Mechanical Design and Analysis of AGV for Cost Reduction of Material Handling in Automobile Industries

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ABSTRACT

Automated Guided vehicle or AGV is one of material handling equipment that has been used widely in most automotive industry today as it provides more flexibility to the system. The basic concept of the AGV incorporates battery powered and driverless vehicles with programming capabilities for path selection and positioning. They are equipped to navigate a flexible guide path network that can be easily modified and expanded. Years ago when the AGV technology first implemented, it was called driverless vehicle and navigated base on embedded wire or reflected light from paint strip mounted on the floor where the route is preprogrammed in the AGV system. Instead of navigating using fixed path, the AGV now able to navigate freely distance it has traveled or using other landmark or equipment as a reference. Through this report, the types of AGV, the basic concept, the classification of the AGV, types of navigation techniques and the steering mechanism that usually used in common AGV will be reviewed. The, this report will be focusing on the mechanical design concept of the AGV which combines knowledge on mechanical parts such as the electric motor, gears, wheels, structure of the AGV, control system and so on.

Keywords: AGV, Control System, Driverless vehicles

1. INTRODUCTION

An automated guided vehicle or automatic guided vehicle (AGV) is a mobile robot that follows markers or wires in the floor, or uses vision or lasers. They are most often used in industrial manufacturing facility or a warehouse. Automated guided vehicles increase efficiency and reduce costs by helping to automate a manufacturing facility or warehouse. The AGV can tow objects behind them in trailers to which they can autonomously attach. The trailers can be used to move raw materials or finished product. The AGV can also store objects on a bed. The objects can be placed on a set of conveyor and then pushed off by reversing them. Some AGVs use forklifts to lift objects for storage. AGVs are employed in nearly every industry, including, pulp, paper, metals, newspaper, and general manufacturing. Transporting materials such as food, linen or medicine in hospitals is also done.
2. PROBLEM STATEMENT

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 combination of suitable and 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 this project, basic mechanical of AGV will be designed by combining all the factors for this project, basic mechanical of AGV will be designed by combining all the factors for this project.

3. MECHANICAL DESIGN AND ANALYSIS

3.1 Chassis

The chassis was designed in NX 9 Modeling software and it was analyzed in ANSYS R15. The chassis was designed to take a static load of 20kg minimum. The Top part of chassis has lots of drilled holes which serves as holes for bolting other parts and reduce the weight of the chassis. The Holes are arranged in a zigzag linear arrangement so that the decrease in strength of chassis is not considerable. The flange which holds the motor was designed in a way that there is at least 10mm so that it can safely accommodate any bending due to loading above the designed value. The flange which holds the motor was designed in a way that there is at least 10mm so that it can safely accommodate any bending due to loading above the designed value. The chassis incorporates mounting holes for both Ackermann steering and Differential steering system.


<table>
<thead>
<tr>
<th>Dimension</th>
<th>Data of AGV (mm)</th>
<th>Data of Trolley (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>1512</td>
<td>1500</td>
</tr>
<tr>
<td>Breadth</td>
<td>810</td>
<td>800</td>
</tr>
<tr>
<td>Height</td>
<td>200</td>
<td>645</td>
</tr>
<tr>
<td>Wheel diameter</td>
<td>150</td>
<td>100</td>
</tr>
</tbody>
</table>
3.2. Load Tests

We made a done the load test for the trolley to know the maximum load capacity of our trolley. The load test was done in R15 analysis software. The following load tests were made on the trolley based on the working load of 200N for each tray and the result.

![Fig.9 Deformation diagram](image9)

![Fig.10 Strain analysis of trolley](image10)

![Fig.11 Stress analysis of trolley](image11)

The following load tests were made on the trolley based on the Extreme load of 10000N for each tray and the result for the minimum factor of safety value 1.0691.

![Fig.12 Deformation diagram](image12)

![Fig.13 Stress analysis at maximum load](image13)

![Fig.14 Factor of safety](image14)

![Fig.15 Structural error](image15)
4. PATH PLANNING

4.1 Spatial graph theory

Let us assume the factory machines arranged in grids. The Blue Lines represent the pathway through which the AGV can move. For reaching the destination, the AGV has to go 6 Units right and 4 units forward.

For ease, let us denote going up as ‘u’ and right as ‘r’. Therefore the path shown above is $r r r u u u r r$.

By Using Permutations and combination the different combinations for the path is equal to $rac{10!}{6!4!} = 210$.

Therefore, to move x units in one direction and y units in another perpendicular direction to reach the destination, a AGV has Ways.

$$\frac{(x + y)!}{x!y!}$$

The ways are still less when more than one AGV is used as the path allotted to an AGV is subject to the following considerations

- The path is not currently in use by other AGV
- The path does not cross the lines being used by other AGV.
- The path is under maintenance
5. ANALYSIS VEHICLE BASED SYSTEM

\[ T_c = delivery\ cycle\ time\ (min/del) \]
\[ TL = time\ to\ load\ (min)\ — 0.75\ min \]
\[ Tu = time\ to\ unload\ (min)\ -- 0.5\ min \]
\[ Ld = distance\ b/w\ load\ to\ unload\ (110m) \]
\[ Le = distance\ b/w\ unload\ to\ load\ (80\ m) \]
\[ v = \text{vehicle\ velocity}\ (50\ m/min) \]
\[ T_c = TL + \frac{Ld}{v} + \frac{Le}{v} + Tu \]
\[ T_c = 0.75 + \frac{110}{50} + \frac{80}{50} + 0.5 \]
\[ T_c = 5.05\ min \]

Tc ideal value because it ignores
- Traffic congestion
- Reliability problems etc

5.1 Rate of Deliveries Per Vehicle

Possible time loss includes;
- Availability (A) - Proportion of total shift time that the vehicle is operational and not broken down or being repaired.
- Traffic congestion (Tf)- blocking, waiting in queue etc
- Efficiency (E)-of manual drivers if any (worker efficiency)

if not apply is taken as unity (1)
\[ AT = \text{available\ time}\ (min/hr\ per\ vehicle) \]
\[ AT = 60 \times A \times Tf \times E \]
\[ Rdv = \text{rate\ of\ deliveries\ per\ vehicle}\ (del/hr\ per\ vehicle) \]
\[ Rdv = \frac{AT}{T_c} \]

5.2 Number of Vehicles Required

\[ Rf = \text{specified\ delivery\ schedule\ or\ total\ delivery\ requirements}\ (del/\ hr\ per\ vehicle) \]
\[ WL = \text{Work\ load}(\text{min/hr}) \]
\[ n = \text{number\ of\ vehicle\ required} \]
\[ n = \frac{WL}{AT} \]
\[ n = \frac{Rf}{Rdv} \]

7. CONCLUSION

From this the optimization the following factors are implemented in the automobile industries. In the material handling process, the cost of this process is decreased considerable amount. The production time management is also decreased. The defect of the product is also decreased. The machining area is decreased by implementing the self-driving of vehicle using Line follower technology Concept.
REFERENCES


