International Journal of Latest Engineering Research and Applications (IJLERA) ISSN: 2455-7137

Volume – 02, Issue – 04, April – 2017, PP – 145-150

Design and Fabrication of Kinametic Walker

Dr. B. Nagalingeswara Raju,
Professor, Department of Mechanical Engineering, Vel Tech, Avadi, Chennai, Tamil Nadu, India.

Mallimala Jagadeesh, Sompalli Yugandhar, Nagireddy Pradeep Kumar, E.Rakesh
Student, Department of Mechanical Engineering, Vel Tech, Avadi, Chennai, Tamil Nadu, India.

Abstract: The aim of our paper is to make this robot walk on any Surfaces with a stiff gait slow and carries a limited load**.** It could be used for surveillance in sewer maintenance. This project Involves the design and fabrication of a kinematic walker. This kinematic walker is six-legged machine. It can walk on any surface. It is an arrangement of six linkages. This device is analogous to a six-legged insect. The kinematic walker Comprises six legs that move Simultaneously to Provide motion. Each of synthesis six linkages are made of a four bar mechanism. These six legs move synchronously with several angular intervals in between them so that they give a walking motion just like a six-legged insect. These legs are supported by a four fixed links. These fixed links are connected to the leg by a crank link which is the source of rotation. These legs are also connected to the connecting rod through a rocker arm which guides it. When the crank link rotates, the leg rotates and moves front and thus the walking motion is achieved. All the six legs must be rotated simultaneously to achieve the perfect walking motion.

I. Introduction

In today's technological society, people have grown accustomed to daily use of several kinds of technology from personal computers to supercomputers, from personal vehicles to commercial airplanes, from mobile phones to communicating through the Internet and everything in between. As such, the use of robots has also become increasingly common. Robots can be used to complete repeated tasks, increase manufacturing production, carry extra weight and many other common tasks that humans do.

Generally the walking mechanisms are developed by imitating natures like insects movement. The nature inspired the researchers and new innovative ideas come in mind but sometimes they are simple and effective, sometimes cumbersome and critical. One of the first walking machines was developed in about 1870 by Russian Mathematician Chebyshev. This walking machine had four legs arranged into pairs. Legged machine have been used for at least a hundred years and are superior to wheels. Legged locomotion should be mechanically superior to wheeled or to tracked locomotion over a variety of soil conditions and certainly superior for crossing obstacles. US army investigation reports that about half the earth surface is inaccessible to wheeled tracked vehicles, whereas this terrain is mostly exploited by legged animals. Wheeled robots are the simplest and cheapest also tracked robots are very good for moving, but not over almost all kinds of terrain. There are different types of legged walking robots. They are roughly divided into groups according to the number of legs they possess. Bipeds have two legs, quadrupeds four, hexapods six and octopods have eight legs. Bipeds robots are dynamically stable, but statically unstable, such robots are harder to balance, and dynamic balance can only be achieved during walking. Hexapods are six legged robots, on the other hand, have advantages of being statically stable. During walking they can move three legs at a time, thus leaving three other legs always on the ground forming a triangle.

II. Literature Survey

ii.i History of Legged Mechanism

The scientific study of legged locomotion began just very a century ago when Leland Stanford, then governor of California, commissioned Edward Muyridge to find out whether or not a trotting horse left the ground with all four feet at the same time. Stanford had wagered that it never did. After Muybridge proved him wrong with a set of stop motion photographs that appeared in Scientific American in 1878, Muybridge went on to document the walking and running behaviour of over 40 mammals, including humans. His photographic data are still of considerable value and survive as a landmark in locomotion research. The study of machines that walk also had its origin in Muybridge's time. An early walking model appeared in about. It used a linkage to move the body along a straight horizontal path while the feet moved up and down to exchange support during stepping. The linkage was originally designed by the famous Russian mathematician Chebyshev some years earlier. During the 80 or 90 years that followed, workers viewed the task of building walking machines as the task of designing linkages that would generate suitable stepping motions when driven by a source of power.

Many designs were proposed but the performance of such machines was limited by their fixed patterns of motion, since they could not adjust to variations in the terrain by placing the feet on the best footholds. By the late 1950's, it had become clear that linkages providing fixed motion would not sufficient and that useful walking machines would need control. Ralph Mosher used this approach in building a four-legged walking truck at General Electric in the mid-1960s.The project was part of a decade-long campaign to build advanced operators, capable of providing better dexterity through high-fidelity force feedback. The machine Mosher built stood 11 feet tall, weighed 3000 pounds, and was powered hydraulically. Each of the driver's limbs was connected to a handle or pedal that controlled one of the trucks four legs. Whenever the driver caused a truck leg to push against an obstacle, force feedback let the driver feel the obstacle as though it were his or her own arm or leg doing the pushing. After about 20 hours of training, Mosher was able to handle the machine with surprising agility. Films of the machine operating under his control show it ambling along at about 5 MPH, climbing a stack of railroad ties, pushing a foundered jeep out of the mud, and maneuvering a large drum onto some hooks. Despite its dependence on a well-trained human for control, this walking machine was a landmark in legged technology.

Computer control became an alternative to human control of legged vehicles in the 1970s. Robert McGhee's group at the Ohio State University was the first to use this approach successfully. In 1977 they built an insect like hexapod that could walk with a number of standard gaits, turn, walk sideways, and negotiate simple obstacles. The computers primary task was to solve kinematic equations in order to coordinate the 18 electric motors driving the legs. This coordination ensured that the machines center of mass stayed over the polygon of support provided by the feet while allowing the legs to sequence through a gait. The machine traveled quite slowly, covering several yards per minute. Force and visual sensing provide a measure of terrain accommodation in later developments.

The hexapod provided McGhee with an excellent opportunity to pursue his earlier theoretical findings on the combinatorics and selection of gait. The group at Ohio State is currently building a much larger hexapod (about 3 tons), which is intended to operate on rough terrain with a high degree of autonomy. Gurfinkel and his co-workers in the USSR built a machine with characteristics and performance quite similar to McGhee's at about the same time. It used a hybrid computer for control, with heavy use of analog computation for low-level functions.

With the ability to generate x, y, and z translations of each foot by merely choosing an actuator, the control computer was freed from the arduous task of performing kinematic solutions. The mechanical linkage was actually helping to perform the calculations needed for locomotion. The linkage was efficient because the actuators performed only positive work in moving the body forward. Hirose used this leg design to build a small quadruped, about one yard long. It was equipped with touch sensors on each foot and an oil-damped pendulum attached to the body. Simple algorithms used the sensors to control the actions of the feet. For cleared the obstacle, the cycle would repeat.

The use instance, if a touch sensor indicated contact while of several simple algorithms like this one permitted the foot was moving forward, the leg would move Hirose's machine to climb up and down stairs and to backward a little bit, move upward a little bit, then negotiate other obstacles without human intervention resume its forward motion, if the foot had motion. These three walking machines, McGhee's, Gurfinkel's, and Hirose's, represent a class called static crawlers. Each differs in the details of construction and in the computing technology used for control, but shares a common approach to balance and stability. Enough feet are kept on the ground to guarantee a broad base of support at all times, and the body and legs move to keep the centre of mass over this broad support base. The forward velocity is kept sufficiently low so that stored energy need not be figured into the stability calculation. Each of these machines has been used to study rough terrain locomotion in the laboratory through experiments on terrain sensing, gait selection and selection of foothold sequences.

III. Kinematic Walker

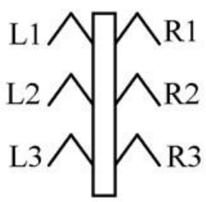
The hexapod robot has, by definition, six legs and is inspired by insects such as ants. It is also called as the "kinematic walker". This gives it the ability to move flexibly across various terrains and, as stated in section 1.2.3.3, does not require any balancing mechanisms to stand upright. The main purpose for building this robot is to study the motions and movements of an insect. Applications for such a robot include environment exploration, search and rescue, and as a computer numerical control machine. This robot works on the principle of the four bar mechanism.

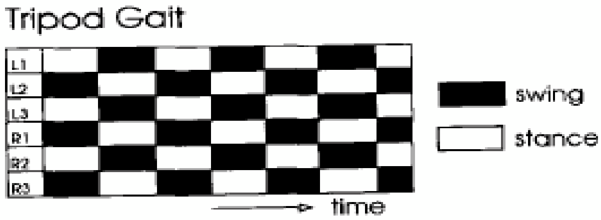
IV. Construction

The materials used in the construction of the kinematic walker are mica board of three different sizes, connecting rod (spokes used in the bicycles). Holes are drilled in the respective places of the boards as shown in the design. Mica board (400x20x2 mm) acts as a fixed link otherwise called as the body of the kinematic walker. Mica board (50x100x2 mm) acts as a kinematic leg. Mica board (245x20x2 mm) acts as a rocker arm. The rocker arm's length is calculated by using the Pythagoras theorem. The connecting rod is inserted into the holes of the walker as shown in design. The leg is connected to the fixed link through a crank link(spokes). The leg is connected to the common rod through rocker arm. The board and the rod are joined together by applying m-seal between them in order to avoid slip of the links.

V. WORKING

The working of this robot is mainly by the simultaneous motion of the wheel.





When the handle is rotated, the rod connected with the handle rotates. This handle is called as the crank link. As the crank link rotates the legs connected with them also rotates. These legs are supported by the rocker arm connecting the legs with the common rod at the center. This robot moves based on the tripod gait(i.e.), three legs will have the similar motion and other three legs will have the similar motion. During the first 90^0 of rotation, the connecting rod and the legs will come in the same line of axis. For next 90^0 of rotation, the legs L1 & L3 move forward. For the next 90^0 of rotation, the connecting rod and the legs will come in the same line of axis. For the last 90^0 of rotation, the leg L2 moves forward.

VI. 2d Model for Kinematic Walker

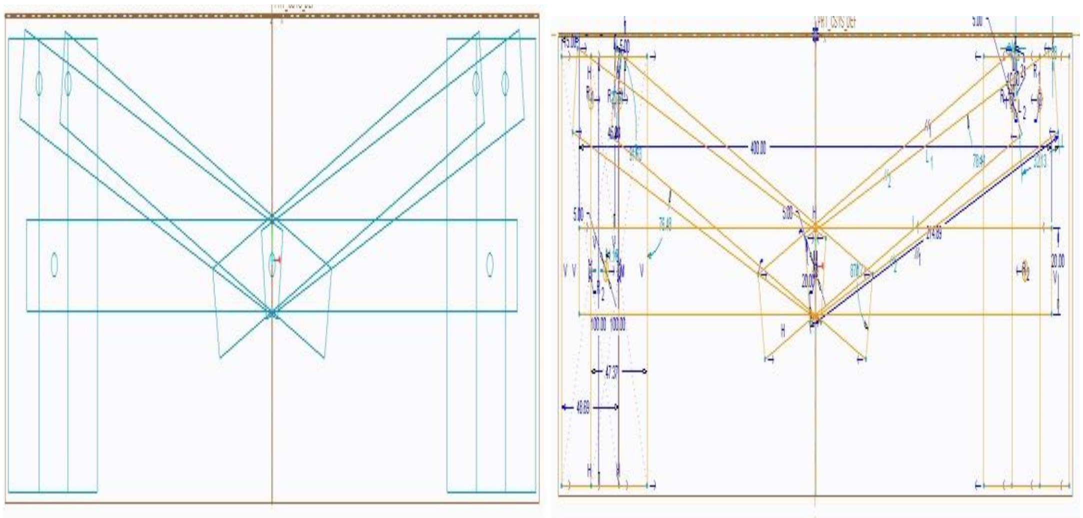


Fig 1 - Kinematic walker (Front view)

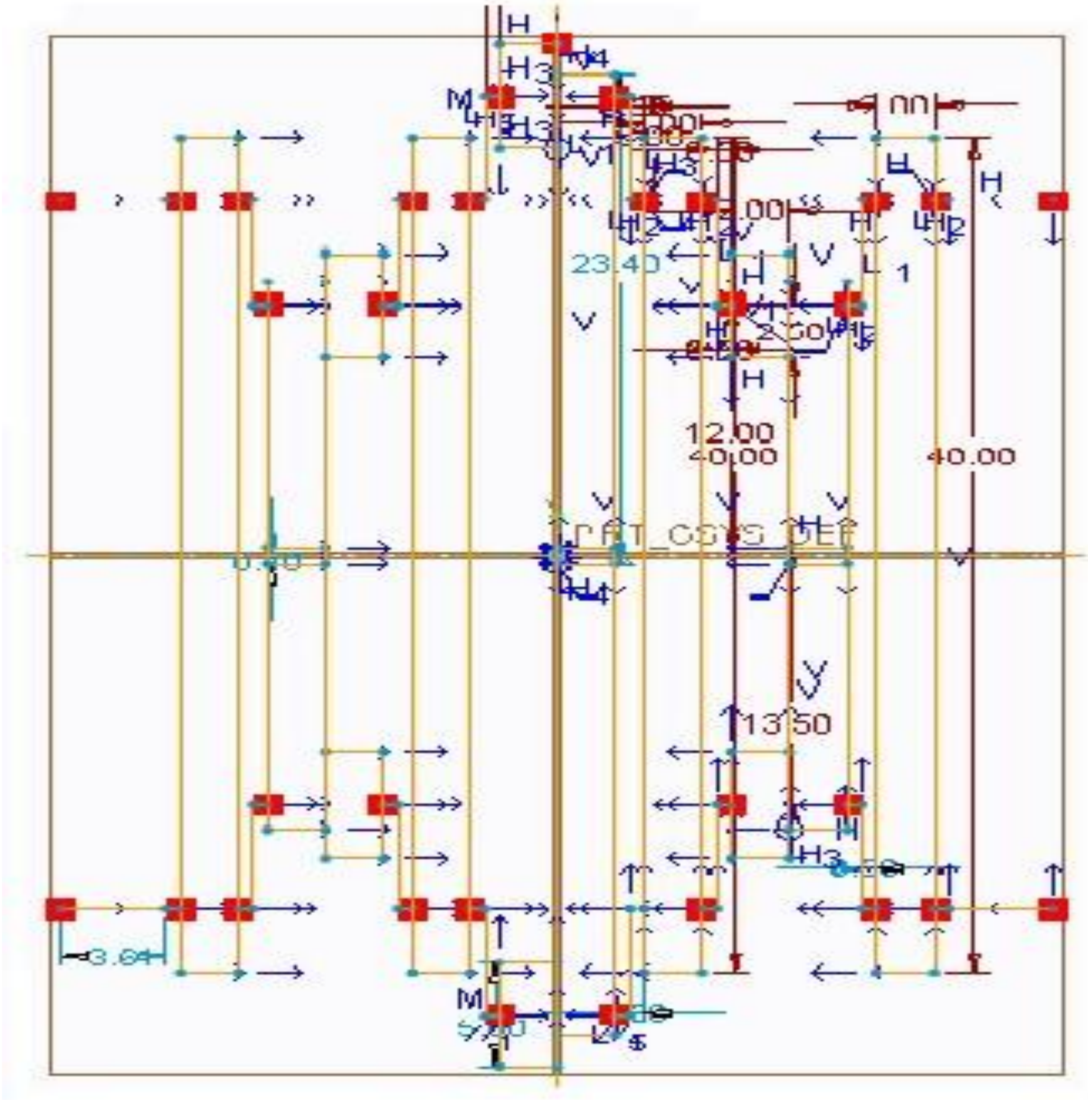
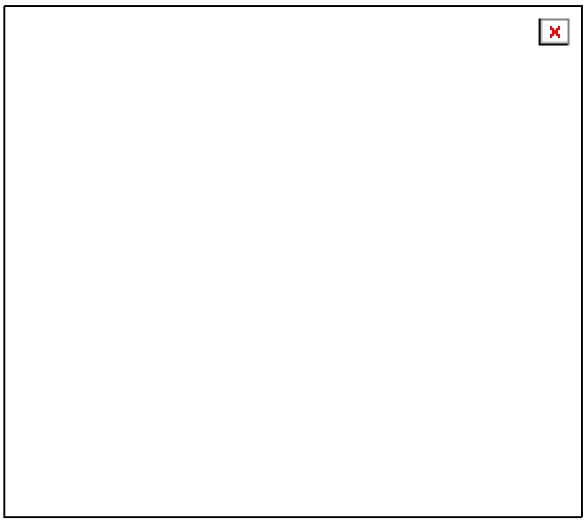


Fig 2 - Kinematic walker (Top view)



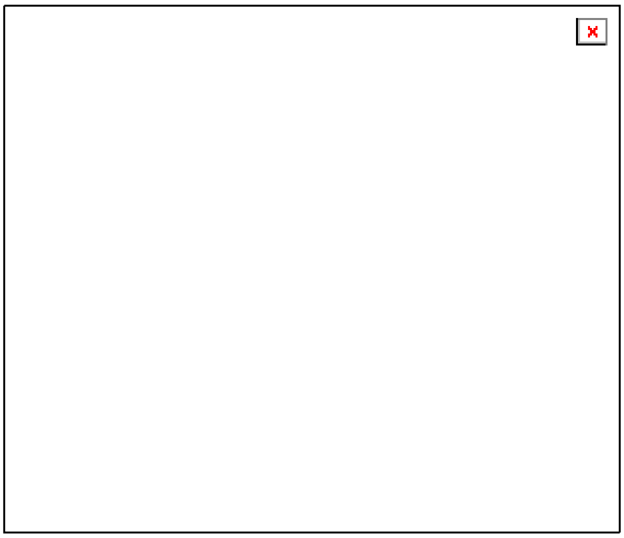
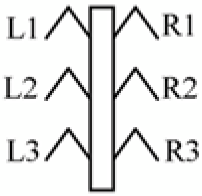


Fig 3 - Isometric view of kinematicwalker Fig 4 - Fabrication of kinematic walker

VII. Model Calculation

Here, the angle between each leg and the surface is 90^0 and the length of the crank link is 5 cm.



Consider the axis of the connecting rod(C) be the origin.
Then, the leg L1 & L3 will be at +5cm and L2 will be at -5cm.
At 90^0 of rotation,

L1=L2=L3=C=0. (i.e.) the axis of the connecting rod and the axis of each leg will be at same position. At 180^0 of rotation,

L1=L3= -5 cm, C=0, L2= +5 cm. (i.e.) the L1 and L3 will be behind the connecting rod and L2 will be ahead of the connecting rod. At 270^0 of rotation,

L1=L2=L3=C=0. (i.e.) the axis of the connecting rod and the axis of each leg will be at same position.

At 360^0 of rotation,

L1=L3= +5 cm, C=0, L2= -5 cm. (i.e.) the L1 and L3 will be ahead of the connecting rod and L2 will be behind the connecting rod.

For first half of the revolution, the legs move 5 cm front and for the second half of the revolution, the legs move 5 cm front.

Hence for one complete revolution, the legs would have moved 10 cm.

W.K.T,

From newton's law,
F = m*a where, F = Force applied in newton, a = acceleration of robot in m/s^2, m = mass of the robot in kg.

From above equation, it is clear that force applied is directly proportional to the speed of the robot. Hence for more speed more forcemust be applied on the crank link. If any external force is acting on the robot then the equation becomes,
F= m*a – W where, W = external force in newton.
If we know the applied force, external force, and the mass of the robot, we can calculate the speed in which the robot can move.

VIII. Future Development and Recommendations

The kinematic walker only walks with tripod gait. It is our recommendation to include a wave gait walking method in the program. The hexapod should be able to distinguish even and uneven terrain. On even terrain, it should use tripod gait for walking and on uneven terrain, it should use wave gait. Infrared sensors must be used to detect the obstacles in the path of the motion. Alternately, the infrared sensor can be replaced by ultrasonic sensor because we found this type of sensor is more reliable over infrared sensors. Additionally, it has come to our attention that the servo motors can be used to provide more torque to support the kinematic walker chassis. The battery packs will need to be able to supply a continuous current in order for those servos to operate properly. When the kinematic walker is climbing over obstacles, the front body is tilting upwards. A gyro sensor can be installed on to the kinematic walker to determine the tilting levels and maintain a balanced body position. The Arduino Mega ADK board is able to interface with Android phones. The kinematic walker can becontrolled from an android phone or from a laptop viaBluetoothorWi-Fi. The kinematic walker is designed to walk on rough terrain and it can be used as a SARbot (Search and Rescue Robot), remote technical repair bot, and mobile military vehicle. A higher level of obstacle detection can be developed using camera instead of infrared sensors. This will require high level of image processing to detect obstacle and faster microcontroller to reduce image processing time.

IX. CONCLUSION

Our team has built an autonomous 6-legged robotics walker (Kinematic walker Robot). The robot is used to study and simulate the walking motion of a 6-legged insect. The kinematic walker robot consists of 6 legs with 4 degrees of freedom on each leg to allow for better mobility and exceptional range of movement. A

2D model was created to compare the results with the calculation. The leg position was measured to match the 2D model. The tripod gait walking method works great on even terrain. Unfortunately, the robot was having trouble climbing over obstacles. Overall, the kinematic walker has achieved its main objective to autonomously walk over the uneven terrains in which the wheeled or tracked robots cannot move. For that reason, this project has been deemed a success.

X. REFERENCES

[1]. Meriam - Webster Inc., "Robot - Definition and more from the free Merriam – Webster Dictionary," 2012

[2]. PROSPECTOR, "Robot Gossip: Jumping Robot Leg," 13 September 2006.

[3]. N. G. Lokhande, V.B. Emche, Mechanical Spider by Using Klann *Mechanism* Shri Datta Meghe Polytechnic, Hingna Nagpur-16, India, 2006.

[4]. Yoseph Bar-Cohen, Biomimetics: mimicking and inspired-by biology, California Institute of Technology, March 2005.

[5]. Patil Sammed Arinjay, Prof. V.J. Khot Design of Bio-Mimic Hexapod, Department of Mechanical Engg., J. J. Magdum College of Engineering, Jaysingpur, Shivaji University, India,2004.

[6]. Gabriel Martin Nelson, learning about Control of Legged Locomotion using a Hexapod Robot with Compliant Pneumatic actuators, Case Western Research University, May 2002.

[7]. Saranli, U., Buehler, M. and Koditschek, D.E., “Rhex– a simple and highly mobile hexapod robot”,Int. J. Robot,2001.

[8]. Delcomyn, F. and Nelson, M.E., “Architectures for a biomimetic hexapod robot”, Robotics and Autonomous Systems, Vol. 30, 2000.

[9]. “Fabrication of Six Legged Kinematic Moving Mechanism” Sajet Vol.2, No.23

