement does not at all times serve a purely structural task (reinforcing the compound), but is as well used to change physical properties such as coefficient of friction, wear resistance, or thermal conductivity. The reinforcement may be continuous, or discontinuous. Discontinuous MMCs can be isotropic, and can be worked with typical metalworking techniques, such as forging, extrusion, or rolling. In addition to that, they may be machined using usual techniques, but commonly would need the use of polycrystaline diamond tooling (PCD).

Continuous reinforcement uses monofilament wires or fibers such as carbon fiber or silicon carbide. Because the fibers are implanted into the matrix in a certain direction, the final result of process is an anisotropic structure in which the alignment of the material affects its strength. One of the primary MMCs used boron filament as reinforcement. Discontinuous reinforcement uses "whiskers", short fibers, or particles. The most common reinforcing materials in this category are alumina and silicon carbide.

3. Introduction to Ansys

ANSYS is an engineering simulation software provider founded by software engineer John Swanson. This develops general-purpose finite element analysis and computational fluid dynamics software. While ANSYS has developed a range of computer-aided engineering (CAE) products, it is perhaps well known for its ANSYS Mechanical and ANSYS Multiphysics goods. ANSYS Mechanical and ANSYS Multiphysics software are non exportable analysis tools incorporating pre-processing (meshing, geometry creation and solver) and post-processing modules in a graphical user interface. These are the general-purpose finite element modeling packages for numerically solving mechanical problems, together with static/dynamic structural analysis (both linear and non-linear), heat transfer and fluid issues, as well as acoustic and electro-magnetic problems.

ANSYS Mechanical technology incorporates both structural and material non-linearities. ANSYS Multiphysics software has solvers for structural, thermal, electromagnetic, and acoustics and can sometimes pair these separate physics together in order to address multidisciplinary applications. ANSYS software can be used in electrical engineering, civil engineering, physics and chemistry.

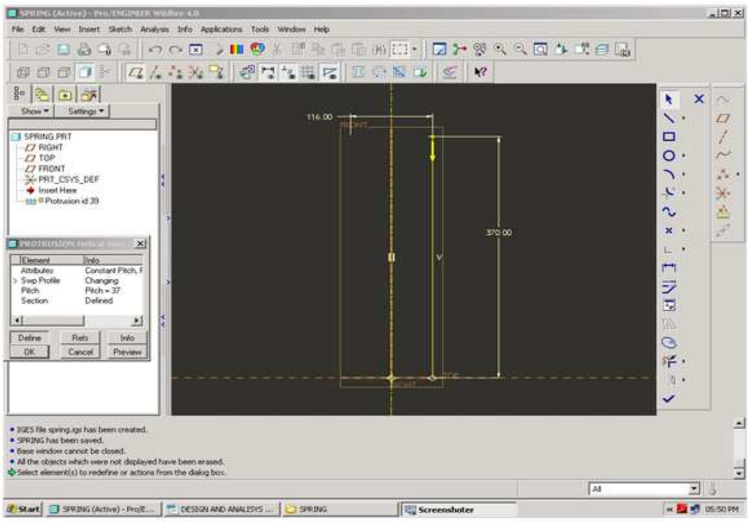
ANSYS, Inc. acquired the CFX computational fluid dynamics code in 2003 and Fluent, Inc. in 2006 CFD packages from ANSYS are used for engineering simulations. ANSYS acquired soft Corporation in 2008, it was a

Vol.2 Issue.5,
May 2014.
Pgs: 44-49

most important developer of high-performance electronic design automation (EDA) software, and added a group of products designed to simulate high-performance electronics designs found in mobile communication and internet devices, broadband networking apparatus and systems, integrated circuits, printed circuit boards, and electromechanical systems. The acquisition permitted ANSYS to address the continuing convergence of the mechanical and electrical worlds across a whole range of industry sectors. The finite element method (FEM), or finite element analysis.

4. Modelling Software Description: PRO-E

Pro/ENGINEER, PTC's parametric, integrated 3D CAD/CAM/CAE solution, is used by separate manufacturers for mechanical engineering, design and manufacturing formed by Dr. Samuel P. Geisberg in the mid-1980s, Pro/ENGINEER was the industry's first booming parametric, 3D CAD modeling system. The parametric modeling approach uses parameters, dimensions, features, and relationships to confine intended product behavior and create a recipe which enables design automation and the optimization of design and product development processes. This powerful and affluent design approach is used by companies whose product strategy is family-based or platform-driven, where a rigid design strategy is critical to the success of the design process by embedding engineering constraints and relationships to quickly optimize the design, or where the resulting geometry perhaps complex or based upon equations. Pro/ENGINEER provides a whole set of design, analysis and manufacturing capabilities on one, essential, scalable platform. These capabilities comprise Solid Modeling, Surfacing, Data Interoperability, Routed Systems Design, Rendering, Tolerance Study, Simulation, NC and Tooling Design.



Composite materials are very light weight and also posses corrosion resistance; it can also withstand high temperature. But manufacturing composite material is quite costlier than the steel spring. The use of composite material is beneficial if it can increase the efficiency of the vehicle and hence overcome the material cost. The composite material used in the research is Glass Fiber/Epoxy. The main reason of neglected use of the composite material is its stiffness which limits its application to light weight vehicle only. In order to overcome this problem, it tried to use combination of steel and composite material which is engaged parallel.

Due to the feasibility of application of composite material in automotive suspension system, many researchers are involved in study of composite material. Chang-Hsuan Chiu, Chung-Li Hwan, Han-Shuin Tsai and

Wei-Ping Lee have conducted the experiment on mechanical behaviour of helical composite springs. They have made the springs with diverse material like, unidirectional laminates, rubber core unidirectional laminates, and rubber core unidirectional laminate by a braided outer layer. Henry and c. Robert has tried to replace the metal coil spring of a Rover saloon car using carbon fiber. P.K. Mallick has fabricated and conducted the performance test for the composite elliptic springs. The composite leaf springs are successfully used in the suspension of the light vehicles. The fibers used in these are unidirectional E-glass due to their high extensibility, toughness and low cost. The composite leaf spring is designed and analyzed using ansys.

The results showed that an optimum spring width decreases hyperbolically and the thickness increases linearly from the spring eye towards the axle seat. Compared to steel springs the optimized composite spring has strength that are much lower, the natural frequency is high and the spring weight is nearly 80% lower. D. Abdul Budan and T.S. Manjunatha have investigated the use of different composite material in helical coil spring of suspension system and other automotive applications. In all of the above research papers it has been observed that the application of composite materials has been limited to light weight vehicles. An effort has been made here to prepare a solution for application of composite materials in regular vehicle.

This project focus on chassis lightness and low running resistance realized a weight saving and a significant reduction in running resistance. Lightness promotes the basic performance attributes of running, turning and stopping. With the chassis, the combination of low weight and high rigidity thus realizes outstanding dynamic-performance potential in addition to superior fuel economy. Safety requirements for crashes lead designers to conceive vehicles in order to let the occupants remain unharm thru normalized crash tests representative of most real accidents. The problem in early conception stages is that real crash test are not affordable in cost or in time.

5. Conclusion

Use of composite material is beneficial if it can increase the efficiency of the vehicle and hence overcome the material cost. Other spring materials can be sugested for enhancements of fatigue life prediction. Modified design needs to be manufactured and tested for deformation and stress results.

The simulation part will be carried out using the Analysis software, Ansys. The model is exported to ANSYS by converting it to IGES format. The imported model is meshed in ANSYS and boundary constrains are defined. With the Boundary constrains, the stresses and strain of the component can be determined and the values are tabulated. Thus the investigation of stress and strain is carried out using ANSYS. This project will also help to learn modeling software and also ANSYS

6. Future scope

- Modified spring design can further be categorized for standardization of spring design.
- Complexity of fitting and maintained of spring need to be considered.
- Other spring materials can be suggested for enhancement of fatigue life predication.
- Modified design needs to be manufactured and tested for deformation and stress results.

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