THERMAL AND DAMPING ANALYSIS ON COMPOSITE CIRCULAR BAR

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Abstract: Composite materials have interesting properties such as high strength to weight ratio, ease of fabrication, good electrical and thermal properties compared to metals. A laminated composite material consists of several layers of a composite mixture consisting of matrix and fibres. Each layer may have similar or dissimilar material properties with different fibre orientations under varying stacking sequence

There are many open issues relating to design of these laminated composites. Design engineer must consider several alternatives such as best stacking sequence, optimum fibre angles in each layer as well as number of layers itself based on criteria such as achieving highest natural frequency or largest buckling loads of such structure. Analysis of such composite materials starts with estimation of resultant material properties

1. INTRODUCTION

Laminated composite materials are extensively used in aerospace, defence, marine, automobile, and many other industries. They are generally lighter and stiffer than other structural materials. A laminated composite material consists of several layers of a composite mixture consisting of matrix and fibres. Each layer may have similar or dissimilar material properties with different fibre orientations under varying stacking sequence. Because, composite materials are produced in many combinations and forms, the design engineer must consider many design alternatives. It is essential to know the dynamic and buckling characteristics of such structures subjected to dynamic loads in complex environmental conditions. For example, when the frequency of the loads matches with one of the resonance frequencies of the structure, large translation/torsion deflections and internal stresses occur, which may lead to failure of structure components. The structural components made of composite materials such as aircraft wings, helicopter blades, vehicle axles and turbine blades can be approximated as laminated composite beams.

2. INTRODUCTION TO CATIA

CATIA (Computer Aided Three-dimensional Interactive Application) is a multi-platform CAD/CAM/CAE commercial software suite developed by the French company Assault Systems. Written in the C++ programming language, CATIA is the cornerstone of the Assault Systems product lifecycle management software suite.

CATIA competes in the CAD/CAM/CAE market with Siemens NX, Pro/E, Autodesk Inventor, and Solid Edge as well as many others.

Table 2.1: Details of CATIA

Developer(s)	Dassault Systems
Stable release	V6R2011x / November 23, 2010
Operating system	Unix / Windows
Type	CAD software
License	Proprietary
Website	WWW.3ds.com

2.1 History of CATIA

CATIA started as an in-house development in 1977 by French aircraft manufacturer Avions Marcel Dassault, at that time customer of the CADAM CAD software to develop Dassault's Mirage fighter jet, and then was adopted in the aerospace, automotive, shipbuilding, and other industries.

Initially named CATIA (Conception Assisted Tridimensional Interactive - French for Interactive Aided Three-dimensional Design) - it was renamed CATIA in 1981, when Dassault created a subsidiary to develop and sell the software, and signed a non-exclusive distribution agreement with IBM.

In 1984, the Boeing Company chose CATIA as its main 3D CAD tool, becoming its largest customer.

In 1988, CATIA version 3 was ported from mainframe computers to UNIX.

In 1990, General Dynamics Electric Boat Corp chose CATIA as its main 3D CAD tool, to design the U.S. Navy's Virginia class submarine.

In 1992, CADAM was purchased from IBM and the next year CATIA CADAM V4 was published. In 1996, it was ported from one to four UNIX operating systems, including IBM AIX, Silicon Graphics IRIX, Sun Microsystems SunOS and Hewlett-Packard HP-UX.

In 1998, an entirely rewritten version of CATIA, CATIA V5 was released, with support for UNIX, Windows NT and Windows XP since 2001.

In 2008, Dassault announced and released CATIA V6. While the server can run on Microsoft Windows, Linux or AIX, client support for any operating system other than Microsoft Windows is dropped.

2.1.1 Release History

Name/Version	Latest Build Number	Original Release Date	Latest Release Date
CATIA v4	R25	1993	January 2007
CATIA v5	R20	1998	February 2010
CATIA v6	R2012	29/05/2008	May 2011

Table 2.2: versions of CATIA

2.2 Scope of Application

Commonly referred to as 3D Product Lifecycle Management software suite, CATIA supports multiple stages of product development (CAx), from conceptualization, design (CAD), manufacturing (CAM), and engineering (CAE). CATIA facilitates collaborative engineering across disciplines, including surfacing & shape design, mechanical engineering, equipment and systems engineering

2.2.1 Surfacing & Shape Design

CATIA provides a suite of surfacing, reverse engineering, and visualization solutions to create, modify, and validate complex innovative shapes. From subdivision, styling, and Class A surfaces to mechanical functional surfaces.

2.2.2 Mechanical Engineering

CATIA enables the creation of 3D parts, from 3D sketches, sheet metal, composites, and molded, forged or tooling parts up to the definition of mechanical assemblies. It provides tools to complete product definition, including functional tolerances, as well as kinematics definition.

2.2.3 Equipment Design

CATIA facilitates the design of electronic, electrical as well as distributed systems such as fluid and HVAC systems, all the way to the production of documentation for manufacturing.

2.2.4 Systems Engineering

CATIA offers a solution to model complex and intelligent products through the systems engineering approach. It covers the requirements definition, the systems architecture, the behavior modeling and the virtual product or embedded software generation. CATIA can be customized via application programming interfaces (API). CATIA V5 & V6 can be adapted using Visual Basic and C++ programming languages via CAA (Component Application Architecture); a component object model (COM)-like interface.

Although later versions of CATIA V4 implemented NURBS, V4 principally used piecewise polynomial surface. CATIA V4 uses a non-manifold solid engine.

Catia V5 features a parametric solid/surface-based package which uses NURBS as the core surface representation and has several workbenches that provide KBE support.

V5 can work with other applications, including Enova, Smarteam, and various CAE Analysis applications.

2.3 Supported Operating Systems and Platforms

CATIA V6 runs only on Microsoft Windows and Mac OS with limited products.

CATIA V5 runs on Microsoft Windows (both 32-bit and 64-bit), and as of Release 18Service Pack4 on Windows Vista 64.IBM AIX, Hewlett Packard HP-UX and Sun Microsystems Solaris are supported.

CATIA V4 is supported for those Unixes and IBM MVS and VM/CMS mainframe platforms up to release 1.7.

CATIA V3 and earlier run on the mainframe platforms.

2.4 Notable Industries Using CATIA

CATIA can be applied to a wide variety of industries, from aerospace and defense, automotive, and industrial equipment, to high tech, shipbuilding, consumer goods, plant design, consumer packaged goods, life sciences, architecture and construction, process power and petroleum, and services. CATIA V4, CATIA V5, Pro/E, NX (formerly Unigraphics), and Solid Works are the dominant systems.

2.4.1 Aerospace

The Boeing Company used CATIA V3 to develop its777 airliner, and is currently using CATIA V5 for the787 series aircraft. They have employed the full range of Dassault Systems' 3D PLM products — CATIA, DELMIA, and ENOVIALCA — supplemented by Boeing developed applications.

The development of the Indian Light Combat Aircraft has been using CATIA V5.

Chinese Xian JH-7 A is the first aircraft developed by CATIA V5, when the design was completed on September 26, 2000.

European aerospace giant Airbus has been using CATIA since 2001.

Canadian aircraft maker Bombardier Aerospace has done all of its aircraft design on CATIA.

The Brazilian aircraft company, EMBRAER, use CATIA V4 and V5 to build all airplanes.

Vought Aircraft Industries use CATIA V4 and V5 to produce its parts.

The British Helicopter company, Westland, use CATIA V4 and V5 to produce all their aircraft. Westland is now part of an Italian company called Finmeccanica the joined company calls themselves AgustaWestland.

The main supplier of helicopters to the U.S Military forces, Sikorsky Aircraft Corp., uses CATIA as well.

2.4.2 Automotive

Many automotive companies use CATIA to varying degrees, including BMW, Porsche, Daimler AG, Chrysler, Honda, Audi, Jaguar Land RoverVolkswagen, Bentley Motors Limited, Volvo, Fiat, Benteler AG, PSA Peugeot Citroën, Renault, Toyota, Ford, Scania, Hyundai, Skoda Auto, Tesla Motors, Valmet Automotive, Proton, Tata motors and Mahindra & Mahindra Limited. Goodyear uses it in making tires for automotive and aerospace and also uses a customized CATIA for its design and development. Many automotive companies use CATIA for car structures — door beams, IP supports, bumper beams, roof rails, side rails, body components — because CATIA is very good in surface creation and Computer representation of surfaces. Bombardier Transportation, Canada is using CATIA software to design its entire fleet of Train engines, Coaches.

2.4.3 Ship Building

Dassault Systems has begun serving shipbuilders with CATIA V5 release 8, which includes special features useful to shipbuilders. GD Electric Boat used CATIA to design the latest fast attack submarine class for the United States Navy, the Virginia class. Northrop Grumman Newport News also used CATIA to design the Gerald R. Ford class of super carriers for the US Navy.

2.4.4 Industrial Equipment

CATIA has a strong presence in the Industrial Equipment industry. Industrial Manufacturing machinery companies like Schuler and Metso use CATIA , as well as heavy mobile machinery and equipment companies like Claas, and also various industrial equipment product companies like Alstom Power and ABB Group.

2.4.5 Other

Architect Frank Gehry has used the software, through the C-Cubed Virtual Architecture company, now Virtual Build Team, to design his award-winning curvilinear buildings. His technology arm, Gehry Technologies, has been developing software based on CATIA V5 named Digital Project. Digital Project has been used to design buildings and has successfully completed a handful of projects.

3. INTRODUCTION TO ANSYS

ANSYS is commercial finite-element analysis software with the capability to analyze a wide range of different problems. ANSYS runs under a variety of environments, including IRIX, Solaris, and Windows NT. Like any finite-element software, ANSYS solves governing differential equations by breaking the problem into small elements. The governing equations of elasticity, fluid flow, heat transfer, and electro-magnetism can all be solved by the Finite element method in ANSYS. ANSYS can solve transient problems as well as nonlinear problems. This document will focus on the basics of ANSYS using primarily structural examples.

ANSYS is available on all MEnet Sun and SGI machines. It is available on the Linux machines by remote-login only. On the right side, rumor has it that ANSYS is looking into a Linux port. Currently, MEnet uses the Research/Faculty version of ANSYS 12.1. The Research/Faculty license level permits larger, more complex models than does the current level running on the IT Labs machines. This document is meant to be a starting point. The material covered here is by no means comprehensive. In fact, we will only scratch the surface of ANSYS's capabilities. Given that, I will try to cover most of what I know about ANSYS and some tricks I have learned while using it. The document will begin with two simple examples, taking the user through all of the steps of creating a model, meshing, adding boundary conditions, solving, and, finally, looking at the results. The remainders of this document will over tips and tricks for each of the steps.

3.1 Basic Methodology of ANSYS

ANSYS is followed up by the method called Finite Element Modeling Methods (FEM).

3.1.1 Finite element method

The finite element method (FEM) (its practical application often known as finite element analysis (FEA) is a numerical technique for finding approximate solutions of partial differential equations (PDE) as well as of integral equations. The solution approach is based either on eliminating the differential equation completely (steady state problems), or rendering the PDE into an approximating system of ordinary differential equations, which are then numerically integrated using standard techniques such as Euler's method, Runge-Kutta, etc.

In solving partial differential equations, the primary challenge is to create an equation that approximates the equation to be studied, but is numerically stable, meaning that errors in the input and intermediate calculations do not accumulate and cause the resulting output to be meaningless. There are many ways of doing this, all with advantages and disadvantages. The Finite Element Method is a good choice for solving partial differential equations over complicated domains (like cars and oil pipelines), when the domain changes (as during a solid state reaction with a moving boundary), when the desired precision varies over the entire domain, or when the solution lacks smoothness. For instance, in a frontal crash simulation it is possible to increase prediction accuracy in "important" areas like the front of the car and reduce it in its rear (thus reducing cost of the simulation). Another example would be in Numerical weather prediction, where it is more important to have accurate predictions over developing highly-nonlinear phenomena (such as tropical cyclones in the atmosphere, or eddies in the ocean) rather than relatively calm areas.

ANSYS Workbench is a common platform for solving engineering problems. Typical tasks you can perform in Workbench are:

• Importing models from a variety of CAD systems.

• Conditioning models for design simulations using the Design Modeler.

• Performing FEA simulations using Simulation.

• Optimizing designs using DesignXplorer or DesignXplorer VT.

The underlined words above are the names of different processors within ANSYS Workbench. Basically, you will use the Design Modeler to create the geometry and the Simulation to set up the materials, FE-mesh, loads and boundary conditions, solve the problem and analyses the results. The standard interface ANSYS Classic (used in the first computer workshop) is still the core of ANSYS. ANSYS Workbench is a new modern interface with more up to date functions such as, for example, the integration of CAD geometries.

3.1.2 Design Modeler

Design Modeler is designed to be used as a geometry editor of existing CAD models. Design Modeler is a parametric feature-based solid modeler designed so that you can intuitively and quickly begin drawing 2D sketches, modelling 3D parts, or uploading 3D CAD models for engineering analysis pre-processing.

4. RESULT AND COMPARSION

In this project we designed composite circular bar using CAD software tool namely CATIA V5 R20 employing composite design workbench and then later those design is converted and imported into ANSYS 16 workbench for thermal and modal analysis

There results is calculated and compared below for both composite bar and ordinary bar below

Composite bar damping results

Frequency	Deformation
64.645	0.63787
64.825	0.63761
210.94	0.72815
211.41	0.72763
360.38	0.57803
401.33	0.77262

Ordinary bar damping results

Frequency	Deformation
79.331	2.56
79.4	2.6
482.22	2.533
482.22	2.53
1118	1.855
1292.1	2.501

Thermal results

	Temperature	Heat flux
Composite bar	29.184	88354
Ordinary bar	44.335	1.95e5

5. CONCLUSION

Composite materials have interesting properties such as high strength to weight ratio, ease of fabrication, good electrical and thermal properties compared to metals. A laminated composite material consists of several layers of a composite mixture consisting of matrix and fibres. Each layer may have similar or dissimilar material properties with different fibre orientations under varying stacking sequence

By above comparison we conclude that composite bar have good thermal properties as well as damping analysis. While comparing damping analysis composite bar have very low deformation factor at same factor of ordinary bar which have large deformation factor. In thermal factors composite bar has good factors when compared to ordinary bar.

REFERENCES

[1] M. Hajianmaleki and M. S. Qatu, 'Vibrations of straight and curved composite beams: A review‟, Composite Structures, Vol. 100, pp 218-232,2013.

[2] V.Yildirim, „Effect of the longitudinal to transverse moduli ratio on the in-plane natural frequencies of symmetric cross-ply laminated beams by the stiffness method‟, Composite structures, vol.50, pp.319-326, 2000.

[3] L. Jun, H.Hongxing and S.Rongying, „Dynamic finite element method for generally laminated composite beams‟, Int. J.Mechanical Sciences, vol.50, pp. 466-480, 2008.

[4] H.B.H.Gubran and K.Gupta, „The effect of stacking sequence and coupling mechanisms on the natural frequencies of composite shafts‟, J.Sound and Vibration, vol.282, pp.231-248, 2005.

[5] Yegao Qu, Xinhua Long, Hongguang Li, Guang Meng, „A variational formulation for dynamic analysis of composite laminated beams on a general higher-order shear deformation theory"", Composite Structures, Vol. 102 ,175–192, 2013.

[6] Y.Qu, X. Long, S.Wu and G.Meng, „A unified formulation for vibration analysis of composite laminated shells of revolution including shear deformation and rotary inertia"", Composite structures, vol.98, pp.169-191, 2013.

[7] Xiang Xie, Guoyong Jin, Yuquan Yan, S.X. Shi, Zhigang Liu, „Free vibration analysis of composite laminated cylindrical shells using the Haar wavelet method"", Composite Structures, vol. 109, pp 167-199,2014.

[8] R.Sahoo and B.N. Singh, „A new trigonometric zigzag theory for static analysis of laminated composite and sandwich plates"", Aerospace science and technology, vol.35, pp.15-28, 2014.