

# Development of Six Legged Spider Robot Using Klann Mechanism with the Integration of Wheel for varied Terrain

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**ABSTRACT:** Wheel is the common mode of locomotive movement. But for the places like stair, uneven surfaces, the wheel movement is not suitable. The human beings moving easily on the stairs due to flexibility in the legs as it functions like links connected with joints. Various mechanisms are used with imitating the leg movements of animals for the rough terrain maneuver. Two most effective leg mechanisms used are Joe Klann's mechanism which resembles a spider leg and Theo Jansen's mechanism which resembles a human leg. This paper discusses about the development of spider mechanism (Klann's mechanism) for any rough terrain motions. By spider mechanism (Klann's mechanism) with random movements it is possible to combine the moment of walking as well as wheel movement. The walking mechanism is well known for rough terrain movement and the wheel movement of the mechanism results in fast movement for smooth surfaces. The function of the controlling device is to identify the type of surface and change over to required feature to move forward. Klann mechanism with six legs are used which are controlled by motor designed for required moment and the same motor drives the wheel during movement on the flat surface at high speed. The developed mechanism has been analysed for the strength of the link by FEA and the stresses developed are within the limits. The movement of the links are tested for the designed positions. Speed and Velocity analysis was carried out for the links and crank movement which are well within the desired limit.

**KEYWORDS:** Klann Mechanism, Kinematic link, Walking Robot, Unmanned system.

## I. INTRODUCTION

It is a mover that can go over a rough terrain at speeds which are remarkably higher than practically possible with wheeled vehicles. Indeed, even an individual, by getting down on each of the four legs if necessary, can travel or climb over terrain which is inaccessible for a wheeled or followed vehicle. Motions are achieved by wheels attached to the system which can have smooth riding. Science man started inventing the robot the design of new versions of robots had always been revised by all the inventors for improved features. The walking mechanism is one system where it is employed for movement rough terrain and unmanned vehicles either in space or on the earth. But the challenge faced by this type of robot is the surface is always combination of rough and smooth terrain where the speed needs to be optimised for smooth terrain as compared to rough terrain. Legged robots can be utilized for space missions on extra-terrestrial planets and in risky places, for example, within an atomic reactor, giving autonomous legged robots a great potential. Low power consumption and weight are further advantages of walking robots, so it is important to use the minimum number of actuators.

In this context, the goal for this project is to fabricate a six legged robot which will stroll using Klann mechanism. However moving on the rough terrain, steps, Mountains poses challenge to the movement by wheels. The Klann linkage is a open loop six-bar planar mechanism designed to simulate walking movement of animal and function as a wheel replacement. The invention of various links and mechanisms has made it easy to move on the uneven surface. But the surfaces with various different combination of rough, smooth, uneven, even nature calls for the up gradation of the maneuver system to have combination of wheel and the links with constant switching from one to another. The speed of the system also can be increased with this combination of mechanism and wheels. This system could enhance the utility of existing system which has either wheels or link mechanism. This robot is a combination of both wheel and walking links which is more suitable for multipurpose movements and faster in travelling. Klann mechanism was used to get movement on rough terrain and wheels are provided to for travelling on smooth surfaces, both are driven by single motor controlled by arduino with remote.

II. DESIGN OF SIX LEGGED ROBOT

The Klann Mechanism is a planar mechanism which is designed to simulate walking in any terrain. It was designed to navigate uneven terrain and can also be effective on flat surfaces, capable of replacing the wheel. It is a simple system with only one degree of freedom. This mechanism consists of two conjoined four bar mechanism ie. The input of the second mechanism depends on the output of the first. This causes the system to be unstable if the proportion of the linkages are not constrained to a certain tolerance. It has many advantages of walking mechanisms compared to other existing mechanism in terms of their shortcomings. Some of the advantages include the ability to traverse uneven terrain, step over stairs, ramp and obstructions and ability to have an efficient mechanism with only one degree of freedom. It does not, however, offer the control and precision that modern walking mechanisms do with higher degrees of freedom and the ability to dynamically modify its gait.

Klann mechanism is used for a wheeled or follower vehicle motion. It is therefore of immense enthusiasm to realize what machines for land locomotion can do if they are intended to imitate nature. Legged robots can be utilized for space missions on extra-terrestrial planets, Mountain regions, slippery ground and in risky places, for example, within an atomic reactor, giving autonomous legged robots a great potential. Low power consumption for operation and weight are further advantages of walking robots, so it is important to use the minimum number of actuators for links. In this context, the goal for this project is to fabricate a six legged robot which will move with the wheels and links. Fig 1 indicates the configuration and link details of Klann mechanism used for the robot.

The kinematics of this robot will allow it to move on different terrain at different speeds. It has six links per leg 180 degrees of crank rotation per stride. The linkage consists of the frame, crank, two pivoted rockers, and two couplers all connected by pivot joints. The kinematics of robots structure enables it to convert the rotating motion of the crank into the movement of foot similar to that of creature strolling. The most important benefit of this mechanism is that, it does not require microprocessor, controller and other actuator mechanisms. By copying to the physical structure of legged animals, it may be possible to improve the performance of the mobile robot.

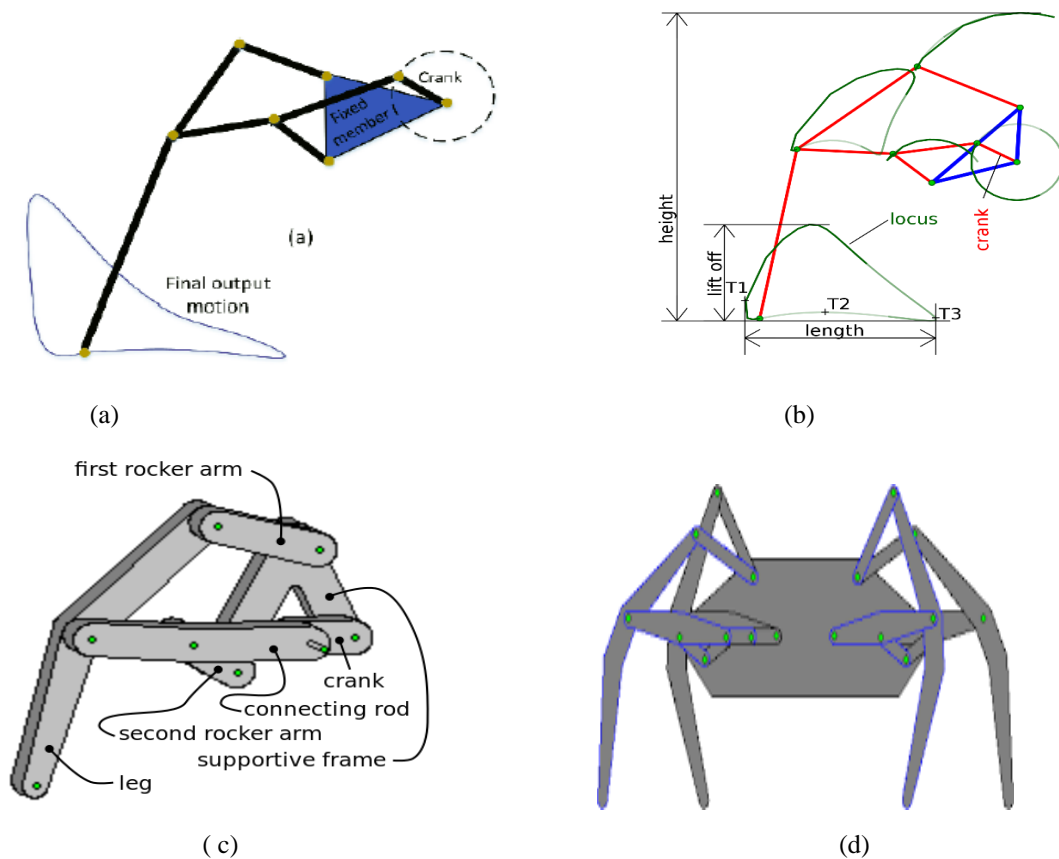


Fig. 1 Klann mechanism configurations (a) Links and path of output motion (b) Path parameters of link movement (c) Nomenclature of Klann Mechanism links (d) Assembled Klann mechanism on the frame.

Klann mechanism shown in fig 1 is similar to a tabular mechanism used to simulate the gait (movement) of leg-like animal and work such as move, performance as a wheel replacement. It consists of a link frame, cranks and two grounded rockers, and two couplers connected by a pivot joint. It is an eight bar kinematic chain. It provides advantages in walking machines application; step over curbs, climb stairs, travel into areas which are not possible by wheels that don't need microprocessor control or actuator mechanism.

The motor speed was the critical in determining the liner velocity of the robot. It is seen by the below calculation that the speed achieved for the robot walking is estimated as 1.1506 m/sec.

**Linear velocity of the Links**

$$\text{Angular velocity } \omega = 2\pi n / 60$$

$$= 2\pi \cdot 100 / 60$$

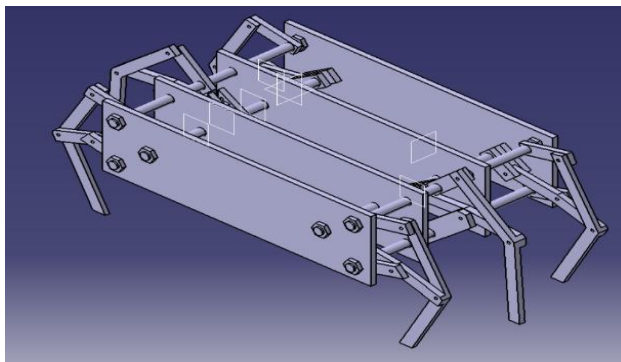
$$= 10.46 \text{ rad/sec}$$

$$\text{Linear velocity (v)} = \omega r \text{ m/sec}$$

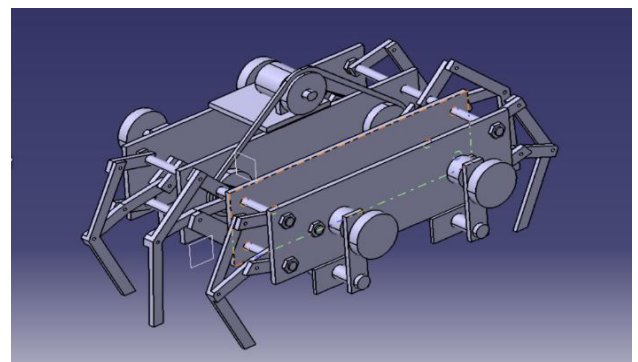
$$= 10.46 \times 110 \text{ (mm)}$$

$$= 1.1506 \text{ m/sec}$$

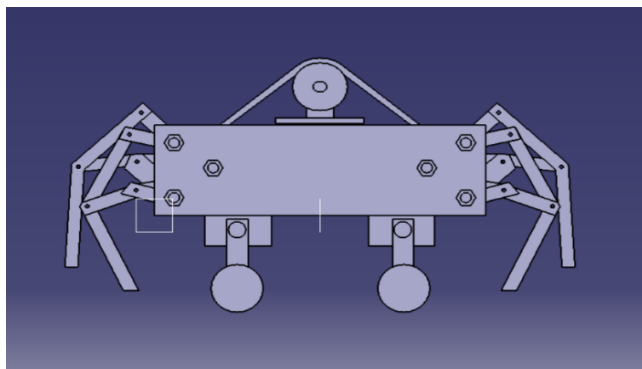
The dimensions of the links are taken based on the standard literature and on the size of the robot capacity for which it is designed. The process of synthesis of mechanism means process of mechanism selected, it might be a linkage, a geared system, belts and pulleys, or even a cam system. This stage of the design problem, importance was given to factors such as manufacturing processes, materials, safety, space, and economics. The material for the links are taken as aluminium alloy which has low density and environmental stability. 3D model of the Mechanism, robot were developed and shown in fig 2 with different positions of wheel and mechanism.



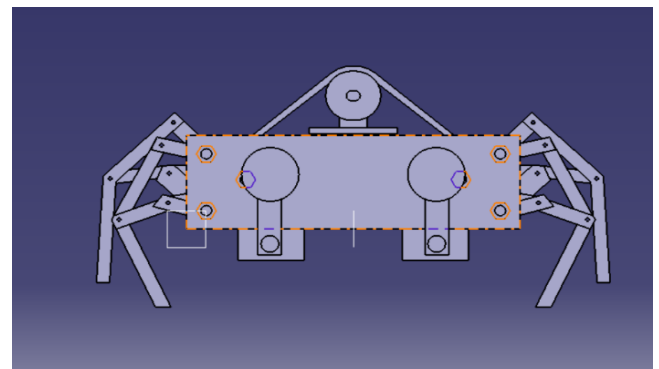
(a)



(b)



(c)



(d)

Fig. 2 Solid models of Robot (a) Solid model with six Klann mechanism (b) Solid model of complete robot with Klann mechanism and Wheels attached. (c) Front view of the model with wheels on ground position (d) Front view of the model with wheels retracted.

III. FABRICATION OF SIX LEGGED ROBOT

We first find a specific motor for this project & collect its specification. The motor is main part of machine. The legs & wheels are connect to the motor shaft. In this project motor is used 1.2v, 30rpm. 1) The motor fitted in between middle of Klann with spur gear. This spur gear is connected to another spur gear. Another spur gear is mounted on shaft with nut fitting. The shaft is nut and both side of nut are attached to acrylic body. 2) Before attaching to acrylic body 2 spur gear are attached on both side & this gear are connect with two side wheels. 3) The middle leg front and back side are connect to the one side of wheel and body. The other four legs are connect to the middle of wheel and body. The fabricated six legged Robot is shown in fig 3 with all the six legs and the wheels are operated by single motor controlled by arduino and remote.



(a)



(b)

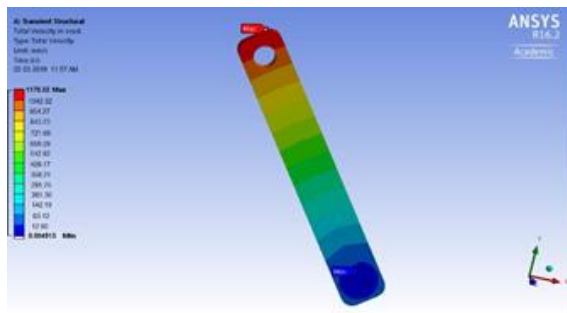
Fig. 2 Six Legged Robot with wheels attached (a) Fabricated Six legged Robot with wheels on the ground (b) Top view of Fabricated Robot with Klann mechanism and Wheel

IV. ANALYSIS AND TESTING OF SIX LEGGED ROBOT

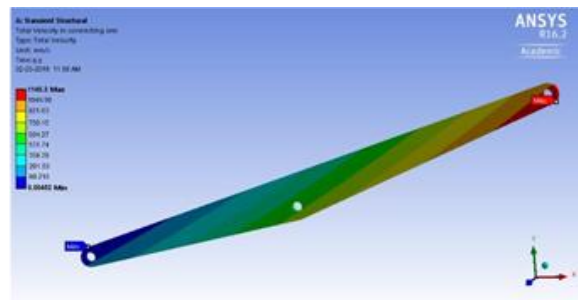
The Finite element analysis of the links are carried out for the designated length and applying the torque existing during mauldering. For both the walking and during rolling with wheels the links experiences the stress. During walking the links are subjected to more stress magnitude than during rolling with wheels. For the process of the analysis, it was considered that a DC Motor which is fixed of 100 rpm with a torque of 16 kgcm. The boundary conditions are considered as pin joints between the links. The load is considered as torque existing on the links due to movement of the links. The figure shows the static analysis of the link for stress and deformation in one of the link.

It indicates the developed stress under static condition are well within in the limits.

For the purpose of testing the robot was tested for a maximum speed of the walking at 15m/min was obtained. The speed of the robot with wheels are achieved with maximum velocity of 20m/min. The movement of the robot with wheels and with the links are working satisfactory. The velocity analysis of the crank, link, connecting rod and rocker are simulated for the given motor speed and it matches with desired speed of the robot.



(a)



(b)



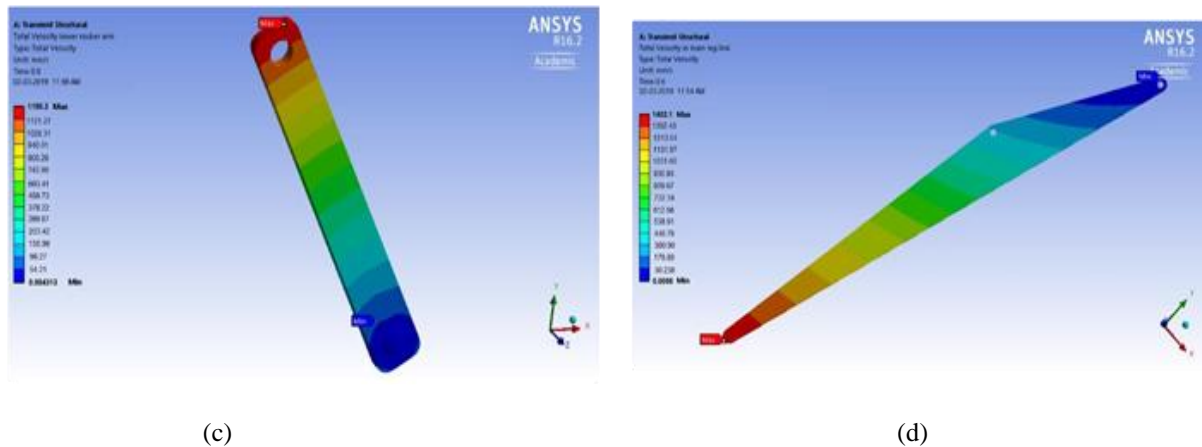


Fig.4.FEA Results (a) Results of Velocity analysis for Lower rocker arm. (b) Results of Velocity analysis for connecting rod (c) Results of Velocity analysis for crank (d) Results of Velocity analysis for leg.

### V. CONCLUSION

A novel idea of combining the legged movement for rough terrain and rolling movement for fast movement of smooth terrain is presented in the paper. The design involves the popular Klann mechanism with four mechanism in front and four in back for simulating the walking movement and two wheels on each profile side of the vehicle for rapid movement is adopted. The walking mechanism working in efficient as compared to wheels attached as well. Walking bots that can adapt to various situations and generate appropriate stable trajectories would extend their capabilities beyond intended applications. Currently a six legged hybrid robot based on the Klann mechanism is being constructed to validate the robustness of the produced gaits and control approaches. Future work may include the improved switch over between the two movements during rapid travel. Also improvement in weight carrying capacity of the mechanism to carry the load may be taken up.

1. Combined rolling and walking types of Klann mechanisms are used to enable effective motion of the walking machine leg mechanism for walking operation.
2. Simple mechanism is integrated with wheel to generate motion path for the leg mechanism of a walking machine and wheel rotation by a motor.
3. Speed regulation will be controlled by Arduino for movement of the links and the rotation of the wheels during travelling.
4. The travel time is reduced due to combined movement of the robot on the varying terrain.

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