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Analysis of Fuselage Using Static and Thermal Interface for Different Joints

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Abstract: ***Fuselage forms the main structure of the aircraft that accommodates the passenger and cargo. The fuselage is continuously subjected to various loads during flight as well as after landing. The integrity of the fuselage-structure is very important for the safety of the aircraft. This project describes a conceptual design of fuselage structure by using CAD software. This project aims to design and analysis of fuselage using static and thermal interface for different joints (riveted, bonded, hybrid) loads for static and thermal stiffness. For this purpose, CAE simulations will be performed on a fuselage model using static and thermal conditions.***

Keywords: fuselage; types of structures; types of joints; analysis of hybrid joint; aluminum material.

I. INTRODUCTION

A. Aero-Plane

Airplane, also called aero-plane or plane, any of a class of fixed-wing aircraft that is heavier than air, propelled by a screw propeller or a high-velocity jet, and supported by the dynamic reaction of the air against its wings . The essential components of an airplane are a wing system to sustain it in flight, tail surfaces to stabilize the wings, movable surfaces to control the attitude of the plane in flight, and a power plant to provide the thrust necessary to push the vehicle through the air. Provision must be made to support the plane when it is at rest on the ground and during takeoff and landing. Most planes feature an enclosed body (fuselage) to house the crew, passengers, and cargo; the cockpit is the area from which the pilot operates the controls and instruments to fly the plane.

Airplanes come in a variety of sizes, shapes, and wing configurations. The broad spectrum of uses for airplanes includes recreation, transportation of goods and people, military, and research. Worldwide, commercial aviation transports more than four billion passengers annually on airliners and transports more than 200 billion ton-kilometers of cargo annually.

II. LITERATURE SURVEY

The design philosophy in the field of aircraft construction is getting transfer from fail safe design to damage tolerance design. Damage tolerance design improves the life of a component. A two seater aircraft structural member was found to have an expected life of ten thousand hours. The fatigue life of the aircraft if increased, could give an improvement to the life of the aircraft too. The aircraft had a history of structural failures at the rear part of the fuselage, at the wing spars etc. The rivets used are areas of greater stress concentrations and thereby chances of failures due to them are high. The riveting pattern is what determines the amount of stress concentrations there. Also the residual stresses add to this factor. In this project a piece similar to the fuselage skin, of same material and the riveting pattern is tested for deformation, fatigue and multi site damage. Then the riveting pattern is changed to other types of riveting and tested again. The data obtained are then compared. This could be used as an improvement to the skin structure of that aircraft. The testing is to be one both with FEA software and also experimentally done.

III. FUSELAGE DESIGN

An airplane or aero-plane (informally plane) is a powered, fixed-wing aircraft that is propelled forward by thrust from a jet engine, propeller or rocket engine. Airplanes come in a variety of sizes, shapes, and wing configurations. The broad spectrum of uses for airplanes includes recreation, transportation of goods and people, military, and research. Worldwide, commercial aviation transports more than four billion passengers annually on airliners and transports more than 200 billion ton- kilometers of cargo annually . The fuselage is an aircraft's main body section. It holds crew, passengers, and cargo. In single-engine aircraft, it will usually contain an engine, as well, although in some amphibious aircraft the single engine is mounted on a pylon attached to the fuselage, which in turn is used as a floating hull. The fuselage also serves to position control and stabilization surfaces in specific relationships to lifting surfaces, which is required for aircraft stability and maneuverability.

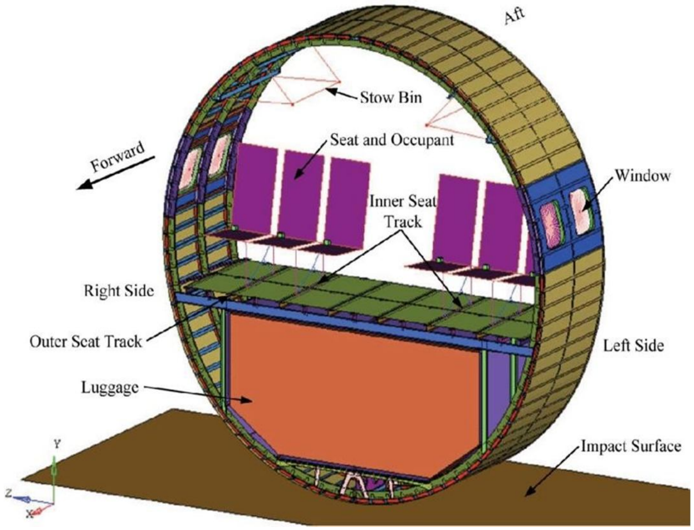


Fig :1 Fuselage Structure

IV. MATERIALS SELECTION

A. Aluminium

Advancements in engine technology in the 1930s allowed engineers to turn to metal designs, and aluminum was the primary metal to usher in the dawn of the all-metal aircraft. The aluminum used to make planes is always blended with other metals to make it strong and light. While aluminum fuselages don't corrode as easily as those made of steel, aluminum isn't used on the surface of many supersonic planes because heat generated by the friction from flying at such speeds causes aluminum's strength to decrease. Boeing's 247D and the Douglas DC-3 are largely credited with the mainstreaming of metal aircraft during the 1930s and these planes don't appear all that different fromthe aircraft we see today.

The 247D was around 50 percent faster than the competition when it was put into service by United Air Lines in 1933. It is lightweight and strong. Aluminum alloys don't corrode as readily as steel. But because they lose their strength at high temperatures, they cannot be used for skin surfaces that become very hot on airplanes that fly faster than twice the speed of sound.

V. FINITE ELEMENT METHOD

The finite element method (FEM) is a numerical technique for solving problemswhich are described by partial differential equations or can be formulated as functional minimization. A domain of interest is represented as an assembly of finite elements. The finite element method (FEM) is the most widely used method for solving problems of engineering and mathematical models. Typical problem areas of interest include the traditional fields of structural analysis, heat transfer, fluid flow, mass transport, and electromagnetic potential. The FEM is a particular numerical method for solving partial differential equations in two or three space variables (i.e., some boundary value problems). To solve a problem, the FEM subdivides a large system into smaller, simpler parts that are called finite elements. This is achieved by a particular space discretization in the space dimensions, which is implemented by the construction of a mesh of the object: the numerical domain for the solution, which hasa finite number of points. The finite element method formulation of a boundary value problem finally results in a system of algebraic equations. The method approximates the unknown function over the domain.

VI. FINITE VOLUME METHOD

The Finite Volume Method (FVM) was introduced into the field of computational fluid dynamics in the beginning of the seventies (McDonald 1971, Mac-Cormack and Paullay 1972). From the physical point of view the FVM is based on balancing fluxes through control volumes, i.e. the Eulerian concept is used.

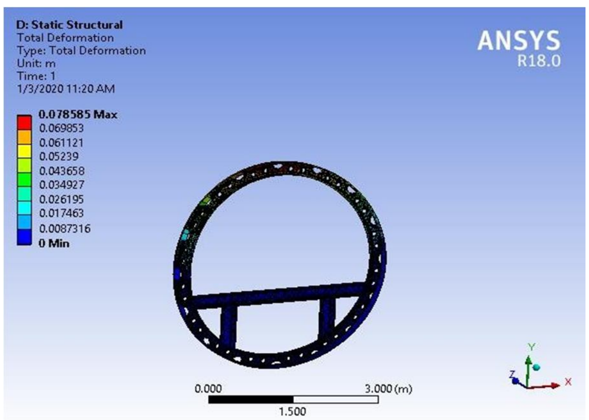
The integral formulation of conservative laws are discretized directly in space. From the numerical point of view the FVM is a generalization of the FDM in a geometric and topological sense, i.e. simple finite volume schemes can be reduced to finite difference schemes. The FDM is based on nodal relations for differential equations, whereas the FVM is a discretization of the governing equations in integral form.

The Finite Volume Method can be considered as specific sub domain method as well.FVM has two major advantages: First, it enforces conservation of quantities at discretized level, i.e. mass, momentum, energy remain conserved also at a local scale. Fluxes between adjacent control volumes are directly balanced. Second, finite volumeschemes takes full advantage of arbitrary meshes to approximate complex geometries. Experience shows that non-conservative schemes are generally less accurate than conservative ones, particularly in the presence of strong gradients.

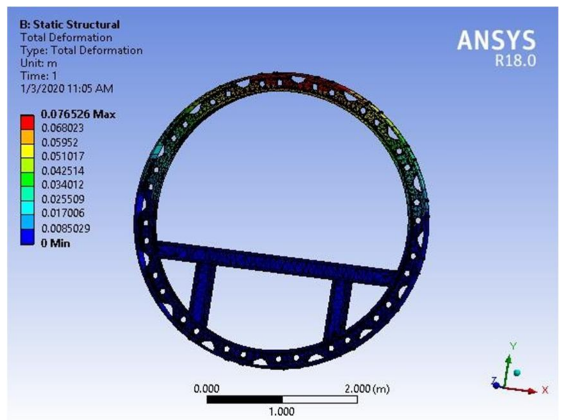
VII. STATIC STRUCTURAL ANALYSIS

Static analysis is used to determine the displacements, stresses, strains, and forcesin structures or components caused by loads that do not induce significant inertia and damping effects. Structural analysis is the determination of the effects of loads onphysical structures and their components. Structures subject to this typeof analysis include all that must withstand loads, such as buildings, bridges, vehicles, furniture, attire, soil strata, prostheses and biological tissue. Structural analysis employs the fields of applied mechanics, materials science and applied mathematics to compute a structure's deformations, internal forces, stresses, support reactions, accelerations, and stability. The results of the analysis are used to verify a structure's fitness for use, often precluding physical tests. Structural analysis is thus a key part of the engineering design of structures.

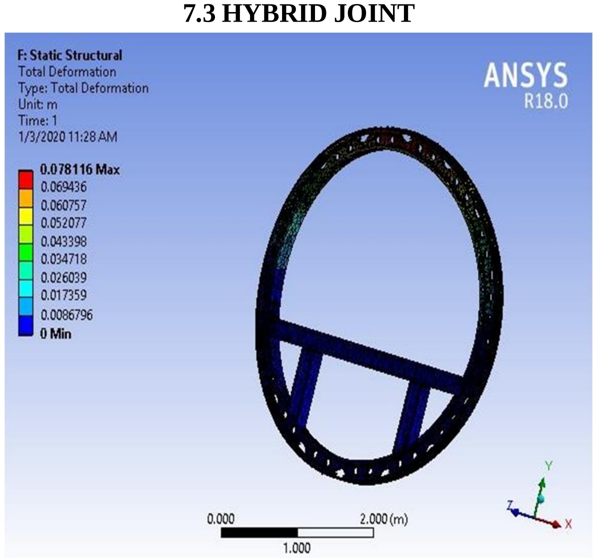
7.1 BONDED JOINT



7.2 RIVETED JOINT



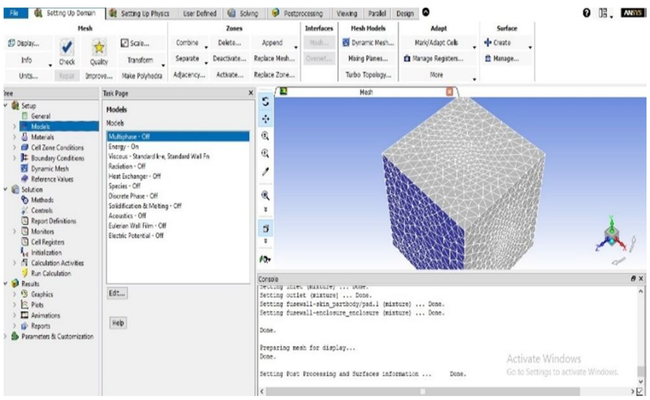
7.3 HYBRID JOINT

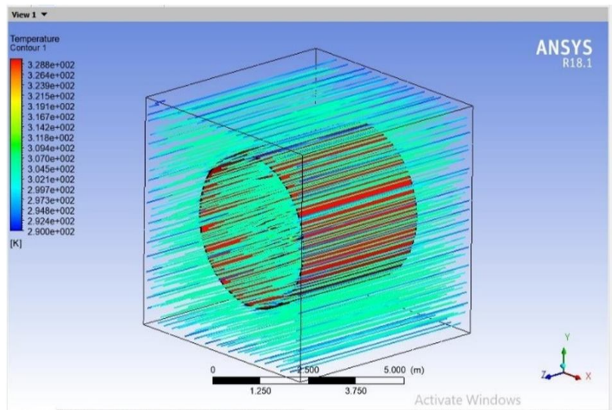


VIII. COMPUTATIONAL FLUID DYNAMICS

(CFD) is a branch of fluid mechanics that uses numerical analysis and data structures to analyze and solve problems that involve fluid flows. Computers are used to perform the calculations required to simulate the free-stream flow of the fluid, and the interaction of the fluid (liquids and gases) with surfaces defined by boundary conditions. With high-speed supercomputers, better solutionscan be achieved, and are often required to solve the largest and most complex problems. Ongoing research yields software that improves the accuracy and speed of complex simulation scenarios such as transonic or turbulent flows.

Initial validation of such software is typically performed using experimental apparatus such as wind tunnels. In addition, previously performed analytical or empirical analysis of a particular problem can be used for comparison. A final validation is often performed using full- scale testing, such as flight tests.



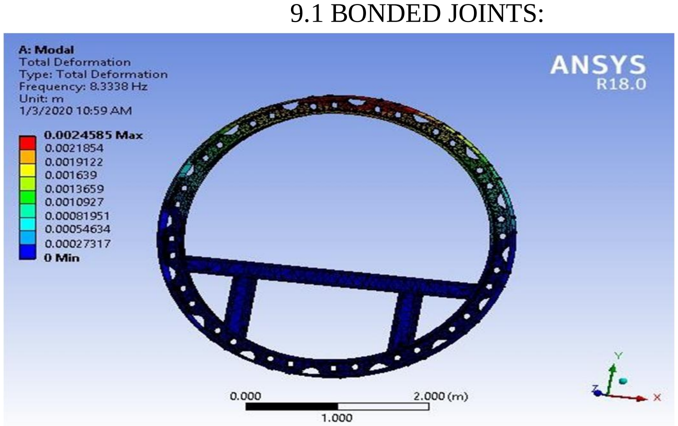


IX. MODAL ANALYSIS

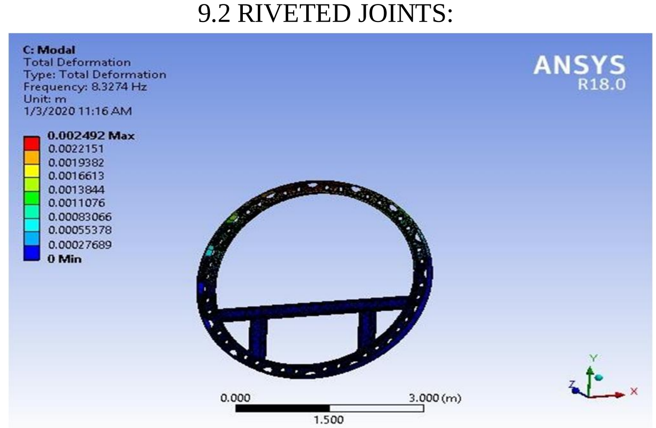
Modal analysis is the study of the dynamic properties of systems in the frequency domain. Examples would include measuring the vibration of a car's body when it is attached to a shaker, or the noise pattern in a room when excited by a loudspeaker. Modern day experimental modal analysis systems are composed of ,sensors suchas transducers (typically accelerometers, load cells), or non-contact via a Laservibrometer, or stereophotogrammetric cameras , data acquisition system and an analog-to-digital converter front end (to digitize analog instrumentation signals) and host PC (personal computer) to view the data and analyze it.

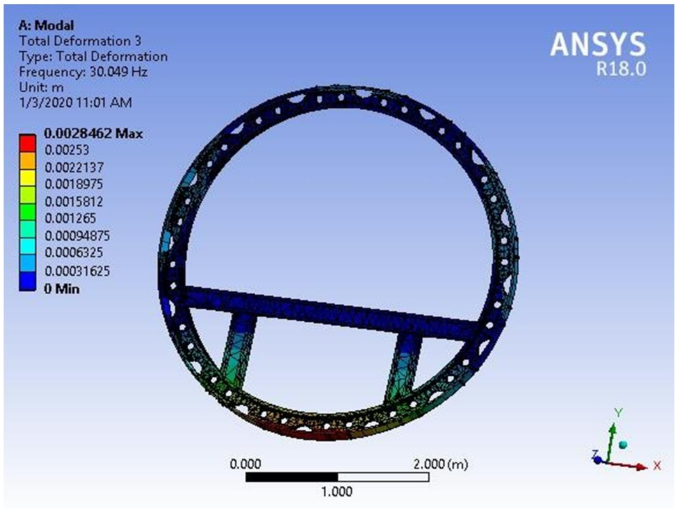
Classically this was done with a SIMO (single-input, multiple-output) approach, that is, one excitation point, and then the response is measured at many other points. In thepast a hammer survey, using a fixed accelerometer and a roving hammer as excitation,gave a MISO (multiple-input, single-output) analysis, which is mathematically identical to SIMO, due to the principle of reciprocity. In recent years MIMO (multi- input, multiple-output) have become more practical, where partial coherence analysis identifies which part of the response comes from which excitation source. Using multiple shakers leads to a uniform distribution of the energy over the entire structure and a better coherence in the measurement. A single shaker may not effectively excite all the modes of a structure. The resulting transfer function willshow one or more resonances. whosecharacteristic mass, frequency and damping can be estimated from the measurements. The results can also be used to correlate with finite element analysis normal mode solutions.

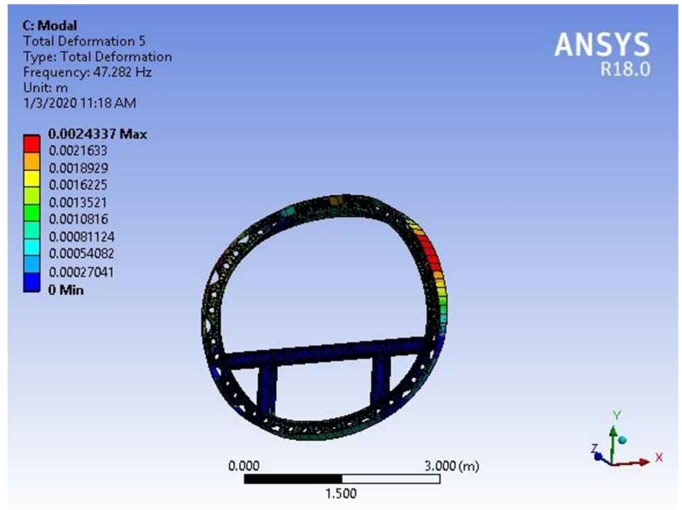
9.1 BONDED JOINTS:

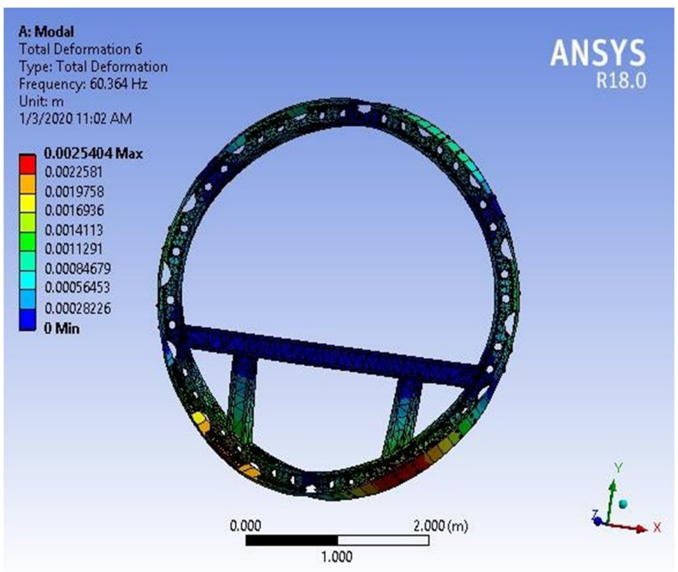


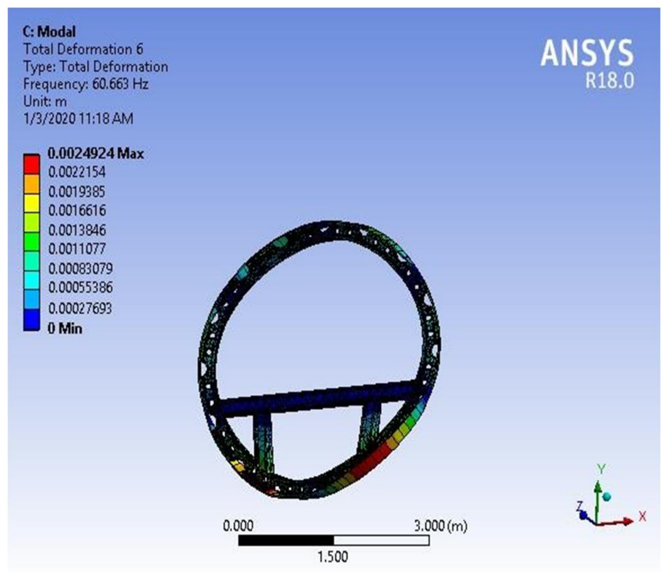
9.2 RIVETED JOINTS:



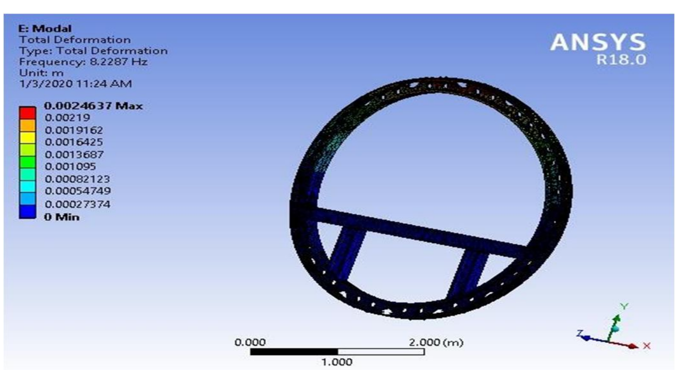








9.3 HYBRID JOINTS:



10. RESULT

	Total Deformation (mm)	**Equivalent Stress (N/mm^2)**
Bonded Joint	**78.5**	**767.91**
Riveted Joint	**76.5**	**438.16**
Hybrid Joint	**78.11**	**437.41**

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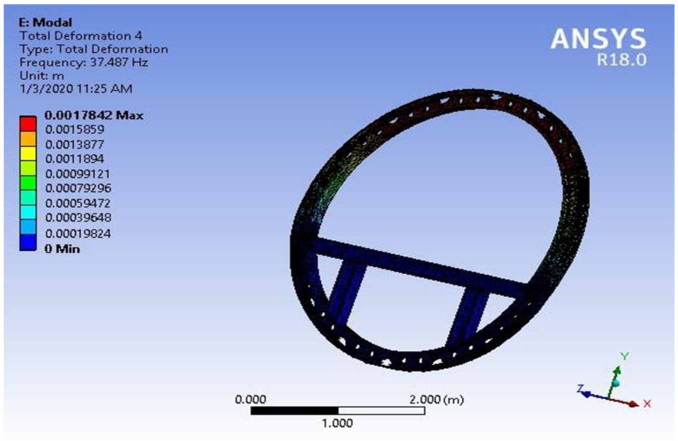

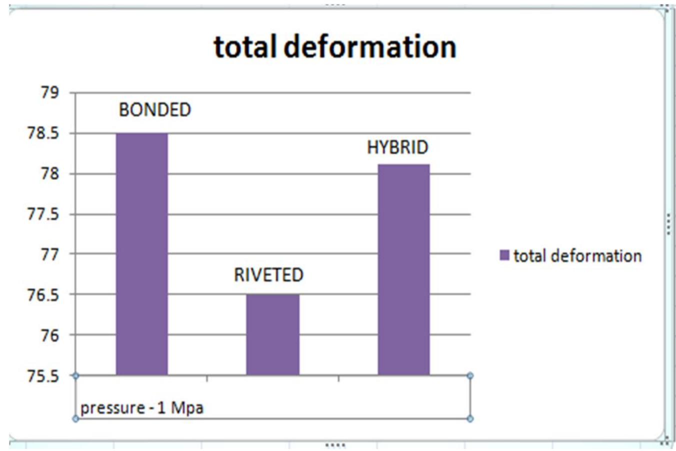

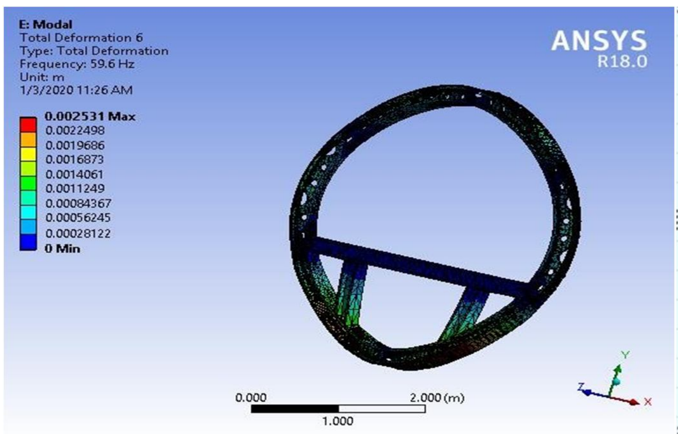

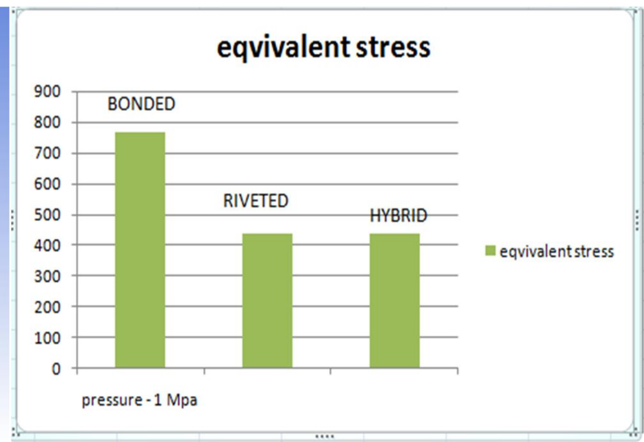

X. CONCLUSION

In this analysis, the simulation of stress distribution and deformation in joints such as bonded, riveted and hybrid joints has been carried out successfully. The stress and deformation values are used to compare the results with three joining methods. The equivalent stress for a hybrid joint is found to be less compared to rivet and bonded joint. The stress induced by using ANSYS is less than the materials ultimate stressand ultimate limit. The total deformation for a hybrid joint is comparatively less than other two joints. It is found that a well designed hybrid joint is very efficient and preferable when compared to bonded, riveted joints as they cause least deformation and efficient stress distribution.

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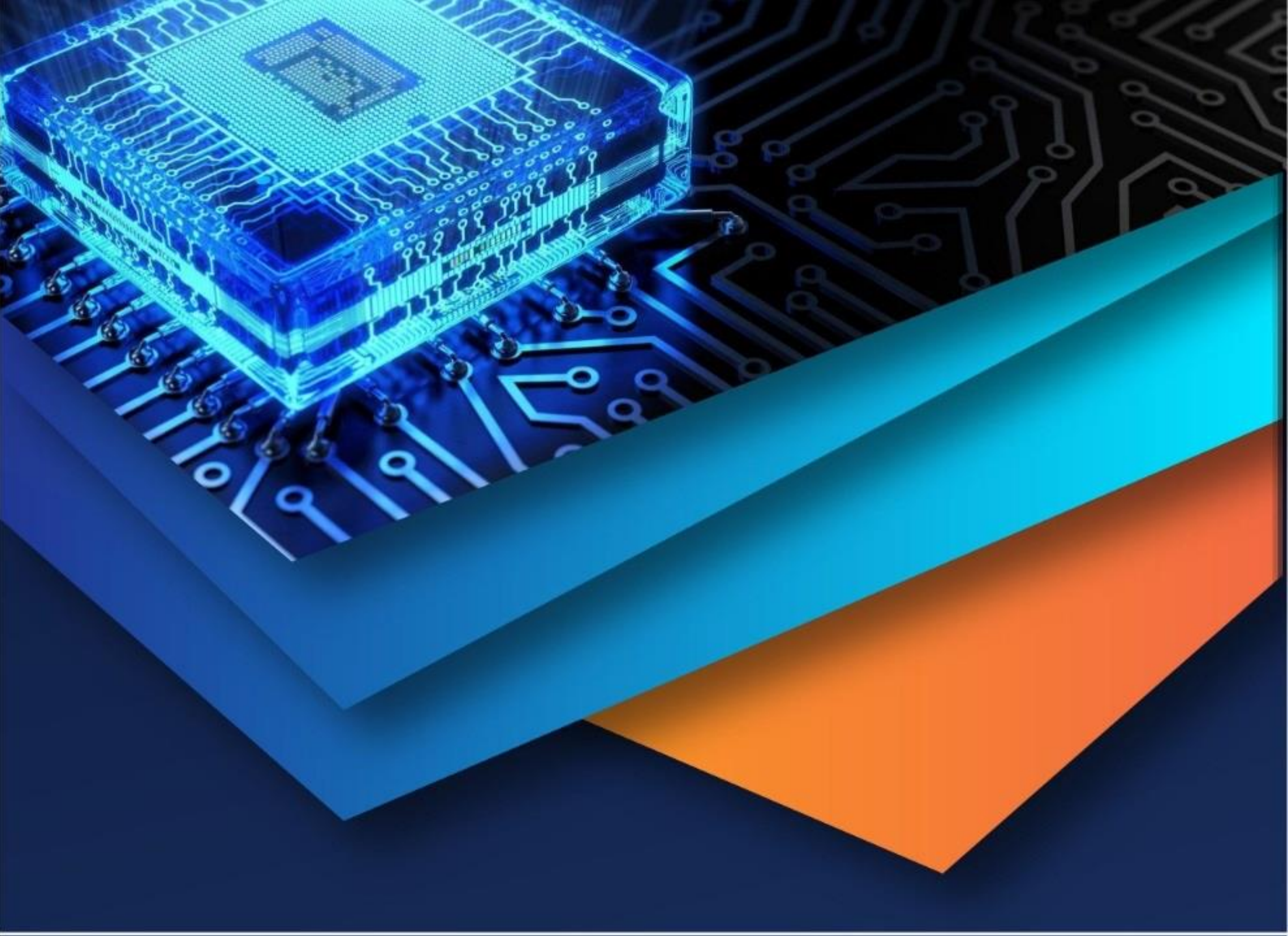

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