IJMTARC – VOLUME – IX – ISSUE – 34, APR - JUN, 2021 ISSN: 2320-1363

# DESIGN AND ANALYSIS OF AUTOMATIC FIRE FIGHTING VEHICLE BY USING CAE TOOLS

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**Abstract:** *Fire Fighting is an extremely dangerous task that has caused severe loss of life and property because of lack in technological advancement. The current firefighting methods mostly employing humans are inadequate, inefficient and are subjected to errors. This paper presents the design and analysis of a Fire Fighting Vehicle that monitors a hazardous fire prone area with the feature of continuous scanning for any occurrence of fire. It is a re-programmable multifunctional manipulator designed to move materials, parts, tools or specialized devices through variable programmed motions for the performance of a variety of tasks. When a fire is spotted it locates the exact source of fire and extinguishes the fire with an extinguisher mounted on the Vehicle. Monitoring a critical area is done by line following mechanism using Infrared sensors. Fire detection is also carried out using IR detectors. This Vehicle will find application in monitoring critical fire hazardous site ensuring minimum damage with maximum human safety. For the determination of forces on the elements, models and drawings are to be made in CAD software like Catia and analysis by Ansys software. The quality mesh is prepared in for converged solution and the solver set. The resultant calculation process can be used for designing the geometry and determination of the properties regarding the vehicle.*

## I- INTRODUCTION

Robotics is one of the fastest growing engineering fields of today. Robots are designed to remove the human factor from labor intensive or dangerous work and to act in inaccessible environment. The use of robots is more common today than ever before and it is no longer.

Exclusively used by the heavy production industries, the need of fire extinguisher robot that can detect and extinguish a fire on its own is long past due. With the invention of such a device, people and property can be saved at a much higher rate with relatively minimal damage caused by the fire. Our task as engineers was to design and build a prototype system that could autonomously detect and manually extinguish a fire. Also aims at minimizing air pollution.

In this project, we have design a wireless controlled robot. If a robot is used instead, which can be controlled from a distance or which can perform actions intelligently by it, which will reduce the risk of this task of firefighting. Robot is a mechanical device that is used for performing tasks that includes high risk like firefighting. There are many types of robots like fixed base robot, mobile robot, underwater robot, humanoid robot, space robot, medicines robot etc.

Nowadays, machinery and robotic design become important in helping human. This Fire Protection Robot was design to help people in any destructive burnt situation where this robot can extinguish burnt area immediately using autonomous system. This autonomous system will be designed using programming and others additional circuit. In real life, destructive burnt area often happens without our realization. Therefore, this type of robot will require a high demands in the market because of its usefulness to the human as well as the environment transmit

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fire information to cell phone using GSM modern.

Firefighting and rescuing the victims is a risky task. Fire Fighters have to face dangerous situations while extinguishing the fire. Fire Fighters extinguish fires in tall buildings, drag heavy hoses, climb high ladders, carry victims from one building to another. In addition to long and irregular working hours, fire fighters also face unfriendly environment like high temperature, dust and low humidity. Besides, they also have to face life threatening situations like explosion and collapse buildings. According to the report of IAFF in the year 2000, 1.9 fire fighters per 100,000 structure fires have lost their lives per year in USA. However, this rate was increasing to 3 per 100,000 structure fires. The different causes of Line of Duty Deaths (LODD) are smoke inhalation, burns, crushing injuries and related trauma. Statistics shows that the deaths of fire fighters are constant every year. This results in need of firefighting machines to assist the fire fighters to avoid deaths by handling the dangerous situations. So if a robot is used instead, which can be controlled from a distance or which can perform actions intelligently by it, which will reduce the risk of this task of fire fighting. Robot is a mechanical device that is used for performing tasks that includes high risk like fire fighting.

## II -LITERATURE SURVEY

In today's era fire fighting is a dangerous issue. Many authors are working on different techniques for fire fighting. Author Ratnesh Malik et al. has developed an approach towards fire fighting robot. The robot is designed and constructed which is able to extinguish fire. The robot is fully autonomous. It implements the concept likes environmental sensing and awareness, proportional motor control. The robot processes information from its sensors and hardware elements. Ultraviolet, Infrared and visible light are used to detect the components of environment. The robot is capable of fighting tunnel fire, industry fire and military applications are designed and built. Ultraviolet sensors are used to detect fire. Once fire is detected, robot sounds an alarm. Then the robot activates an electronic valve which release sprinkles of water on the flame. Detailed concept of robot is explained which automatically detects fire and extinguishes it in short time by the use of sensors, microcontroller etc. This robot is used in places where human lives are at high risk.

Author Kristi Kokasih et al. has developed intelligent fire fighting tank robot. Tank robot is made from acrylic, plastic, aluminum and iron. Robot components are two servo motors, two DC motors, ultrasonic sensor, compass sensors, flame detector, thermal array sensor, white detector (IR and photo transistor), sound activation circuit and micro switch sensor. The objective is to search certain area, find and extinguish the flame for different flame positions, room configuration with disturbance. Robot is activated through DTMF transmitter and receiver.

Control of an Autonomous Industrial Fire Fighting Mobile Robot is developed by H.P. Singh et al. The paper describes the construction and design of mobile fire fighting robot. The system contains two optically isolated D.C. motors. Robot performs analog to digital conversion of the data provided by infrared sensors. Five infrared sensors are used. Two

sensors control the motion of the robots and three are for flame detection. The extinguisher comprises of D.C water pump and a water container. The basic theme of the paper is to sense the flames of fire and extinguish it. For this infrared sensor is used as input sensor which senses the infrared rays coming out of the fire. The microcontroller controls the extinguishing system.

Wireless fire fighting robot is developed by Swati Deshmukh et al. It comprises of machine which has ability to detect fire and extinguish it. The fire fighting robot can move in both forward and reverse direction and can turned in left and right directions. Thus fire fighter can operate the robot over a long distance and there is no need for human near the area on fire. Light dependent resistors are used for detection of fire. These resistors are highly sensitive devices and are capable of detecting very small fire. The robot provides security at home, buildings, factory and laboratory. It is an intelligent multisensory based security system which contains fire fighting system in daily life.

## III - OBJECTIVES AND PROBLEM STATEMENT

The objectives for this project are:

i. To study a robot which can search, detect and extinguish burnt area immediately and develop a program using to control the movement of the robot. Besides, lean how to connect microcontroller and GSM modem.
ii. To design the robot that includes the flame sensor to detect the fire and then send notification.
iii. To analyze how the robot performance to detect the angle of burnt area in front of the robot and detecting burnt area.

**Project Scope**

The project scopes for this project are:

i. The robot detecting burnt area.
ii. Robot detect fire event, and use extinguish to fight the fire source and the modem connected to the programmable device.
iii. The robot can turn 360° and then robot can extinguish fire at angle 30° from the fire extinguisher nozzle.
iv. The robot can extinguish fire from petrol, gasses and electrical appliance.

**Problem Statement**

The security of home, laboratory, office, factory and building is important to human life. We develop security system that contains a fire protection robot using sensor. The security system can detect abnormal and dangerous situation and notify us. First, we design a fire protection robot with extinguisher for the intelligent building. Besides, Human had difficulties to detect the small burnt cause by electrical appliances. The late time user takes to extinguish the fire. User may take a late time to extinguish fire like finding the water source to extinguish fire when want to extinguish the fire. The fire difficulties to detect the small burnt area and location that is hard to be reach by the user. Sometimes tough fire extinguished for example spaces are hard to see. Besides is cost the loss suffered in the event of fire slow to act.

## IV - WORKING METHODOLOGY AND DESCRIPTION OF PROJECT

A robot is an automatically guided machine, able to do tasks on its own. This project, which is our Endeavour to design a Fire Fighting Robot, comprises of a machine which not only has the basic features of a robot, but also has the ability to detect fire and extinguish it this robot processes information from its various sensors and key hardware elements through microcontroller. It uses thermostats or ultraviolet

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or visible sensors to detect the fire accident. A robot capable of extinguishing a simulated tunnel fire, industry fire and military applications are designed and built. Ultraviolet sensors/thermostats/flame sensors will be used for initial detection of the flame. Once the flame is detected, the robot sounds the alarm with the help of buzzer provided to it; the robot actuates an electronic valve releasing sprinkles of water on the flame.

The project helps to generate interests as well as innovations in the fields of robotics while working towards a practical and obtainable solution to save lives and mitigate the risk of property damage. Fire fighters face risky situations when extinguishing fires and rescuing victims, it is an inevitable part of being a fire fighter. In contrast, a robot can function by itself or be controlled from a distance, which means that firefighting and rescue activities could be executed without putting fire fighters at risk by using robot technology instead. In other words, robots decrease the need for fire fighters to get into dangerous situations. This robot provides fire protection when there is fire in a tunnel or in an industry by using automatic control of robot by the use of microcontroller in order to reduced loss of life and property damage. This robot uses dc motors, castor wheel, microcontroller, sensors, pump and sprinkler. Microcontroller is the heart of the project. Microcontroller controls all the parts of the robot using programming. In this robot as the fire sensor senses the fire, it sends the signal to microcontroller; since the signal of the sensor is very weak the amplifier is used so that it can amplify the signal and sends it to microcontroller. As soon as microcontroller receives the signal a buzzer sounds, the buzzer sound is to intimate the occurrence of fire accident. After the sounding of the buzzer microcontroller actuates the driver circuit and it drives the robot towards fire place, as the robot reaches near the fire microcontroller actuates the relay and pump switch is made ON and water is sprinkled on the fire through the sprinkler.

## Description of Components

### Microcontrollers

Microprocessors and microcontrollers are widely used in embedded systems products. Microcontroller is a programmable device. A microcontroller has a CPU in addition to a fixed amount of RAM, ROM, I/O ports and a timer embedded all on a single chip. The fixed amount of on-chip ROM, RAM and number of I/O ports in microcontrollers makes them ideal for many applications in which cost and space are critical.

### Voltage regulator

As the name itself implies, it regulates the input applied to it. A voltage regulator is an electrical regulator designed to automatically maintain a constant voltage level. In this project, power supply of 5V and 12V are required. In order to obtain these voltage levels, 7805 and 7812 voltage regulators are to be used. The first number 78 represents positive supply and the numbers 05, 12 represent the required output voltage levels. The L78xx series of three-terminal positive regulators is available in TO-220, TO-220FP, TO-3, D2PAK and DPAK packages and several fixed output voltages, making it useful in a wide range of applications. These regulators can provide local on-card regulation, eliminating the distribution problems associated with single point regulation. Each type employs internal current limiting, thermal shut-down and safe area protection, making it essentially indestructible. If adequate heat sinking is provided, they can deliver over 1 A output current. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltage and currents.

### LCD screen

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LCD screen consists of two lines with 16 characters each. Each character consists of 5x7 dot matrix. Contrast on display depends on the power supply voltage and whether messages are displayed in one or two lines. For that reason, variable voltage 0-Vdd is applied on pin marked as Vee. Trimmer potentiometer is usually used for that purpose. Some versions of displays have built in backlight (blue or green diodes). When used during operating, a resistor for current limitation should be used (like with any LE diode).

**DC MOTOR**

A DC motor is an electric motor that runs on DC electricity. It works on the principle of electromagnetism. A current carrying conductor when placed in an external magnetic field will experience a force proportional to the current in the conductor.

**OPERATION OF A DC MOTOR**

There are two magnetic fields produced in the motor. One magnetic field is produced by the permanent magnets and the other magnetic field is produced by the electrical current flowing in the motor windings. These two fields result in a torque which tends to rotate the rotor. As the rotor turns, the current in the windings is commutated to produce a continuous
Torque output this makes the motor to run.

## V - DESIGN METHODLOGY OF FIRE FIGHTING VEHICLE

CATIA (Computer Aided Three-dimensional Interactive Application) is a multi-platform CAD/CAM/CAE commercial software suite developed by the French company Dassault Systems. Written in the C++ programming language, CATIA is the cornerstone of the Dassault Systems product lifecycle management software suite. CATIA competes in the high-end CAD/CAM/CAE market with Cero Elements/Pro and NX (Unigraphics).

Sets of workbenches can be composed according to 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/ENGINEER, NX (formerly Unigraphics), and Solid Works are the dominant systems.

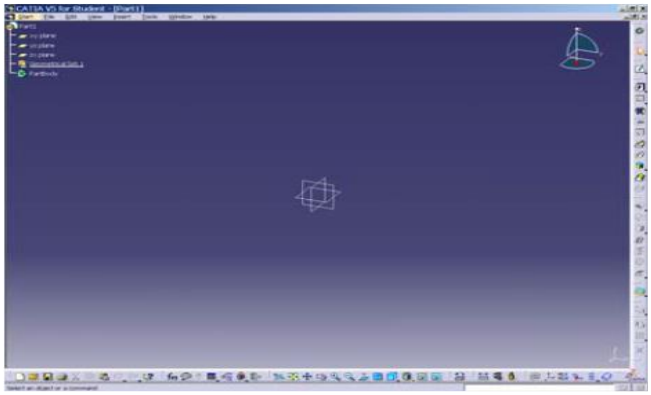

***Fig: 5.1: Home Page of CatiaV5***

**Modeling Of Fire Fighting Vehicle In Catia V5**

This **FIRE FIGHTING VEHICLE** is designed using CATIA V5 software. This software used in automobile, aerospace, consumer goods, heavy

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engineering etc. it is very powerful software for designing complicated 3d models, applications of CATIA Version 5 like part design, assembly design.

The same CATIA V5 R20 3d model and 2d drawing model is shown below for reference. Dimensions are taken from. The design of 3d model is done in CATIA V5 software, and then to do test we are using below mentioned software's.

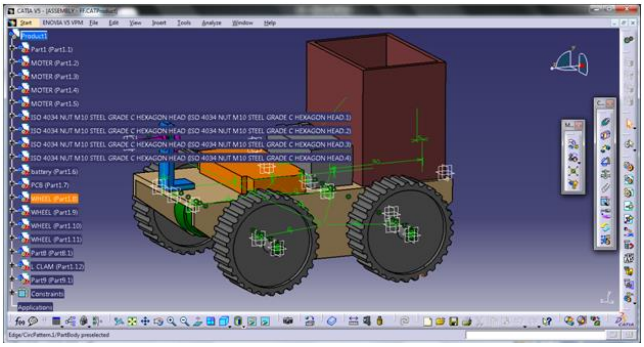

*Fig: 5.2: Model design in CATIA-V5*

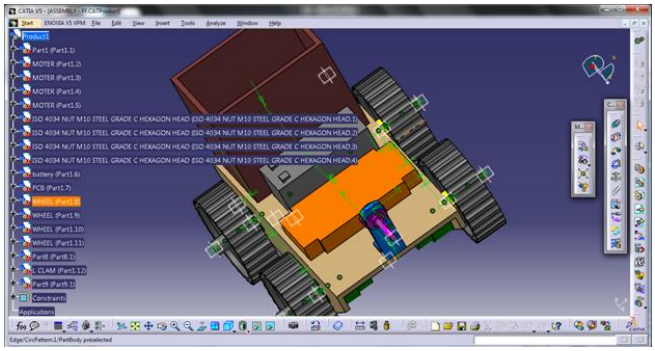

*Fig: 5.3: Model arrangement in CATIA-V5*

## VI - ANALYSIS OF FIRE FIGHTING VEHICLE

**Procedure for FE Analysis Using ANSYS:**

The analysis of the components is done using ANSYS. For motor and attached system is to carried out by applying moments at the rotation location along which axis we need to mention. Fixing location is bottom legs of the components.

**Preprocessor**

In this stage the following steps were executed:

- **Import file in ANSYS window**

File Menu > Import> STEP > Click ok for the popped up dialog box > Click

Browse" and choose the file saved from CATIAV5R20 > Click ok to import the file

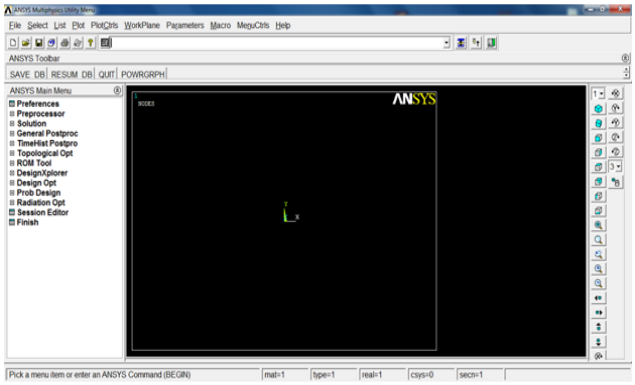

**Fig.5.1: Import panel in Ansys.**

## VII - DISCUSSION ON ANALYSIS RESULT

**7.1 Results of Displacement analysis:**

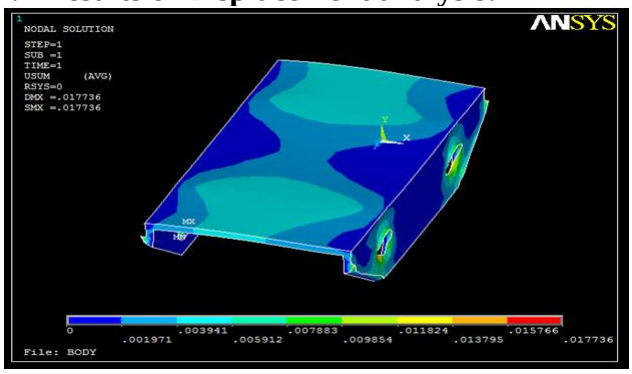


**Fig: 7.1: Displacement of Body**

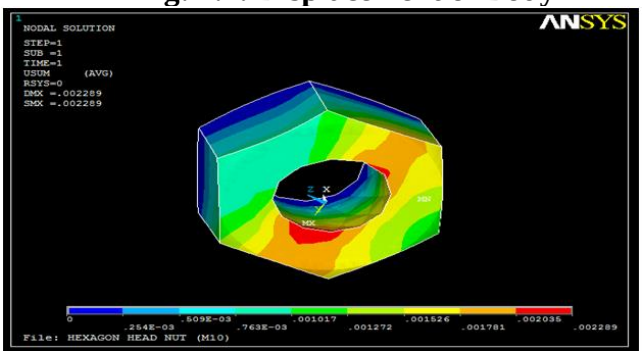


**Fig: 7.2: Displacement of Hexagonal nut**

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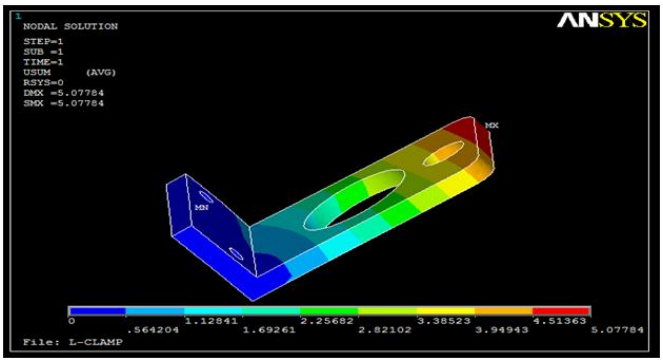


**Fig: 7.3: Displacement of L-clamp**

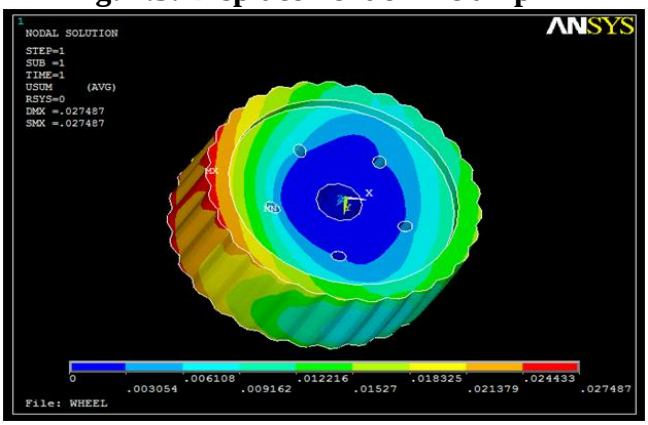


**Fig: 7.4: Displacement of Wheel**

## 7.2 Results of Stress analysis:

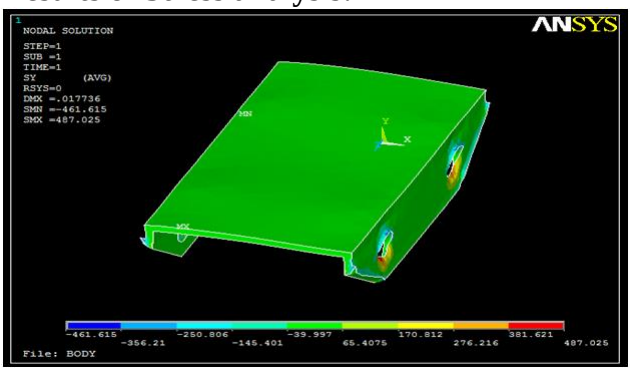


**Fig: 7.5: Stress Analysis of Body**

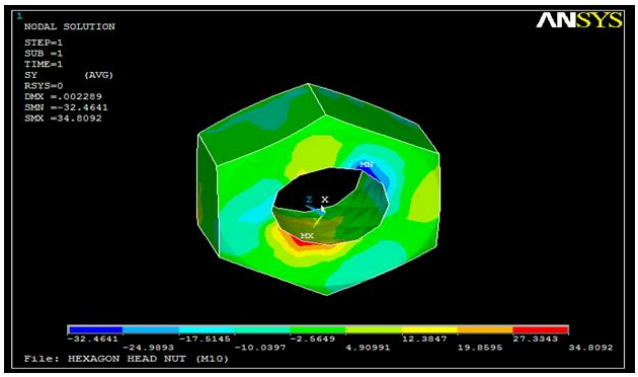


**Fig: 7.6: Stress Analysis of Hexagonal nut**

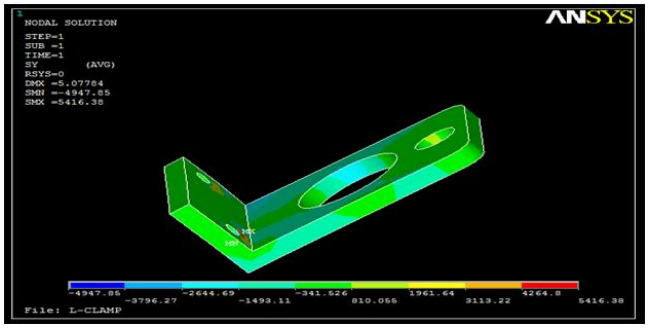


**Fig: 7.7: Stress Analysis of L-clamp**

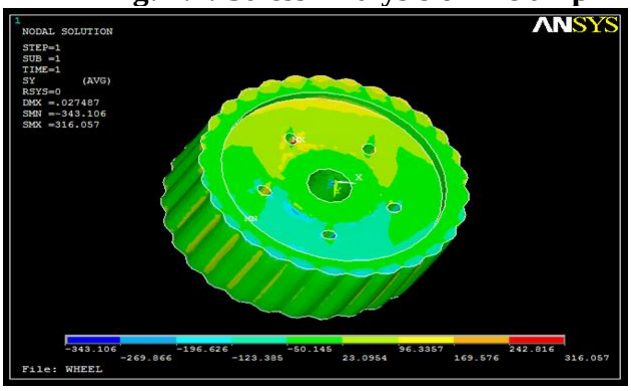


**Fig: 7.8: Stress Analysis of Wheel**

## 7.3 Results of Strain analysis:

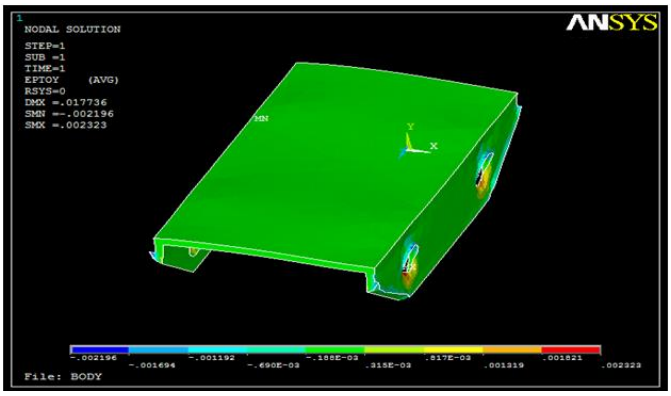


**Fig: 7.9: Strain Analysis of Body**

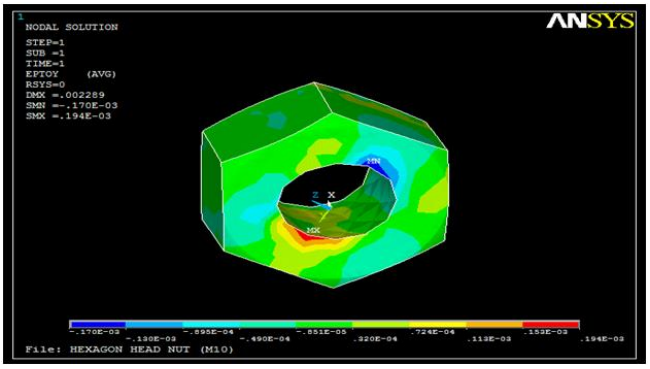


**Fig: 7.10: Strain Analysis of Hexagonal nut**

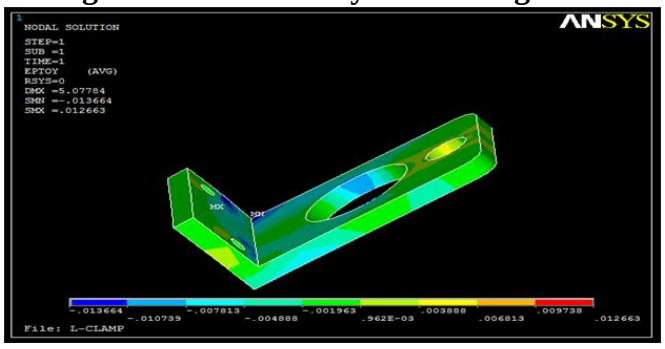


**Fig: 7.11: Strain Analysis of L-clamp**

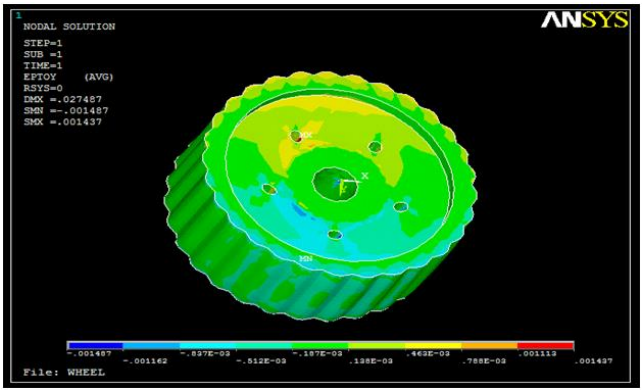


**Fig: 7.12: Strain Analysis of Wheel**

## VIII - CONCLUSION

The project "Fire Fighting Vehicle" has been successfully designed and tested. Presence of every module has been reasoned out and designed and analyzed carefully thus contributing to the best working of the unit. Secondly, the trend towards low power hand held transceivers increases all of these challenges. Keeping all the above parameters in view we have designed a low cost integrated system for monitoring the different types of parameters between two systems. As shown above figures, the displacement of the design is meshed and solved using Ansys and displacement is 0.0177mm which is very less. This is showing us that clearly each component in assembly is having minor displacement. Stress is at the fixing location (Minimum Stress which is acceptable), stress value is 487.025MPa. The value which is very less compared to yield value of Aluminum; this is below the yield point. The maximum stress is coming, this solution solving with the help of Ansys software so that the maximum stress is less .so we can conclude our design parameters are approximately correct. This process may be incremental but the overall concept requires a shift in the way we think about mechanization for autonomous machines that is based more on needs and novel ways of meeting them rather than modifying existing techniques.

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