Development of Low Cost Pellet Loading and Unloading AGV

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Abstract. This paper explains the steps and processes and components used in the fabrication of an Automated Guided Vehicle (AGV) for loading and unloading pellets in a tank producing industry. In this work, an AGV based on indoor mapping mechanism is proposed for the purpose of material handling efficiently in confined space. The AGV has four geared DC motors at the base for the wheels, the top of the AGV has a set of four rollers which are coupled by gears with one main motor, a pallet will be placed on the rollers in which the pellets will be collected. The AGV will collect the pellets on the pallet from the cutter initially. Once the pellet is filled it is detected by level sensor, and the AGV moves to the next location by avoiding obstacles with the help of the camera. The roller on top will start to rotate on reaching the required spot and this will transfer the pallet on the roller.

Keywords- AGV; indoor mapping; material handling; rollers; camera;

INTRODUCTION

An automated guided vehicle is the remote operated or automatic programmed machine which is used to transfer the material in the industry. It is the automated transporting material from one place to another with low cost manner. Using AGVs in the industry it is increase the flexibility and production time also due path is easily selected and reconfigured to accommodate new locations [1]. In olden days wires is buried under the earth and magnetic strips/ electric cable also used for the navigation, and global position system, laser techniques [2]. In the market many Unit loads AGVs is available [3]. Compare to other system this AVGS system more flexible and faster one, other system more complex and slower. [4]. The material handling is the wide process starting from the storing of raw material to the product manufacturing, it is taken so much time and cost too. To minimize the cost the process should be faster and labour cost is to be reduced. AVGS have some advantages: Reduction in Labour Charge, Increase in productivity, accuracy, High reliability, Material handling ability because to programmability, integrated operation of all AGVs [5]

There are many method is there to control the AVGS, one of the best method is the path following, based on the programming the robot is follows the path. The robot is take the decision based on the instruction is given in the programming. The predefined data store in the system once the robot move from the one place to another place it follows the path, the path data acquired from the sensors it sent to the processor and it compare to the stored data based on that the decision is taken. [6]

Most common guidance technologies in AGV are
- Landmarked based navigation system
- Behaviours based navigation system
• Vision based navigation system

1. MODELLING AND CALCULATION

1.1 Design of AGV

The AGV has a lower frame, upper frame, columns, rollers, and a tray[7]. The lower frame has four wheels coupled to geared DC motor. The columns are supported between the lower and upper frame. The upper frame has four rollers which are coupled by gears and sprockets. A tray will be placed on the top of the roller. The dimensions of AGV are length is 50cm, the breadth is 40cm, the height is 40cm.

1.2 Method

The wheels in the lower frame are coupled to a motor. Once the tray is filled with pellets the motors will start to rotate resulting in the movement of AGV. The AGV moves in the path which is already given to the AGV by means of indoor mapping. By this method the AGV will avoid obstacles[8]. After reaching the destination the IR sensor will sense it and starts the rotation of the roller, so the tray on the roller will be placed on the required spot. Then the AGV will follow its own path to the starting location.

1.3 Material Strength Selection:

Material selection equation shown in equation 1

\[
\frac{\mu}{l} = \frac{\sigma}{y}
\]  

(1)

\(\mu\)- Load  
\(\sigma\)-Stress  
I-Moment of Inertia  
y-Length
The material strength calculation is done to find the correct material that is required to fabricate the lower frame, upper frame and the column. The material is found by comparing the yield stress of the materials.

Motor Selection for wheels

\[ F = \mu \times N \]  \hspace{1cm} (2)

Where
- \( F \) - Friction
- \( \mu \) - Coefficient of friction
- \( N \) - Speed

\[ = 0.8 \times 24.5 \]

\( F \) (friction) = 19.6N

Total load for one wheel (F) = \( F\times (N/4) + F\) (friction)

Total load (F) = \( 98/4 + 19.6 = 44.1 \)N

\[ T = F \times r \]  \hspace{1cm} (3)

Where
- \( T \) – Torque
- \( F \) – Force
- \( R \) – Radius

\[ = 44.1 \times 0.05 \]

\( T = 2.21 \)N

\( N \) (speed) = \( (10 \times 60) / 2 \times 3.14 \)

\( N = 95.5 \) rpm

\[ A = \frac{v}{r} \]  \hspace{1cm} (4)

Where
- \( A \) - Angular velocity
- \( V \) – Velocity
\[ R \text{ - radius} \]
\[ v = \frac{d}{t} \]
\[ P = T \times A \] (5)

Were

\( P \) – Power
\[ P = \frac{2\pi N}{60} \] (6)

Were

\( N \) – speed
\[ v = \frac{15}{30} = 0.5 \text{m/s} \]

Angular velocity = \(0.5/0.05\) = 10 rad/sec

Power = 2.21 * 10 = 22.1 W

**Motor selection for Rollers**

Friction (F) = 7.81 N
Total Load = 27.44 N
Torque = 0.82 N
Speed = 31.52 rpm
Power = 5.4 W

**Column Calculation**

Crippling load by Euler’s equation:
\[ P_{cr} = \frac{n\pi^2 EA}{\left(\frac{L}{k}\right)^2} \] (7)

\[ P_{cr} = 11.03 N \]

**Slenderness ratio** = \( l/k \)
\[ l/k = 257.5 \]

The boundary condition is satisfied and this column is safe.

2. **ELECTRONICS COMPONENTS**

2.1 **Level Sensor:**

This sensor is used to find the level of the pellets collected in the tray. Once the sensor senses the signal will pass and the motor in the wheels will start and the AGV will move[9,10].


2.2 IR (InfraRed) Sensor:

The IR sensor is used to detect the AGV near the end location [11,12]. After the AGV reaches the end point, the IR sensor senses and the roller will start to rotate and the tray will move and land in the required spot.

2.3 Circuit Diagram:

The Arduino controller board use for the prototype purpose. The level sensor and IR sensor also connected to the arduino. The IR sensor used to find the obstacle and level sensor used to find the level of pallets. The circuit diagram of the AGV shown in figure 5.
3. RESULT AND DISCUSSION

The proposed model is in absolute working condition. The AGV is cost efficient and weighs less. The AGV starts from the cutter after loading the pellet and moves through the industry by avoiding the obstacles and unloads the pellets in the hopper. After unloading it returns back in the same path and stops in the starting point. The cycle time is perfectly achieved in its to and fro path. Using the AVG in the industry it is increase the productivity. Through designing this AGV we have provided the basic functions like path following and collision avoiding. And the main function, transportation of goods from one station to another station. The listed factors are considered while design the prototype model.

- Delivery Speed
- Vehicle speed adjustment
- Path flexibility
- Layout changes
- Collision avoidance
- Reducing labour cost
- Running cost reduced compare to conveyor system
- Add more sensors
- Continues cycle of working

By comparing the results of this project and the KhosroBijanrostami, “Design and Development of an Automated Guided Vehicle for Educational Purposes”, shows that the efficiency of this project increased.

![Performance Chart](image)

**Figure 6.** Comparison

![Fabricated AGV](image)

**Figure 7.** Fabricated AGV
4. CONCLUSION

In this project, design and fabrication of the pellet loading and unloading AGV is done. The AGV has four geared DC motors at the base for the wheels, the top of the AGV has a set of four rollers which are coupled by gears with one main motor. The AGV completes its given function of loading and unloading. The industry layout is fed into the AGV and thus the AGV moves in the exact same path and returns in the same path. Thus the functioning of the AGV is as expected.

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