STUDY ON COMPACT THERMAL ENERGY STORAGE WITH COUNTER FLOW HEAT EXCHANGER

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ABSTRACT

The experimental investigation of a thermal energy storage system by Phase Change Materials (PCM) is presented in this research. It is part of a thermal storage system used for heating, cooling, and DHW production that uses solar collectors and capable heating devices. It consists of a PCM-filled tank and a heat exchanger with staggered fins (HE). The tank is built for stored energy density and rate of heat transfer and experimental findings validated the tank's ability to meet up the need of a DHW fitting while also increasing system output.

Keywords: PCM, Heat exchanger, Heat transfer, Sensible heat, Latent heat.

1.INTRODUCTION

The major powerful causes behind the effort to extra efficiently utilize diverse sources of non- conventional energies are the ongoing increase in greenhouse gas emission and the increase in fuel cost. Direct solar radiation is regarded as one of the most promising sources of energy in many parts of the world [1-3]. Globally, scientists are looking for non- conventional energies. One approach is to expand energy storage technologies, which are crucial as well as new energy sources. It reduces energy waste and capital costs, which saves premium fuel and makes the arrangement more price effective [4-6]. Heat exchangers with phase change material are an energy storage solution. In winter and summer, such storage units can be used for cooling and heating.

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1.1 Thermal Energy Storage

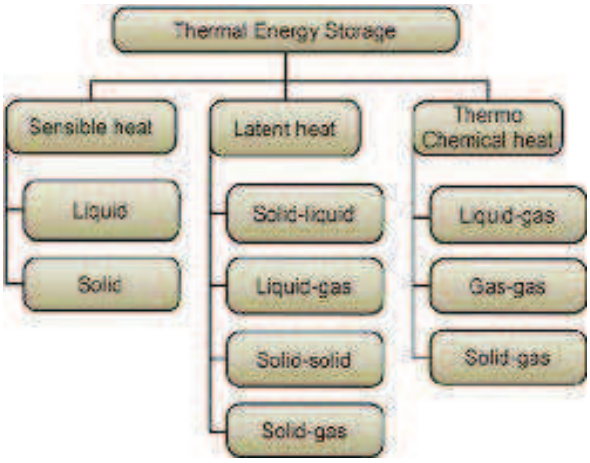

Fig.1 Classification ofThermal Energy Storage

The thermal energy is capable of storing as PCM, internal energy as perceptible heat, latent heat, or thermo chemical energy or as a mix of these. Heat is stored in the medium without changing phase in Sensible heat storage materials [7-9]. The high temperature is stored in the medium with the phase change in the latent heat storage substance.

1.2 Sensible Heat

Thermal energy is stored in sensible heat storage by raising the temperature of the substance. During charging and discharging processes, the SHS system makes use of the material heat capacity and temperature change. Due to reasonably priced and more specific heat, water looks like good sensible heat storage accessible. Oils, molten salts, and liquid metals are employed over 1000 °C [10-13]. The amount of heat held is determined by the medium's specific heat, temperature change, and storage substance [14-15].

1.3 Latent Heat

The heat absorption or discharge as a storage substance transitions from the solid to liquid, liquid to gas, or vice versa is called latent heat. A phase change material is a material with a more fusion heat that is able to store and release huge quantities of energy. As a substance transitions from the solid to the liquid phase and back, heat is absorbed or released. PCMs are therefore also known as latent heat storage materials. LHS materials are phase change materials, when a substance transitions from solid to liquid or liquid to solid, thermal energy transfer happens. This is referred to as a Phase transition. These solid into liquid PCM behave like traditional storage material at first, with temperature rising and absorb the heat. PCM absorbs and releases heat at a practically constant temperature, unlike conventional (sensible) storage materials. They hold 14 times extra heat per unit volume than water, brick, or rock.

For application in thermal energy storage systems, solid to liquid transition is required to be cost-effectively appealing. PCMs can't be employed as a heat transfer intermediate by itself. To transport energy from the source to PCM and as of the PCM to the weight, a separate heat transfer medium with a heat exchanger must be used. Because of the less thermal diffusivity of PCM, heat

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exchangers that will be used must be properly developed. Because the volume of the PCMs changes when they melt, a unique volume design of the tank for the entire PCM is required. As a result, understanding three key topics is required for the creation of a latent heat thermal energy storage system: PCM, container materials, and operational temperature.

1.4 Classification of PCM

In any temperature range, a great number of PCM like inorganic, organic and eutectic are accessible. From the standpoint of melting point and latent heat of fusion, a vast range of inorganic and organic chemical compounds are recognised as phase change material. Hot water thermal energy storage, aquifer thermal energy storage and cavern thermal energy storage are the various types of sensible seasonal thermal storage. The classification of phase change materials is shown in figure 2.

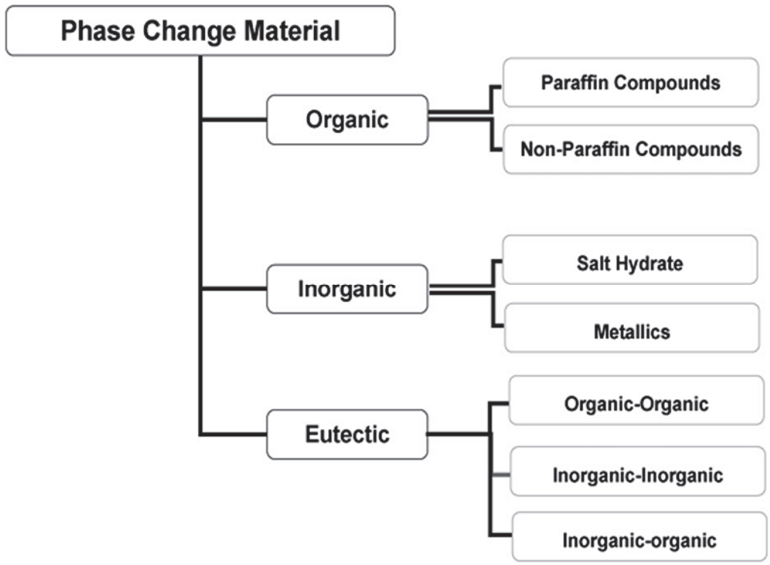

Fig.2 Classification of PCM

1.5 Heat Exchanger

Heat exchangers with PCM are an energy storage solution. In the winter and summer, storage units are able to be employed for both heating and cooling. The heat exchanger is a device that transfers heat from a hot medium to a cold medium without mixing the two fluids since they are normally separated by a solid wall. Depending on the application, many types of heat exchanger are employed. The counter flow heat exchanger, for example, is employed in chemical processes such as condensing vapour to liquid.

This heat transfer is aided by the temperature gradient, or temperature disparities. Radiation, conduction, and convection are the three main methods of heat transfer. Radiation does occur when heat exchangers are used. Radiation, on the other hand, is minor in comparison to conduction and convection. The heat from the higher-temperature fluid travels through the solid wall, causing conduction. The wall should be thin and composed of a highly conductive substance to enhance heat transfer. Convection makes the most contribution to heat transmission in a heat exchanger.

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1.5.1 Double-Pipe Heat Exchanger

The effective method of heat exchange done by heat exchanger is the double-pipe heat exchanger. Because one fluid runs inside a pipe and the second fluid flows between that pipe and another pipe that surrounds the first, it's termed a double-pipe exchanger. This is a concentric tube arrangement. In a heat exchanger, the flow can be parallel or counter. When two streams run in the same direction, it is called parallel flow; when the streams flow in opposite directions, it is called counter flow.

2. Methodology

- Freezing latent heat, Melting latent heat, freezing temperature, melting temperature, density, thermal conductivity, and specific heat are all addressed in the design of a heat exchanger.
- Lauric acid, Palmitic acid and Myristic acid were chosen as phase change material.
- Plans for projected designs have been calculated.
- The consequence of mass flow rate and melting latent heat on temperature differential was studied.
-

2.1 Methodology for Design

The heat exchanger could be represented as a two pipe heat exchanger to examine the thermal behavior of the phase change material while considering volume expansion. When one of the fluids in the heat exchanger experiences a phase shift under certain conditions. The mass of the PCM can also be determined using the equation below.

Mass = volume × density

Volume of PCM can be found by the following equation.

Volume of the PCM = outer pipe volume – inner pipe volume

In order to obtain the outer and inner pipe volume by the equation given below.

$$Innerpipe = \frac{\pi}{4} \times Di^2 \times Li$$

$$Outerpipe = \frac{\pi}{4} \times Do^2 \times Lo$$

Inner pipe diameter (Di), inner pipe length (Li), outer pipe diameter (Do), outer pipe length (Li) are all included in the above equation (Lo). The heat transfer rate from hot fluid to the PCM must equal the heat transfer rate to the phase change material, according to the first rule of thermodynamics.

$$Q = mC_pT$$

3. Design Analysis

3.1 Assumption

- The analysis is a steady state flow.
- A two pipe heat exchanger with a constant volume is designed.
- Water is the working fluid.
- The temperature outside is 380°C.
- The heat received by the phase change material is equivalent to heat absorbed by working fluid.

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Table 1. Prototype of Double Pipe Heat Exchanger Characteristics

Parameter	Symbol	Value	Unit
Inner diameter	Do	15	mm
Outer diameter	Di	40	mm
Mass of PCM	M	0.5	kg
Length	L	50	mm

Table 2. Prototype Material

Parameter	Material
Inner pipe	Copper
Outer pipe	Cast Iron

4. Conclusion

The proposed two pipe heat exchanger design has undergone a thermal analysis. PCMs that are needed for the analysis are chosen. The materials necessary for the manufacture of heat exchangers were also chosen. The impact of phase change material in counter flow heat exchanger has been theoretically assessed. The selected PCMs melt at 42°C, 52°C, and 58°C, respectively. As a result, the heat lost during PCM melting should be minimal. The thermal characteristics of a specified PCM will be investigated at various temperature intervals, such as 50°C, 60°C, and 70°C. The manufacture of the double pipe heat exchanger was completed during this phase of the project. In a counter flow heat exchanger, the authority of PCM is discovered.

Experimentally, the consequence of PCM in a counter flow heat exchanger is discovered. Experiments had been conducted to authenticate the result of various governing parameters like thermal conductivity, temperature, and so on. Following completion of this experiment, it was determined that Lauric acid is best suited for residential use. This is due to its ease of usage and the fact that it has a precise melting temperature for residential use. It also outperforms Myristic and Palmitic acids in terms of heat capacity and efficiency.

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DEVELOPMENT OF INBUILT AUTOMATIC PNEUMATIC JACK FOR FOUR WHEELER

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Abstract

The work has been conceived having studied the difficulty in lifting any passenger and light moving vehicle type of light vehicle that some difficult methods involving physical efforts were adopted in lifting the vehicles for reconditioning. Our project is mainly concentrated on this difficulty. The combination of two main stages. Compressed air production using vehicle suspensor: in this project, the atmospheric air is sucked using our experimental setup and gets compressed by non-conventional method just by driving vehicle air is stored in the storage tank. Automatic pneumatic jack for four wheelers: by utilizing the compressed air, the pneumatic jack which is mounted on the chassis can be operated in order to lift the vehicle for the purpose of changing tyre or for wheel alignment.

Keywords: Automation, pneumatics, compressor, pneumatic jack, suspension.

1. Introduction

1.1 Need for Automation

The main advantages of all pneumatic systems are economy and simplicity [1-3]. Automation plays an important role in mass production. Nowadays almost all the manufacturing processes are being made automatic in order to deliver the products at a faster rate. By utilizing the compressed air, the pneumatic jack which is mounted on the chassis can be operated by switching on the valve and toggling the switch in order to lift the vehicle for the purpose of changing tires or for wheel alignment and for any kind of maintenance work [4]. As the vehicle suspends while running these double acting pneumatic cylinders will suck the atmospheric air and compress it to the 7.8 bar pressure and store it in the compressed air storage tank. In order to build the required pressure for operation of pneumatic jack with the help of vehicle suspension one needs to understand the minimum requirement of the suspension to be used and the respective design [5-6]. From the evolution of Vehicles, the common problem when tires go flat is changing of tires by lifting the vehicle using Jack and lever and it's a tedious job for any person in that case. Generally to operate it a person must bend down to a squatting position which may lead to back pain. Especially for Senior citizens, female drivers and physically challenged drivers it is an impossible task. The work input on the jack completely depends on the weight of the vehicle that

is to be lifted. In this project an inbuilt automatic pneumatic jack is built and placed in each of the wheels. Nowadays we are using an automated hydraulic jack which consists of a spring, compressor, pressure gauge, storage, and single acting cylinder [7-9]. This automated jack doesn't require any kind of human effort and can be operated by anyone like children, women, and old people. It does not make a person to bend or to be in a squat position to operate.

2. Description of components pneumatic cylinder

2.1 Pneumatics

Today pneumatics is mainly understood to mean the application of air as a working medium in industry, especially the driving and controlling of machines and equipment. Pneumatics has for some considerable time been used for carrying out the simplest mechanical tasks in more recent times has played a more important aspect in pneumatic technology for automation.

Pneumatic systems operate on a supply of compressed air which must be made available in enough quantity. When the pneumatic system is being adopted for the first time, however, it will indeed be necessary to deal with the question of compressed air supply [10-11]. The key part of any facility for supply of compressed air is by means using reciprocating compressors. A compressor is a machine that takes in air, gas at a certain pressure and delivers the air at a high pressure. Compressor capacity is the actual quantity of air compressed and delivered and the volume expressed is that of that of the air at intake conditions namely at atmosphere pressure and normal ambient temperature [12-13]. The compressibility of the air was first investigated by Robot Boyle in 1962 and that found the product of pressure and volumes of particular quantities of gas. The usual written as

$PV = C$ (or) $P_iV_i = P_2V_2$

In this equation the pressure is the absolute pressure which for free is about 14.7Psi and is of courage capable of maintaining a column of mercury, nearly 30 inches high in an ordinary barometer. Any gas can be used in a pneumatic system but air is the most used system nowadays.

3. Selection of Pneumatics

Mechanization is broadly defined as the replacement of manual effort by mechanical power. Pneumatic is an attractive medium for low Cost mechanization particularly for sequential (or) repetitive operations [14-16]. Many factories and plants already have a compressed air system, which is capable of providing the power (or) energy requirements and control system (although equally pneumatic control systems may be economic and can be advantageously applied to other forms of power).

The main advantages of an all pneumatic system are usually Economic and simplicity, the latter reducing maintenance to a low level. It can have outstanding advantages in terms of safety.

3.1 Pneumatic Power

3.1.1 Production of Compressed Air

Pneumatic systems operate on a supply of compressed air, which must be made available. When the pneumatic system is being adopted for the first time, however, it will indeed be necessary to deal with the question of compressed air supply. The key part of any facility for supply of compressed air is by means using reciprocating compressors. A compressor is a machine that takes

in air, gas at a certain pressure and delivers the air at a high pressure. Compressor capacity is the actual quantity of air compressed and delivered and the volume expressed is that of the air at intake conditions namely at atmosphere pressure and normal ambient temperature. Clean condition of the suction air is one of the factors, which decides the life of a compressor. Warm and moist suction air will result increased precipitation of condense from the compressed

4. Technical Data of Pneumatic Components Specification

4. 1. Double acting pneumatic cylinder

Stroke length: cylinder stroke length 100 mm = 0.1m

Piston rod: 10 mm =10 $X10^{-3}$m

4.2. Solenoid Valve

Size: $0.635x10^{-2}$m

Part size: $G0.635x10^{-2}$m

Maximum pressure: 0-10 $x10^5$ N/m^2

Inner diameter: 3.5mm =$3.5\ x10^{-3}$m

4.3. Pneumatic unit

Type of cylinder: Double acting cylinder

Type of valve: flow control valve &solenoid valve

Max air pressure: 8 $x10^5$ N/m^2

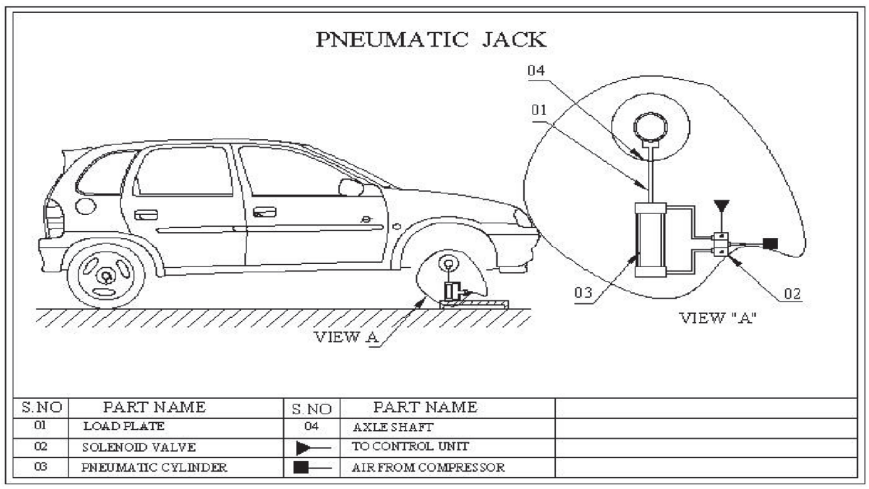
5. Design Calculation

Max pressure applied in the cylinder (p): 8 $x10^5$ N/m^2

Area of cylinder (A): (3.14/4 x (D2):80.38 mm^2

Force (F): Pressures x area

5.1. Pneumatic jack CAD diagram



S.NO	PART NAME	S.NO	PART NAME
01	LOAD PLATE	04	AXLE SHAFT
02	SOLENOID VALVE	▶—	TO CONTROL UNIT
03	PNEUMATIC CYLINDER	■—	AIR FROM COMPRESSOR

Fig.1 Pneumatic jack CAD diagram

5.2. CAD Design

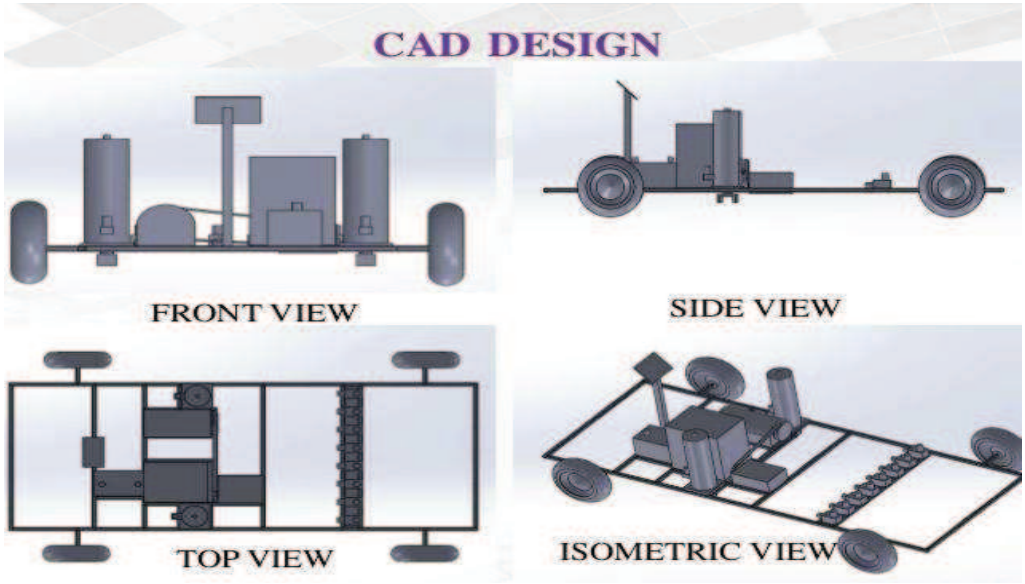


Fig.2 CAD design

6. Conclusion

The compressed air production using vehicle suspension get its energy requirements from the mobility of the vehicle, there is no need of depending on external source for air compression. The Inbuilt automatic pneumatic jack can be operated using the compressed air in order to lift the vehicle for changing of tires, wheel alignment, under chassis repair work. The project is an experimental setup in which there is no engine or gearbox assembly to run and compress the air but the methodology used in our work can be implemented which is practically possible. Thus, the development of an Inbuilt Automatic Pneumatic Jack for passenger vehicles or any LMV's is a low cost automation. The operating procedure of this system is very simple, so any person can operate. As we know that our jack is inbuilt this has less chances of fatigue.

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FABRICATION OF INTELLIGENT BRAKING SYSTEM

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Abstract

In conventional brake system, the drivers effort is utilized to actuate. The brake shoes expanding mechanism. When releasing the brake pedal force, the brake shoes will come back by action of retractor spring, leaving the drum to rotate freely. Most of the accidents in four wheeled vehicles occur because of failure of braking systems. Manual method of applying brakes is always is dangerous as it leads to accidents. Unconsciousness of driver, failure in the linkages of braking systems, road conditions, uncontrollable speed of the vehicle, manual operation of braking systems are the reasons of accidents. It is necessary to control brakes automatically through electronics devices to minimize the accident problems. In this project we can propose methodology for automatic control of braking system to avoid accidents. In this technology we used controller circuit, relay, Proximity conductive sensor for effective function of braking control systems. This complete system can be fitted on to dashboard of a vehicle and effectively used for automatic control of braking system.

Keywords:ABS, Braking system, Traction control, Smart vehicle, Microcontroller.

1. INTRODUCTION

Road accidents are a common place in today's scenario. Accident prevention has been one of the leading area of research. In indian scenario normally vehicles are equipped with ABS (ANTI-LOCK BRAKING SYSTEM), traction control, brake assist etc. for driver's safety. This paper focuses on a which employ several sensors to respond when emergency condition occur. The micro controller and arduino is used to detect the pulses and apply breaks to the vehicles [1-3]. The extremely rapid response time provided by the electronic control can be used for crucially shortening the braking distance by introducing advanced control of braking system operation. The research on smart vehicle and intelligent highway are receiving ample attention. The system when integrated with other subsystems like automatic traction control system, intelligent throttle system, and auto cruise system, etc. will result in smart vehicle maneuver [4-6].

The driver at the end of the day will become the passenger, safety accorded the highest priority and the journey will be optimized in term of time duration, cost, efficiency and comfortability. The impact of such design and development will cater for the need of contemporary society that aspires quality drive as well as to accommodate the advancement of technology especially in the area of smart sensor and actuator [7-9]. The emergence of digital signal processor enhances the capacity and features of universal microcontroller. The overall system is designed so that the value of inter-vehicle distance from infrared laser sensor and speed of follower car from speedometer are fed into the DSP for processing, resulting in the DSP issuing commands to actuator to function appropriately[10-11].

1.1 NEED OF PROPOSED SYSTEM

Accidents occur because of technical problem within the vehicle or because of mistake of driver. Sometimes the drivers lose control over the vehicle and sometimes accident occurs because of rash driving. When the drivers come to grasp that vehicle goes to collide they become nervous and that they don't apply the brakes. Majority of the accidents occur this fashion. The system designed will prevent such accidents [12-15]. It keeps track of any vehicles ahead. It'll continuously keep the track of the space between the 2 vehicles. When two vehicle come dangerously close the Relay Control unit within the system actuates the brakes and it'll stop the vehicle.

1.2 EXISTING SYSTEM

Honda's idea of ABS which helps the rider get stress free braking experience in muddy and watery surfaces by applying a distributed braking and prevents skidding and wheel locking moreover as Volvo which was equipped with laser assisted braking. This can be capable to sense a collision up to 50 mps and apply brakes automatically. ABS can activate only help if the rider applies it in right time manually and maintains the space calculations. ABS has its own braking distance.

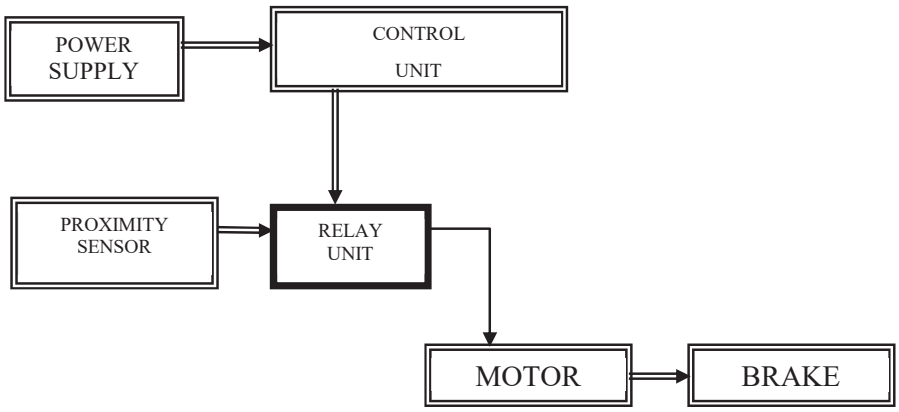
1.3 PROPOSED SYSTEM

In our Proposed System, we are using Proximity sensor as a sensing unit. Sensor is connected to the relay unit and to the braking system and motor. Once the vehicle reaches the closer distance to the other vehicle the sensor detects the distance and actuates the relay unit to stop the vehicle with automatic braking. By this methods we can achieve zero accidents of vehicle.

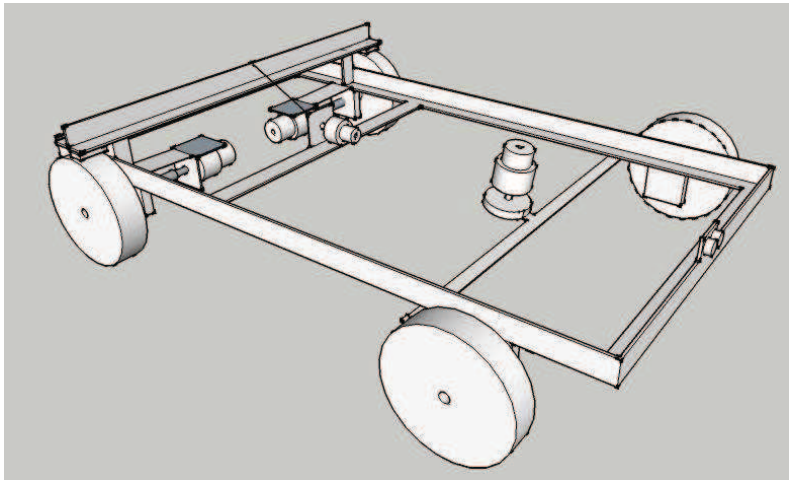
2. METHODOLOGY

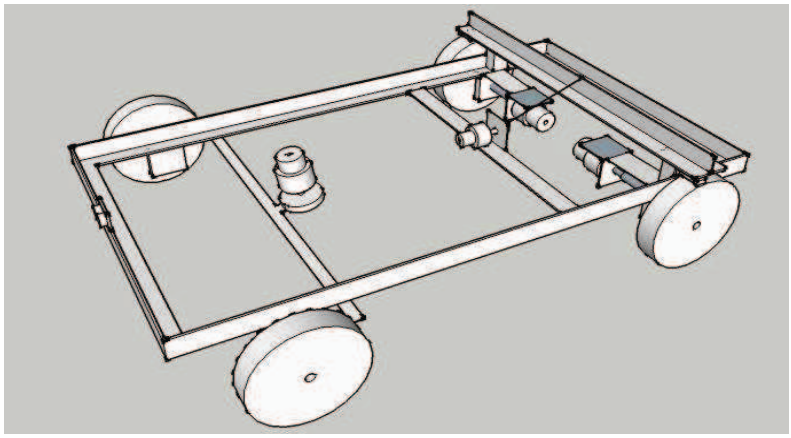
An intelligent mechatronic system includes an Proximity sensor. Capacitive proximity sensors work by detecting changes in capacitance between the sensor and an object. Factors such as distance and the size of the object will affect the amount of capacitance. The sensor simply detects any changes in capacity generated between the two. The extremely rapid response time provided by the electronic control can be used for crucially shortening the braking distance by introducing advanced control of braking system operation. The control of commercial vehicle's braking system operation is related not only to vehicle speed but also to lateral acceleration together with the yaw moment control and significantly reducing the possibilities of the vehicle rolling over.

2.1 LAYOUT DIAGRAM

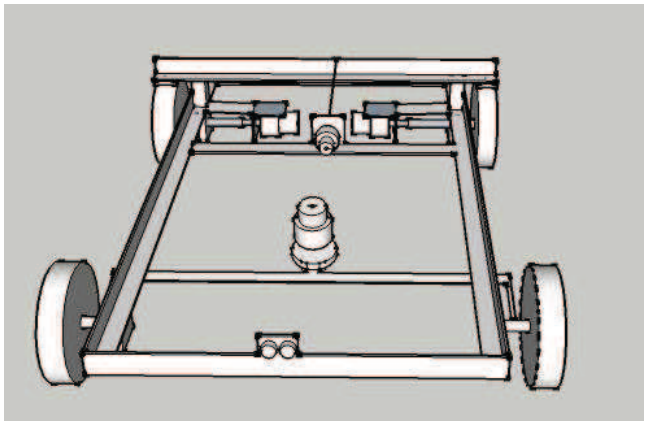


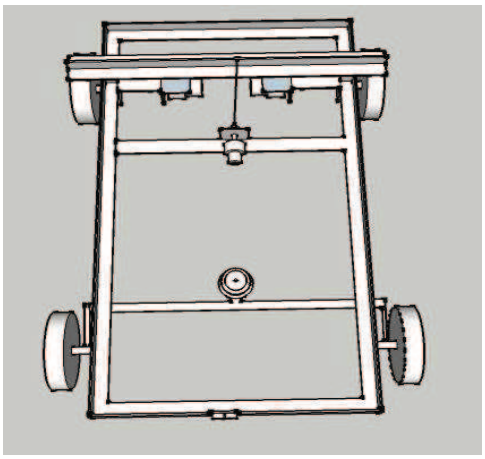
Front view



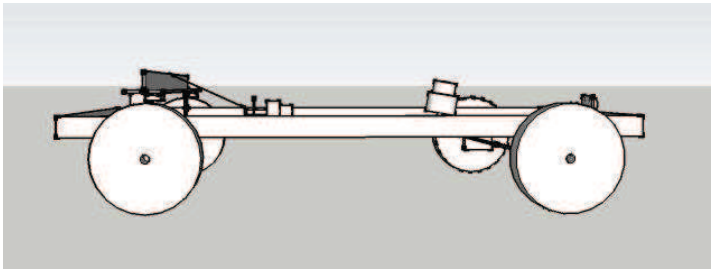


Top view

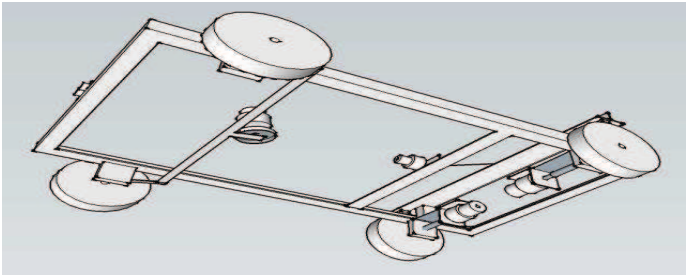




Side view



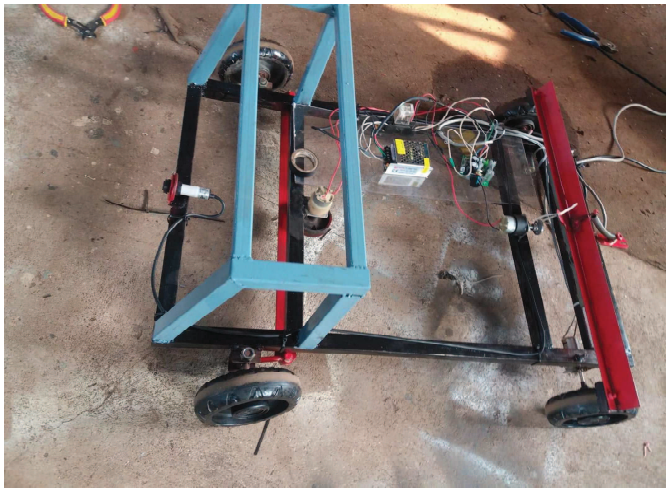
Bottom view



Construction of Front view

Rear view

Top view



3. DESCRIPTION OF PARTS

Major part of our project is described below

1. DC Motor
2. 12v Power supply
3. Steering mechanism
4. Relay unit
5. Control switch

3.1. 12 v power supply

12V power supplies (or 12VDC power supplies) are one of the most common power supplies in use today. 12V regulated power supplies, and 12V unregulated power supplies.12V regulated power supplies come in three styles: Switching regulated AC to DC, Linear regulated AC to DC, and Switching regulated DC to DC. Switching regulated 12VDC power supplies, sometimes referred to as SMPS power supplies, switchers, or switched mode power supplies, regulate the 12VDC output voltage using a complex high frequency switching technique that employs pulse width modulation and feedback. Acopian switching regulated power supplies also employ extensive EMI filtering and shielding to attenuate both common and differential mode noise conducted to the line and load.

Galvanic isolation is standard in our 12VDC switchers, affording our users input to output and output to ground isolation for maximum versatility. Acopian switching regulated power supplies are highly efficient, small and lightweight, and are available in both AC-DC single and wide-adjust output and DC-DC configurations. Our Low Profile wide adjust output switchers can be voltage or current regulated and are externally programmable. Unregulated 12VDC power supplies are basic power supplies with an AC input and an unregulated 12VDC output. The output voltage changes with the input voltage and load. These power supplies are inexpensive and extremely reliable.

The traditional form of a relay uses an electromagnet to close or open the contacts, but other operating principles have been invented, like in solid state relay which use semiconductor properties for control without relying on moving parts. Latching relays require only a single pulse of control power to operate the switch persistently. Another pulse applied to a second set of control terminals, or a pulse with opposite polarity, resets the switch, while repeated pulses of the same kind have no effects. Magnetic latching relays are useful in applications when interrupted power should not affect the circuits that the relay is controlling.

3.2 WORKING OPERATION

M.S square tubes are used for the frame arrangement; 500 RPM DC motor is used on the back wheels for the forward and backward drive. 12v DC power supply drives the motor. Proximity sensor are placed in front of the vehicle, the terminals of the sensor are connected to relay unit and the output of the relay unit is connected with motor. We are also used steering mechanism in our project for turning purpose. The steering operation is done with DC motor drive with control switch. On coming to the operation of vehicle drive, when the vehicle reaches closer distance towards the obstacle, the proximity sensor detects the closer distance and send signal to the relay unit and it send the output signal to the Braking unit.

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