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Design and Fabrication of Mechanical Mover Using Klann Mechanism

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Abstract: As it's seen in the present scenario the wheels are inefficient on rough and rocky areas and so movement using legs would be beneficial for advanced walking. It can access areas that are not currently accessible with wheels. This project deals with implementing linkage based system replacing conventional tyres in mechanical movers. The first mechanism that we came across was THEO-JANSEN MECHANISM. The central crank link moves in circles as it is actuated by a rotary actuator such as an electric motor. All other links and pin joints are not actuated and move because of the motion imparted by the crank. Their positions and orientations are uniquely defined by specifying the crank angle and hence the mechanism has only one degree of freedom (1-DoF).On observing further in detail it was found that there were many drawbacks for Jansen mechanism specially its complexity. The most flexible mechanism that got settled with is KLANN MECHANISM. It mimics the motion of crab. In this mechanism the links are connected by pivot joints and convert the rotating motion of crank into movement similar to animal walking. Objective of the project is to replace the function of wheel with an alternative in order to overcome the difficulty of movement in uneven terrain. This paper is useful in mechanical movers, hazardous material handling (military applications), clearing minefields or an area without putting life at risk.

Keywords: Klann mechanism, Theo Jansen mechanism, Linkage, Degree of freedom.

I. Introduction:

Walking mechanisms are generally developed by imitating nature, like insects movement. Nature inspires the researchers with innovative ideas which are simple and effective, sometimes cumbersome and critical. Legged locomotion are mechanically superior to wheeled or to tracked locomotion over a variety of soil conditions and certainly superior for crossing obstacles. J.C Klann [1] developed a combination of links imitating crab which could produce a similar gait as that of crab leg, which could be found by using a geometric algorithm. But he himself says that, all the combination developed using the algorithm may not be correct all the time. So, we used Linkage software to design the leg. Pratik Walimbe et al [2] elaborates with simulation and experiments about the variation in gait pattern based on the changes in angle of ternary links. From Vinayak Borge et al [3] it was understood that these legs coupled together can act as a wheel replacement and provide vehicles with a greater ability to handle obstacles and travel across uneven terrain. Omkar Bhongale et al [4] proposes an approach to enhance the current project, additional features can be integrated onto the system, namely the wireless communication module, so that it can communicate between the operator and the victims and so on. [5] - [8] Presents a set of similar robots using Klann mechanism.US army investigations reveal 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 and are the best for moving, but not over all kinds of terrain. We are fabricating an eight legged Klann robot to move on any type of soil and in all sorts of terrain. This paper details the design and fabrication of an eight legged Klann robot, for deployment on different soil conditions and terrains. A Klann leg is designed, gear and shaft is designed; fabrication of Klann robot is done. This robot demonstrates a mechanism that can be implemented in mechanical movers.

Designing of Klann leg

A free software "Linkage" is used to design the Klann leg. The length and breadth of each link are determined using the same.

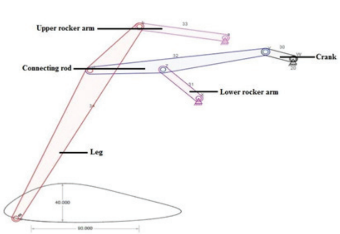

Figure 1: Designed Klann leg using Linkage.

Figure.1 shows the length of links obtained using Linkage:
-Leg = 225mm
-Upper rocker arm = 73mm
-Lower rocker arm = 43mm
-Connecting rod = 148mm
-Crank = 24mm
Components and description
Frame

The model consists of four frames which are fixed vertical to each other with nuts and bolts. Dimensions of frame were determined using the software Linkage.
Figure.2 shows the determined dimensions:
Length = 30 cm
Breadth = 10 cm

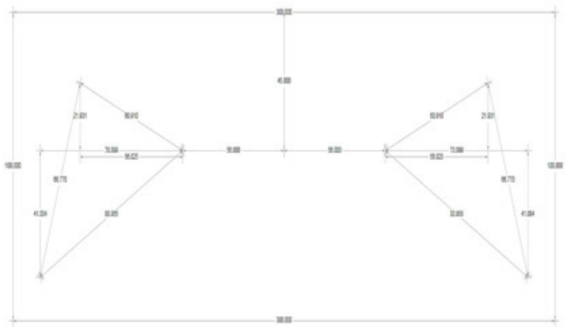

Figure 2: Frame with point of fixation of legs.
DC Motor

Since the system involves tangible components and is a small speed application, low speed motor is needed. But it should be able to drive the legs well. So motor should have high torque. A gear motor suitable for these conditions is selected.
Specification:
Speed N = 60 rpm
Voltage V = 12 Volt
Current I = 3 A
Power P = V x I
= 12*3 = 36 W
Torque T = (P*60)/ (2*3.14*N)
= (36*60)/ (2*3.14*60) = 5.8 Nm

Battery

A rechargeable battery comprises one or more electrochemical cells, and is a type of energy accumulator. It is known as a secondary cell because its electrochemical reactions are electrically reversible. Rechargeable batteries come in many different shapes and sizes. Several different combinations of chemicals are commonly used, like: Lead-acid, Nickel-Cadmium (NiCd), Nickel-Metal Hydride (NiMH) and Lithium ion (Li-ion) in batteries. Rechargeable batteries have less environmental impact than disposable batteries. Here a Lead-acid battery (12V) is selected that powers both the motor.
Material selection
Table 1: Material properties.

Material	Weight of 1m2*0.02m sheet (Kg)	Brinell hardness (BHN)	Resistance to break (Joules)	Corrosionrate (mm/year)
Aluminium	2.6	67	105	0.21

Mild Steel	7.7	130	190	0.36
Stainless Steel	7.5	123	178	0.38
Galvanized Iron	8.1	229	218	0.16

Table .1 shows that the material Aluminium has:
- Good corrosion resistance.
- Light weight.
- Good strength and ductility.

It can also be understood that Galvanized Iron sheet has:
- Very good corrosion resistance.
- Greater resistance to break.
- Good hardness.

So, Aluminium sheet is selected as the material for fabrication of frames and Galvanized Iron sheets for the fabrication of links.

Design of gear and shaft
Design of gear
As the rotation from motor needs to be transmitted to two parallel shafts simultaneously we require pinion and spur gears.
We selected a pinion of 15 teeth (plastic material) which has a diameter of 2.3 cm.
Teeth, T1 = 15
Diameter, D1 = 2.3 cm
Rotations per minute, N1 = 60
We require crank rotation of 16 times per minute.
So, N2 = 16
Hence the requirement of designing a spur gear.
Using gear ratio formula:
D1/D2 = N2/N1 = T1 /T2
i.e., 2.3/D2 = 16/60 = 15 /T2
D2 = (60/16) * 2.3
= 8.6 cm
T2 = (60/16) * 15 = 56
So, a gear of 8.6 cm diameter with 56 teeth is required.
Design of shaft
Length of shaft = (length of body of motor + clearance space + double the thickness of crank + thickness of spur gear + thickness of washer + double the thickness of frame)
= (5 + 3 + 0.6 + 2 + 1 + 0.4) = 12 cm
1 Kg = 1000g = 9.81 N
1 g = 9.81 * 10-3 N
Weight of crank = 25g = 0.24 N
Weight of gear = 40 g = 0.39 N

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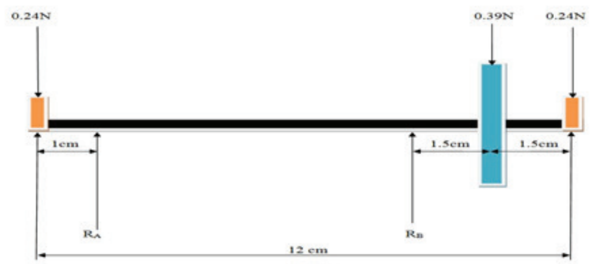

Figure 3: Free body diagram.

From Figure.3, RA + RB = (0.24 +0.39 + 0.24) = 0.87 N
(-0.24 * 9) + (RA * 8) + (0.24 * 3) + (0.39 * 1.5) = 0
(-2.16 + 8RA +0.585 + 0.72) = 0
Therefore, RA = 0.106 N
RB = 0.764 N

Shear Force Diagram:

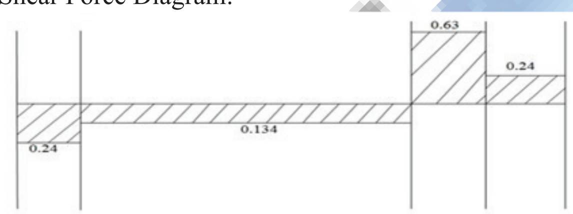

Figure 4: Shear force diagram.

Bending Moment Diagram:
From Figure.5, it is understood that the maximum bending moment is at point where load of gear acts.
Maximum bending moment = (0.24*9) + (-0.106*8)
= 1.30 Ncm = 0.013 Nm.

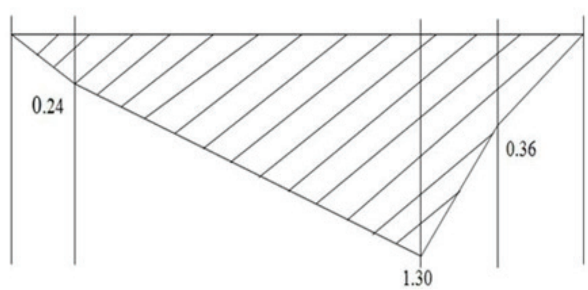

Figure 5: Bending Moment diagram.

M = 0.013 Nm
P = (2π*N*T)/60
36 = (2*3.14*60*T)/60
ie, T = 5.8 Nm.
T equivalent = (M2 + T2)1/2 = (0.0132 + 5.82)1/2 = 5.8 Nm

We selected material mild steel, which has a shear stress in the range 200 MPa to 400 MPa.
Here we took the shear stress of mild steel as 300 MPa.

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□□= 16 T/ πd3
300*106 = (16*5.8)/(3.14*d3)
Solving we get,
d = 4.62*10-3m = 4.62 mm

Standardizing the diameter with reference to data hand book by K. Mahadevan (4th Edition), Design of shaft – page no: 57, Table 3.5(a).
We get d = 6 mm.
So, a shaft of diameter 6 mm is required.
3D Modeling
3D modeling is done using the software Solid Edge ST5.

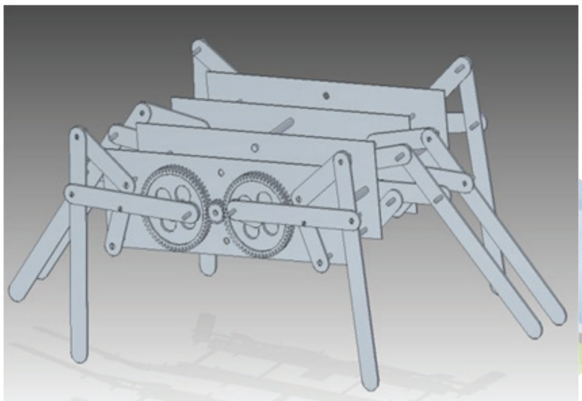

Figure 6: ISO view of total assembly.

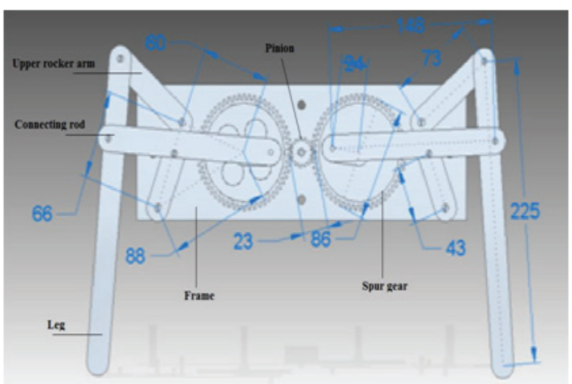

Figure 7: Front view.

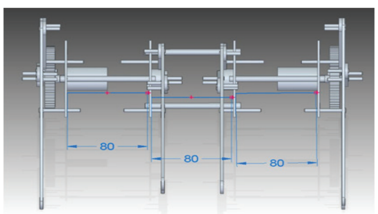

Figure 8: Side view.

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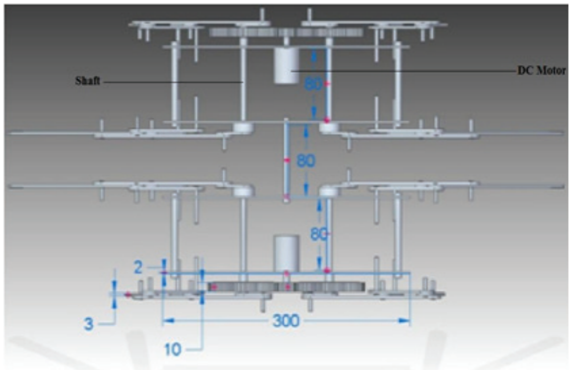

Figure 9: Top view.

II. Conclusion:

This work has provided us an excellent opportunity and experience, to use our limited knowledge. We gained a lot of practical knowledge regarding, planning, purchasing, assembling and machining while doing this work. We are proud that we have completed the work with the limited time successfully. The mechanical mover using Klann mechanism is working well with satisfactory conditions.

Wheels would be more efficient on smooth hard surface but on uneven terrain linkage becomes more adaptable, wheels of smaller size cannot handle obstacles that this linkage is capable of. Eight legged mechanism have a wide range of application in the manufacturing of robots. This can be implemented in mechanical movers which make them accessible to places where wheels can't. It can also be used for military purpose. By placing bomb detector in the machines we can easily detect the bomb, preventing harm to humans. It can be used as a heavy tanker machine for carrying bombs as well as carrying other military goods. It is also applicable for industrial application for the transportation of goods inside the industry, the mountain roads or other difficulties where ordinary vehicles cannot move easily can be replaced by our eight legged mechanical robot. If we make this a bigger one it can carry heavy loads. Thus Klann robot could replace the wheels where surface is uneven.

III. Future Scope of Work:

This mechanism can be made more flexible by using different link lengths for front, middle and hind legs. Range of motion and moments available at each joint can be altered based on the positioning and lengths of links. Thus could be implemented in large application levels.

IV. References

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