DESIGN AND DEVELOPMENT OF AUTOMATED GUIDED VEHICLE (AGV) WITH ROBOTIC ARM

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Abstract—AGV with a robotic arm is a special case of the more general requirement for material transfer in a manufacturing environment. The AGV with a robotic arm describes an implemented solution for the material distribution problem in the machining shop of an automotive factory using automated guided vehicles (AGVs). I briefly describe the AGV and its associated material handling system, and then describe the intelligent components and their underlying program software, which, when put together, create an intelligent distribution system that autonomously assesses demands for materials and accordingly plans, prioritizes and executes deliveries. The system has been tested extensively in a mock environment in our laboratory.

Keywords—Automated Guided Vehicle, AGV scheduling, Intelligent System, Path Tracking & Robotic Arm.

I. INTRODUCTION

The world is approaching for a new design, why not it should be applied for the material movement system. To improve efficiency and reduce the cost of human operators in manufacturing as well assign logistics, the corporate and organizations use the robots as an efficient tool in order to achieve the remarkable tasks. [1][4] Automated guided vehicle (AGV) is one type of effeminate mobile vehicle designed primarily to move the material from one place to another. In this proposal, a robotic arm is mounted over the vehicle to transfer the load from station to the AGV and from AGV to the station. Since robots are the efficient equipment for the use of movement of material which neglects the human operator. AGV’s are commonly used in manufacturing plant, warehouses, distribution centers and terminals. [2] For navigation, AGV’s mostly use lane paths, signal paths & program paths. Various predominant sensors were also using in the AGV’s; for example, optical sensor, laser sensor, magnetic sensor and camera. Modern AGV’s are free ranging AGV’s in which their tracks are software programmed and especially they are customized one when new stations and flows are added. [3] The obstacles were also detected by the AGV and forthcoming danger in their path.

II. LITERATURE SURVEY

Prabir K. Pal*, Rahul Sakrikar, P. V. Sarngadharan, Sanjeev Sharma, V. K. Shrivastava, Vaibhav Dave, Namita Singh and A. P. Das [1] Material distribution is a special case of the more general requirement for material transfer in a manufacturing environment, and as such it permits simpler solutions. The present article describes an implemented solution for the material distribution problem in the machining shop of an automotive factory using automated guided vehicles (AGVs). We briefly describe the AGV and its associated material handling system, and then describe the intelligent components and their underlying algorithms, which, when put together, create an intelligent distribution system that autonomously assesses demands for materials and accordingly
plans, prioritizes and executes deliveries. The system has been tested extensively in a mock environment in our laboratory.

Tuan Le-Anh*, MBM De Koster, 2004 [2] this paper presents a review on design and control of automated guided vehicle systems. We address most key related issues including guide-path design, estimating the number of vehicles, vehicle scheduling, idle-vehicle positioning, battery management, vehicle routing, and conflict resolution. We discuss and classify important models and results from key publications in literature on automated guided vehicle systems, including often-neglected areas, such as idle-vehicle positioning and battery management. In addition, we propose a decision framework for design and implementation of automated guided vehicle systems, and suggest some fruitful research directions.

Mudit Sharma, 2012 [3] this paper develops a classification scheme that provides a structured mechanism for organizing the relevant information about the design of the AGVS from a control perspective. It allows the system designer to determine how design decisions will impact the control complexity. It also provides the foundation for a design aid that will help the system designer determine the most appropriate AGVS design for a specific application.

III. PROBLEM STATEMENT

The task is to devise and fabricate an AGV (automated guided vehicle) which has programmed path and with manually controlled wireless robotic arm that can pick object and place it on the vehicle and carry through a guided path to reach final destination.

IV. OBJECTIVES

An Automatic Guided Vehicle (industrial applications) to handle materials. The obstacle is sensed by means of an infrared sensor placed in front end of the robot. When the obstacle is sensed the stepper motor changes the direction of motion of the robot as per the program embedded in it or stop. The path is pre-programmed as we know where we use the robot the change in direction of motion when the obstacle is sensed can also be preprogrammed. We present approaches to perception and manipulator motion planning that enable a general purpose robotic arm to recognize and manipulate a variety of objects at a rate of one pick-and-place operation work with a remote controller carrying objects one place to another.

V. PROPOSED METHODOLOGY

A motor controller is a device that serves to control in a predetermined manner of the performance of an electric motor. A motor controller may also include an automatic or manual means for starting and stopping the motor and also in the selection of the forward or reverse rotation, selection and regulation of the speed, regulation or limitation of the torque, and also in protection against overloads and faults. For this application, the two base motors axes have a large amount of load because of the heavy arm and to drive motor smoothly a motor controller is needed. During starting and stopping, the motor controller helps to accelerate and decelerate the motor in a predefined speed to avoid damage and inaccuracy. Also the reason is that, the PLC analog output interface current is not sufficient to operate the motors. Depending upon the task, the motors are driven at defined speeds and directions which can be easy controlled using the motor controller. A DC motor is an electric motor that runs on direct current (DC). A DC motor is used for driving the axis of the robot. The axis of the arm needs a larger amount of torque than the nominal torque which is supplied by the DC motor in its nominal speed. So, the torque of the motor is amplified with the help of a gear system which is embedded in the DC motor.

VI. BLOCK DIAGRAM

![Block Diagram](https://via.placeholder.com/150)

**FIG-1: BLOCK DIAGRAM**

VII. SCOPE

- Development of automated guided vehicle plays a major role in engineering industries to improve the material handling technique for recent years.
- In this paper, an automated guided vehicle (AGV) includes a material transfer system located on the top and driving device at the bottom to move the vehicle as desired.
- The vehicle is a customized AGV in which it will do the special material handling task and also used for custom applications.
- The vehicle works on its own once the program is feed into the control device.
VIII. WORKING PRINCIPLE

It contains the all working of AGV in step wise manner the step is as following:

- Switch on the button which is place on AGV which will start the AGV then it takes the signal from Ardino Kit where all program function is to be stored. The program is to be read and signal are send to the motor controller kit then there is control of motor speed running and the AGV starts moving.
- In the path of AGV if there is an obstacle then it is sense by IR sensor an AGV is stopped till the obstacle is removed.
- After sensing obstacle IR sensor send signal to Ardino kit where processing is done on that signal and it is send to motor the motor running and AGV get stop. The accident is not happening and any damage is not due to IR sense to AGV.
- After stopping AGV then by using robotics arm the object is to be picked. In this process, there is a remote controller that can operate by a user and on AGV the receiver of that signal is placed.
- On remote control, there are 6 keys for operation. The six keys are as follows
  a) 2 keys for LEFT and RIGHT rotation
  b) 2 keys for Arm UP and DOWN
  c) 2 keys for the gripper hold and leave the object.
- When the receiver press any one key on remote controller then it sends signal to AGV that signal is taken by receiver control kit. Then send to Ardino kit where processing on that signal is done and the signal to motor and the required operation is to be done by pressing that keys properly the user pick the object and by using arm.

- Then the obstacle is removed it sensed by IR sensor then it sends signal to Ardino kit. The processing on that signal to motor driving kit to start the motor and run the AGV with object in the arm on AGV.
- AGV carries hat object for some given distance then any obstacle is detected by IR sensor then it stops again till obstacle is removed and object is placed at right place.

- After all the switch on robot is that is total working of AGV with Robotic Arm.

IX. AGV MODEL

FIG-2: CATIA 3D MODEL VIEW

X. CALCULATION

1. Voltage: 12.0VDC
2. Output Speed: 60 +/- 10% RPM
3. Torque: 14 kg cm
4. No-Load output current: <= 50 mA
5. Rotation Output: CW / CCW
6. Noise: No Gear Noise
7. Stall output: Slip Gear, Broken Gear is no allowed
8. Output shaft of the axial clearance: <= 0.1 ~ 0.3mm, Horizontal clearance requirement <= 0.05 Electrical Spec

1. PINION ON UPPER PLATE
   Teeth=38
   I.D=52mm
   O.D=60mm
   Width=12mm
   PCD=56mm

2. GEAR ON UPPER PLATE
   Gear teeth=56
   I.D=76mm
   O.D=84mm
   Width=12mm
   PCD =80mm

1. Calculation of module
   \[ m = \frac{(PCD \text{ of pinion})}{(Number \text{ of teeth on pinion})} \]
   \[ m = \frac{56}{38} \]
   \[ m = 1.473 \]
   We are taken standard value of module is 1.5
   Therefore m=1.5
   Now we are calculating following values
   1. Addendum = 1*m
      \[ = 1*1.5 \]
      \[ = 1.5 \]

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2. Dedendum = 1.25 * m = 1.25 * 1.5 = 1.875

3. Clearance = 0.25 * m = 0.25 * 1.5 = 0.37

4. Working Depth = 2 * m = 2 * 1.5 = 3

5. Tooth thickness = 1.5708 * m = 1.5708 * 1.5 = 2.3562

6. Tooth Space = 1.5708 * m = 1.5708 * 1.5 = 2.356

7. Fillet radius = 0.4 * m = 0.4 * 1.5 = 0.6

2. Centre distance between two gears = (PCD of pinion) + (PCD of gear) ÷ 2 = (80 + 56) ÷ 2 = 68

3. Permissible shear stress = (S_u) ÷ (FOS) = (75) ÷ 2 = 37.5

4. Lewis Form Factor For Pinion = 0.484 - (2.87) / (Z_p) = 0.408

Lewis Form Factor For Gear = 0.484 - (2.87) / (Z_g) = 0.448

Now, \( \sigma_{op} \times Y_p = 37.5 \times 0.408 = 15.3 \)

And, \( \sigma_{og} \times Y_g = 37.5 \times 0.448 = 16.8 \)

As \( \sigma_{op} \times Y_p < \sigma_{og} \times Y_g \), Pinion is weaker than gear so design is based on pinion

5. BEAM STRENGTH = \( \sigma_{op} \times b \times m \times Y_p = (37.5 \times 12 \times 1.5 \times 0.408) = 275.4 \)

6. WEAR STRENGTH = d_p * b * Q * K

8. \( Q = (2 \times Z_g) / (Z_g + Z_n) \)
= \( (2 \times 56) / (56 + 38) \)
= 1.1914

9. \( K = 0.16(\text{BHN} \div 100)^2 \)
= 0.16(200 \div 100)^2
= 0.64

Therefore Wear Strength = 56 * 12 * 1.1914 * 0.64 = 513.51

So, beam strength is less than wear strength

So, design is based on beam strength

For low speeds & light loads permissible pitch line velocity (m/s) is < 10,

10. VELOCITY

\( V = \pi \times d \times N_p / 60 \)
= \( (\pi \times 56 \times 60) / (60 \times 10^3) \)
= 0.1759 m/s

11. VELOCITY FACTOR

\( K_v = [3 / (3 + V)] \)
= 0.9446

12. POWER

\( P = [(2 \pi N T) / (60 \times 10^3)] \)
= [(2 \pi \times 60 \times 1373.4) / (60 \times 10^3)]
= 8.629 Watts

13. TANGENTIAL FORCE

\( F_t = P / V \)
= 8.629 / 0.179
= 49.05 N

14. MAXIMUM TANGENTIAL LOAD

\( F_{t\ max} = (K_v \times K_m \times F_t) \)
= \( (1 \times 1.25 \times 49.05) \)
= 61.31

15. DEFORMATION FACTOR

\( C = 11500 \times e \)
\( e = e_p + e_g \)
\( e_p = 8 + 0.63(1.5 + 0.025 \times (d_p)^{1/2}) \)
\( e_g = 8 + 0.63(1.5 + 0.025 \times (d_g)^{1/2}) \)
\( e = 10.12 \)
\( e = 10.12 + 10.35 \)
= 20.47

\( C = 11500 \times e \)
= 11500 \times (20.47 \times 10^3)
= 235

16. DYNAMIC LOAD

\( F_d = [21(V(bC + F_{t\ max})) / [21V + (bC + F_{t\ max})]^{1/2}] \)
= [21 * 0.1759((12 * 235) + 61.31) / [(21 * 0.1759) + ((12 * 235) + 61.31)]^{1/2}] \)
= 185.45

17. EFFECTIVE LOAD

\( F_{eff} = F_d + F_{t\ max} \)
= 246.76

18. FACTOR OF SAFETY
FOS = \frac{F_s}{F_{eff}}
= \frac{275.4}{246.76}
= 1.116

Factor of safety is < 2
Hence Design Is Safe

19. MOTOR SELECTION

1) ARM TORQUE

Lifting Load = 0.2 gm.
Distance of arm = 180 mm
Torque = 0.2 \times 9.81 \times 180
= 353.16 N-mm

2) MOTOR TORQUE

1373.4 N-mm
Hence motor torque > Arm torque
So, Motor design Is Safe

XI. CONCLUSION

It is clear that the design of this proposal is very modern and advanced. The salient feature of this proposal is that the vehicle suppresses a Robotic arm on the top for easy transaction of material. It is expected that this investigation will give higher efficiency than the existing vehicles. The cost saving is another privilege of this proposal wherein the existing AGV’s need a separate material transfer system for the transaction of material.

REFERENCES