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Design and Fabrication of Automatic Sensor based Material Handling Vehicle

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Abstract – *In the recent times the need of automation is increasing day by day which helps us to enhance the creation and application of technologies to produce and deliver goods and services with minimal human intervention. The implementation of automative technologies, techniques and processes improve the efficiency, reliability, speed of many activities that were previously performed by humans. Therefore an automatic human following sensor based material handling vehicle is required which decreases the human effort and increases the capacity to finish the work at the small time interval. This research mainly describes the working of ultrasonic sensor attached to the small four wheel trolley cum vehicle which will be run by using renewable source of energy. Also it has been made to help the workers and the frontline workers to carry such materials in this contact less covid era. In this we will also like to explain the combination of the automatic as well as the utility of renewable source of energy to save the energy for future generation and for the welfare of the nature.*

***Key Words*: Ultrasonic sensor, Contact less, Automatic, Frontline workers, Renewable energy.**

1. INTRODUCTION

Manual material handling which means moving or handling things by lifting, pushing, pulling, carrying, holding or restraining which is the most common cause of occupational fatigue, low back pain and lower back injuries. Such activities can be seen on daily basis at construction sites, ware houses, railway stations, airports, shopping malls, super markets, restaurants, etc. In this fastest growing technological world, Automation is an emerging technology in the field of research and development so by making a manual process into a automated one, will reduce the manpower and saves more time.Thereby modelling a versatile vehicle that automatically follows the human to bring the stuff ,which makes carrying loads easier and efficient.

1.1 Working of Ultrasonic Sensor

In this project we will control the direction of a motor using the Ultrasonic sensors (HC-SR04).To control the dc motor from distance Module HC-SR04 as soon as the distance of an object placed in front crosses the set limit, you can rotate this DC motor in the forward direction when the first pin (IN1) is HIGH and the second (IN2)LOW. Ultrasonic sensors emit short, high-frequency sound pulses at regular intervals. These propagate in the air at the velocity of sound. If they strike an object, then they are reflected back as echo signals to the sensor, which itself computes the distance to the target based on the time-span between emitting the signal and receiving the echo. As the distance to an object is determined by measuring the time of flight and not by the intensity of the sound, ultrasonic sensors are excellent at suppressing background interference. Virtually all materials which reflect sound can be detected, regardless of their colour. Even transparent materials or thin foils represent no problem for an ultrasonic sensor, microsonic ultrasonic sensors are suitable for target distances from 20 mm to 10 m and as they measure the time of flight they can ascertain a measurement with pinpoint accuracy. Some of our sensors can even resolve the signal to an accuracy of 0.025 mm.

1.2 Utilization of Solar energy

Solar energy refers to capturing the energy from the Sun and subsequently converting it into electricity. We can then use that electricity to light up our homes, streets, and businesses, and power our machines as well. The Sun's energy is in the form of solar radiation. Solar radiation makes the production of solar electricity possible. The solar panel converts sunlight into DC electricity to charge the battery. This DC electricity is fed to the battery via a solar regulator which ensures the battery is charged properly and not damaged. DC appliances can be powered directly from the battery. Charging the batteries with a solar panel is a great way to use clean, renewable energy. However, before we can get started, we'll need to install a charge controller, which regulates the voltage from the solar panel as it's transferred to the battery. Otherwise, on sunny days, the solar panel may produce more energy than the battery can handle, which can damage the battery.

2. LITERATURE REVIEW

Design and fabrication of human following smart trolley using kinetic sensor for diverse applications, Dept. of Mechanical Engineering

Muthoot Institute of Technology & Science, Kerala.

Human following smart trolley is a good alternative when compared to the conventional shopping trolleys which are being used currently in the supermarkets. Huge amount of work, time and money could be saved by the implementation of the concept. The technologies similar to the ones implemented in the work could be used in other sectors such as in Medicare field as a nurse following robot, in childcare or in material handling in manufacturing industries. The system then identifies the target to follow from the person's location and RGB color characteristics of clothes. The threshold distance between trolley & human could be set through coding. If objects appear to be there in between that value the robot classifies it as an obstacle. Then the robot initiates the collision avoidance process. Kinetic sensor captures the movement of the human arm in real time.[1]

Follow me multifunctional automated trolley, Mechanical Engineering, Sri Lanka Institute of Information Technology Computing (Pvt) Ltd, Srilanka.

Follow Me robot was developed to follow the customer automatically while the customer performs shopping activities in the supermarket. When customer gets the trolley it follows the customer automatically with the help of Sharp IR sensors which is fixed to the Arduino Mega board. Through the sharp IR sensor the distance will be identified within the customer and the trolley. Moreover, to identify the obstacles again the Sharp IR sensors were used. Line following methodology was used to perform the automatic parking facility. To perform this task the research group used IR sensors in order to identify the black line. Arduino UNO was used to develop the line following methodology and all the sensors were fixed to the Arduino UNO board.[2]

Fabrication of Automated Electronic Trolley, Mechanical Engineering, Shri Madhwa Vadiraja Institute of Technology and Management, India.

Shopping trolleys are available in the shopping mall which are wheeled and are to be carried by the person. The shopping trolleys are available in various sizes and with baby sitters. Trolleys are fitted with the castor wheels and normal wheels for easy to move on the floor while shopping. Some people are uncomfortable to carry the trolley since it is tedious and uncomfortable to push or pull it in the crowd. We are proposing to make the automatic trolley for shopping mall which can sense us and follow us. Now a day, automatic trolley has become popular especially in localization scheme. It is a non-touching recognition system where it can tag and send tag data wirelessly at various distances. In order to prevent objects collision, ultrasonic sensor, light dependent resistor was used in this project. The trolley will have the drive and steering mechanism being motorized by DC batteries. The tag when shown to the trolley will get activated and the tag is sticked to the pant and the trolley will sense the tag and starts following the tag on the person. If somebody comes in between, it stops and gives buzzer sound and when the obstruction moves away, it starts moving.[3]

3. COMPONENTS & ITS DETAILS

FRAMEWORK:- Mild steel frame and mild steel chasis will be fabricated by using rectangular angles. It will form the base of the vehicle in which other components could be easily placed for the further movement of the vehicle. It is designed in such a way that it could give good strength and reliability to the vehicle.

BODY:- Vehicle's body which are container, base, holding will be framed of mild steel. The container of the vehicle is of the trapezoidal shape in which the components could easily placed and will give a good hold to the vehicle. It is designed to give a look of a modern container as well as a shopping trolley which would be easy for anyone to give drive to it.

BATTERY:- A battery is a device consisting of one or more electrochemical cells with external connections for powering electrical devices such as flashlights, mobile phones, and electric cars. When a battery is supplying electric power, its positive terminal is the cathode and its negative terminal is the anode. The battery is to be charged directly with the AC supply at a place or by the solar panel depending on the working conditions. As per the requirements of the working of vehicle we have to choose the battery of following specifications:- Voltage output- 12v,Material- Lead, Charging current- 0.3A,Weight- 6.1kg.

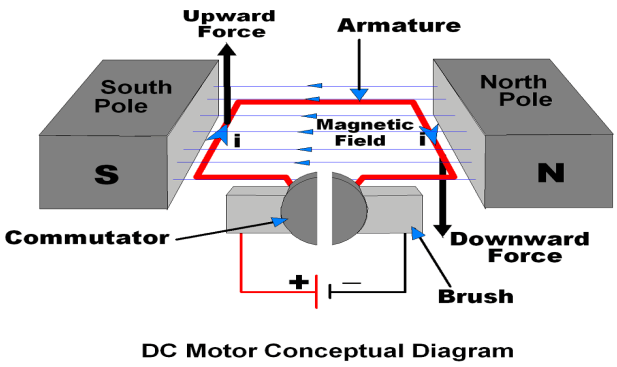
FIG (1)

SOLAR PANEL:-Solar panels absorb sunlight as a source of energy to generate electricity. It will be of silicon material. A 12v solar panel system is the most commonly used type of portable off-grid systems and is used to power electronic items and devices that are also 12v. Such a system requires a number of things, such as a solar charge controller, a battery bank or individual batteries, and solar PV panels. As per to charge the 7Ah battery the specifications of solar panel is used to be is:- Size- 12*14 in^2**,**Capacity for generation-10 watts.

FIG (2)

DC MOTOR:-The DC motor is the motor which converts the direct current into the mechanical work. It works on the principle of Lorentz Law, which states that "the current carrying conductor placed in a magnetic and electric field experience a force". It will have copper winding covered by mild steel. A DC gear motor is a fairly simple electric gear motor that uses electricity, gear box and magnetic field to produce torque, which turns the motor. Its specifications according to the system is:- Volt-12v,Speed-45 rpm.

FIG (3)



DC Motor Conceptual Diagram

FIG (4)

WHEELS:-Four wheels are used in this project which are of plastic and rubber material. Its easy to mount, durable and have good friction. These wheels have a 6 mm hole for shaft with screw for fitting making it very easy to mount on motors big wheels highly durable and resistive heavy load bearing capacity. It has diameter of 9 inches and a thickness of 3 inches. It gives good friction due to which vehicle can easily runs on smooth surfaces.

FIG (5)

FIG (6)

CHAIN AND SPROCKET:- :- Chain and sprocket drives are used to transmit power from one component to another. Specifically, they transfer speed and torque through the use of a linked chain and sprockets.

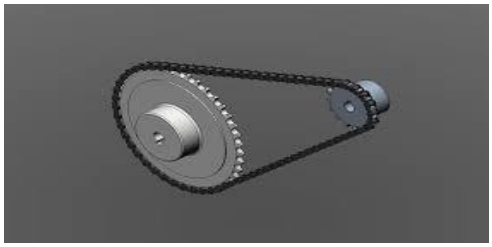


FIG (7)

ULTRASONIC SENSOR :- An ultrasonic sensor is an electronic device that measures the distance of a target object by emitting ultrasonic sound waves, and converts the reflected sound into an electrical signal. Ultrasonic sensors have two main components: the transmitter (which emits the sound using piezoelectric crystals) and the receiver (which encounters the sound after it has travelled to and from the target). The sensor we used is having certain specifications as:- Type:-Ultrasonic, Output:-Digital Sensor, Voltage:-5VDC Detection distance:-2cm-400cm (0.02M-4.0M), Static current :-< 2mA, Level output: high-5V, High precision:- up to 0.3cm.

FIG (8)

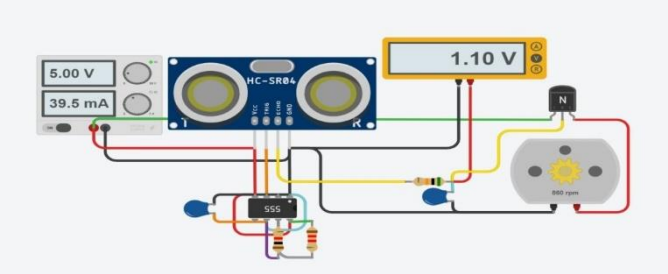


FIG (9)

CHARGE CONTROLLER:- It limits the rate at which electric current is added to or drawn from electric batteries. It prevents overcharging and may protect against overvoltage, which can reduce battery performance or lifespan and may pose a safety risk. It may also prevent completely draining a battery, or perform controlled discharges, depending on the battery technology, to protect battery life. In this vehicle we are using the charge controller of 10 Ah with the output of 12v/24v. Solar Charge Controller supports battery charging when connected between battery and the solar panel. On the LCD display we can see the charging status and switch modes conveniently. With Overload protection, short circuit protection, open-circuit protection and reverse protection, the device will protect the battery and will increase the battery life. Its specifications:-Controller rating-10A, Controller voltage-12v/24v,Max.solarpanel capacity in 12v-120 W

FIG (10)

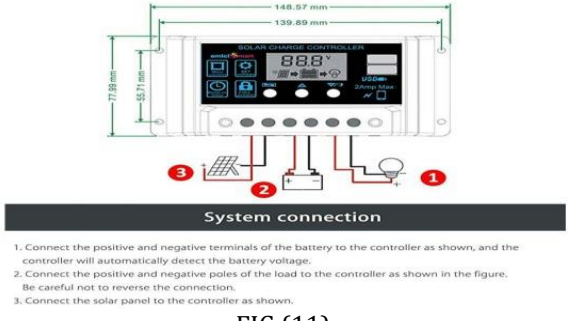


FIG (11)

RELAY:- A relay is a simple electromechanical switch made up of an electromagnet and a set of contacts. Relays are found hidden in all sorts of devices. Relay is used for many control functions and is essentially an electromechanical switch. The construction of a typical relay is shown in fig above. A relay essentially contains a coil of wire wound around an iron core. The relay has set of two contacts, one of which is spring loaded and movable and other is fixed. These contacts are electrically isolated from the coil and are used to make or break another circuit.

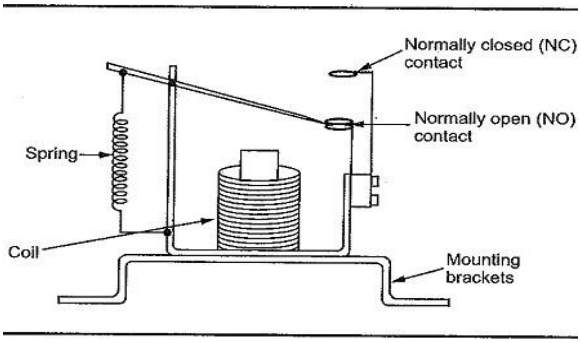


FIG (12)

PRINTED CIRCUIT:- A printed circuit board mechanically supports and electrically connects electronic components using conductive tracks and other features etched from copper sheets laminated on to a non conductive substrate. It can be single sided, double sided or multi layer. Multi-layer printed circuit board allow for much higher component density. Advanced printed circuit board may contain components- capacitors, resistors or active devices embedded in the substrate.

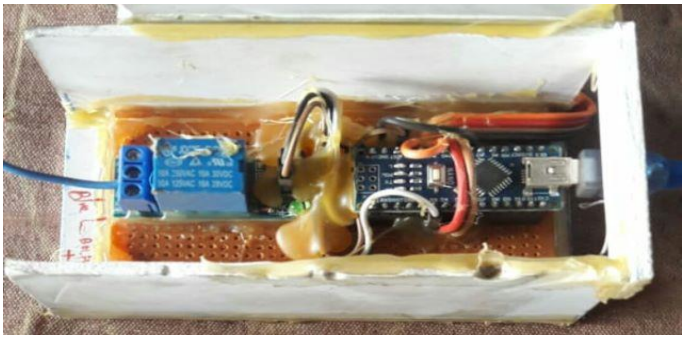


FIG (13)

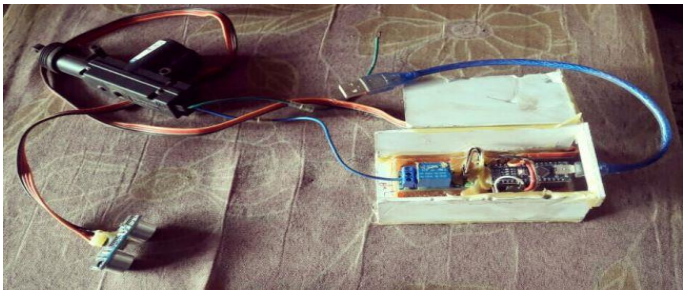


FIG (14)

4. CALCULATIONS

CALCULATION OF TORQUE TRANSMITTED ON THE WHEEL:-

$$TW = Kw \times Wt \times R$$

Where, w = Coefficient of the rolling resistance
Wt = weight of the machine
Rw = Radius of the ground wheel

We have, Kw = 0.40,
Wt = 15 kg = 15×9.81 = 147.72N
Rw =114mm = 0.114m

$$Tw = 0.40 \times 147.72 \times 0.114$$
$$= 6.736 \text{ N-m}$$

POWER REQUIRED FOR MOTOR :-
(N=45 rpm)

P=2*PIE*45*T/60
= 2*3.14*45*6.736/60
=31.72 watts

POWER CAN BE PRODUCED:-
Ratings:- System voltage:12V DC System, Current: 7Amps

P=V x I
P=12 x 7
= 84 watts.

ANGULAR VELOCITY,(WHEEL):-

$$\omega = 2\pi N/60$$
$$\omega = 2\pi \times 45/60$$
$$\omega = 4.71\ rad/s$$

ANGULAR VELOCITY TO LINEAR VELOCITY FORMULA:-

$$v = r \times \omega$$

Where, r = radius of the wheel in m

$$v = 0.114 \times 4.71$$
$$v = 0.53\ m/s$$

SOLAR CALCULATIONS:-

POWER REQUIRED FOR MOTOR:-
Ratings:- System voltage:12V DC System,
Current:-4Amps
P=V x I
P=12 x 4
=48 watts.

PV MODULE SIZE REQUIRED:-
PV module size = watts /Average solar insolation
= 48 /5
= 9.6 Watts
= 10 watts approx.

CURRENT PRODUCED BY SOLAR:-
P = V x I
10=12 x I
I =10/12
= 0.90 Amp

REQUIRED TIME TO CHARGE THE BATTERY:-
= Amps of battery/Input
= 7.0Ah/0.90A
= 7 hrs approx.

5. WORKING OF VEHICLE

In this we are making a four wheel vehicle on top to hold the various types of materials being taken from the various racks of industries and hospitals. At first the ultrasonic sensor attached at the front of the vehicle receives the signal it gives start to the DC motor .The motor will have the drive the vehicle from one to another place with solar panel and battery. A motor is an electrical machine which converts electrical energy into mechanical energy. It starts with the battery in the car that is connected to the motor. Electrical energy is supplied to the stator via the vehicle's battery. The coils within the stator (made from the conducting wire) are arranged on opposite sides of the stator core and act as magnets in a way. Therefore, when the electrical energy from the vehicle battery is supplied to the motor, the coils create rotating magnetic fields that pull the conducting rods on the outside of the rotor along behind it. The spinning rotor is what creates the mechanical energy need to turn the gears of the car, which, in turn, rotate the tires. Then the vehicle moves as the human is moving forward on the path. It can help the workers to carry load without any such pushing or pulling efforts. As well as it consumes less power and can be used as a renewable source as it is charged at the day time and the working at construction sites and any industrial use can easily be completed by having this vehicle.

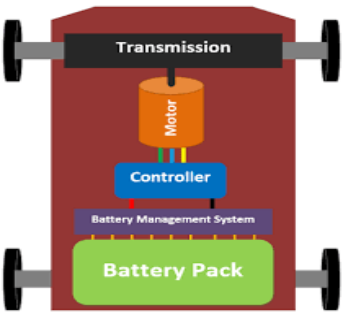


FIG (15)

BLOCK DIAGRAM OF VEHICLE

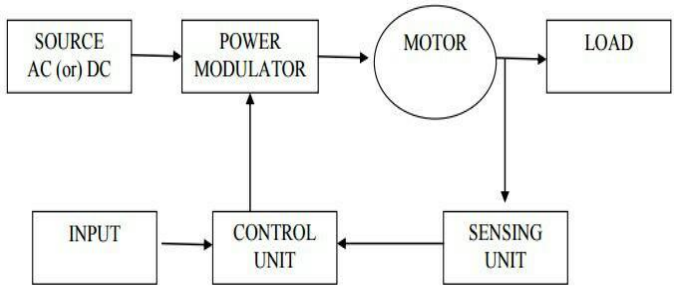


FIG (16)

6. DESIGN OF THE VEHICLE

FIG (17)

The views that are shown in the figure were designed in the solid works software with the dimensions created in the 2D design. A 3D design can clearly show the physical dimensions of the objects and its distance in relation with other objects in the total layout. This will tremendously helps us to see and adjust arrangements of objects based on their sizes to achieve varied objectives like space, movement problems, size corrections, and so on. The design is created in such a way that every component of the vehicle could be placed at the appropriate position. The drive is given at the front wheel so the speed of the vehicle remains constant with the movement. The solar panel is attached to the hinge type holder so it can be used as per the requirements.

ACTUAL MODEL

As shown in the figure we completed the model by placing the components required to start the vehicle after the final assembly. From the side view we can clearly elaborate our model design and the size of vehicle. We were able to get the actual design of the model as compared to the 3D design by doing proper fabrication and finishing to it.

FIG (18)

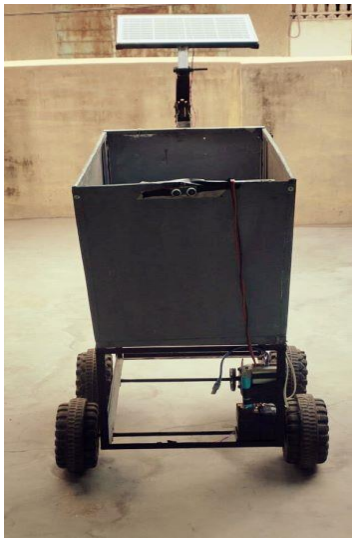


FIG (19)

From the front of the vehicle we can clearly show the sensor location and the actual height description of the model. The base also kept clear and diminished so there should be no further load could be carried and the motion of the vehicle could remain smooth. The height of wheels had choose to be increased due to which the wheels can easily be run on the rough surface and the base frame does not touch the ground in any case.

7. RESULT AND PERFORMANCE ANALYSIS

By plotting Load vs. Time, tabulations were made for different loads keeping the Distance constant. The following observations were made and graph of Load (W) vs. Time (t) was plotted.

As shown in the table the experiment was taken down with the reference to the research paper and the test was done on the basis of Load vs Time we have taken the same distance so we could easily calculate the load carrying capacity and the motion during it. At first we put no load in the vehicle and it completed the 10m distance in just 25 seconds so it was able to run at the speed of 0.4m/s and we tested by putting different loads in it and the seconds were varying due to load in the vehicle and it completed

the maximum load of vehicle in just the difference of 7 seconds.

Trial no.	Distance in meter	Load in kg	Time in second
1	10	0	25
2	10	2	25
3	10	4	25
4	10	6	27
5	10	8	28
6	10	10	28
7	10	12	30
8	10	14	30
9	10	16	32

It was necessary to take the test because the main utility of this vehicle is to take and handle the material which gives the actual capacity of the vehicle and the ability of the vehicle to run in motion with carrying load. The speed of the vehicle was good enough than expected before the experimental testing which was conducted without the final assembly of the vehicle.

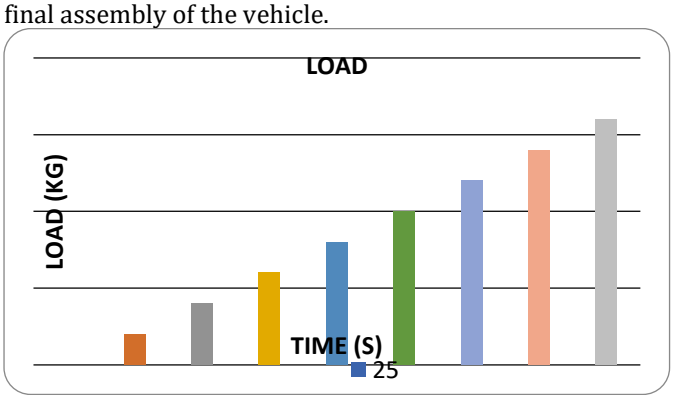


FIG (20)

As shown in the above figure in the x-axis it's the time taken by the vehicle (in seconds) with reference to the load in kg varying in the y-axis of the graph which clearly shows that the time increases gradually and the design has been done due respect to it.

Comparison chart of experimental testing:-

Trial	LOAD	TIME (T1)	TIME (T2)
1	0	25	40
2	2	25	40
3	4	25	40
4	6	27	40
5	8	28	40
6	10	28	40
7	12	30	40
8	14	30	40
9	16	32	40

FIG (21)

As shown in the above figure it is the graph of the vehicle shown in the research paper which has clearly indicated that it has taken 40 seconds for all the load which is dynamically not accurate and it takes more time form which the initial speed could be calculate is 0.25m/sec where as our vehicle was able to run at the speed of 0.4m/sec.

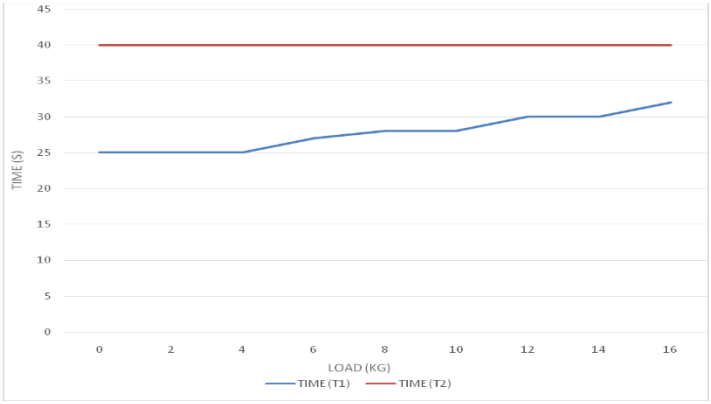


FIG (22)

Now we can take this reading and plot a comparison graph between the two vehicles which can help others to understand the difference between it. From the graph it can be clearly seen that our project has completed its distance earlier than the trolley. One thing good about that trolley is that it remained constant speed with the varying load but our vehicle was having different time intervals but finished the 10 m distance earlier in each load. As the energy consumption was also lower than it due to which we have tested in both the battery and the solar panel.

8. CONCLUSION

By this project we can conclude that human following material handling vehicle is a good alternative when compared to the conventional trolleys and other AGV vehicles which are being used in markets. Huge amount of work, time and money could be saved by the implementation of this concept. The technology can be easily implemented in the hospitals as a nurse following robot, in a child care unit, restaurants and banquets especially in this contactless tracing world and it can be widely used as a material handling equipment. As we have used the renewable source of energy to motivate the concept of clean energy as it has the least negative impact on the environment compared to any other energy source.

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