Design and Development of Pulley Based Movable Crane Robot

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Abstract:

Here we put forward the design and fabrication of a motorized pulley-based crane robot. The system consists of a movable frame chassis which consists of a pulley mechanism using a shaft used to handle the rope. The pulley shaft is mounted in a frame to hold it in at 45 degree angular position for lifting. Also our system consists of motors mounted at bottom of vehicle to drive it in desired directions. Also it consists of another motor used to drive the rope pulley mechanism. The top motorized mechanism is used to drive the lifting logic while below motors are used to drive the vehicle. The vehicle frame and pulley frame are designed to support maximum weight in a small structure for demonstration of mini movable pulley robotic system.

***Keywords*: Metallic Frame, DC Motor, Dummy motors, Supporting arms, Hook, Wheels, Pulleys, Rope.**

1. INTRODUCTION

Pulley based movable crane is a small lifting, and material handling equipment used in engineering workshops as well as in Godowns & Ware houses. Pulley based movable crane can be used for lifting of different type of material in the segments where frequent lifting & handling of material activity is required. Pulley based movable crane is automatically operated. Electrical power is sometimes required for lifting operation, according to the need. Special types of Pulleys based movable crane are also used in positioning the Cameras in shootings.

Because of low cost and versatile use, there is a very good market, potential for this product. As described earlier Pulley based movable crane are used in Industrial Activity for material handling and lifting purposes, therefore the size of market is very big. The market is continuously increasing with the growth of Industrialization and Godowns, Warehouses etc. Since very few units are engaged in manufacturing of this product in this region, there is a bright market potential for Pulley based movable crane in the indigenous.

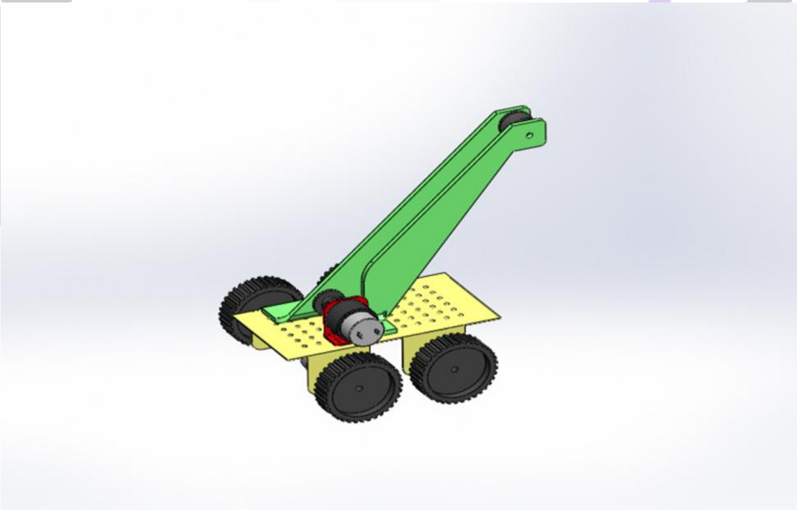


Fig 1. Pulley Based Movable Crane Robot

2 MANUFACTURING

2.1 Finalizing Mechanisms

- Step 1: Make a list of required hardware outputs
- Step 2: Examine the mechanism architecture
- Step 3: Select the architecture

- Step 4: Identify Motion Needs
- Step 5: Start searching for mechanisms & Parts
- Step 6: Examine Costs and Power Constraints. ...
- Step 7: Check part availability
- Step 8: Calculate Sizes
- Step 9: Fabricate parts

2.2 Parts Procurement

- Once the design is complete parts are to be procured so that project development may proceed.

2.3 Parts Fabrication

It is a value-added process that involves the creation of machines, parts, and structures from various raw materials. A fabrication shop will bid on a job, usually based on the engineering drawings, and if awarded the contract will build the product.

2.4 Fabrication Processes

- Turning
- Boring
- Threading
- Welding
- Drilling
- Metal Cutting
- Threading

2.5 Project assembly

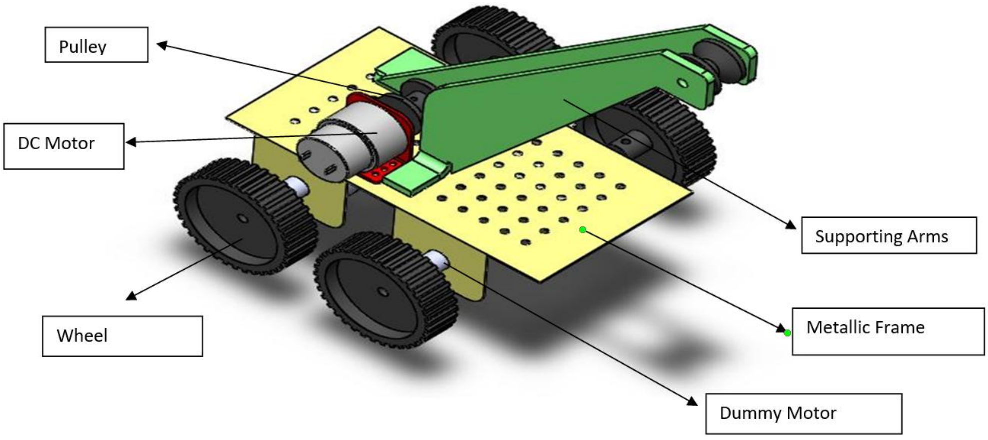
- Mechanical assembly is a common term in the industrial and manufacturing context. It is the process used in the line of assembly production. As products are moved through the chain, parts are added at certain points of the line.

2.6 Testing

Mechanical testing includes testing each part of the machine/robot individually followed by the complete testing after which the project is ready to be used.

2.7 WORKING

The system consists of a movable frame chassis which consists of a pulley mechanism using a shaft used to handle the rope. The pulley shaft is mounted in a frame to hold it in at 45degree angular position for lifting. Also our system consists of motors mounted at bottom of vehicle to drive it in desired directions. Also it consists of another motor used to drive the rope pulley mechanism. The top motorized mechanism is used to drive the lifting logic while below motors are used to drive the vehicle.



2.8. ADVANTAGES AND APPLICATIONS:

Advantages:

- Pulley implementation increases high load carrying capacity.
- Simple in construction.
- Less maintenance.

- Initial cost is less.
- The materials used for fabrication is easily available in the consumer markets.
- Non skilled labours can easily handle this system.
- Space consumption is less, so it can be used for small scale applications too.

Applications:

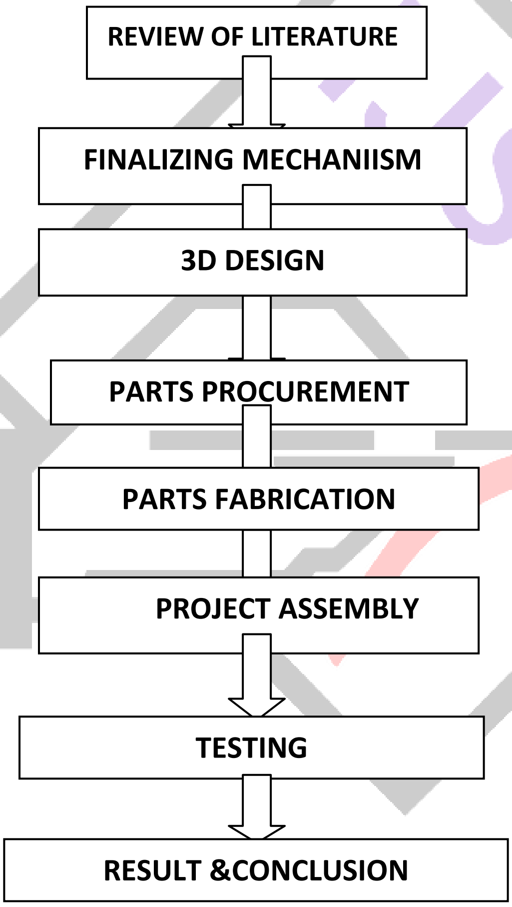
Used for load lifting, carrying and shifting operations in small, medium and large industries like,

1. Foundry
2. Welding workshops
3. Automobile workshops
4. Construction sites, etc.,

3. Research objectives:

The general objective of the research project is to design and produce portable and moveable lifting crane to lift heavy loads that are beyond the capacity of human beings applying only small force in the production machine shop.

4. Proposed Methodology:



5. LITERATURE REVIEW

A hydraulic system is used for transmitting force or motion by applying pressure on a confined liquid. Hydraulic cranes are usually multi-degree-of-freedom (multi-DOF) mechanical booms [1].

In recent years there are many researches has been done in robotics and the development of the robot to for many application in various area for accurate and precise working. In the different form Robots are used in industry for the more and accurate production. Robotic arm is used as prosthetic arm for the amputee person and many other applications of the robotic arm. For this purpose various kind of sensors are required [2].

EMG is compatible for many applications in robotics and as this is used as the control signal of the system so that real time monitoring of the muscle is possible. According to this EMG signal the finger control is achieved [2].

Nowadays, Robotic arms are being used in industries to minimize the human errors and increase efficiency, productivity, precision of the operations taking place. One of the most important advantages of introducing Robotic arm in Industries is that it can work in crucial conditions like high temperatures, pressures where it's risky for humans to work [3].

Nowadays, a different variety of robotic arms are commercially available. Some of them are excellent in accuracy and repeatability. In this paper, we understand the evolution of robotic arm in last 20 years and described different parameters of an arm [4].

A humanoid robotics is a new challenging field. To co-operate with human beings, humanoid robots not only have to feature human like form and structure, but more importantly, they must prepared human like behaviour regarding the motion, communication and intelligence. The model number of this beginner is ASR K-250 [5].

In the field of robotics the beginner can contribute many functional operations in the world. This arm can solve many human's limitations. Many people cannot move from one place to another place for their limitation but they have needed to move for collect something like mug, jog, and so on. For that they require getting help from other persons. When they use this type of robot they can solve their problem easily without help other person for its easy operation system [5].

Position of mechanical arm in people's life is getting higher and higher. It replaces the function of human arm, moving and moving in space. Generally, the structure is composed of mechanical body, controller, servo mechanism, and sensor, and some specified actions are set to complete according to the actual production requirements. +e manipulator has flexible operation, good stability, and high safety, so it is widely used in industrial automation production line [6]. A pulley is a wheel on an axle or shaft that is designed to support movement and change of direction of a cable or belt along its circumference. Pulleys are used in a variety of ways to lift loads, apply forces, and to transmit power. In nautical contexts, the assembly of wheel, axle, and supporting shell is referred to as a "block."A pulley may also be called a sheave or drum and may have a groove between two flanges around its circumference [7]. A flat belt drive is designed by limiting the maximum tension according to the permissible tensile stress specified for the belt material [7].

A fixed pulley has an axle mounted in bearings attached to a supporting structure. A fixed pulley changes the direction of the force on a rope or belt that moves along its circumference. [8] Nowadays, in order to mine the ore economically, it became necessary to increase the tonnage of mined ore, as well as to improve the method of transporting the ore that is to be mined. Belt conveyors are essential equipment for transferring the material from one place to targeted place and conveyor pulleys are the major component of conveyor system. Such kind of conveyor system needs reliable conveyor pulleys. Different type of conveyor pulleys is used throughout the conveyor system as per their function [9].

Successive crane development ran thus: 1880 saw the hand-powered movable crane, 1900 the electrically driven movable crane with a motor for each motion; by 1920 definite standards had been established for a movable crane in general and for various types of services; 1940 brought the enclosed gear cases, roller bearings, and standardized designs; and 1960 produced the changes in crane control which resulted in smoother operation, safer handling of the load, remote operation and new safety features for protection of equipment and personnel (Greiner, 1967)[10].

6. DESIGN AND ANALYSIS:

SERIAL NO.	SYMBOL	DESCRIPTION
1	ID	Inner diameter
2	P	Power in kw
3	N	Motor speed in rpm
4	Q	Discharge in l/min
5	f	Frequency in Hz
6	I_N	Current in ampere
7	L	Length
8	B	Breadth
9	H	Height
10	W	Total weight
11	F	Fiber stress in bending

12	D	Depth of joist
13	L	Length of joist
14	ρ	Density of fluid at room temp.
15	A	Cross sectional area of hose
16	μ	Coefficient of friction

Table 6.1 List of Symbols

Sr. no.	Name	Material	Dimensions
1.	Metallic frame	Steel Alloy	LxWxH 195 x 105 x 46 Sheet Thickness- 1.2 mm Motor Fitting Hole Diameter- 13.75 mm Perforated hole Diameter- 3 mm
2.	Supporting arms	Acrylic	Length- 300 mm Thickness- 70 mm
3.	Hook	Wrought iron	Large Diameter- 5 mm Small Diameter- 3 mm Thickness- 2 mm
4.	Wheels	Virgin plastic	Shaft Diameter – 6 mm Wheel Diameter – 66 mm Wheel Width – 20 mm
5.	Small pulley	Fiber	Large Diameter- 24 mm Small Diameter- 6 mm
6.	Large pulley	Fiber	Large Diameter- 48 mm Small Diameter- 12 mm Thickness- 4 mm
7.	Rope		Diameter- 2 mm

Table 6.2 Specifications of the Project

Calculation for Crane Stability:

Forces on part one-

- Load applied to the arm at the hook is 0.2kg i.e. = 0.2*9.81 =1.962N
- Volume of Metallic frame = L*B*H
  =195*105*46
  = 941850 cu mm
  = .000941850 cu m
- Density of the material used is = 8030 kg/cu m
- Mass of the Metallic frame = Volume*Density
  = 0.000291696*8030
  = 7.563 kg
- Weight of the Metallic frame = 2.2898*9.81
  = 74.193 N

Force on part two-

- Volume of supporting arm = L*B*H
  = 300*20*70
  = 420000 cu mm
  = 0.00042 cu m
- Density of material used = 1190 kg/cu m
- Mass of the supporting arm = Volume*Density
  = 0.00042*1190
  = 0.4998 kg
- Weight of supporting arm = 0.4998*9.81 = 4.903N

Design of Pulley:

Volume of pulley = Area * Thickness

= π/4 * d2 * t

= π/4 * (48)2 * 4

= 7238.229 mm3

Density of the Material used = 1340 kg/m3

Mass of Pulley = Volume * Density

= 0.000007238 * 1340

= 0.0097 kg

Weight of Pulley = 0.0097*9.81

= 0.0951 N

Torque required = Force * Radius

= 0.0951*0.024

= 0.00228 Nm

DC Motor:

Speed = 200 rpm

Angular speed = 2πN/60

= 2π*200/60

= 20.943 rad/s

Power = Torque*Angular speed

= 0.00228*20.943

= 0.0477 W

Table 6.3 Observation Table:

Take: Height (H) = 230 mm = 0.23 m

Speed = 200 rpm, $\mu = 0.25$, θ = 270 ° = 270 × $\frac{\pi}{180}$ =4.712 rad

Load (m) kg	**Weight (w) N w= m × g (g= 9.81 m/s2)**	**Work (W) N-m W= Weight × Height**	**Time (t) Seconds**	**Power (P) Watt P= Work/Time**
m_1 = 50 g = 0.05 kg	w_1 = 0.05 × 9.81 = 0.4905 N	W_1 = 0.4905 × 0.23 = 0.1128 N-m	t_1 = 15 sec	P_1 = 0.1128/15 = 0.00752 Watt
m_2 = 100 g = 0.1 kg	w_2 = 0.1 × 9.81 = 0.981 N	W_2 = 0.981 × 0.23 = 0.22560 N-m	t_2 = 20 sec	P_2 = 0.22560/20 = 0.01128 Watt

m_3 = 150 g = 0.15 kg	w_3 = 0.15 × 9.81 = 1.4715 N	W_3 = 1.4715 × 0.23 = 0.3384 N-m	t_3 = 25 sec	P_3 = 0.3384/25 = 0.0135 Watt
m_4 = 200 g = 0.2 kg	w_4 = 0.2 × 9.81 = 1.962 N	W_4 = 1.962 × 0.23 = 0.4512 N-m	t_4= 30 sec	P_4 = 0.4512/30 = 0.015 Watt
m_5 = 250 g = 0.25 kg	w_5 = 0.25 × 9.81 = 2.4525 N	W_5 = 2.4525 × 0.23 = 0.564 N-m	t_5 = 35 sec	P_5 = 0.564/35 = 0.0161 Watt

The Average Power (P) = $(P_1+P_2+P_3+P_4+P_5)/5$

P = (0.00752+0.01128+0.0135+0.015+0.0161)/5

P = 0.01268 Watt

The Total Power (P) = 2πNT/60

0.01268 = (2π×200×T)/60

T = 0.0006054 N-m

T = 0.605 N-mm

Let, $T = (T_1 - T_2) R$

From the relation,

$\frac{T1}{T2} = e^{\mu\theta} = e^{0.25\times4.712}$ =3.247

$T_1 = 3.247\, T_2$

From given relation,

$0.0006054 = (3.247T_2 - T_2) \times \frac{0.012}{2}$

$\mathbf{T_2 = 0.044\ N,\ \ T_1 = 0.145\ N}$

7. CAD Design

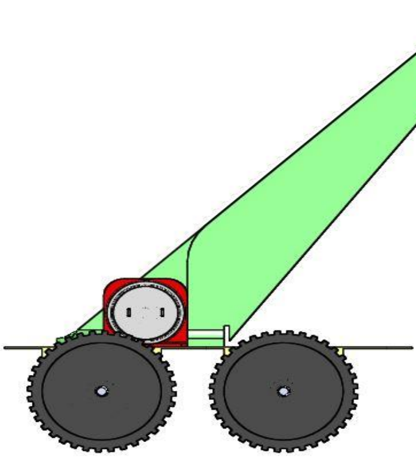


Fig.7.1 Side View

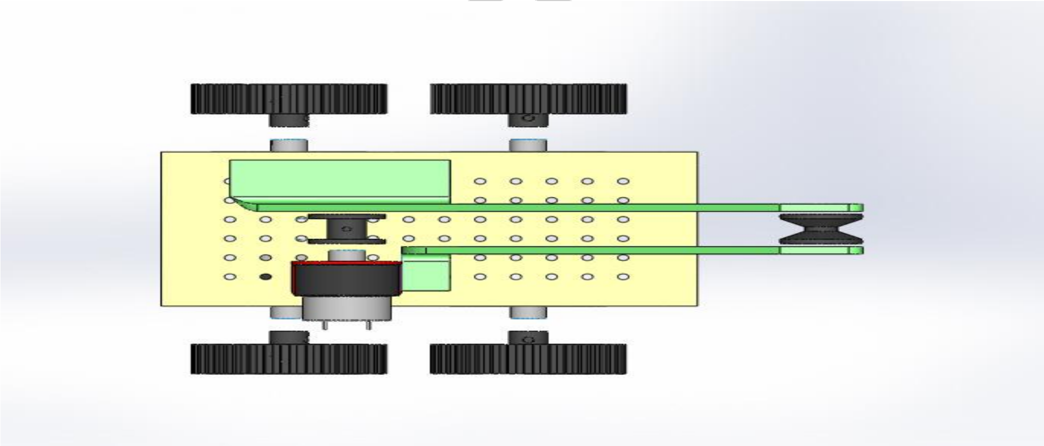


Fig.7.2 Top View

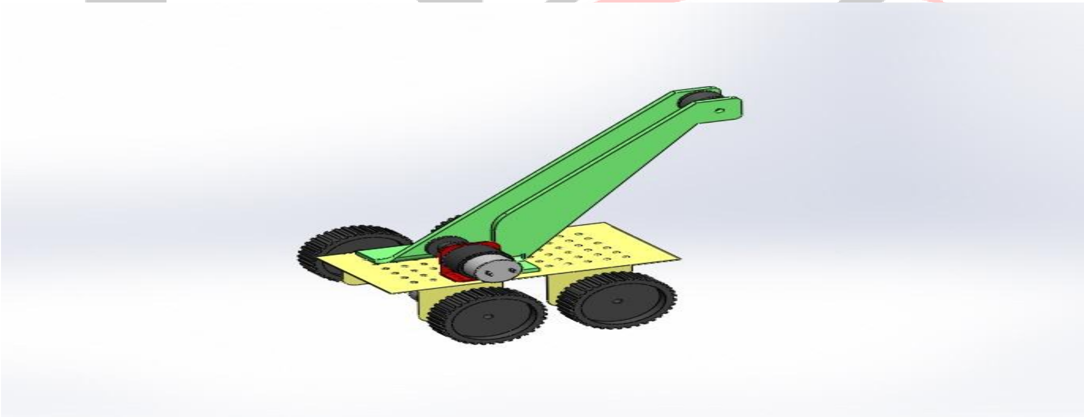


Fig.7.3 3D View

8. RESULT:

In this way we have studied **PULLEY BASED MOVABLE CRANE ROBOT**.

The system can produce Torque **T = 0.605 N-mm**.

The following graphs shows observation on the result:

1) The fig. 7.1 shows mass × time column graph. We have seen when mass increases time taken also increases.
2) The fig. 7.2 shows line graph.

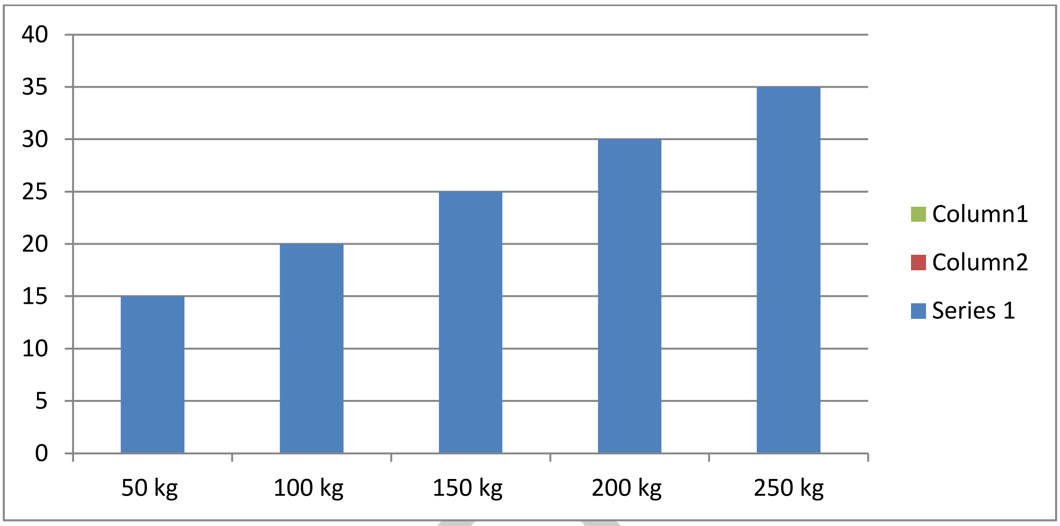


Fig 8.1: Mass ×Time column Graph

Fig 8.2: Mass ×Time Line Graph

3) The fig 6.5 shows time × power column graph. We have when time increases power also increases.
4) The fig 6.6 shows time × power line graph.

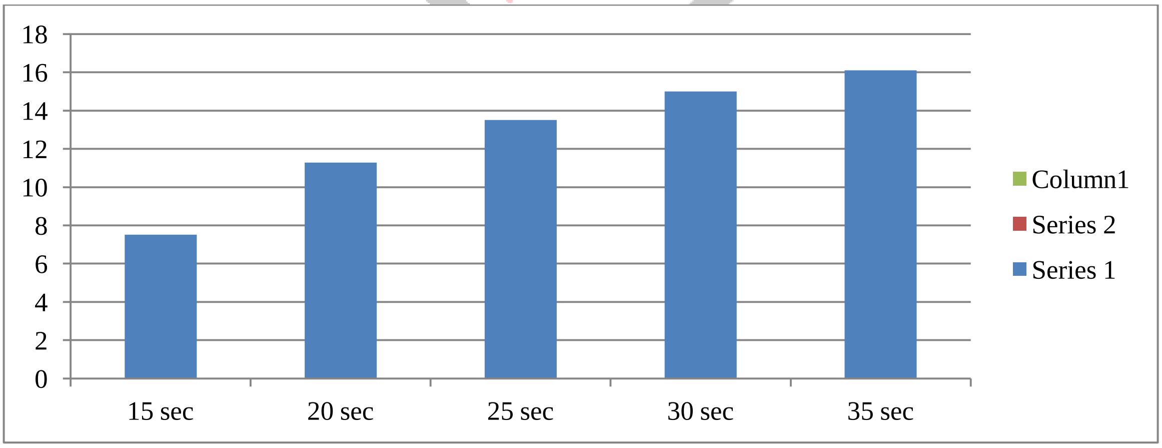


Fig 8.3: Time × Power Column Graph

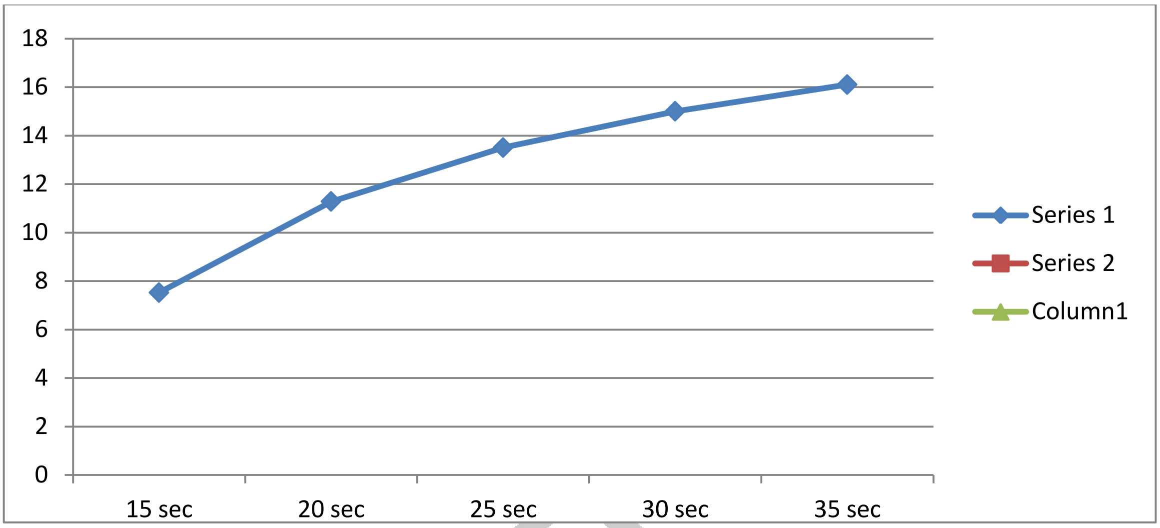


Fig 8.4: Time × Power Line Graph

9. COCLUSION:

The aim of our project was to build a fully functional PULLEY BASED MOVABLE CRANE ROBOT mechanism which is capable of lifting load with the hook and pulley system and a load of the hook attached to the supporting arm. We accurately achieved our first goal of lifting the load from both the hooks and 360° rotary motion of the pulley as well as up and down movement of the hook. We feel that our design and development was a great success both in terms of strength and stiffness

The vehicle frame and pulley frame are designed to support maximum weight in a small structure for demonstration of mini movable pulley robotic system.

10. FUTURE SCOPE:

In subsequent development a robotic device should be incorporated in the machine to enable it function automatically by self-manoeuvring. In this way there will be work station for its mode of operation. This will save time and energy because it will be faster and more efficient. It will also help to minimize accident in the workshops and factories. If more time and more efforts put into the model, more complexity could have brought out. Furthermore varieties and more flexibility to add or replace any part according to the requirement can be done to improve its use and increase field of usage and make it more universal and flexible. On some mobile cranes, there may be numerous load charts for differing boom and counterweight configurations. The load charts may be complex and include numerous conditions that must be complied with to ensure the crane can safely lift a load. Two important factors that are often overlooked when reading load charts are. The need to subtract the mass of the hook block and lifting slings from the capacity of the crane at the particular radius, unless otherwise noted on the load chart

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