International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 11 Issue 06, June-2022

Design and Fabrication of Walking Bot -Theo Janson Walking Mechanism

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***Abstract*— On uneven ground, legged robots have the potential to be a walking machine. Theo Jansen's mechanism, which consists of eleven bar linkages, reproduces a smooth walking pattern known as gait. Parallel motions are commonly used in heavy machinery and have recently been highlighted in a biological motion model. Due to the singularity problem, the close-loop connection just gives a designed end-effectors' trajectory, which is believed to be less changeable. The singularity on the modified Theo Jansen mechanism was addressed in this study by introducing the parametric orbit as a new freedom point at the joint center, and multibody dynamics were used to examine its kinematics and dynamics (MBD). In the numerical simulation, the mechanism's extendibility in terms of gait trajectory flexibility was clearly established, resulting in novel functional gait trajectories controlled by two control parameters that modify the form of the parametric oval in the joint center.**

The morpho-logical changes of generated trajectories in the phase-rotation-amplitude parameter space were revealed in systematic determinant analyses of how broken trajectories were generated depending on four parameters, namely horizontal and vertical amplitudes, rotation angle of the joint center movement, and its phase difference with the driving link. Theo Jansen's mechanism's extension capability was therefore demonstrated not only in smooth walking but also in jumping, climbing, and running-like motions. When it comes to controlling the mechanism, the current findings show that there is an inverse relationship between the rotation angle and the phase difference that can significantly reduce the occurrence of singularity and breakage failures, which is consistent with biological evidence of coupling oscillators that allow the nervous system to control the complex musculoskeletal system by using a few simple parameters frequently represented by the phasors.

Keywords -Theo Janson Mechanism, Robots, Walking Bot.

I. INTRODUCTION

Animals are widely renowned for their ability to travel over uneven terrain at speeds far greater than wheeled or tracked vehicles.

When going over uneven terrain, it has been proven that legged off-road vehicles have better mobility, higher energy efficiency, and enable more comfortable movement than tracked or wheeled vehicles.

A leg mechanism, as opposed to a wheel, may be better suited and more energy efficient over uneven ground because it can step over obstacles.

A leg mechanism (walking mechanism) is a connection made up of links and joints that simulates the motion of humans or animals walking. Mechanical legs can have one or more actuators and can move in simple or complicated ways.

All of this points to the need to develop and build a device that produces a smooth leg-like action.

As previously said, nature has always picked legs as the optimum means of locomotion, therefore we used linkages to try to replicate nature and come up with a walking mechanism that would be suitable for any terrain.

After studying a few research papers and articles suggested by our guide Prof. Anand Relkar , we came across Theo Jansen Mechanism which proved to be very efficient to accomplish our objective.

After searching through the market we procured all the raw materials, fittings and equipment's that were required to construct the walking bot.

1.1 THEO JANSEN WALKING MECHANISM

Theo Jansen created a series of multi-legged walkers known as 'Strand Beasts,' which travel over the beach solely propelled by the wind. Jansen designed a planar linkage mechanism that resembles the leg motion pattern of a walking mammal for these walkers. The Jansen leg mechanism can be employed in gait analysis and mobile robotic applications.

It is a 12-link mechanism with a rotary actuator-actuated crank link and a' stationary' link that is part of the legged system's chassis and so does not move with regard to the chassis. This fixed link between the crank center and a pin joint is 11.6" above the horizontal. All other links and pin joints are unactuated and move as a result of the crank's action. Because the crank angle is the only way to describe their locations and orientation, the mechanism has only one degree of freedom (I-DoF).

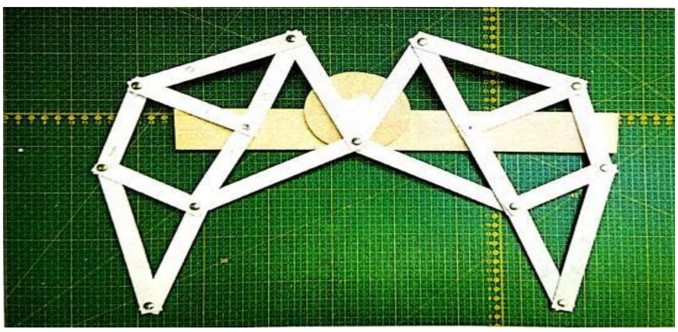

Figure No. 1.1: Theo Jansen Walking Mechanism

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Haul roads inflict significant damage to transport vehicle tyres, necessitating frequent and routine replacement. The cost of maintaining haul highways is likewise significant, necessitating the creation of a distinct wing. In haul roads, weight distribution is uneven, generating increased stress in transport trucks. Legs have an edge over tyres on rocky

terrain, thus I chose Klann Mechanism. After researching this mechanism on the internet, reading a few reviews, and witnessing it in action on YouTube videos, we discovered that the Klann Mechanism has its own set of flaws, including steering and stability.

This mechanism has the smoothest motion and can move loads without requiring excessive force. We began looking for different applications of the Jansen leg mechanism after being inspired by Jansen's walking mechanisms. We found multiple photographs and videos on the Internet depicting various implementations of this concept, both large and tiny, that assisted me in determining how we wanted our design to look.

This mechanism is incredibly easy to construct, and it runs on very little energy. However, the only disadvantage of this system is its slowness. With the exception of that one aspect, the Jansen design is unrivalled in terms of leg mechanism simplicity.

1.2 OBJECTIVES

The goal of this project is to develop a low-energy method for moving a bot over varying terrain. The following are our objectives:

- **Energy efficiency:**

We want to use the least amount of energy every locomotive cycle in our design. We'll do this by constructing a linkage that reduces torque on the crank and sequencing a gait in which one leg's upward movement is balanced out by the downward movement of another leg; this requires the walker to have '2n' legs.

- **Ability to avoid obstacles:**

The capacity to avoid obstacles is the primary argument for choosing a walking mechanism over a wheel, as we discussed in the previous section. In order to achieve this goal, the linkage must be designed.

- **Less costly:**

We'd like to create a mechanism that can be constructed with low-cost materials (Acrylic) while still being strong. This entails reducing the use of components such as bearings, hinges, and springs, among others.

- **Smooth Walking Movement:**

We'd like to create a system that can simulate the smooth animal-like movement of its links (legs), allowing the bot to easily navigate difficult terrains.

1.3 CRANK BASED WALKING MECHANISM:

When the circular movement of one point in a linkage translates to movement elsewhere in the linkage, it is said to be "crank-based," which implies the circularly moving element of the linkage can be coupled to a crank and the mechanism's motion can be readily operated.

As shown in Figure, the foot of a walking mechanism is the component of the mechanism that makes direct contact with the ground. The foot traces a cyclical path relative to the walker's body as the crank revolves; this path is known as locus.

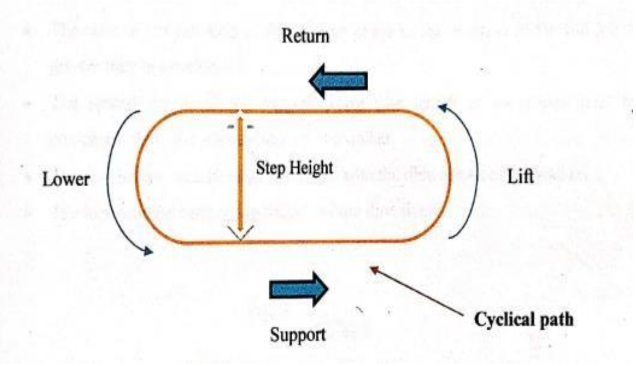

Figure No.1.3: Crank based walking mechanism

The linkage to the crank and the foot's travel through the locus are indicated. A fixed position in the linkage relative to the walker's body is also represented with a Black Square.

The support, lift, return, and lower phases are the four sections of the locus. In Figure, these phases are depicted. During the support phase, the foot should be in perfect touch with the ground. The foot moves toward its maximum height in the locus during the lift. During the return, the foot rises to its highest point off the ground and goes in the same direction as the walker's body. Finally, the foot drops in height until it makes touch with the earth during the lower.

1.4 DESIRABLE TRAITS OF THE WALKING MECHANISM:

In this section, we'll talk about the characteristics that we'll look for when designing and optimizing our walking mechanism. The following are the characteristics:

- During the support phase, the locus must maintain a constant velocity.
- Throughout the locomotive cycle, the crank must have a constant angular velocity.
- During the whole locomotion cycle, the inertial forces and inertial torques on the crank should be balanced.
- The lower leg should recoup the energy expended during the raise.
- The duration of the support phase is larger than or equal to 0.5 times the duration of the whole leg cycle.
- In comparison to the dimensions of the walker, the support phase's spatial length (the length of the stride) must be long.
- The step height must be substantial in comparison to the walker's proportions.
- In both directions, the locus should have a step height.

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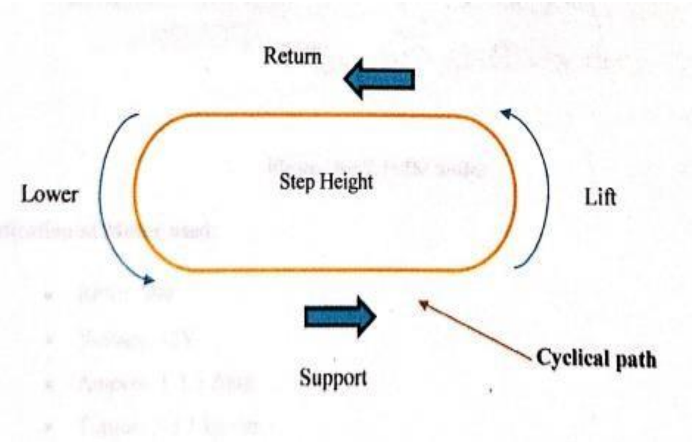

Figure No.1.4: Crank based walking mechanism

II. COMPONENT OF WALKING BOT -THEO JANSEN WALKING MECHANISM

2.1 DC Motor

Any of a group of rotating electrical machines that transform direct current electrical energy into mechanical energy is known as a DC motor Magnetic fields are used to generate forces in the most frequent kinds. Almost all types of DC motors use a similar internal mechanism, either electromechanical or electronic, to change the direction of current flow in a portion of the motor on a regular basis.

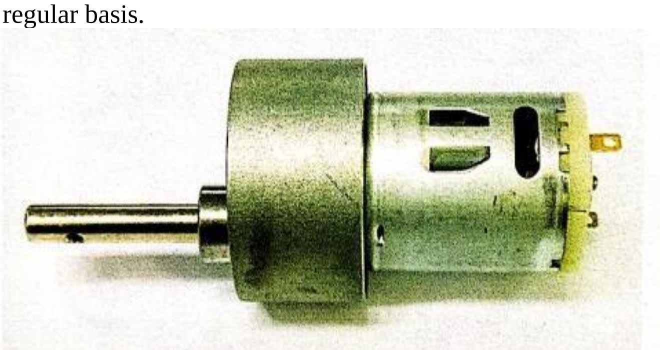

Figure No.2.1: Dc motor

Specification of Motor used:
RPM: 300
Voltage: 12V Ampere: 1-1.5 Amp.
Torque: 3-3.5 kg-cm Shaft Diameter: 6mm
Gear Material: Metal (Stainless Steel Spur Gear)

2.2 AC Adapter

Direct Current (DC) is created by converting alternating current (AC). DC motors demand constant voltage, so we must convert AC to DC using an adapter to obtain those consistent voltage levels (DC Levels).

Figure No.2.2: Ac adapter

Specification:
Input: 100-240 (1.5A, 50Hz))
Output: 12V, SA Efficiency Level: IV
Manufacturer: Delta Electronics Inc.

2.3 Frame

The frame is responsible for sustaining the system's different assemblies and accessories. The motor is supported by the frame, which is also where the leg connections are attached.

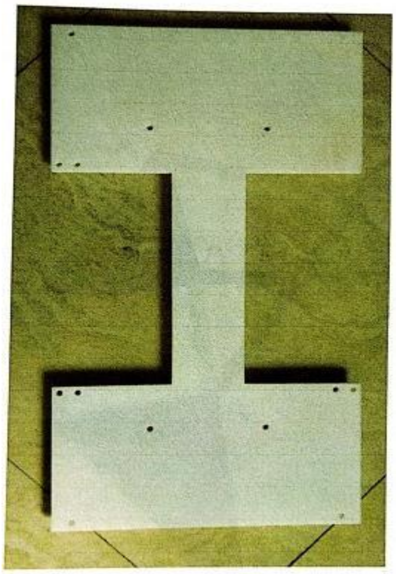

Figure No.2.3: Frame

2.4 Leg Linkages:

It is the main component of the Theo-Jansen Mechanism that translates the motor's spinning motion into linear motion in order to drive the walking mechanism. The mechanism's legs are formed by joining all of the linkages together. The DC Motor is attached to give the necessary rotating motion. The legs are made in such a way that they provide a secure walking motion.

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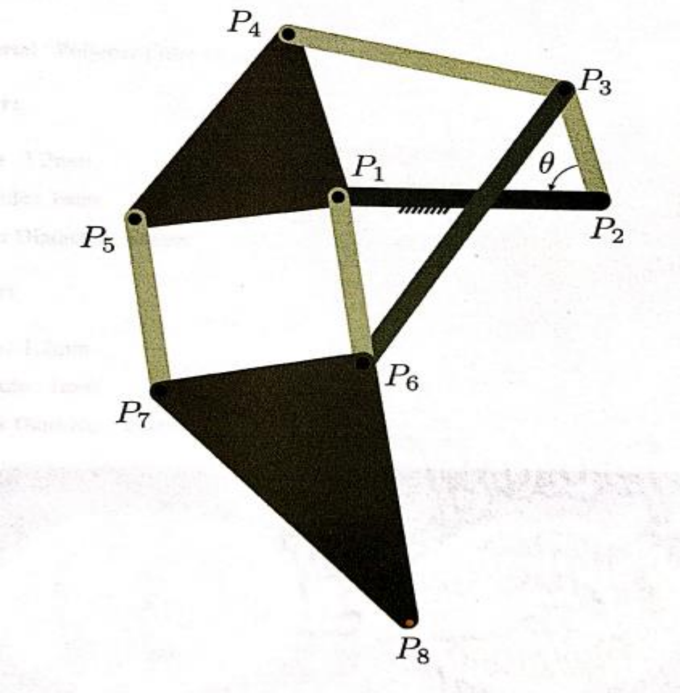

Figure No.2.4: Leg Linkages

2.5 Gears:

A gear is a revolving machine part with cut teeth, or inserted teeth (called cogs) in the case of a cogwheel, that mesh with another toothed part to convey torque. Geared devices can change the speed, torque, and direction of a power supply. Through their gear ratio, gears almost always cause a change in torque, creating a mechanical advantage, and so can be called a simple machine. The teeth on both meshing gears have the same shape. A gear train, also known as a transmission, is a group of two or more meshing gears that operate in a predetermined sequence.

Specifications:
Material: Polymer (Spur Gears)
Driven Gear:
Pitch: 1.2mm
Module: 1 mm
Outer Diameter: 64mm
Driver Gear:
Pitch: 1.2mm
Module: 1 mm
Outer Diameter: 23mm

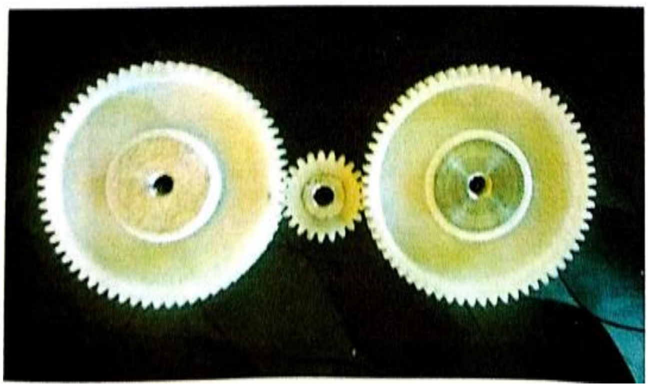

Figure No.2.5: Gears

2.6 Wires:

Wires were utilized to connect the battery and motor in the electrical circuits. Soldering was used to join wires together.

Figure No.2.6: Wires

2.7 Remote:

The remote was used to send signals to the circuit, which drove the walker mechanism.

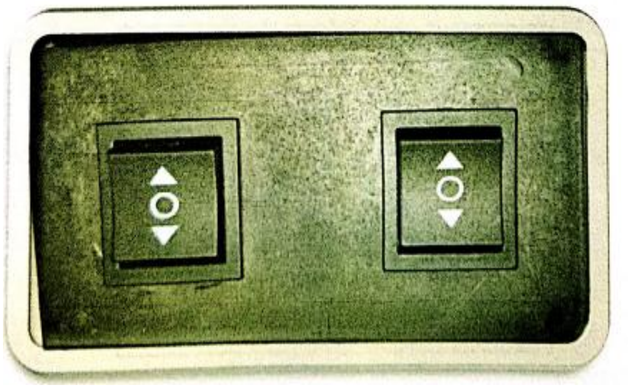

Figure No.2.7: Remote

2.8 Nut and Bolts:

To keep the links from moving, a nut and bolt were utilized. The leg connections had a robust and smooth joint as a result of this.

Figure No.2.8: Nut and Bolts

2.9 Grub screw:

A set screw is a screw that is used to secure an object within or against another object without the use of a nut.

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Figure No.2.9: Grub screw

III. DESIGN OF WALKING BOT -THEO JANSEN WALKING MECHANISM

3.1 BASE PLATE**:**

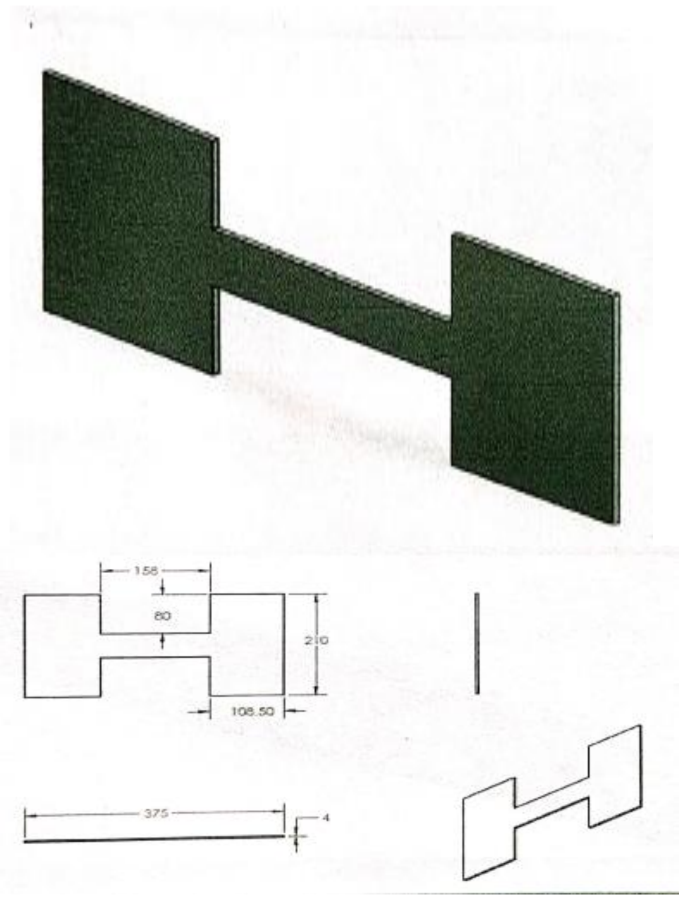

Figure No.3.1: Base plate

3.2 SIDE PLATES: 1

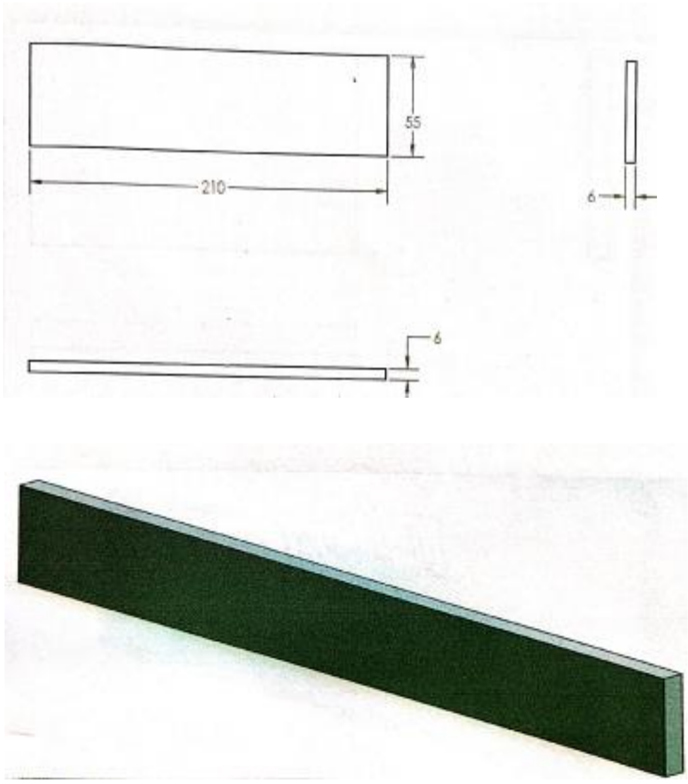

Figure No.3.2: Side plate 1

3.3 SIDE PLATES: 2

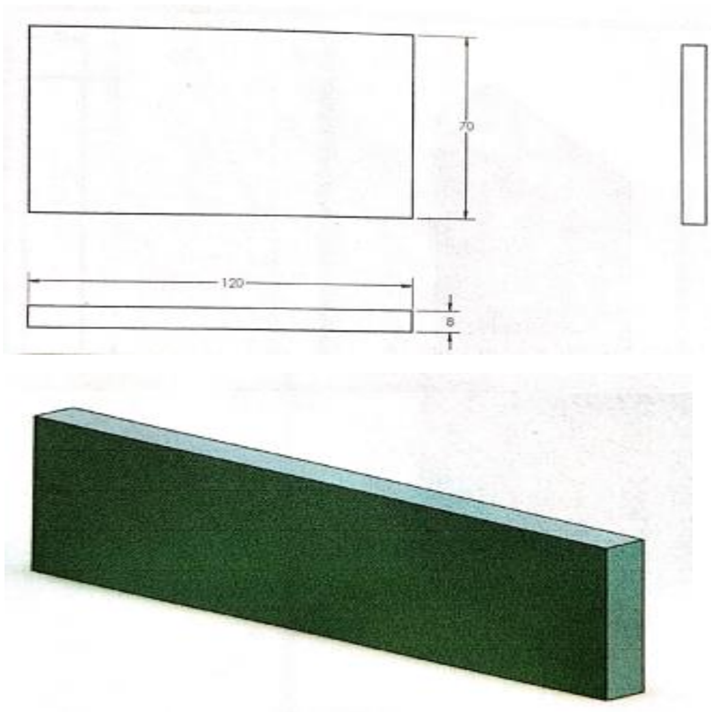

Figure No.3.3. Side plate 2

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3.4 CENTRE LEG SUPPORT PLATE:

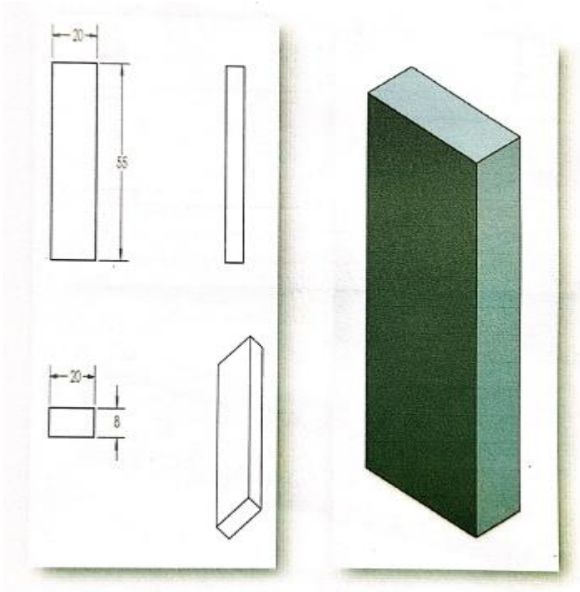


Figure No.3.4: Centre leg support plate

3.5 MECHANISM DESIGN:

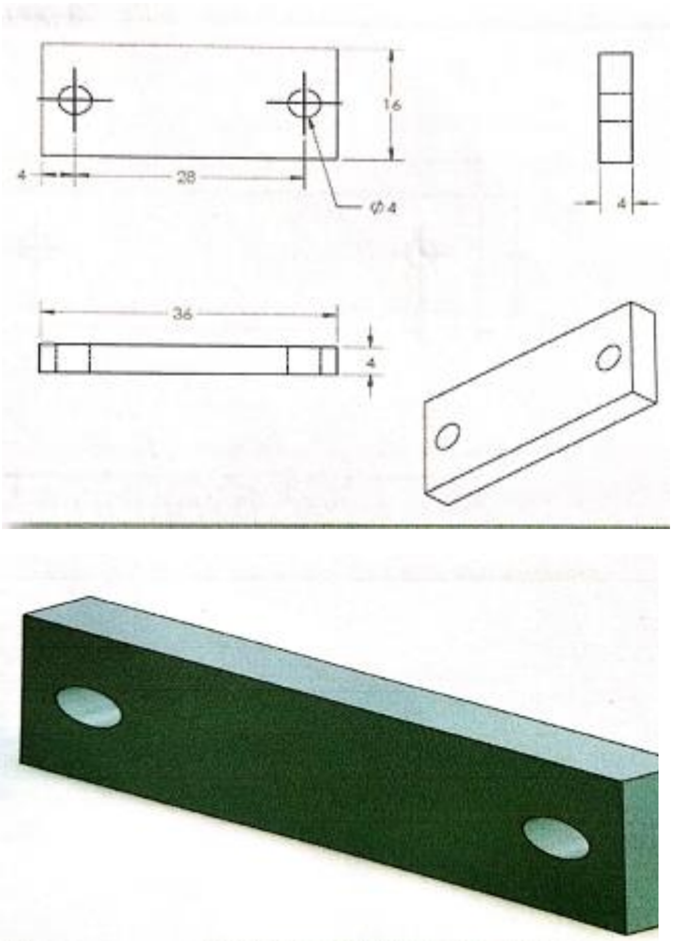


Figure No.3.5: Mechanism design

3.6 LINKAGES:

3.6.1 LINK: D

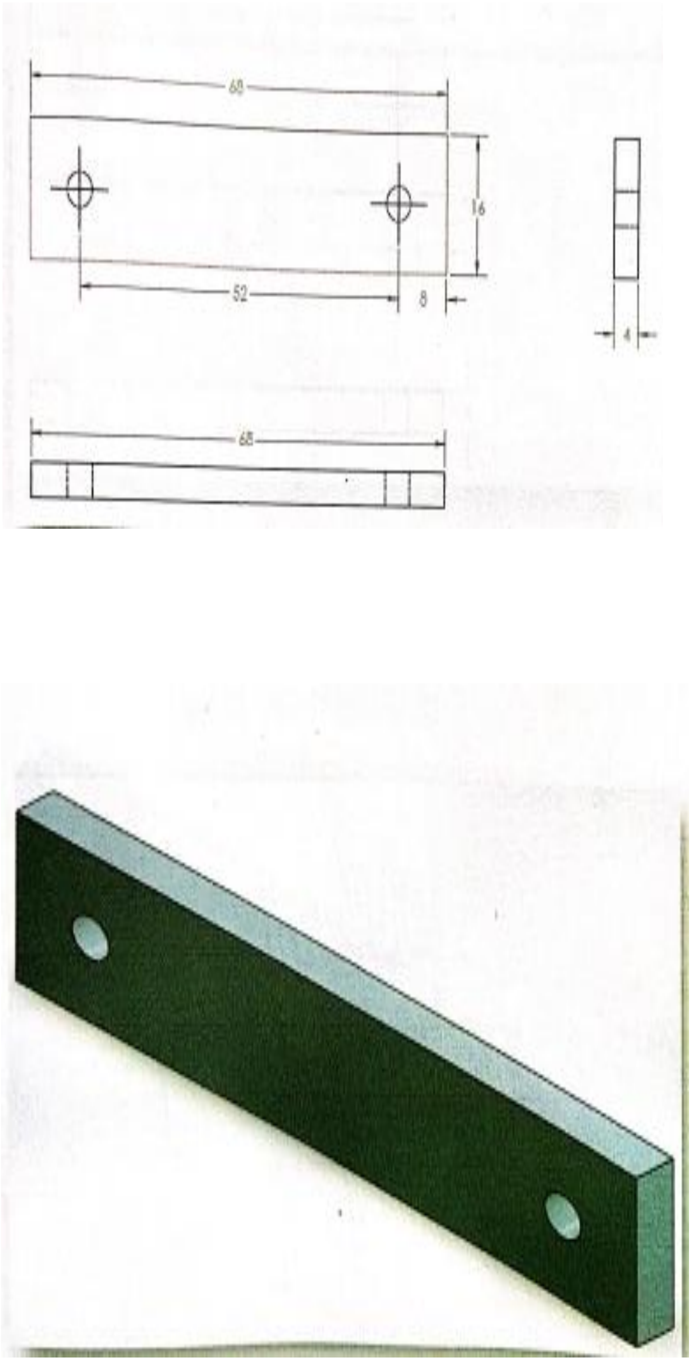
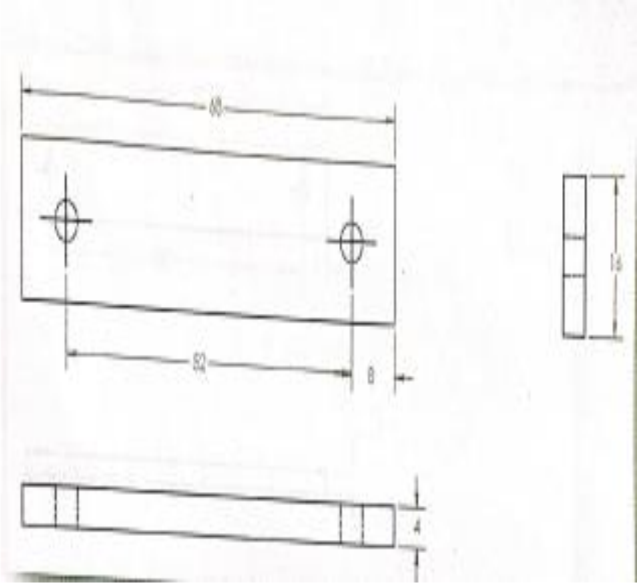


Figure No.3.6.1: Link D

3.6.2 LINK: E



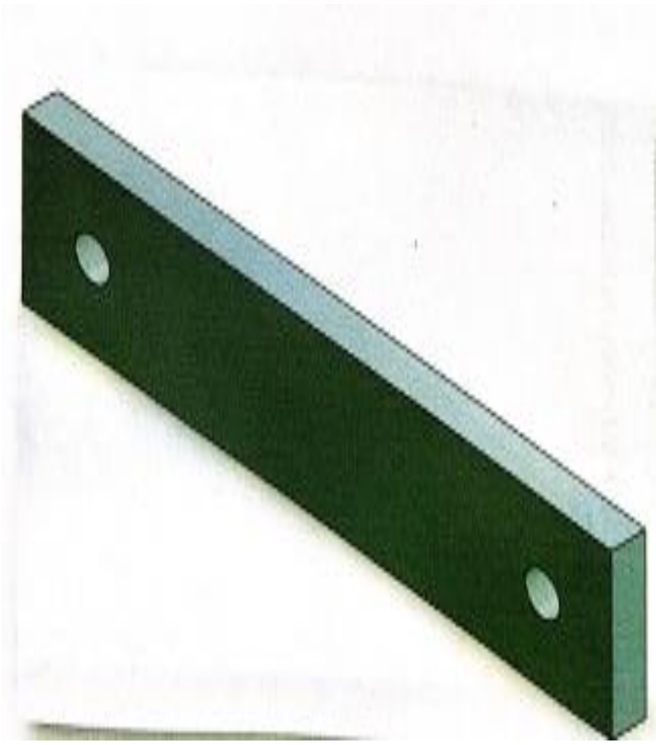


Figure No.3.6.2: Link E

3.6.3 LINK: I

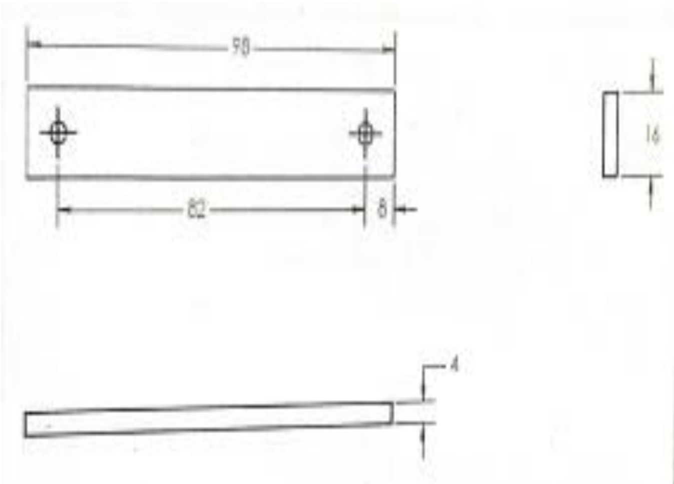


Figure No.3.6.3: Link I

3.6.4 LINK: F

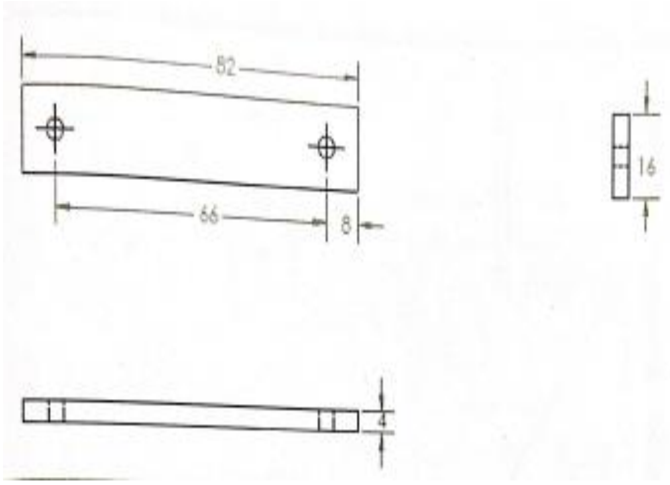


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Figure No.3.6.4: Link F

3.6.6 TERNERY LINK

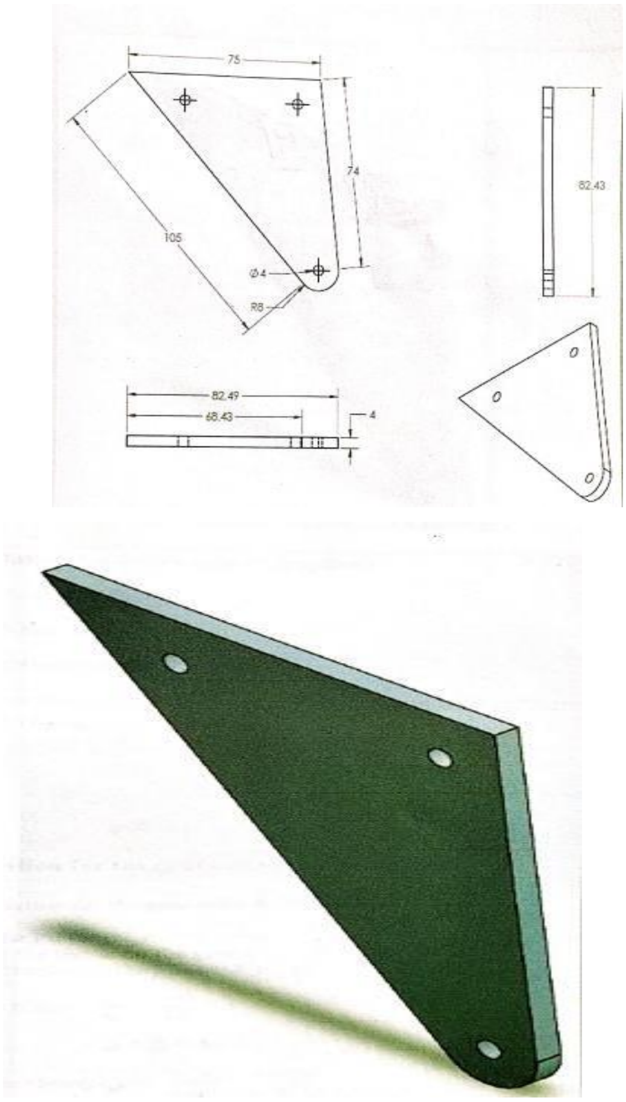

Figure No.3.6.6: Ternary link

IV. CONCLUSION

1. Legged off-road vehicles have better mobility, higher energy efficiency and easier to control as compared with those of conventional track wheeled vehicle, while moving on rough terrains. Development of such vehicle represents challenging problems and has attracted the attentions from both engineering and art fields. Mr. Theo Jansen created amazing kinetic sculptures such as Wind Beasts, which are actuated by wind power. Walking gracefully on the beaches of Netherlands.
2. To demonstrate the proposed design is feasible, a prototype of the leg mechanism based on the optimal design was built to demonstrate that the desired motion was achieved. Art and engineering are often being considered to be separate fields and resistance to merge comes from both sides, this work is an initial attempt to imitate an art work using the engineering design theories and to cross the border between art and engineering.
3. As explained above it has certain applications in the field of security, spying, locating as well as interplanetary missions. Also it would help to diminish the requirement of wheels in some cases, as there is no living creature moving on wheels, instead they use legs.

V. REFERANCES

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