

TERRABOT: The All-Terrain Robot

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Abstract— Robots are being used today for a wide variety for applications. Each of these applications has their own unique set of requirements. Some will spend their entire lifetime in one location doing a repetitive task while others will venture far beyond Earth completely a wide array of tasks. The existing rovers are found to have limitations because of their design. To overcome these problems an attempt is made in this project to develop the rover mechanism, design and its working. Due to these different environments and applications the design requirements for each robot are unique. The main objective of the project is to work under different environments such as to overcome the harsh terrains, large obstacles by using and Designing inverse kinematic links and to achieve maneuverability. Projects consist of rover which runs on six wheels and has flexible bogie. It also has two integrated robotic arms consisting of mechanical gripper and electromagnetic arm to perform task such as pick and place, material handling, etc. The arms are controlled by DC motors and two poles switches which help to get pitching, rolling and yawning actions of the arms.

Key words: TERRABOT, CHEBYSHEV'S Lambda Mechanism, Terrain Robot

I. INTRODUCTION

As per International Standards Organization's defines of an industrial robot, mobile robot can be defined as 'A mobile robot is an autonomous system capable of traveling a terrain with natural or artificial obstacles. Its chassis is equipped with linkage wheels and possibly a manipulator setup mounted on the chassis for handling of work pieces, tools or special devices. Various pre-planned operations are executed based on a pre-programmed navigation strategy taking into account the current status of the environment.

This definition any intelligent machine which moves with respect to environment within limited human interface (autonomously) called 'Mobile robot'. Mobile robots can be classified by significant properties as; Locomotion (wheeled) Suspension (independent drive), Steering (Skid), Control (Fully-Autonomous, semi-autonomous) and Usage Area (Rough Terrain, even surface). Mobile robots can be used in several applications. Dangerous area operations like Nuclear plants, planetary exploration and pipe investigation, extreme temperature and narrow field investigations (pyramid exploration robots). Floor cleaning robots and servant robots are common examples for indoor use. It is not a dream that, in near future robots will be a part of our daily life. There is no doubt that a mobile robot's most important part is its locomotion system which determines the stability and capacity while traversing on rough terrain. The difference of robotic locomotion is distinct from traditional types in that it has to be more reliable without human interaction. While constructing a robot, designer must have decided on the terrain requirements like stability criteria, obstacle height, and surface friction. There is no only one exact solution while comparing the mobility systems. There are several types of locomotion mechanisms were designed

depending on nature of the terrain. Locomotion systems can be divided into groups as; wheeled, tracked, legged (walking robots), limbless (snake and serpentine robots) and hopping robots. Wheeled rough terrain mobile robots are called as 'Rover'

II. PROBLEM STATEMENT

The goal of this ROVER is to design, development and manufacturing a prototype of a sophisticated mechanism capable of functioning in constrained and harsh terrain region consisting of electromagnetic and gripper arms

III. OBJECTIVE

The objective of our project is not only to pick & place object but also to overcome the hurdles in its path without any difficulty.

- working in constrained space
- Elimination of suspension
- Study and synthesis of combined mechanisms

IV. SCOPE OF PROJECT

- 1) A Weather proof casing for all the driver motors and associated electronics.
- 2) Steering system should have been used to rotate the structure and wireless remote control access can be made in future design.
- 3) Programmable microcontroller can be introduced to make the vehicle intelligent.
- 4) For more precise movement, timer circuit can be used.
- 5) For sensing purpose several packages can be use which includes gyroscope, accelerometer, differential GPS system etc.
- 6) Increasing in high torque bogie provides more tolerance for obstacle.
- 7) Presence of sensors will actuate the actuators according to obstacles

V. CHEBYSHEV'S LAMBDA MECHANISM

(Hoeken Mechanis although most of the books named Hoeken mechanism; the first definitions of lambda (λ) mechanism are proposed by famous mathematician Chebyshev, Pafnuty Lvovich in 1869. Lambda mechanism is another four-bar straight line generator. Crank link can rotate 360 degrees while the coupler point moves on coupler curve. Curve has two characteristic motions. First part is straight line and second part is a quick return curve Chebyshev's mechanism is defined by three independent parameters; a, b and d To move the coupler point M, along a line sufficiently and necessary to fulfil the relation: $3d-a=2b$ The length of fixed d can be changed according to relation; $1.55a \leq d \leq 3a$ If $d=3a$ and $b=4a$, triangle BDC equilateral triangle in the middle position of the mechanism.

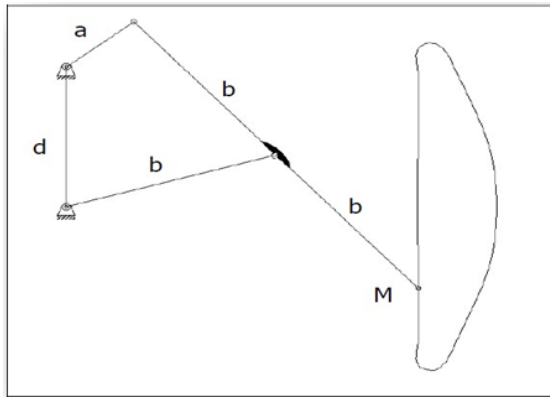


Fig. 1: Chebyshev's Lambda

VI. DOUBLE-LAMBDA-MECHANISM CONNECTION

New bogie design consists of two lambda mechanisms which are connected symmetrically. Thus, wheels move on a straight line but in opposite direction of each other. This design balances the reaction forces on each wheel; therefore the transfer force remains same for each wheel whether one wheel is on upper position. Symmetric connection of two mechanisms is a critical process. Since the both sides of the bogie will work in linear part of the curve, one side will Double-Lambda Mechanism

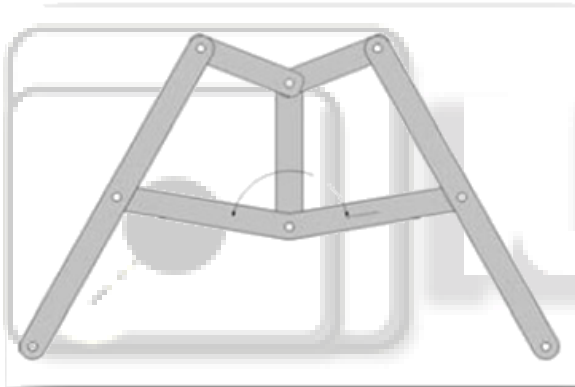


Fig. 2: Double-Lambda

VII. CALCULATION

A. Weight Calculation:

1) Weight Calculation of Rover:

Mass of Link1=Length of link1*cross section*density
 $= 300 \times 25 \times 6 \times 2712 = 0.122 \text{ kg}$. Similarly calculating weight for link2, link3 & link4 we got, Mass of link2= 0.0331 kg. Mass of link3= 0.0608 kg. Mass of link4= 0.403 kg. Total weight of rover = 2.32 kg.

- 1) Weight Calculation Of Gripper Total Weight Of Gripper = 0.770 Kg.:
- 2) Total Weight Of Mechanism Total Weight Of Mechanism = 4.39 Kg.:

B. Stress Calculation:

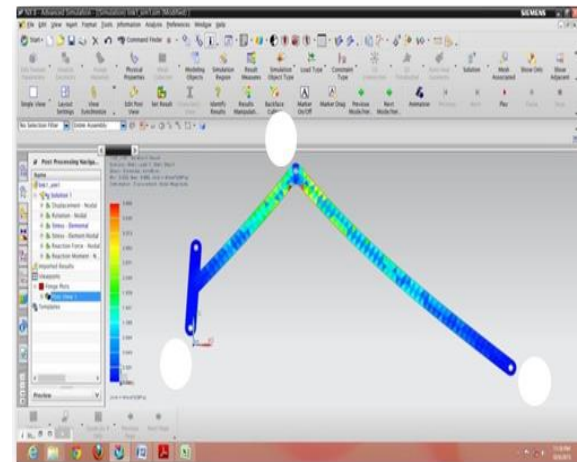


Fig. 3:

Required Data for Stress Calculation

- Net weight of mechanism: 10 kg
- Static force due to weight : 98.1 N
- Reaction force on each wheel: ~ 17 N
- Cross section: 25*6
- Yield strength: 241 MPa.
- Ultimate strength: 300 MPa.

C. Stress Calculation of Rover:

Consider link4 for maximum stress calculation because it's one pivoted, rest all links are free. Therefore, moment of inertia (i) $= bd^3/12 = 6 \times 25^3 / 12 = 7812.5 \text{ mm}^4$ cg distance from base (y) $= d/2 = 25/2 = 12.5 \text{ mm}$ m at point a=reaction force at point b*perpendicular distance= $17 \times 439.49 = 7471.33 \text{ n-mm}$ bending stress (σ_b) $= my/i = 7471.33 \times 12.5 / 7812.5 = 11.95 \text{ n/mm}^2$ hence design is safe as $\sigma_b > \sigma(\text{allowable})$. Similarly calculating stresses for other rest of the links. Link3= 4.02 n/mm² (design is safe as $\sigma_b > \sigma(\text{allowable})$). Link1= 1.95 n/mm² (design is safe as $\sigma_b > \sigma(\text{allowable})$).

D. Stress Calculation of Pins

For pin12 shear stress (τ) $= 0.5 \times \sigma_{yt} = 0.5 \times 241 = 120.5 \text{ n/mm}^2$ $\tau = p/a$ assume $d = 6 \text{ mm}$ $a = \pi/4 \times d^2 = 28.27 \text{ mm}^2$ $= 100/28.27 = 3.536 \text{ n/mm}^2$. Hence design is safe as $\tau_b > \tau(\text{allowable})$. Similarly for pin18 pin18 = 0.9295 n/mm² (design is safe as $\tau_b > \tau(\text{allowable})$).

E. Fits and Tolerance:

By studying the tolerances used for shaft and hole we have sought out the different pairs of it. 1. Basic size = 6mm first combination for shaft = g6-04-12 for hole = h7+12-00 the tolerance pair obtained is 6h7g6. Second combination for shaft = d8-30-48 for hole = h8+14-00 the tolerance pair obtained is 6h8d8. So we have selected 6h8d8 for all the pin joints which has the basic size of 6mm. 2. Basic size = 10mm for shaft = d8-30-48 for hole = h8+14-00 the tolerance pair obtained is 10h8d8. From the above pair obtain we have selected h8d8 tolerance because of their loose running type and this pair can be easily manufactured on conventional machine

VIII. SOME IMAGES FOR ROVER

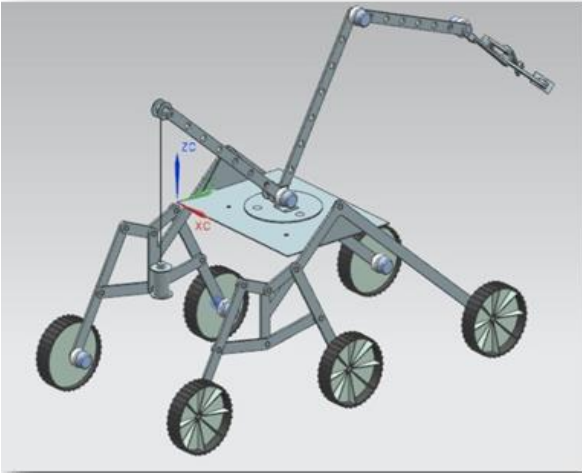


Fig. 4: Isometric view of Terrabot

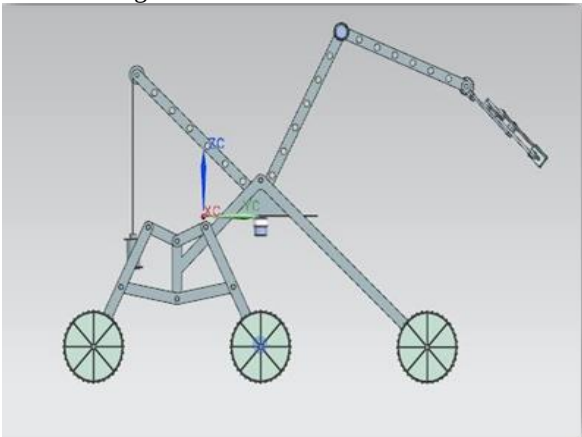


Fig. 5: Front View of Terrabot



Fig. 6: Actual Constructed TERRABOT

IX. APPLICATION

- Material handling in industries.
- To pick and place object on accurate location even in harsh terrain.
- Easy working in constrain environment. Lifting of thin metallic sheets.
- Military surveillance.
- Pipe and duct investigation.
- Maintenance in nuclear power plants.
- Bomb diffusing in bomb diffuser squad.
- Spraying of water and pesticides in agricultural field.

X. OUTCOME OF OUR PROJECT

After successful test run we have achieved our design requirements as expected. While operating in normal condition, if the vehicle finds any obstacle the front wheel link goes up and down automatically without the help of any kind of sensor during Ascent Descent on uneven surface respectively. The maximum average speed on the flat surface was 0.157 m/s. For reducing the weight of vehicle the frame and platform were used of aluminium instead of M.S. Due to the presence of Double Lambda mechanism the mechanism works better. The maximum height of the hurdle it can climb is mm and maximum ram angle is 90°. The vehicle can move in forward as well as reverse direction and the movements are given simply by using DC motors.

XI. CONCLUSION

We presented the modelling, analysis and simulation of long range planetary exploration rover using Uni-Graphics. Linear motion mechanism of Chebyshev has been improved to Double Lambda Mechanism and applied for the Terrabot rover suspension mechanism. Theoretical calculations for the safe design along with fits & tolerances of various links of the rover mechanism as well as of the two robotic arm mechanisms have been successfully carried out up to the date. Validation of the theoretical results is also done using UG software. We have selected pure mechanical robotic gripper and have design electromagnetic arm. The mechanism was shown to provide great flexibility in the robotics system to move over obstacles and successfully pass through harsh terrain environments. Terrabot has been tested in many areas within the laboratory and open fields. The performance of rover was observed to be excellent.

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