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Mechanical Design of an Automated Guided Vehicle (AGV)

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Abstract

An Automated Guided Vehicle (AGV) is a set of cooperative driverless vehicle, used on manufacturing floor and coordinated by a centralized or distributed computer-based control system. AGVs-based Material Handling Systems (MHSs) are widely used in several Flexible Manufacturing Systems (FMS) installations. One of the challenge in MHSs is how flexible and adequate is the utilization. The key issue of the flexibility of MHSs is the routing system. It should be designed in a way that can be easily modified to become adaptable to new or replaced machines. The main focus of this study is to make an AGV with the convenient materials, simple and applicable routing system and more importantly reducing the cost and increasing the flexibility. For this propose an AGV is basically modeled and designed with CATIA software and developed with special specifications.

Keywords: Fuzzy logic, steering system, programmable logic control (PLC), flexible manufacturing system (FMS), material handling system (MHS)

1. INTRODUCTION

Basic Automated Guided Vehicle (AGV) technology is not a new technology. Fifty years ago when AGVs were first used they were called driverless systems. Through the years, advances in electronics have led to advances in guided vehicles. Nowadays, the technology of AGV is widely used in industrial environment to perform variety of task that involves automation. Technological developments have given AGVs more flexibility and capability in performing its tasks. These AGVs is widely used for its advantage which is the ability to move from one place to another without proper supervision by human or operators. This advantage can increase the productivity and efficiency in manufacturing process of certain product. However, designing an AGV system that can actually move and function such as stated above is not an easy task. Most AGVs in industry operated using electric power and moved by the use of electric motor. The electric motor is connected to combination of suitable and appropriate gears, which then further connected to the wheel of the AGVs. Through this mechanism, the AGV will be able to move or navigate with help of appropriate control system in order for the AGV to move correctly along path as required. Based on these factors, the relationship between total loads that the AGV can withstand with the electric power supplied to the system is very important .Besides that, the design of control system as well as the use of sensor also playing an important role in these AGVs. Thus, for our project, basic mechanical of AGV will be designed by combining all the factors such as stated above and hopefully that combination will bring exposure to manufacturing process system.

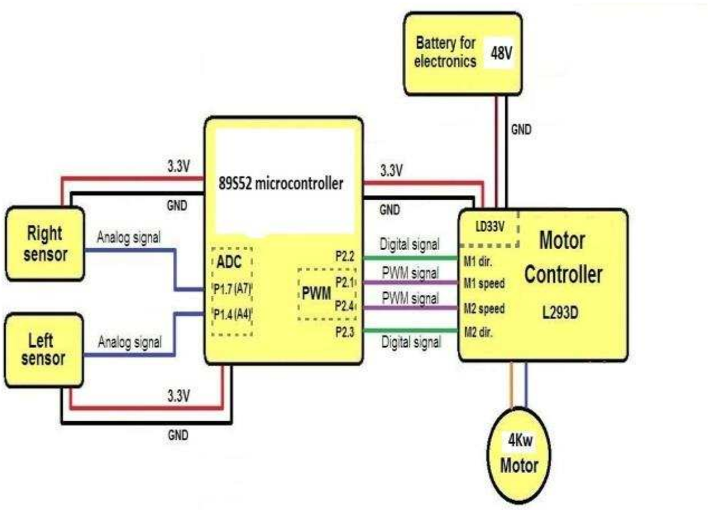

Fig.1 A general Block Diagram of An Automated Guided Vehicle.

2. LITERATURE REVIEW

The first big development for the AGV industry was the introduction of a unit load vehicle in the mid-1970s. This unit load AGVs gained widespread acceptance in the material handling marketplace because of their ability to serve several functions; a work platform, a transportation device and a link in the control and information system for the factory. Since then, AGVs have evolved into complex material handling transport vehicles ranging from mail handling AGVs to highly automated automatic trailer loading AGVs using laser and natural target navigation technologies. Material handling in manufacturing system is becoming easier as the automated machine technology has improved. One of the material handling methods that has been widely used in most industry nowadays is the Automated Guided Vehicle System or better known as the AGVS. It has become one of he fastest growing classes of equipment in the material handling industry (Tanchoco and Bilge, 1997). Until today there are many researchers that have shown interests in improving the system in order to achieve more productivity and flexibility in manufacturing environments. According to (Groover, 1987) an Automated Guided Vehicle System (AGVS) is a materials handling system that uses independently operated, self propelled vehicles known as the automated guided vehicle or AGV that moves along defined pathways between delivery points or stations. A typical AGV will consist of the frame, batteries, electrical system, drive unit, steering, on board controller and work platform.

3. PROPOSED SYSTEM

In the proposed system, AGV model can follow a trail of line on a flat surface horizontally. This AGV model is using microcontroller to control all navigation and lifting functions during its operation. In other words, the microcontroller acts just like the brain for the model that controls all operation of the system.

3.1. MODEL DESCRIPTION

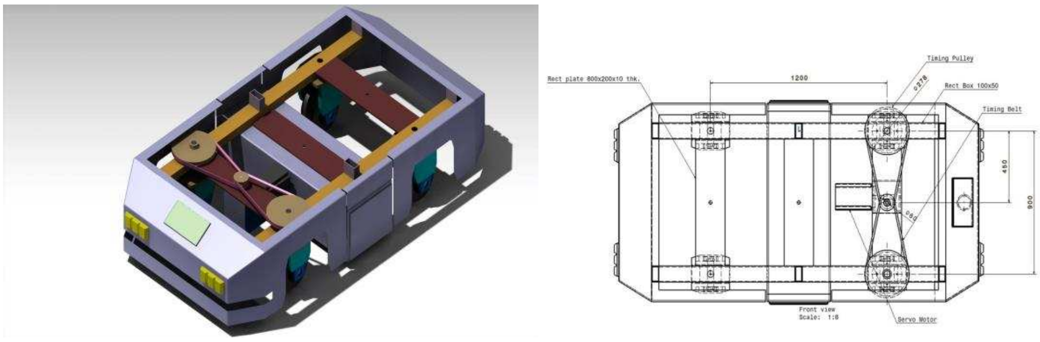

Fig. 2 Automated Guided Vehicle System architecture

3.2. FRAME

The frame is fabricated from Dent Proof Sheet Metal MS. This is done for ease of fabrication, and to reduce the overall weight. It is designed in Catia. The frame is designed to take a load of 800kg. The frame consist of two C- channel hollow bars made up of MS and are cold rolled and connected to each other by three support plates which are also made up of MS of yield 210 Mpa. The frame also consist of six rectangular boxes also made up of Mild steel between the each C cross section bar and support plates on either sides. The rectangular boxes are provided to distribute the weight load of material which is to be handled by AGV uniformly across the structure. And also to provide a provision for timing belt to rotate without coming in contact with C- channel bar. The frame welded together by spot welding and is in the shape of a ladder. The whole frame is mounted on top plate of both front and rear wheels.

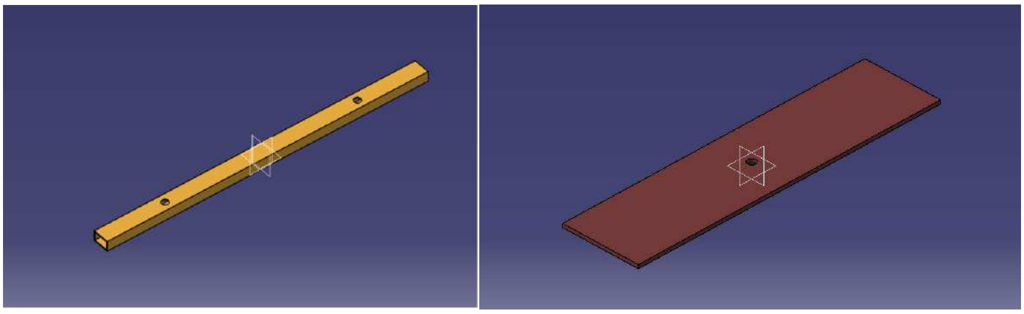

Fig. a) C- Channel b) Support Plate

3.3. TURNING MECHANISM

In our design, instead of using Ackerman mechanism or Davis mechanism for steering because of their complex design and high cost we have developed a mechanism using timing belts and pulley to achieve perfect steering required at the front wheels for turning.

A 1500 RPM DC Motor powered by a 48V Battery is used to actuate the mechanism. The motor is connected to a worm and worm wheel which is used to reduce the speed of motor by 30:1.The output of worm gear is fed to a double crown pulley pivoted at the centre and two pulleys are connected to it by timing belts. The two timing belts are used in the mechanism. The 1st pulley fits between bottom of the centre pulley and the right hand side pulley whereas the 2nd pulley fits between top side of the centre of the centre and the left hand side pulley.

To achieve perfect steering conditions, all wheels need to be perfectly rolling on the road surface. Thus, while taking a turn, the inner wheels need to turn by a greater angle than the outer wheels. **Turning radius** refers to the smallest circle that the outer wheel can trace.

When sensor from the electronic unit senses a curve in the optical path it gives feedback to the Microcontroller about the path which in turn operates the dc motor. Then the DC motor starts rotating which drives the worm gear which reduces the input from the motor. Now Timing belt is used to control the motor speed and accordingly steer the wheels.

Suppose the vehicle has to make a right turn, then the inner wheel i.e. the right front wheel is to be turned by a greater angle so as to achieve perfect steering. The timing belt rotates the right pulley with a higher speed than that of the left pulley hence the inner wheel is turned by a greater angle and the desired steering is achieved. The rotational speed of timing belt is controlled by microcontroller on the basis of control signal sent by the sensing unit. This system is simple in construction, rugged in structure and cost-effective as explained above.

3.4. DRIVING MECHANISM

In the design we have used four wheels –rear wheel drive. The driving motor is mounted at the rear end and the front axle only houses steering mechanism. Because of the high weight on the driving shaft, it provides excellent traction and grip even under high loads. The system consists of a 1500 RPM DC Motor which is driven by a 48V battery.The output speed required at the wheels is 7 MPM Hence for reduction of speed from 1500 RPM to desired value we have used Worm gears .Worm gears are silent in operation and they provide high gear reduction ratio. For further reduction in gear ratio we have used Bevel gears and for power transmission we have used Spur gears. Engagement and disengagement of gears is done by lead screw mechanism. Two V-belts are provided so as to safeguard the motor against no load condition.

The DC Motor is driven by a 48V battery and the power is transmitted to worm gears by means of V-belts. The worm Gear provides the necessary Gear Ratio Reduction I.e. 30:1 now the worm is connected to the bevel gears of the gearbox for further reduction in speed. The required output is very low at wheels hence large reduction is required in speed of motor. The bevel gear drives the rear shaft which can slide in X-direction on which is mounted 4 spur gears. Each alternative gear is rotating in opposite direction. We have used spur gears despite of their low transmission efficiency to keep the mechanism simple and cost-effective. Also it is not possible to engage-disengage helical or herringbone gear by sliding because of their helix angle.

The Rear axle which drives the wheels also has 4 spurs gears mounted on it which are driven by pinions. For forward motion, the Gear A and Gear C engages with Gear E and Gear G. The drive is transmitted from the gears to axle and on each end of the axle a wheel is mounted. Similarly, for Reverse Motion of the vehicle the Gear B and gear D are engaged with Gear F and Gear H after the Disengagement of the 1st Set of gears. Hence this way Vehicle can be moved in forward and reverse Direction.

The 2 V-belts are used for preventing the motor from damage under no-load. The whole system is kept in a casing in which an oil sump is there for lubrication. We have used white grease for lubrication as it is durable and lasts long. For Engagement and disengagement of gears and automatic transmission we have used lead screw. The lead screw is operated by a small motor whose rotary motion is converted into translation motion through worm gears. According to the Input given by the Control Unit Microcontroller operates the lead screw and motion is transmitted.

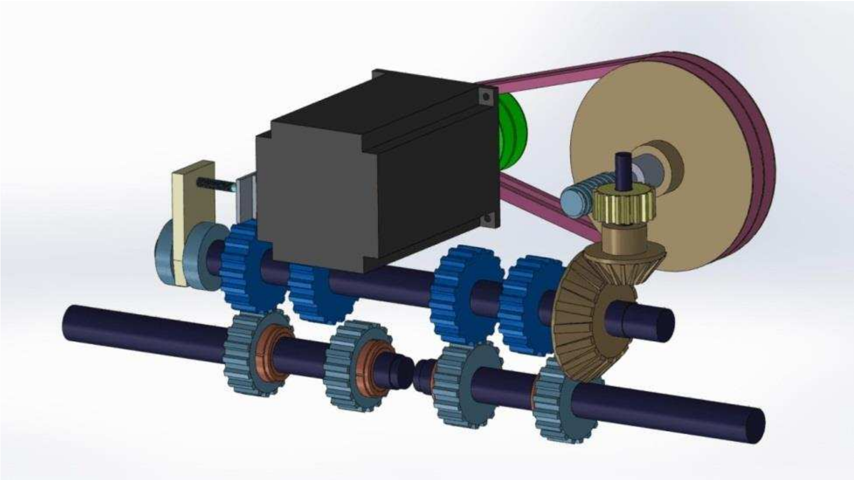

FIG: SCHEMATIC DIAGRAM OF GEARBOX

3.5. DC MOTOR

1500 RPM, 48 V DC Motor with Gearbox generally used for robotic application is used for the driving mechanism, steering mechanism. We can adjust it to desired RPM using gear box. It is drift proof and enclosed.

3.6. BATTERY

The power required for the entire working process is given by a Rechargeable 48 V valve regulated Li-iron-phosphate battery. The power from the battery is split it into two and one part is given to microcontroller, display unit, driving unit and other part is given to lifting motor.

3.7. MICROCONTROLLER

A microcontroller (µC, uC or MCU) is a small computer on a single integrated circuit containing a processor core, memory, and Programmable input/output Peripherals.

Microcontrollers are designed for embedded applications, in contrast to the microprocessors used in personal computers or other general purpose applications. We have used the **Atmel AT89S51** which is a powerful microcontroller which provides a highly-flexible and cost-effective solution to many embedded control applications

3.8. SENSORS

GP2Y0A710K0F is a distance measuring sensor unit, composed of an integrated combination of PSD position sensitive detector), IRED (infrared emitting diode) and signal processing circuit. The variety of the reflectivity of the object, the environmental temperature and the operating duration are not influenced easily to the distance detection because of adopting the triangulation method. This device outputs the voltage corresponding to the detection distance. So this sensor can also be used as a proximity sensor.

4. RESULTS AND DISCUSSION

The AGV is a productivity increasing feature in a factory. During designing this AGV we have provided the basic functions like line follows and collision avoiding. And the main function, transportation of goods from station to station. The followings are the main features of the prototype which we have designed.

1. Speed of delivery
2. Adjustment of vehicle speed
3. Flexibility of path
4. Adaptive to changes in factory layouts
5. Avoid collision with other objects
6. Reduction in labour cost
7. Reduction in running cost compared to conveyer systems
8. Ability to add sensors to detect the payload conditions
9. Continues cycle of working
10. Conditions for line following can be changed easily

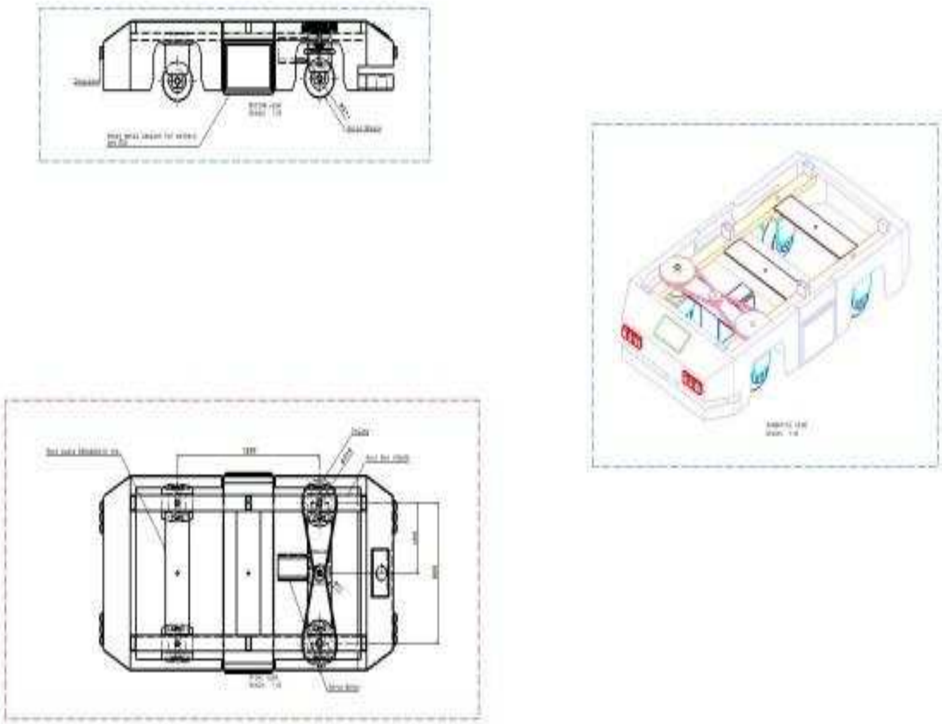

Fig 3. (a) Side view, (b) Top view, (c) Isometric view

5. CONCLUSION AND FUTURE SCOPE

Automated guided vehicle (AGV) is defined as a set of cooperative driverless vehicle, which is used on manufacturing floor and coordinated by a centralized or distributed computer-based control system. The main usage of them as mentioned is to facilitate automation process of doing manufacturing subjects.

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