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UNMANNED GROUND SURVEILLANCE ROBOT

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Abstract: Our research aims to enhance the effectiveness of the rocker-bogie mechanism for military purposes by creating an affordable and dependable platform that can tackle difficult tasks while safeguarding soldiers. The main objective of our project is to design a six-wheeled vehicle's suspension system that integrates the rocker-bogie mechanism. This system has a considerable advantage in providing linear bogie motion that prevents rollovers during high-speed operations, improving the platform's safety in the field[1]. Moreover, the improved suspension system increases the vehicle's reliability on rough terrain, allowing it to travel quicker and clear obstacles that are twice as high as before, enhancing the system's mobility and speed. To achieve this objective, we used mild steel for the bogie's construction and utilized SolidWorks and AutoCAD software for the design process. Static and dynamic force analysis was performed using ANSYS software to ensure that the system performs optimally under various operating circumstances. We integrated a 360-degree camera at the front of the bogey to provide real-time information to soldiers, particularly when monitoring border areas. Our project's primary aim is to improve the platform's fundamental operations, resulting in better overall performance and a more efficient tool for military operations.[2]

Key Words: Mild Steel, Mobility System, Rocker, Bogie, L298n Motor Controller, Esp32 Web Cam, Lm2596 Dc Buck Converter, Battery, Servo Motor, DC Motor.

I. INTRODUCTION

In realm of military operations its effectiveness, reliability of vehicles play a pivotal role in ensuring the safety of soldiers and accomplishing challenging tasks. The rocker-bogie mechanism has emerged as a promising solution for enhancing performance of military vehicles in demanding terrains. This research endeavors to leverage potential of this mechanism by developing an affordable and dependable platform that addresses the arduous tasks faced by military personnel while ensuring their utmost protection. The central objective of this project is to design a suspension system for a six-wheeled vehicle that seamlessly integrates the rocker-bogie mechanism. By incorporating this mechanism, we aim to capitalize on its significant advantage of providing linear bogie motion, which serves as a preventive measure against rollovers during high-speed operations. This enhanced safety feature contributes to the improved functionality of the platform, particularly in hazardous and unpredictable environments frequently encountered by military units. One of the critical advancements achieved through our project is the augmentation of the vehicle's suspension system, enabling it to navigate through rough terrains with heightened reliability. This enhancement empowers the platform to traverse obstacles that are twice as high as previously possible, thereby amplifying its mobility and speed. The resultant increase in the platform's maneuverability equips military personnel with a more agile and versatile tool for accomplishing their missions effectively. To realize these objectives, we employed mild steel for the construction of the bogie, ensuring durability and cost-effectiveness. The design process extensively utilized industry-standard software such as SolidWorks and AutoCAD to meticulously craft a suspension system that optimally integrates the rocker-bogie mechanism. Furthermore, to validate the performance of the system under diverse operating conditions, comprehensive static and dynamic force analyses were conducted using ANSYS software. Recognizing the importance of real-time situational awareness in military operations, we integrated a cutting-edge 360-degree camera at the front of the bogie. This advanced camera system provides soldiers with vital real-time information, particularly when monitoring border areas. By equipping military personnel with such a valuable asset, our project aims to enhance their operational effectiveness and improve their ability to make informed decisions on the field. The primary objective of this research endeavor is to enhance the operational capabilities of military platforms, ultimately resulting in improved performance and efficiency during military operations. By prioritizing the reinforcement of the vehicle's safety, reliability, mobility, and speed, our aim is to provide military personnel with an exceptional tool that enables them to carry out tasks with increased effectiveness while ensuring their well-being. Throughout the subsequent sections, we will delve into a detailed examination of the design and expansion process. This includes an in-depth exploration of the material selection, the utilization of advanced software, and the meticulous analysis performed to guarantee the optimal performance of the system. Furthermore, we will explore the integration of a state-of-the-art 360-degree camera and its profound impact on real-time situational awareness in military operations. By undertaking this analysis, our intention is to contribute to the ongoing efforts to advance military vehicle technology. We strive to provide our armed forces with cutting-edge equipment that aligns with the latest technological advancements, empowering them to fulfill their critical missions with unparalleled efficiency and success.

II. OBJECTIVE

The objective of this research project is to enhance the effectiveness of the rocker-bogie mechanism for military purposes by creating an affordable and dependable platform that can successfully tackle difficult tasks while ensuring the safety of soldiers. The primary focus is to design a six-wheeled vehicle's suspension system that seamlessly integrates the rocker-bogie mechanism. By incorporating this mechanism, the objective is to provide linear bogie motion, thus effectively preventing rollovers during high-speed operations and significantly improving safety in the field. Additionally, the aim is to increase the vehicle's reliability on rough terrains, enabling it to travel faster and overcome obstacles that are twice as high as before. This enhancement will greatly enhance the platform's mobility and speed, enabling it to efficiently navigate challenging environments. Furthermore, the overarching objective is to improve platform's fundamental operations, resulting in overall good performance and a more efficient tool for military operations. This contains enhancing the platform's functionality, durability, and maneuverability, ensuring that it meets the rigorous demands of military's missions. To achieve these goals, the research will involve the use of mild steel for the construction of the bogie, providing a balance between strength and cost-effectiveness. The design process will employ industry-standard software such as SolidWorks and AutoCAD to meticulously craft a suspension system that optimally integrates the rocker-bogie mechanism. Comprehensive static and dynamic force analysis will be conducted using ANSYS software to ensure the system's optimal performance under various operating circumstances. Furthermore, the integration of a state-of-the-art 360-degree camera at the front of the bogie will provide real-time information to soldiers, particularly when monitoring border areas, further enhancing operational effectiveness and decision-making capabilities in the field. By achieving these objectives, the research aims to contribute for the development of a highly effective and reliable military vehicle platform. This platform will serve as a valuable tool for military operations, improving overall performance, safety, and efficiency, and equipping soldiers with capabilities they need to successfully carry out their missions.

III. LITERATURE REVIEW

A large portion of space exploration [4] can be categorized into three groups: the search for a greater understanding of the cosmos, interest in and potential economic benefit from harnessing natural resources found outside of our planet, and future colonization of extraterrestrial entities[4]. Moreover, our moon and mars have received the greatest attention. Due to their proximity and the existence of settings that are suitable for rovers and possibly future colorization The moon is also ideal for measuring transmissions that might otherwise be disrupted or eliminated on earth using apparatus like radio observatories or Infrared telescopes because it has no atmosphere.

The main reason for interest in mars is to learn more about the planet, particularly with regard to whether or not a human colony may exist there. Finding out more about mars' atmosphere and soil composition will help us determine whether or not it would be able to sustain microbial life. NASA has been using rovers to explore the surface of Mars since 1976, beginning with the simultaneous landing of the Viking 1 and Viking 2 Landers. The Mars Pathfinder (MPF) Lander successfully brought the Sojourner rover to the surface in 1997. Most recently, in early 2004, NASA successfully [4][5] landed Spirit and Opportunity, two additional rovers, on Mars. NASA launched the Mars Science Laboratory (msl) in November 2011 along with the curiosity rover.[5]

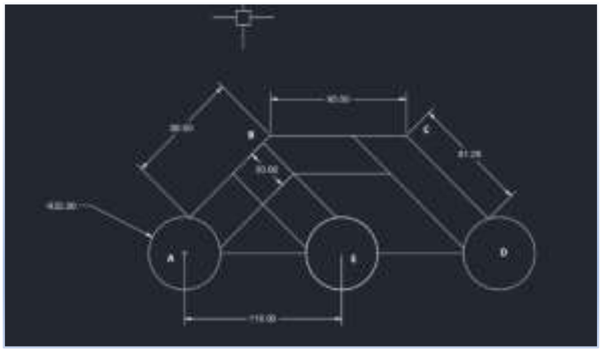
Despite the fact that NASA has deployed numerous rovers to Mars, each mission has a similar set of goals. Given the comparatively lengthy time delays in delivering commands, NASA has improved previous mars rovers and continuing to develop autonomous navigation to make it simpler and faster to direct their rovers. To do this, an image of the surroundings was developed using on-board stereo vision processing, which recognized positive and negative barriers relative to the ground plane. The mobility hardware of MERs, which allowed them to move across the Martian surface reasonably easily, is one of their other important characteristics. The rocker-bogie suspension was used, continuing the tradition of previous Mars rovers.

The rover's six wheels and numerous axles enable it to move over obstacles bigger than its wheel diameter. The rover's customized wheels have a particular aluminum flexure structure that joins the hub and rim, and they measure about 26 cm in diameter. These flexure joints serve as shock absorbers, which lowers the shock loads placed on other rovers' parts. Also, each wheel contains tiny cleats that have been proven useful for maneuvering over pebbles and soft sandy ground. When it comes to its capacity for lining a road, curiosity is advantageous.

Using its three-axis inertial measurement unit (IMU), the rover can move precisely while also keeping track of how much tilt it is experiencing. The 900-kilogramme rover uses a 6-wheel rocker-bogie suspension, much like earlier Mars exploration rovers did, to address the mobility issue. The rover can overcome barriers 60–75 cm higher because to its larger size and rocker–bogie suspension than it could with 50 cm wheels. In addition to being safe, curiosity has also developed treads that are comparable to those used by MER rovers, which were discovered to be the best choice for Martian terrain. It was the quickest rover dispatched to Mars, reaching a top speed of 4 cm/sec. There are many parallels in both the mechanical design and the software that allow NASA's rovers for surface exploration on Mars to undertake on-board path planning. These rovers are exceptional platforms for dependably transporting and positioning their scientific instruments because they have autonomous planetary navigation in addition to hazard avoidance and other self-preservation autonomy. The size of the rover and the kinds of scientific instruments it supports have undergone the most alterations between missions. One such business, Astrobotic Technology Inc., was established with the goal of making space exploration viable through the delivery of payloads and the provision of robotic services on the moon. In order to develop a rover and lander for their first surface lunar exploration mission, they are now working with Camogie Mellon University and others. If this mission is successful, it will meet the requirements for the X-Prize as well as other goals. One of the most advanced lunar exploration rovers, their robot is dubbed the red rover, and it is reviewed here. The Red Rover is made to be a scout, investigating locations like polar ice fields or lava tube skylights on the moon. Based on its study of chemical composition and high-quality 3D pictures, it seeks to locate the intriguing spots. In order to improve the rocker-bogie mobility system in conventional heavy loading vehicle behavior when high-speed traversal is necessary, the proposed article develops a novel design. The suggested adjustment improves stability and has proven more beneficial than 3D model simulations in SolidWorks. As the system is used in heavier and off-road vehicles, the complexity and power required for maintenance will likely decrease. Potential applications include military weapon transportation and locating coal seams in mines. The idea and parameter design of a robust stair climbing compliant modular robot that can climb steps with overhangs are covered in this paper. Overhangs can be overcome by altering the geometry of our robot's wheels' perimeter. To reduce performance variation, robust design parameters are established in addition to the concept design. The Grey-based Taguchi Method is used to determine the best configuration for the robot's design specifications. The robot prototype is demonstrated to have successfully scaled steps with overhang that range in size, corroborating the analysis done. This project demonstrates how the rocker bogie system functions on various substrates. Torque imparted to a link depends on the various weights acting on it. Accurately dimensioned rocker bogie can climb the

steps with great stability by assuming accurate stair dimensions. The model that was created and built can ascend an angle of up to 45 degrees. Additionally, we tried a webcam with AV recording that was mounted on a rocker bogie system and discovered that it performed satisfactorily throughout the test, which involved rotating the wheels 360 degrees. System cannot ascend stairs that are less than 375 mm (15 inches) in length during stair climbing tests. New rocker-boogie models that can climb steps with short lengths may be developed.

IV. CALCULATIONS



Diameter of wheel = 50mm, N = 30rpm

Link Design and Calculation

If the horizontal length of stairs is 350 mm

Then, Wheelbase = horizontal length of stairs – $(R_f + R_r)$

R_f = Radius of front wheel, R_r = Radius of rear wheel

So, Base portion of wheel = 270 – (25+25) = 220 mm

Considering the right-angle triangle ABE

Using Pythagoras theorem in triangle ABD

Length of link DC: $DC^2 = AB^2+AD^2$

$270^2 = 2(AB)^2 \Rightarrow BD = 190$ mm

Length of link AB

$AB^2 = AE^2+BE^2 \Rightarrow 135^2= 2(AE)^2$

AE = 95.45

V. DESIGN Of ROCKER-BOGIE

This Design is done by the CAD Software (SolidWorks).

A. Dimensions:

Height from the Ground 40 cm.
Length 30cm
Width 15cm
Thickness of the Material: 0.5cm.
Weight of the bogie: 1500gm
Diameter of the wheel: 0.7cm

B. Ansys Analysis

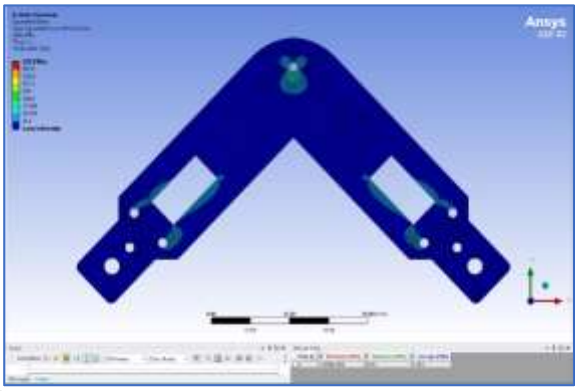


Fig. 2

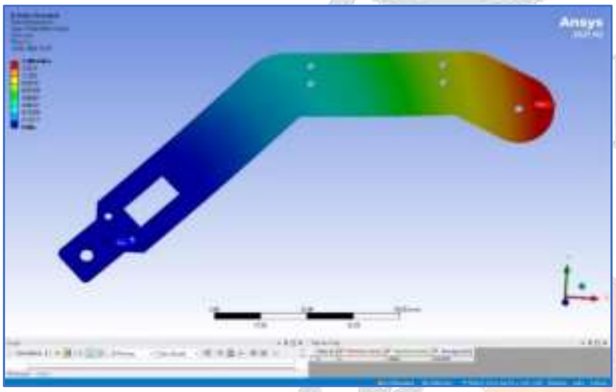


Fig. 1

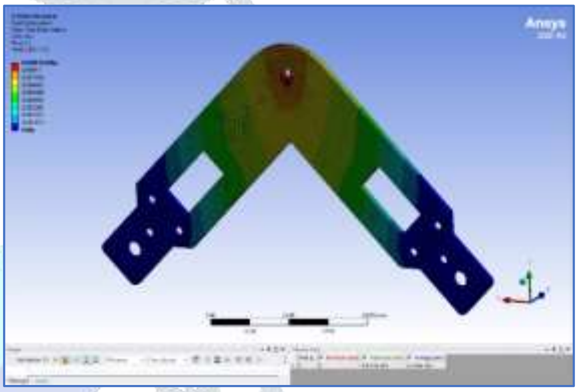


Fig. 3

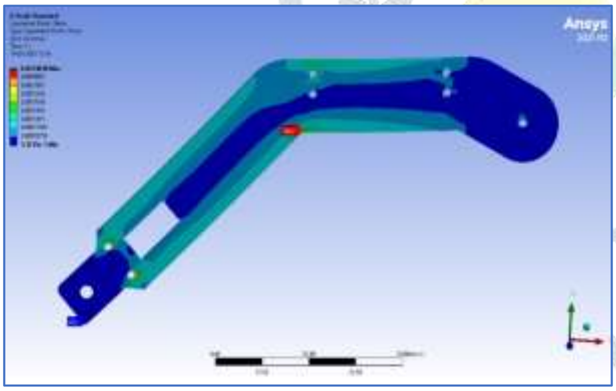


Fig. 4

All these picture shows that the Stress and elongation at the body and section. The rocker stress can sustain up to 1000N. The bogie stress can sustain up to 226Mpa. The rocker elongation starts after exceeding 0.70571 mm. The bogie starts elongation after exceeding 0.0099124 mm.

VI. METHODOLOGY

- There are two different kinds of limbs in a rocker-bogie mechanism: rocker arms and bogie arms. In order to climb over inclined surfaces, the rocker arm moves freely over the surface. Through the joints, the bogie arm is joined to the rocker arm. High torque dc motors attached to the system's wheels can be used to drive the rocker-bogie setup. In comparison to other wheel drives, the six-wheeled Rocker-bogie mechanism offers more flexibility. We can move the rover over incline terrain by utilizing higher torque DC motors. The vehicle's forward and reverse motion can be managed by applying power control to the battery source.
- By adjusting servo motors to regulate the position of the wheels, we can also rotate the rover. The robot is rotated about 360 degrees by servo motors. By connecting a microcontroller device to the system, these can be controlled wirelessly. We can send inputs to the microcontroller using an RC kit, and the microcontroller will then direct the rover's actions in accordance with the input it gets.
- By managing the servo motor, it also regulates the orientation of the vehicle's motion. The microcontroller for the system is the ESP32 Cam Board.
- The microcontroller was chosen primarily because it has built-in Wi-Fi, making it appropriate for IOT remote control and monitoring applications.
- It also has a camera slot, and an ESP32 camera can be utilized on the rover.
- The technology uses a rocker bogie kind of suspension so that the rover can be driven on and off and over any terrain.
- The app is utilized for remote control of the robot and also allows users to view camera video streaming from the robot.
- Because the rover is connected to an app, it is simple, quick, and efficient to control the rover via the app.

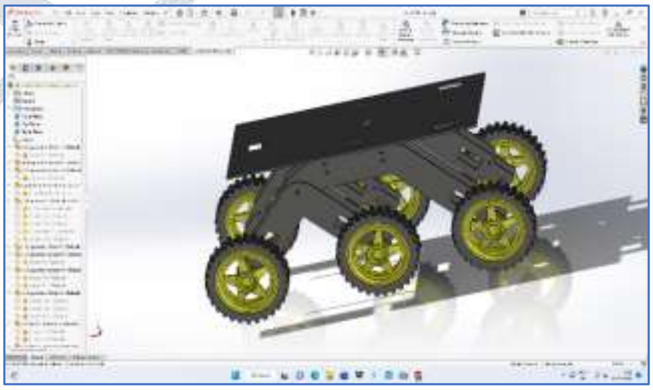
VII. FABRICATION

We used mild steel for the bogie structure of surveillance robots due to its combination of strength, durability, and affordability[7]. It has a relatively low carbon content, which makes it easy to form and weld, while still providing sufficient strength for the demands of the bogie structure. Mild steel is also resistant[8] to corrosion, which is important for outdoor applications. The material can be further strengthened through heat treatment or the addition of alloying elements, making it versatile and adaptable to a range of design requirements. Overall, the use of mild steel for the bogie structure in surveillance robots is a practical and effective solution that can provide a long-lasting and reliable platform for a variety of surveillance applications.

Property	Material
Density	7,860kg/m^3
Hardness	24HRB
Elongation	30%
Tensile Strength	400MPA
Yield Strength	250MPA

TABLE 1

VIII. ASSEMBLY OF ROCKER BOGIE



IX. ADVANTAGES

The proposed system is highly suitable for space exploration due to its numerous advantages:

• Six-wheeled vehicles offer superior control over topography, making them ideal for navigating difficult terrain.

• The rocker-bogie mechanism enables the rover to navigate around obstacles and travel across surfaces with non-parallel terrain.

• The use of lightweight materials, such as mild steel, results in a lighter vehicle, which increases its mobility and speed.

These features make the system highly effective and efficient for space exploration,[6] providing a reliable and versatile platform for various applications.

X. DISADVANTAGES

One of the drawbacks of utilizing a rocker-bogie mechanism in a ground surveillance robot is its slow movement speed. This is due to the complex mechanics, multiple motors, and increased weight involved in the mechanism's operation. As a result, it may not be ideal for applications that require high speed and agility. Moreover, the complexity of the mechanism may necessitate more maintenance, resulting in increased downtime and reduced overall efficiency in the long run.

XI. FUTURE SCOPE

The research findings provide a solid foundation for exploring exciting prospects in military vehicle technology. Improvements in the rocker-bogie mechanism's effectiveness and reliability open up new avenues for innovation. Integrating advanced autonomous capabilities is a promising direction, allowing the vehicle to navigate complex terrains and perform tasks autonomously using AI and machine learning. This reduces risks to human operators and enhances operational efficiency. Lightweight materials like advanced composites and alloys can further enhance the suspension system, reducing weight while maintaining strength and durability. This boosts fuel efficiency, mobility, and the ability to traverse challenging terrains over long distances. Advanced sensor technology, including radar, LiDAR, and infrared cameras, improves situational awareness, aiding in threat detection and decision-making. Advanced communication systems enable seamless connectivity and coordination among military units, resulting in higher mission success rates. Simulation and virtual reality technologies optimize design iterations, reducing development costs. Exploring alternative power sources like hybrid or electric propulsion systems supports greener and more energy-efficient operations with reduced environmental impact, lower noise signatures, and increased stealth capabilities. These advancements contribute to the effectiveness and safety of military vehicles, aligning with sustainability goals and improving operational outcomes..

XII. CONCLUSION

The choice of mild steel for the construction of the bogie ensures a balance between durability and cost-effectiveness, making it an optimal material for the task at hand. Through the utilization of industry-standard software such as SolidWorks, AutoCAD, and ANSYS, we were able to streamline the design process and optimize the performance of the suspension system across various operational scenarios. Additionally, the integration of a cutting-edge 360-degree camera at the front of the bogie significantly enhances situational awareness for military personnel, particularly during border surveillance operations. This advanced camera system provides real-time information, equipping soldiers with crucial insights and enabling them to make informed decisions swiftly and effectively while in the field. By focusing on enhancing the fundamental operations of the platform, our project makes a valuable contribution to the overall performance and efficiency of military operations. The successful integration of the rocker-bogie mechanism, combined with the improved suspension system and the incorporation of the 360-degree camera, equips military personnel with an advanced tool that enhances their capabilities, ensures their safety, and empowers them to accomplish missions with greater effectiveness.

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