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Design and Analysis of Aerospace Vehicle Cockpit Element

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Abstract:

A cockpit or flight deck is the area, usually near the front of an aircraft, from which a pilot controls the aircraft. Most modern cockpits are enclosed, except on some small aircraft.The cockpit of an aircraft contains flight instruments on an instrument panel, and the controls that enable the pilot to fly the aircraft. In most airliners, a door separates the cockpit from the aircraft cabin. The cockpit exposes to air under high pressure while the aircraft is flying. The pressure depends upon aircraft velocity. In this thesis we are going to design the aircraft cockpit and performing static analysis. Being the aircraft components tend to vibrations we are going to perform the model analysis to determine the natural frequency and deformation in resonance.The design will do in 3d parametric software catia v5 and analysis will do in FEA based software ANSYS 14.5.

1.INTRODUCTION:

A cockpit or flight deck is the area, usually near the front of an aircraft, from which a pilot controls the aircraft. Most modern cockpits are enclosed, except on some small aircraft.The cockpit of an aircraft contains flight instruments on an instrument panel, and the controls that enable the pilot to fly the aircraft. In most airliners, a door separates the cockpit from the aircraft cabin. After the September 11, 2001 attacks, all major airlines fortified their cockpits against access by hijackers.In a span of only a few years, the cockpits of new light aircraft have undergone a transition from conventional analog flight instruments to digital based electronic displays commonly referred to as “glass cockpits.” These new displays integrate aircraft control, autopilot, communication, navigation, and aircraft system monitoring functions, applying technology previously available only in transport category aircraft. The enhanced function and information capabilities of glass cockpits represent a significant change and potential improvement in the way general aviation pilots monitor information needed to control their aircraft.

The National Transportation Safety Board (NTSB) initiated this study to determine if the transition to glass cockpits in light aircraft has improved the safety record of those aircraft.Three different approaches were used in this study. First, a retrospective statistical analysis of manufacturer records, aircraft investigation information, and activity survey data was conducted to compare the accident experience of recently manufactured light single-engine airplanes equipped and not equipped with glass cockpit displays. Second, an evaluation of glass cockpit training requirements and resources was conducted to characterize the training and to identify areas for potential safety improvement. Finally, accident cases were reviewed to identify emerging safety issues associated with the introduction of glass cockpit displays into this class of aircraft. The statistical analysis found that for 2002 -- 2008, light single engine aircraft equipped with glass cockpit displays experienced lower total accident rates but higher fatal accident rates than the same type of aircraft equipped with conventional analog instrumentation.

Accidents involving glass cockpit aircraft were more likely to be associated with personal/business flights, longer flights, instrument flight plans, and single pilot operations, while accidents involving conventional analog cockpit aircraft were more likely to be associated with instructional flights, shorter flights, and two pilot operations. Accident pilots flying glass cockpit equipped aircraft were found to have higher levels of pilot certification and more total flight experience than those flying conventional aircraft.The evaluation of light aircraft glass cockpit training requirements found that the Federal Aviation Administration (FAA) has been updating training handbooks and test standards to incorporate generic information about electronic flight instrument displays. However, current airman knowledge written tests (such as private pilot, instrument rating, commercial pilot, and flight instructor certificates) do not assess pilots’ knowledge of the functionality of glass cockpit displays. In addition, the FAA has no specific training requirements for pilots operating glass cockpit equipped light aircraft.

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The lack of equipment specific training requirements from the FAA results in a wide range of initial and recurrent training experiences among pilots of glass cockpit aircraft. With the exception of training provided by airframe manufacturers with the purchase of a new aircraft, pilots must currently seek out and obtain equipment specific glass cockpit training on their own. The review of accidents involving light aircraft equipped with glass cockpits found that pilots' experiences and training in conventional cockpits do not prepare them to safely operate the complex and varied glass cockpit systems being installed in light aircraft today. Further, the lack of information provided to pilots about glass cockpit systems may lead them to misunderstand or misinterpret system failures. As a result, there is a need for new training procedures and tools to ensure that pilots are adequately prepared to safely operate aircraft equipped with glass cockpit avionics.The results of this study suggest that the introduction of glass cockpits has not resulted in a measurable improvement in safety when compared to similar aircraft with conventional instruments. The analyses conducted during the study identified safety issues in two areas:

1.The need for pilots to have sufficient equipment specific knowledge and proficiency to safely operate aircraft equipped with glass cockpit avionics.

2.The need to capture maintenance and operational information in order to assess the reliability of glass cockpit avionics in light aircraft.

2. LITERATURE SURVEY:

The first airplane with an enclosed cabin appeared in 1912 on the Avro Type F; however, during the early 1920s there were many passenger aircraft in which the crew remained open to the air while the passengers sat in a cabin. Military biplanes and the first single-engined fighters and attack aircraft also had open cockpits, some as late as the Second World War when enclosed cockpits became the norm.The largest impediment to having closed cabins was the material the windows were to be made of. Prior to Perspex becoming available in 1933, windows were either safety glass, which was heavy, or cellulose nitrate (i.e.: guncotton), which yellowed quickly and was extremely flammable. In the mid-1920s many aircraft manufacturers began using enclosed cockpits for the first time. Early airplanes with closed cockpits include the 1924 Fokker F.VII, the 1926 German Junkers W 34 transport, the 1926 Ford Trimotor, the 1927 Lockheed Vega, the Spirit of St. Louis and the passenger aircraft manufactured by the Douglas and Boeing companies during the mid-1930s. Open-cockpit airplanes were almost extinct by the mid-1950s, with the exception of training planes, crop-dusters and homebuilt aircraft designs. Cockpit windows may be equipped with a sun shield. Most cockpits have windows that can be opened when the aircraft is on the ground. Nearly all glass windows in large aircraft have an anti-reflective coating, and an internal heating element to melt ice. Smaller aircraft may be equipped with a transparent aircraft canopy.In most cockpits the pilot's control column or joystick is located centrally (center), although in some military fast jets the side-stick is located on the right hand side. In some commercial airliners (i.e.: Airbus—which features the glass cockpit concept) both pilots use a side-stick located on the outboard side, so Captain's side-stick on the left and First-officer's seat on the right.

Except for some helicopters, the right seat in the cockpit of an aircraft is the seat used by the co-pilot. The captain or pilot in command sits in the left seat, so that he can operate the throttles and other pedestal instruments with his right hand. The tradition has been maintained to this day, with the co-pilot on the right hand side. The layout of the cockpit, especially in the military fast jet, has undergone standardization, both within and between aircraft different manufacturers and even different nations. One of the most important developments was the "Basic Six" pattern, later the "Basic T", developed from 1937 onwards by the Royal Air Force, designed to optimize pilot instrument scanning.

Ergonomics and Human Factors concerns are important in the design of modern cockpits. The layout and function of cockpit displays controls are designed to increase pilot situation awareness without causing information overload. In the past, many cockpits, especially in fighter aircraft, limited the size of the pilots that could fit into them. Now, cockpits are being designed to accommodate from the 1st percentile female physical size and the 99th percentile male size. In the design of the cockpit in a military fast jet, the traditional "knobs and dials" associated with the cockpit are mainly absent. Instrument panels are now almost wholly replaced by electronic displays, which are themselves often re-configurable to save space. While some hard-wired dedicated switches must still be used for reasons of integrity and safety, many traditional controls are replaced by multi-function re-configurable controls or so-called "soft keys".

Controls are incorporated onto the stick and throttle to enable the pilot to maintain a head-up and eyes-out position – the so-called Hands On Throttle And Stick or HOTAS concept,. These controls may be then further augmented by new control media such as head pointing with a Helmet Mounted Sighting System or Direct voice input (DVI). New advances in auditory displays even allow for Direct Voice Output of aircraft status information and for the spatial localization of warning sounds for improved monitoring of aircraft systems.The layout of control panels in modern airliners has become largely unified across the industry. The majority of the systems-related controls (such as electrical, fuel, hydraulics and pressurization) for example, are usually located in the ceiling on an overhead panel. Radios aregenerally placed on a panel between the pilot's seats known as the pedestal. Automatic flight controls such as the autopilot are usually placed just below the windscreen and above the main instrument panel on the glare shield. A central concept in the design of the cockpit is the Design Eye Position or "DEP", from which point all displays should be visible. Most modern cockpits will also include some kind of integrated warning system.In a 2013 comparative study of a number of novel methods for cockpit-user interaction, touchscreen produced the largest number of "best scores".

3 INTRODUCTIONS TO SOFTWARE

3.1 Introduction to CAD:

Throughout the history of our industrial society, many inventions have been patented and whole new technologies have evolved. Perhaps the single development that has impacted manufacturing more quickly and significantly than any previous technology is the digital computer. Computers are being used increasingly for both design and detailing of engineering componentsin the drawing office. Computer-aided design(CAD) is defined as the application of computers and graphics software to aid or enhance the product design from conceptualization to documentation. CAD is most commonly associated with the use of an interactive computer graphics system, referred to as a CAD system. Computer-aided design systems are powerful tools and in the mechanical design and geometric modeling of products and components.There are several good reasons for using a CAD system to support the engineering design function:

1.To increase the productivity
2.To improve the quality of the design
3.To uniform design standards
4.To create a manufacturing data base
5.To eliminate inaccuracies caused by hand-copying of drawings and inconsistency between
6.Drawings

3.2 Introduction to Pro/engineer:

Pro/engineer is the industry's standard 3D mechanical design suit. It is the world's leading CAD/CAM /CAE software, gives a broad range of integrated solutions to cover all aspects of product design and manufacturing. Much of its success can be attributed to its technology which spurs its customer's to more quickly and consistently innovate a new robust, parametric, feature based model, because the Pro/E technology is unmatched in this field, in all processes, in all countries, in all kind of companies along the supply chains. Pro/Engineer is also the perfect solution for the manufacturing enterprise, with associative applications, robust responsiveness and web connectivity that make it the ideal flexible engineering solution to accelerate innovations. Pro/Engineer provides easy to use solution tailored to the needs of small, medium sized enterprises as well as large industrial corporations in all industries, consumer goods, fabrications and assembly, electrical and electronics goods, automotive, aerospace etc.

Advantages of Pro/Engineer:

1.It is much faster and more accurate. Once a design is completed. 2D and 3D views are readily obtainable.
2.The ability to incorporate changes in the design process is possible.
3.It provides a very accurate representation of model specifying all other dimensions hidden geometry etc.
4.It provides a greater flexibility for change. For example if we like to change the dimensions of our model, all the related dimensions in design assembly, manufacturing etc. will automatically change.
5.It provides clear 3D models, which are easy to visualize and understand.

Pro/E provides easy assembly of the individual parts or models created it also decreases the time required for the assembly to a large extent.

Design in Pro/engineer

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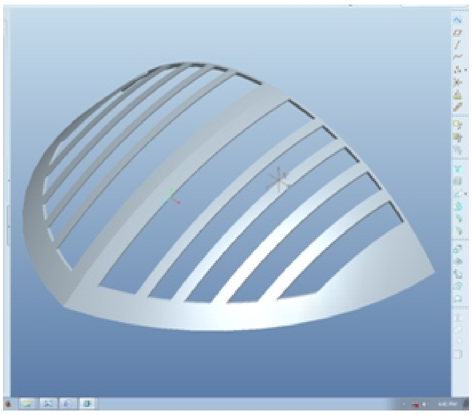

4. ANALYSIS OF A PRODUCT
4.1 Introduction to FEM:

The Basic concept in FEA is that the body or structure may be divided into smaller elements of finite dimensions called "Finite Elements". The original body or the structure is then considered as an assemblage of these elements connected at a finite number of joints called "Nodes" or "Nodal Points". Simple functions are chosen to approximate the displacements over each finite element. Such assumed functions are called "shape functions". This will represent the displacement with in the element in terms of the displacement at the nodes of the element.The Finite Element Method is a mathematical tool for solving ordinary and partial differential equations. Because it is a numerical tool, it has the ability to solve the complex problems that can be represented in differential equations form. The applications of FEM are limitless as regards the solution of practical design problems.

Due to high cost of computing power of years gone by, FEA has a history of being used to solve complex and cost critical problems. Classical methods alone usually cannot provide adequate information to determine the safe working limits of a major civil engineering construction or an automobile or an aircraft. In the recent years, FEA has been universally used to solve structural engineering problems. The departments, which are heavily relied on this technology, are the automotive and aerospace industry. Due to the need to meet the extreme demands for faster, stronger, efficient and lightweight automobiles and aircraft, manufacturers have to rely on this technique to stay competitive. FEA has been used routinely in high volume production and manufacturing industries for many years, as to get a product design wrong would be detrimental.

For example, if a large manufacturer had to recall one model alone due to a hand brake design fault, they would end up having to replace up to few millions of hand brakes. This will cause a heavier loss to the company. The finite element method is a very important tool for those involved in engineering design; it is now used routinely to solve problems in the following areas.

1.Structural analysis
2.Thermal analysis
3.Vibrations and Dynamics
4.Buckling analysis
5.Acoustics
6.Fluid flow simulations
7.Crash simulations
8.Mold flow simulations

Nowadays, even the most simple of products rely on the finite element method for design evaluation. This is because contemporary design problems usually can not be solved as accurately & cheaply using any other method that is currently available. Physical testing was the norm in the years gone by, but now it is simply too expensive and time consuming also.

4.2 Introduction to ANSYS:

The ANSYS program is self contained general purpose finite element program developed and maintained by Swason Analysis Systems Inc. The program contain many routines, all inter related, and all for main purpose of achieving a solution to anan engineering problem by finite element method.

ANSYS finite element analysis software enables engineers to perform the following tasks:

1.Build computer models or transfer CAD models of structures, products, components, or systems.
2.Apply operating loads or other design performance conditions
3.Study physical responses ,such as stress levels, temperature distributions, or electromagnetic fields
4.Optimize a design early in the development process to reduce production costs.
5.Do prototype testing in environments where it otherwise would be undesirable or impossible

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The ANSYS program has a compressive graphical user interface (GUI) that gives users easy, interactive access to program functions, commands, documentation, and reference material. An intuitive menu system helps users navigate through the ANSYS Program. Users can input data using a mouse, a keyboard, or a combination of both. A graphical user interface is available throughout the program, to guide new users through the learning process and provide more experienced users with multiple windows, pull-down menus, dialog boxes, tool bar and online documentation.

4.3 Structural analysis:

Static analysis calculates the effects of steady loading conditions on a structure, while ignoring inertia and damping effects, such as those caused by time-varying loads. A static analysis, however, includes steady inertia loads (such as gravity and rotational velocity), and time-varying loads that can be approximated as static equivalent loads (such as the static equivalent wind and seismic loads commonly defined in many building codes).

4.3.1 Loads in a structural analysis:

Static analysis is used to determine the displacements, stresses, strains, and forces in structures or components caused by loads that do not induce significant inertia and damping effects. Steady loading and response conditions are assumed; that is, the loads and the structure's response are assumed to vary slowly with respect to time. The kinds of loading that can be applied in a static analysis include:

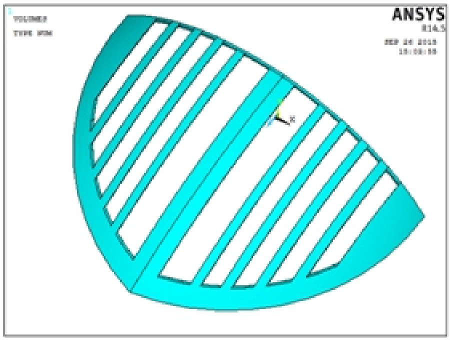
1.Externally applied forces and pressures
2.Steady-state inertial forces (such as gravity or rotational velocity)
3.Imposed (non-zero) displacements
4.Temperatures (for thermal strain)
5.Fluences (for nuclear swelling)

4.4 Modal analysis:

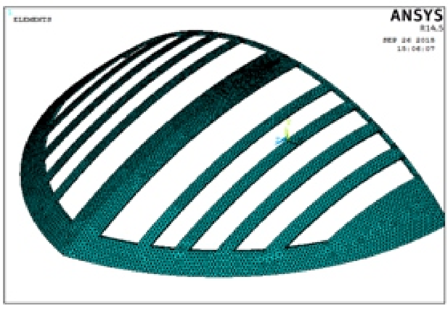
Any physical system can vibrate. The frequencies at which vibration naturally occurs, and the modal shapes which the vibrating system assumes are properties of the system, and can be determined analytically using Modal Analysis.Modal analysis is the procedure of determining a structure's dynamic characteristics; namely, resonant frequencies, damping values, and the associated pattern of structural deformation called mode shapes. It also can be a starting point for another, more detailed, dynamic analysis, such as a transient dynamic analysis, a harmonic response analysis, or a spectrum analysis. Modal analysis in the ANSYS family of products is a linear analysis. Any nonlinearities, such as plasticity and contact (gap) elements, are ignored even if they are defined. Modal analysis can be done through several mode extraction methods: subspace, Block Lanczos, Power Dynamics, Reduced, Unsymmetric and Damped. The damped method allows you to include damping in the structure.

STATIC AND MODEL ANALYSIS OF AIRCRAFT COCKPIT USING MATERIAL ALUMINUM STATIC

Imported model



Meshed Model



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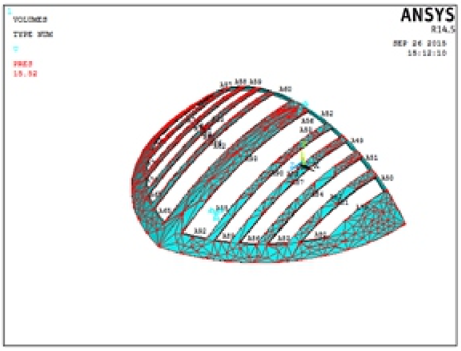
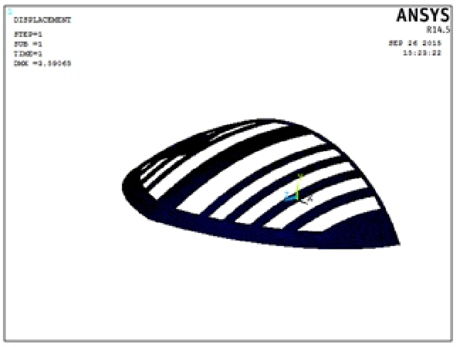
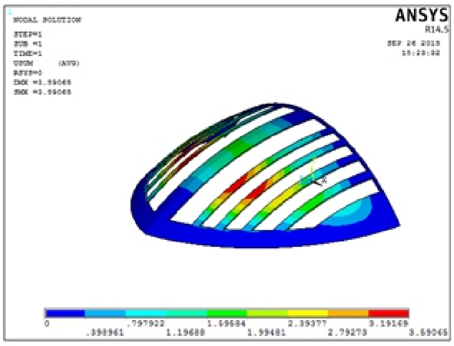
Loads applied model



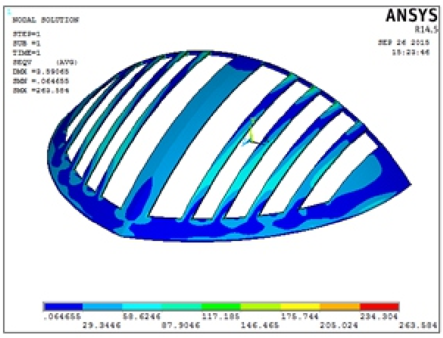
Deformed shape



Displacement vector sum

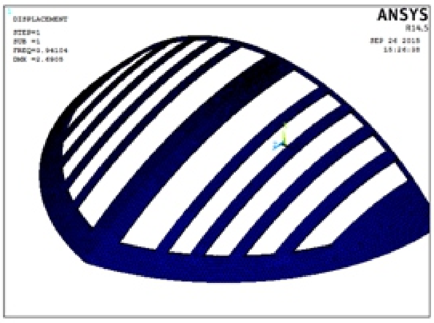


Von misses stress



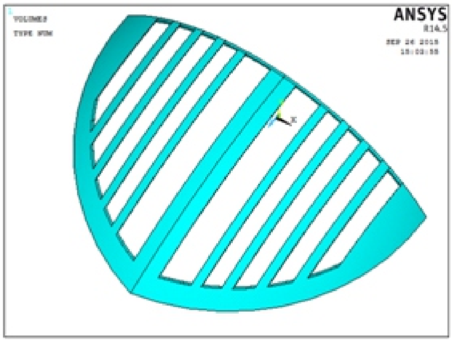
Modal analysis

Mode 1

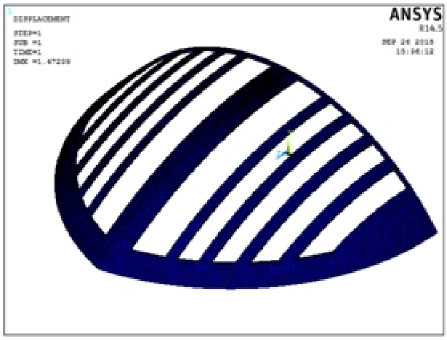


STATIC AND MODEL ANALYSIS OF AIR-CRAFT COCKPIT USING MATERIAL PALSTIC FASCIA

Imported model



Deformed shape



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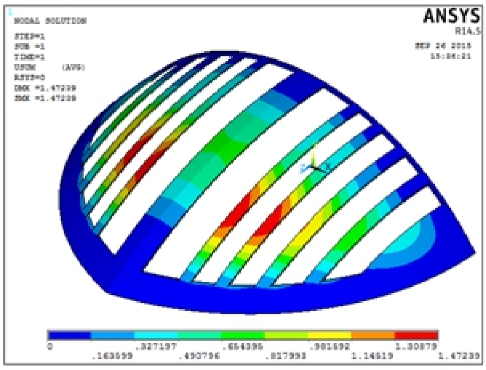
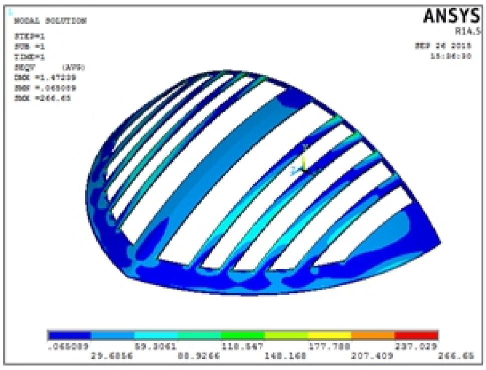
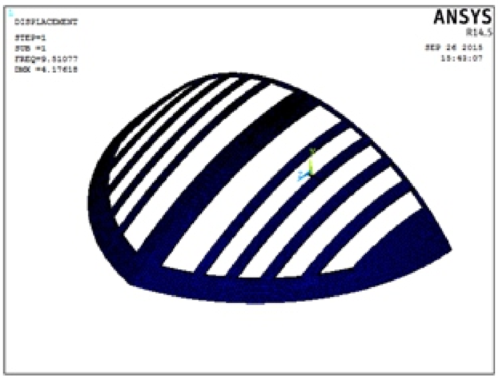
Displacement



Von misses stress



Modal analysis
Mode 1



RESULTS TABLE

5.1 Static analysis

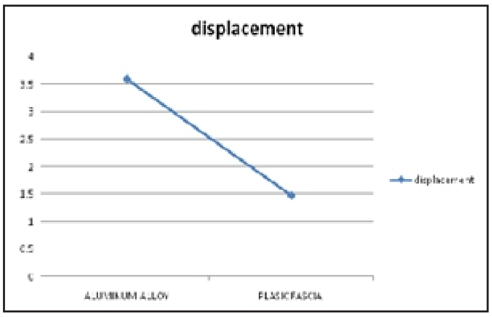
	Displacement	Stress	
		min	max
Aluminum alloy	3.59065	0.64655	263.584
Plasic fascia	1.47239	0.65089	266.65

5.2 Modal analysis results

	MODE 1		MODE 2		MODE 3	
	Freq	Def	Freq	Def	Freq	Def
Aluminum alloy	3.94104	2.6905	3.94172	2.69069	4.68626	2.96798
Plasic fascia	9.51077	4.17618	9.51226	4.17642	11.3078	4.56386

MODE 4		MODE 5	
FREQ	DEF	FREQ	DEF
4.68645	2.967954	4.79655	1.58159
11.308	4.56402	11.5839	2.43679

5.3 Comparison graphs



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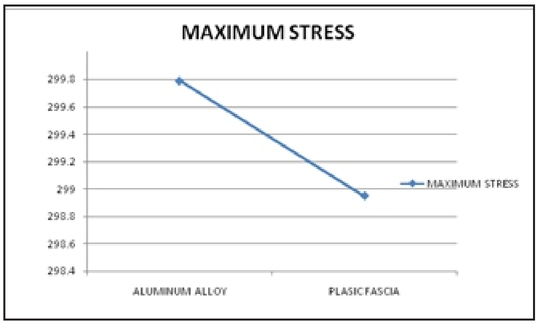
Min stress

Maximum stress



6.CONCLUSION:

Here in our project we have designed a aircraft cockpit, this is one of the major component for a air craft. As the aircraft moves in different layers of the earth, the temperature and the stress also varies. A cockpit or flight deck is the area, usually near the front of an aircraft, from which a pilot controls the aircraft.The cockpit exposes to air under high pressure while the aircraft is flying. The pressure depends upon aircraft velocity. In this thesis we have designed the aircraft cockpit and performed static analysis. Being the aircraft components tend to vibrations we have even performed the model analysis to determine the natural frequency and deformation in resonance.We have done the analysis with the materials Aluminum and Plasic Fascia. As per the results obtained, here the displacement is max for the Aluminum and even the stress factor is very less for the aluminum material, so here we can conclude the best material can be concluded as Aluminum.