IJCRT.ORG ISSN : 2320-2882
INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

GOODS LOADING VEHICLE WITH LIFT AND RAIL CARRIAGE MECHANISM

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ABSTRACT

A Robot is a reprogrammable, multifunctional manipulator designed to move material, parts, tools and specialized devices through variable programmed motion for variety of task. Robotics deals with the design, construction, operation, and use of robots, as well as computer systems for their control, sensory feedback, and information processing.

The goods loading vehicle is used for loading and Unloading of goods by using lead screw mechanism, Lift and Rail carriage mechanism by inducing a set of instructions which will be given to the Robot. Earlier, this process used to be carried out manually but by using this vehicle, process is done easily.

We have built a prototype of goods loading vehicle by inducing set of instructions to it. We can control it by giving instructions through phone by connecting it to Bluetooth.

Keywords: Manipulator, Prototype, Lead and screw mechanism, Lift and rail carriage mechanism and Bluetooth.

1. INTRODUCTION

Robotics is a branch of engineering and science that includes electronics engineering, mechanical engineering and computer science and so on. This branch deals with the design, construction, use to control robots, sensory feedback and information processing. These are some technologies which will replace humans and human activities in coming years. These robots are designed to be used for any purpose but these are using in sensitive environments like bomb detection, deactivation of various bombs etc. Robots can take any form but many of them have given the human appearance. The robots which have taken the form of human appearance may likely to have the walk like humans, speech, cognition and most importantly all the things a human can do. Most of the robots of today are inspired by nature and are knownasbio-inspiredrobots.
Robotics is that branch of engineering that deals with conception, design, operation, and manufacturing of robots. There was an author named Isaac Asimov, he said that he was the first person to give robotics name in a short story composed in 1940's. In that story, Isaac suggested three principles about how to guide these types of robotic machines.

Later on, these three principles were given the name of Issacs's three laws of Robotics. These three laws state that:

- Robots will never harm human beings.
- Robots will follow instructions given by humans without breaking law one.
- Robots will protect themselves without breaking other rules.

1.1 Characteristics:

There are some characteristics of robots given below:

- **Appearance:** Robots have a physical body. They are held by the structure of their body and are moved by their mechanical parts. Without appearance, robots will be just a software program.
- **Brain:** Another name of brain in robots is On-board control unit. Using this robot receive information and sends commands as output. With this control unit robot knows what to do else it'll be just a remote-controlled machine.
- **Sensors:** The use of these sensors in robots is to gather info from the outside world and send it to Brain. Basically, these sensors have circuits in them that produces the voltage in them.
- **Actuators:** These are the devices which converts the stored energy into motion is called Actuators. These actuators something move or operate. Some examples of actuators are motors, pumps, and compressor etc. The brain tells these actuators when and how to respond or move.
- **Program:** Robots only works or responds to the instructions which are provided to them in the form of a program. These programs only tell the brain when to perform which operation like when to move, produce sounds etc. These programs only tell the robot how to use sensors data to make decisions.
- **Behaviour:** Robots behaviour is decided by the program which has been built for it. Once the robot starts making the movement, one can easily tell which kind of program is being installed inside the robot.

1.2 Types of Robots:

These are some types of robots:

- **Articulated:** The feature of this robot is its rotary joints and range of these are from 2 to 10 or more joints. The arm is connected to the rotary joint and each joint is known as the axis which provides a range of movements.
- **Cartesian:** These are also known as gantry robots. These have three joints which use the Cartesian coordinate system i.e. x, y, z. These robots are provided with attached wrists to provide rotatory motion.
- **Cylindrical:** These types of robots have at least one rotatory joints and one prismatic joint which are used to connect the links. The use of rotatory joints is to rotate along the axis and prismatic joint used to provide linear motion.
- **Polar:** These are also known as spherical robots. The arm is connected to base with a twisting joint and have a combination of 2 rotatory joint and one linear joint.

- **Scara:** These robots are mainly used in assembly applications. Its arm is in cylindrical in design. It has two parallel joints which are used to provide compliance in one selected plane.
- **Delta:** The structure of these robots is like spider shaped. They are built by joint parallelograms that are connected to the common base. The parallelogram moves in a dome-shaped work area. These are mainly used in food and electrical industries.[1]

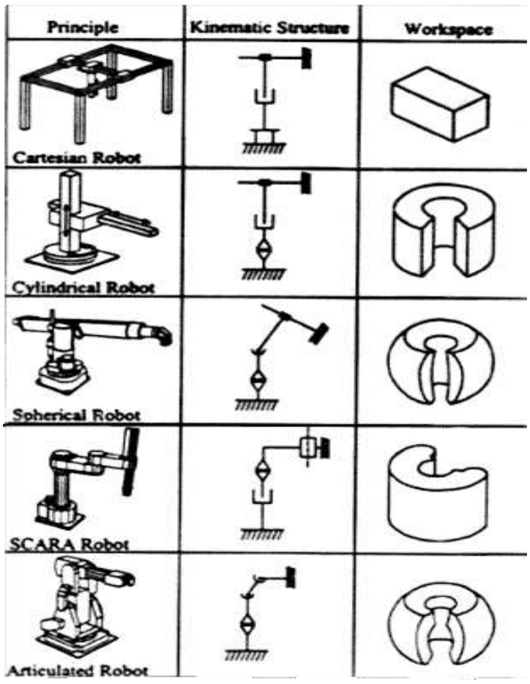

Fig1.1: Different types of robots

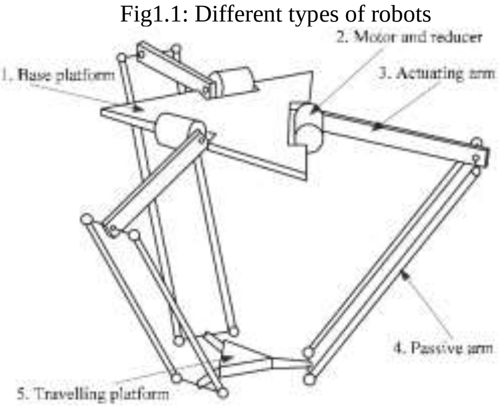

Fig 1.2: Delta Robot

2. LITERATURE REVIEW

George Devol

In 1950, George Devol would invent Unimate, the first industrial robot. Unimate could transport die castings and weld them into automobiles. Similar to modern automation in manufacturing and other industrial fields, these industrial robots would be programmed for a specific function as a means of replacing unskilled labor. Unimate was one of the most important milestones in the history of robots.

In 1956, Devol and his partner Joseph Engel Berger formed the world's first robot company. In 1961, the first industrial robot, Unimate, went online in a General Motors automobile factory in New Jersey.[2]

Joseph F. Engel Berger

In 1956, Engel Berger met American engineer and inventor George C. Devol at a cocktail party where the two discussed the writer Isaac Asimov's robot philosophies and Devol's patent-pending Programmed Article Transfer device. Engel Berger identified the device as a robot, the first ever, and conceived of how it could be used in manufacturing, in particular to perform jobs dangerous to humans.[3]

Ting Zou

He Ph.D., is an assistant professor in the Department of Mechanical Engineering at Memorial University of Newfoundland. Dr. Zou obtained a B.Sc. in electrical engineering from Xi'an Jiao tong University in 2005, a M.Sc. in automatic control engineering from Xi'an Jiao tong University in 2008, and a PhD degree in mechanical engineering from McGill University in 2013. Then she had been working as a postdoctoral fellow at McGill Centre for Intelligent Machines. Her research interests include mechanism design, control and optimization of robotic systems.

Jorge Angeles

He(SM'90-F'06) received the Dipl. Eng. degree in electromechanical engineering and the M.Eng. degree in mechanical engineering from Universidad Nacional Autonoma de Mexico, Mexico City in 1969 and 1970, respectively, and the Ph.D. degree in applied mechanics from Stanford University, Stanford, CA, in 1973. In 1984, he joined the Department of Mechanical Engineering, McGill University, Montreal where, in 1985, he became a founding member of the Centre for Intelligent Machines and is currently James McGill Professor of Mechanical Engineering, and the Founder and Director of the Robotic Mechanical Systems Laboratory. Dr. Angeles is a Fellow of the RSC, The Academies of Arts, Humanities and Sciences of Canada. He is one of the 12 honorary members of IFToMM, the International Federation for the Promotion of Mechanism and Machine Science. He is a Fellow of the Canadian Society for Mechanical Engineers and the American Society of Mechanical Engineers. His professional registration as an Engineer includes Quebec, Mexico, and Germany.

Bernhard Dieber

He is heading the research group 'Robotic Systems' at the Institute for Robotics and Mechatronics of JOANNEUM RESEARCH. He received his master's degree in applied computer science and Ph.D. in information technology from the Alpen-Adria Universität Klagenfurt. His research interests include robotics software, security and dependability of robotic systems, visual sensor networks and middleware.

Daniel Kappler

He is a Roboticist at X, The Moonshot Factory. He was a PhD student at the Autonomous Motion Department (AMD) at the MPI for Intelligent Systems and Karlsruhe Institute of Technology (KIT). His thesis on Combining Model- Based with Learning-Based Approaches for Autonomous Manipulation was performed under the supervision of Prof. Dr. Stefan Schaal and Prof. Dr. Tamim Asfour. He studied Computer-Science at KIT, in Germany, focusing on machine learning and robotics. In 2012 he received his Diploma, conducted as a visiting researcher at the Istituto Italiano di Tecnologia (IIT), for his work on transfer learning. He was a visiting researcher at the Robotics Institute at Carnegie Mellon University (CMU) in 2010, where he worked on object manipulation prior to grasping. His main research interests are in learning techniques for dexterous autonomous manipulation. He is especially interested in continuous learning from sensory experience and learning how to faster improve on novel new tasks from prior task experience.[4]

Robot and Automation Systems

Cloud Robot and Automation systems can be broadly defined as follows: Any robot or automation system that relies on either data or code from a network to support its operation, i.e., where not all sensing, computation, and memory is integrated into a single standalone system. This definition is intended to include future systems and many existing systems that involve networked teleoperation or networked groups of mobile robots such as UAVs , or warehouse robots , as well as advanced assembly lines, processing plants, and home automation systems, and systems with computation performed by humans.[5]

Development of a 30,000 kg heavy goods vehicle for LS-DYNA applications

In this paper, a finite element model of a 30,000 kg Heavy Goods Vehicle (HGV) was developed and validated against full-scale crash test data. Since this vehicle is a standard test vehicle in the European crash test standards, EN1317, development of an accurate vehicle model was deemed to be a positive contribution to the evaluation of roadside safety hardware. The vehicle model reproduces a FIAT-IVECO F180 truck, a vehicle with four axles and a mass of 30,000 kg when fully loaded. The model consisted of 12,337 elements and 11,470 nodes and was built for and is ready to use with LS-DYNA finite element code from Livermore Software Technology Corporation. Data available from two previously performed full-scale crash tests, one on a steel bridge rail and the other on a portable concrete barrier, were used to validate the accuracy of the HGV model. Results of the finite element simulation study show that the developed HGV model shows promise and can accurately replicate the behaviour of an actual HGV in a full-scale crash test. Improvements such as the steering mechanism in the front axles and the suspension system are currently underway to make the model more realistic.[6]

Industrial solutions for loading/unloading goods on a full electrical freight urban robotic vehicle

The authors present four industrial solutions for loading/unloading goods on a freight urban robotic vehicle, named FURBOT. The final design of the FURBOT vehicle allows the movement of two Euro Pallets 800 × 1,200 mm (or FURBOT boxes with similar bottom part). Following a sustainable and efficient mobility approach, a robotic handling device must be designed and positioned on-board of the vehicle. The handling device must realize the loading-unloading operations on the right side of the vehicle and from the ground to the vehicle platform. Active suspensions of the FURBOT vehicle are designed to adapt the stiffness to the payload and by modifying the chassis height on the ground for travel and loading-unloading tasks.[7]

The performance of multiple-load AGV systems under different guide path configurations and vehicle control strategies

The majority of research on multiple-load Automated Guided Vehicle (AGV) systems has been focused on vehicle control problems. None of it investigates how well multiple-load AGVs will perform under different guide path configurations and different vehicle control strategies (i.e. dispatching rules and load selection and delivery rules). This paper investigates the performance of multiple-load AGV systems in two configurations - unidirectional single loop (SL) and segmented bi-directional single loop (SBSL). Simulation experiments are conducted to study the performance of multiple-load AGVs in these guide path configurations when different combinations of dispatching rules and load selection and delivery rules are applied. Based on this study, one is able to select good control strategies for multiple-load AGV systems with SL guide paths or SBSL guide paths.[8]

A preliminary study to optimize safety conditions on a freight urban robotic vehicle

The paper presents a new concept architecture of light duty fully electric vehicle for efficient sustainable urban freight transport which allows the movement of two Euro Pallets 800 × 1200 mm (or boxes with similar bottom part). Active suspensions of the vehicle have been designed in order to adapt their stiffness to the payload on board and to modify the chassis height during loading-unloading tasks. In this paper, a preliminary study to optimize safety conditions on goods on board of the vehicle, and on people near the vehicle is presented. In order to guarantee safety conditions for the vehicle's driver and city areas where the vehicle should be moved, design optimizations on the chassis have been developed. These optimizations have been compared using computational analysis. Two alternative solutions have been proposed and one of the presented results has been included on the real vehicle. The FURBOT vehicle is designed for urban freight transportation, and it is assumed to work within urban areas and streets. The maximum speed of the vehicle is 40 km/h and the maximum slope is considered to be 11%. These considerations were very useful while designing the vehicle and are still a good starting point for analyzing the possible configurations of the vehicle and the load.

Browne et al. (2010) provide a review of the light goods vehicle (LGV) fleet and its activity, with specific reference to operations in urban areas, and sustainability issues associated with the ever-growing use of LGVs. Traditionally these vehicles have received little attention but are becoming an ever-more important element of urban freight transport both for goods collection and delivery and for the provision of a wide range of critical services. Freight transport is a critical issue for urban areas: the population is becoming more and more concentrated in cities and therefore the bulk of industrial production is dispatched to these areas. Moreover, the demand for freight transport is growing at a fast rate due to changes in industry logistics and consumer purchasing patterns [9]

An electro-mobility system for freight service in urban areas

The paper introduces the problem of reducing impact of freight service trips in urban areas and presents the main design objectives, requirements, and steps of a new fully electric vehicle able to autonomously load and unload palletized or boxed freights. The subject is described under a multidisciplinary point of view integrating the mechatronic design, the efficient power supply system, the intelligent mobility control modules, the strategy for freight delivery planning, through a fleet of these vehicles, based on economic and behavioural modelling.[10]

Bluetooth

Remote innovations, for example, Bluetooth give the capacity to reinforce the neighbourhood remote system. Bluetooth innovation was made by Ericsson in 1994 and is utilised to supplant the links in the workplace, in research centers or at home. Bluetooth gadget worked in the scope of 10 meters. Bluetooth gadget can relevant for voice and information recordings and pictures transmission and gathering. Favorable circumstances of Bluetooth have low expenses and low power and nature can be indicated parts of Bluetooth has been included into different sorts of cell phones , for example, cell phones, PDAs and different remote set.[11]

Robot systems

Intelligent robotic systems (IRSs) have attracted more and more attention in the past decades since IRSs have great potential to be widely applied in industry, agriculture, transportation, medical operations and service. However, due to the increasing complexities and uncertainties in real-world tasks, there are still many research challenges in the sensing, planning and control of intelligent robotic systems. In order to promote the research in this area, we organize this special issue which includes five papers. These five papers are extended peer-reviewed versions from selected papers that have been presented in the 2017 Chinese Conference on Intelligent Robots. The topics of the special issue papers cover a wide range from robot sensing, visual navigation, to robot control and service robots. We believe that this special issue will provide a good forum and reference for researchers in the field of intelligent robotics.

The first paper in this special issue presented a visual navigation method that uses an extended Bag-of-Words (BoW) model for feature representation and support vector machines for object classification [12].

The interaction between human and robot was also considered by considering the manually designed semantic maps. Some experimental results on indoor mobile robot navigation were provided to show the effectiveness of the proposed method.

The second paper proposed an initiative service model for service robots [13].

In the proposed service model, there are three layers that are designed for human-robot interaction. Experiments on drinking service were conducted to verify the advantages of the initiative service model.

In order to realize high-performance sensing for autonomous vehicles, the third paper presented a lane detection algorithm by making use of temporal-spacial information matching and fusion [14].

Experimental results on a real autonomous vehicle show that the proposed algorithm can obtain high-precision and stable lane detection results.

The fourth paper in this special issue designed a magnetic orientation system by integrating gyroscope, accelerometer, and magnetometer [15].

The Kalman filtering algorithm was utilized to fuse the data from different sensors. Experimental results were provided to test the performance of the magnetic orientation system.

The last paper in this special issue proposed an indoor localization method for mobile robots with inertial measurement units and stereo vision [16].

In the proposed method, the dual Kalman filtering method was used to decrease the accumulation errors of inertial measurement units. Experimental results on a real mobile robot show the effectiveness of the proposed method.

3. ACCESSORIES OF A ROBOT

3.1 Manipulator

It is the main body of the robot which consists of links, joints and structural elements of robot. Industry-specific robots perform several tasks such as picking and placing objects, and movement adapted from observing how similar manual tasks are handled by a fully functioning human arm. Such robotic arms are also known as robotic manipulators. These manipulators were originally used for applications concerning bio-hazardous or radioactive materials or use in inaccessible places.

Fig3.1: Manipulator

3.2 Actuators

Actuator is an electromechanical device which converts energy into mechanical work. There are several types of actuators used in robots.

3.3 Sensors

Sensor is a window for a robot to the environment. Sensors allow robots to understand and measure the geometric and physical properties of objects in their surrounding environment, such as position, orientation, velocity, acceleration, distance, size, force, moment, temperature, luminance, weight, etc.

3.4 Controller

A controller is a device which takes one or more inputs and adjusts its outputs so a connected device[17]

4.PARTS USED IN MAKING GOODS LOADING VEHICLE

The parts used in making goods loading vehicle are:

4.1 Arduino UNO

Arduino consists of both a physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) that runs on your computer, used to write and upload computer code to the physical board.

The Arduino Uno is a microcontroller board based on the ATmega328. It has 20 digital input/output pins (of which 6 can be used as PWM outputs and 6 can be used as analog inputs), a 16 MHz resonator, a USB connection, a power jack, an in-circuit system programming (ICSP) header, and a reset button.[18]

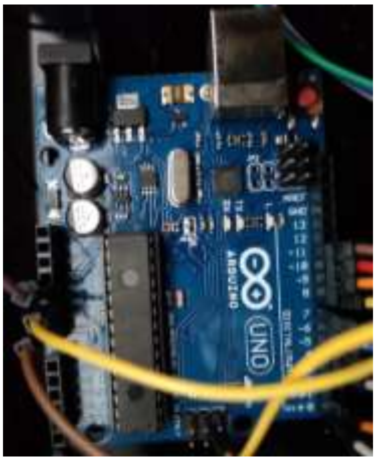

Fig 4.1: Arduinouno Microcontroller

4.2 Motor drives

- Defining a drive can be a bit tricky. Some drives are wholly incorporated into the controller, so that the profile generation takes place in the controller as well as the torque command for the motor. On the other hand, a drive can also refer to the specific power electronic circuitry needed to drive the motor. Electric motors that drive industrial machines need some way to control motor speed. And at its most basic level, a motor drive controls the speed of the motor.

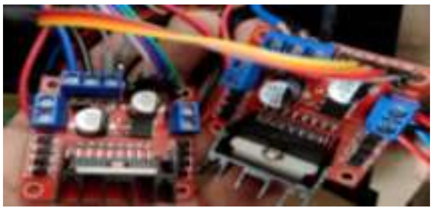

Fig4.2: Motor Drives

4.3 Motor

An electric motor is a device used to convert electricity into mechanical energy—opposite to an electric generator. They operate using principles of electromagnetism, which shows that a force is applied when an electric current is present in a magnetic field.

In this vehicle we have used 100rpm and 30 rpm motors.

Fig4.3: DC Motors

4.4 Distribution Board

A distribution board (also known as panelboard, breaker panel, or electric panel) is a component of an electricity supply system that divides an electrical power feed into subsidiary circuits, while providing a protective fuse or circuit breaker for each circuit in a common enclosure.[19]

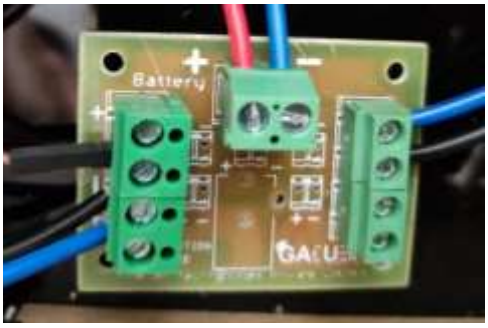

Fig4.4: Distribution Board

4.5 Bluetooth board

- It is used for many applications like wireless headset, game controllers, wireless mouse, wireless keyboard and many more consumer applications.
- It has range up to <100m which depends upon transmitter and receiver, atmosphere, geographic & urban conditions.
- It is IEEE 802.15.1 standardized protocol, through which one can build wireless Personal Area Network (PAN). It uses frequency-hopping spread spectrum (FHSS) radio technology to send data over air.
- It uses serial communication to communicate with devices. It communicates with microcontroller using serial port (USART).

Fig4.5: Bluetooth Board

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5. PROCEDURE AND WORKING OF GOODS LOADING VEHICLE

- The aim of our project is to load and unload the goods after the manufacturing process and make it easy for the industries and it lessen the use of manpower .
- The parts used in making this prototype are Arduino Uno microcontroller, distribution board, motor drives, motors (100rpm[2] & 30rpm[2]), Bluetooth board.
- The connections are given accordingly, from motors to the motor drives then to the distribution board. Next these connections are connected to the microcontroller and the Bluetooth board is also connected to the microcontroller. One connection from the distribution board is given to the battery.

Fig5.1: Connections given to parts

- After all connections are given the coding is done by using the Arduino Uno software.
- The coding is done to move the vehicle forward, backward, to turn right, left and to lift the load and to stop the respective task.
- The coding includes the movement of the vehicle by running the motors. The 100 rpm motors are used to move the vehicle forward, backward, right and left whereas the 30 rpm motors are used to lift the load up and down.

5.1 CODING:

```
char ch;
void setup( ) {
        pinMode (4,OUTPUT);
        pinMode (5,OUTPUT);
        pinMode (6,OUTPUT);
        pinMode (7,OUTPUT);
        pinMode (8,OUTPUT);
        pinMode (9,OUTPUT);
        pinMode (10,OUTPUT);
        pinMode (11,OUTPUT);
        Serial.begin(9600);
}
void motor1_forward( )
{
        digitalWrite(10, LOW);
        digitalWrite(11, HIGH);
}
void motor1_stop( )
{
        digitalWrite(10, LOW);
        digitalWrite(11, LOW);
}
void motor2_forward( )
{
        digitalWrite(8, HIGH);
        digitalWrite(9, LOW);
}
void motor2_reverese( )
{
        digitalWrite(8, LOW);
        digitalWrite(9, HIGH);
}
void motor2_stop( )
{
        digitalWrite(8, LOW);
        digitalWrite(9, LOW);
}
void forward( )
{
        digitalWrite(4, LOW);
        digitalWrite(5, HIGH);
        digitalWrite(6, LOW);
        digitalWrite(7, HIGH);
}
void reverse( )
{
        digitalWrite(4, HIGH);
        digitalWrite(5, LOW);
        digitalWrite(6, HIGH);
        digitalWrite(7, LOW);
}
void left( )
{
        digitalWrite(4, LOW);
        digitalWrite(5, LOW);
        digitalWrite(6, LOW);
        digitalWrite(7, HIGH);
}
void right( )
```

```
{
        digitalWrite(4, LOW);
        digitalWrite(5, HIGH);
        digitalWrite(6, LOW);
        digitalWrite(7, LOW);
}
void stop1( )
{
        digitalWrite(4, LOW);
        digitalWrite(5, LOW);
        digitalWrite(6, LOW);
        digitalWrite(7, LOW);
}
void loop( )
{
        If(Serial.available ( )>0)
{
        ch=(char)Serial.read( );
        Serial.println(ch);
        if(ch=='F')
        {
          forward( );
        }
        else if(ch=='B')
        {
          reverse( );
        }
        else if(ch=='L')
        {
          left( );
        }
        else if(ch=='R')
        {
          right( );
        }
        else if(ch=='S')
        {
          stop1( );
        }
        else if(ch=='a')
        {
           motor1_forward( );
        }
        else if(ch=='b')
        {
           motor1_stop( );
        }
        else if(ch=='c')
        {
          motor2_forward( );
        }
        else if(ch=='d')
        {
          motor2_reverse( );
        }
        else if(ch=='e')
        {
          motor2_stop( );
        }
}
}
```

- After the coding is done , it is dumped into the microcontroller with the help of cable.
- While transferring the code the transmitter and the receiver pin connections must be removed and placed after the code is dumped into the microcontroller.
- By connecting the battery and connecting through Bluetooth from mobile , the vehicle moves accordingly by giving instructions through smart phone.
- This is how the goods loading vehicle prototype works and executes the particular tasks which are given.

6. POWER SCREW CALCULATIONS

We considered some parameters of our vehicle and performed calculations to find lead angle(α), friction angle(ϕ), torque required to raise the load(Tr), torque required to lower the load(Tl), efficiency of power screw(η).

❖ To find lead angle(α)

Let us consider Lead (L) = 1mm

Diameter (d) = 4mm

- α = tan^-1(L/πd)

α = tan^-1(1/π*4)

α = 4.54

❖ To find friction angle(ϕ)

Let us consider coefficient of friction (μ) = 0.11 [from data book]

- ϕ = tan^-1(μ)

ϕ = tan^-1(0.11)

ϕ = 6.27

❖ Torque required to raise the load

Let us consider the load (W) = m*g

= 0.5*9.8

W = 4.9 N

- Tr = W*d [tan(ϕ+α)]/2

Tr = 4.9*4[tan (6.27+4.54)]/2

Tr =1.871 N-mm

❖ Torque required to lower the load

➢ Tl = W*d [tan(ϕ-α)]/2

Tl = 4.9*4[tan (6.27- 4.54)]/2

Tl = 0.36 N-mm

❖ Efficiency of Power screw

➢ η = tanα / tan (α + ϕ)

η = tan (4.54) / tan (4.54 + 6.27)

η = 0.415

η = 41.5%

PARAMETERS	VALUES
Lead angle (α)	4.54
Friction angle (ϕ)	6.27
Torque required to raise the load (Tr)	1.871 N-mm
Torque required to lower the load (Tl)	0.365 N-mm
Efficiency of power screw (η)	41.5%

Table 1: Parameters of Power screw

7. RESULTS

After giving all the connections and coding, the goods loading vehicle prototype performs the particular task accordingly such as moving forward, backward, turning left, right and the end effector moves up and down by the lead screw mechanism. The load is transferred by the rail carriage mechanism.

Fig7.1: Internal connections of the parts

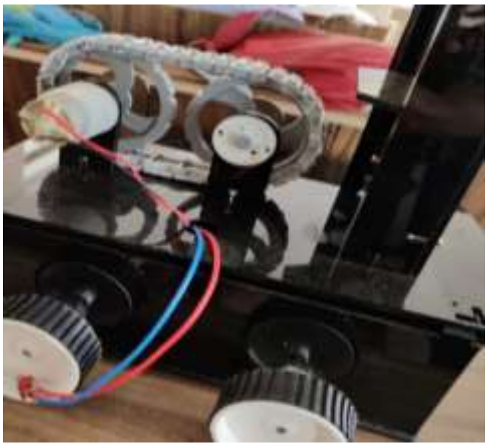

Fig7.2: Goods loading vehicle with rail carriage mechanism

Fig7.3: Goods loading vehicle with lead screw mechanism

7. CONCLUSION

Our project "Goods loading vehicle with lift and rail carriage mechanism" deals with loading and unloading of finished products after the manufacturing process. We prepared a prototype of this vehicle which consists of rail carriage mechanism and lead screw mechanism. By utilizing this vehicle in industries, the loading and unloading process becomes easier and the time taken for this process is also reduced. The manpower is also reduced. The time and manpower is utilized in an efficient way by implementing the usage of this goods loading vehicle.

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