Innovative Convolift Design for Efficient and Scalable Material Handling

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***Abstract*—This study presents the design of a cost-effective flexible convolift for material handling. Automated Guided Vehicles (AGVs) are essential components of contemporary material handling systems, improving automation, safety, and efficiency in sectors like manufacturing, warehousing, and logistics. These autonomous trucks move cargo with little assistance from humans, saving money on labor and increasing operational precision. AGVs use cutting-edge technologies, including as sensors, LiDAR, artificial intelligence, and path-planning algorithms, to follow predetermined paths, stay clear of obstructions, and streamline processes. They can be used for order picking, assembly line support, inventory transfer, and pallet transportation. By incorporating AGVs into material handling procedures, companies may increase worker safety, decrease downtime, and increase productivity. Future intelligent and effective supply chain management is anticipated to be significantly shaped by AGVs as industries continue to embrace automation.**

***Keywords:* AGV, Lidar, Artificial intelligence, Path-planning algorithms, RFID.**

I. DESIGN AND CONSTRUCTION

Automation is essential to increasing productivity, cutting expenses, and guaranteeing safety in today's industrial environment. This change is being led by AGVs, especially in material handling operations. These self-driving cars go across manufacturing floors and warehouses, hauling and moving items without the assistance of a human. Our project's main goal is to create a cutting-edge AGV system for material handling that will improve internal logistics, expedite processes, and raise industrial surroundings' general efficiency. In order to provide smooth material flow, we will examine the system's design, navigation, automation features, and integration with current infrastructure.

Mechanical Design: The AGV's mechanical framework is made to be strong, lightweight, and portable. The chassis of the vehicle is designed to accommodate a range of payloads, guaranteeing stability even when transporting bulky objects. A sturdy frame, wheels for easy mobility, and a versatile load-carrying platform are essential mechanical parts. To make loading and unloading materials easier, the platform could have rollers or extendable arms.

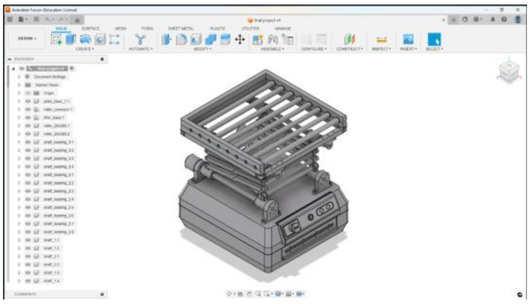

Fig-1(3D Design)

Control System: The AGV's control system is its fundamental component. Autonomous navigation, decision-making, and real-time control are managed by an embedded computer system or on-board microcontroller. For obstacle detection and avoidance, this system incorporates sensors like LIDAR or ultrasonic sensors. The AGV also has encoders for accurate location monitoring and speed control, which guarantees that it precisely follows predetermined routes.

Scissor lift design: This hybrid technology automates both vertical and horizontal material delivery, increasing productivity in manufacturing plants, logistics hubs, and warehouses. The scissor lift mechanism allows vertical movement for loading, unloading, or assembly activities at various heights, while the AGV base allows autonomous navigation using sensors, LiDAR, and AI-driven path planning. In settings where frequent lifting and material movement are necessary, this integration reduces the need for human intervention, enhances workplace safety, and maximizes space usage. Order picking, inventory control, and assembly line automation are a few examples of applications.

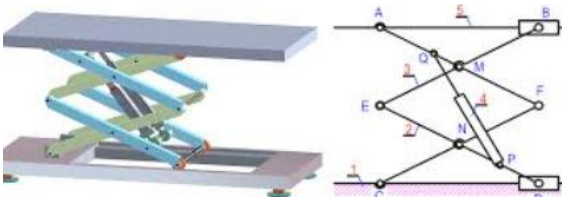

Fig-2(Scissor lift design)

Navigation and Path Planning: The AGV's capacity to move around the workspace on its own is a critical component of its operation. The AGV can create and update a map of its surroundings by combining sensor data and SLAM (Simultaneous Localization and Mapping), which allows it to identify obstacles and choose the best pathways. By preventing collisions and cutting down on delays, this technology guarantees that the AGV can travel effectively even in dynamic surroundings.

Power and Drive System: An energy-efficient and dependable battery system powers the AGV, allowing for ample operating time in between recharges. As the AGV navigates the facility, the drive system's motors, which are managed by a motor driver circuit, allow for accurate movement and speed adjustments.

II. ARCHITECTURE

To accomplish smooth automation in material movement, the Material Handling Automated Guided Vehicle (AGV) is built with a top-to-bottom architecture that combines many subsystems, such as mechanical, electrical, and control components. Using a scissor lift positioned above a roller conveyor, this AGV is designed to manage intricate material handling duties with both vertical and horizontal transfer capabilities. Additionally, the system integrates cutting-edge navigation technology, such as RFID-based station identification, infrared (IR) sensors, and magnetic tape guidance, all of which were managed by a centralized PLC.

Top Layer: Mechanism for Material Handling

The roller conveyor system, located at the uppermost layer of the AGV, makes it easier for goods to travel horizontally during loading and unloading activities. DC motors power the conveyor, ensuring controlled and seamless product movement. For accurate material transfer, the PLC controls these motors, which are coordinated with the AGV's lifting mechanism. The rollers are made to support a range of material weights while remaining stable while being transported.

Fig-4(Roller conveyor)

2. Middle Layer: Sensing and Navigation System

The navigation and sensing parts of the AGV, which are in charge of directing the vehicle along predetermined routes and locating operating stations, are located in the intermediate layer. The main navigation system is based on magnetic tape guiding, in which the AGV's path through the operational area is marked with magnetic tape. To detect this magnetic tape and guarantee precise path-following capabilities, infrared (IR) sensors are installed beneath the AGV. To provide accurate and collision-free navigation, the PLC continuously receives feedback from the IR sensors and modifies the AGV's steering and speed to keep it aligned with the tape.

The AGV employs RFID technology for station identification in addition to navigation. An onboard RFID reader picks up RFID tags that are positioned at strategic points throughout the AGV's path. The PLC initiates related operations, such as stopping the AGV, raising or lowering the scissor lift, or running the roller conveyor, when a certain tag is read.

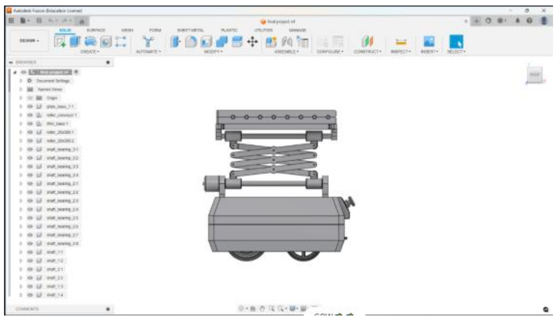

Fig-5(Scissor lift compression)

Bottom Layer: Drive and Power System

The drive and power system, which provides mobility and supplies electricity to all onboard components, occupies the bottom layer of the AGV. Two DC motors mounted on the AGV's wheels provide power. With the help of motor drivers and encoders, these motors may be precisely controlled in terms of both direction and speed. By giving the PLC real-time feedback, the encoders allow the AGV to move dynamically in response to navigational inputs. Even when the scissor lift is completely extended, the dual-motor arrangement enables stable movement and smooth rotations.

The high-capacity lithium-ion battery powers the whole AGV system.Due to its high energy, extended lifespan, and low maintenance needs, this battery was selected.

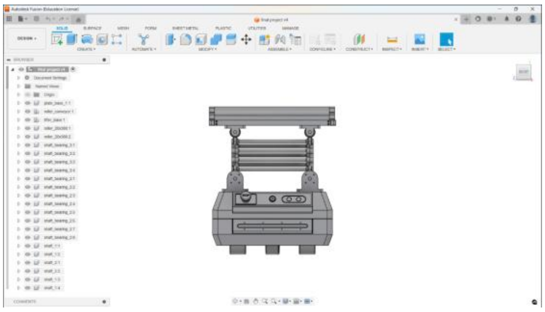

Fig-6(Base model)

Control Layer PLCs, or programmable logic controllers

The controller for programmable logic (PLC), which serves as the main control unit and oversees all of the subsystems, is the essential component of the AGV's architecture. To make informed judgments about navigation, material handling, and safety procedures, the PLC analyzes real-time data from the motor encoders, RFID reader, infrared sensors, and other feedback devices. It guarantees that the roller conveyor and scissor lift run in unison during material transfer operations, avoiding any mistakes or delays in operation.

In order to guarantee that the AGV can manage unforeseen circumstances, including navigational deviations or sensor failures, the PLC also manages error detection and recovery.

Safety and Communication Systems

The AGV has all the necessary safety features, such as alert indicators, obstacle detection sensors, and emergency stop buttons. These characteristics guarantee the security of the AGV and the workers around. The AGV can identify obstacles in its route thanks to its obstacle recognition sensors, and depending on how close an obstacle is, it can either slow down or stop.

The AGV also has wireless communication modules that enable it to connect to other AGVs or warehouse management systems (WMS). When several AGVs are placed in the same area, this communication feature guarantees coordinated operations, avoiding collisions and streamlining material handling procedures.

EQUATIONS

To guarantee dependable and effective operation, the design of a Material Handling AGV with a scissor lift over a roller conveyor necessitates meticulous computation of the overall power and energy consumption. The sum of the power requirements for the three main subsystems—the roller conveyor, the scissor lift mechanism, and the AGV propulsion system—determines the system's overall power need (P_{total}). Every subsystem has a distinct contribution to the total energy usage and needs to be assessed separately.

The power needed to drive the AGV and its load is known as the propulsion power ($P_{propulsion}$). It can be computed by multiplying the force needed to overcome rolling friction by the AGV's intended velocity.

$P_{propulsion} = ((m_{AGV} + m_{load}) * g * \mu * v$ is the equation.

The force necessary to raise the weight vertically and the lifting speed are then used to determine the power needed for the scissor lift mechanism (P_{lift}). The geometry of the scissor lift, specifically the angle of the scissor arms and the intended lifting height, affects the force that the lifting actuator needs to provide.

$P_{lift} = (((W_{load} * H) / (L * \cos(\theta))) * v_{lift}) / \eta_{lift}$ is the formula for lifting power.

The weight of the load and the lifting platform (N) is denoted by W_{load}, the desired lifting height (m), the length of the scissor arm (m), the angle of the scissor arm with respect to the horizontal plane (θ), the lifting speed (m/s) by v_{lift}, and the lifting mechanism's efficiency by η_{lift}. This formula makes sure that the scissor lift runs smoothly and effectively by highlighting the connection between mechanical geometry and power consumption.

Lastly, transporting goods across the conveyor platform requires the roller conveyor power (P_{roller}). The torque necessary to rotate the rollers and the angular velocity at which they function determine how much power is needed. The roller conveyor power equation is:

$(((F_{roller} * r) / \eta_{roller}) * \omega) / \eta_{roller} = P_{roller}$

F_{roller} is the force needed to move the load on the conveyor (N), r is the roller's radius (m), ω is its

angular velocity (rad/s), and η_{roller} is the roller mechanism's efficiency. This guarantees that the chosen motor can manage the frictional forces of the load while preserving seamless material transfer.
These three elements work together to provide the AGV system's overall power usage, which is as follows:

P_{total} is equal to $P_{roller} + P_{lift} + P_{propulsion}$.

Dc Gearmotor calculation

Speed = 1.7km\h = 1.7*1000/3600 = 0.472m/s

Wheel diameter 10cm = 0.1m

Radius = 0.1/2 = 0.05m

Formula:
RPM = Speed(m/s)*60 / Wheel circumference(m)

Calculation:
RPM = 0.472*60 / 0.314 = 90.3 RPM

The required wheel RPM is 90RPM

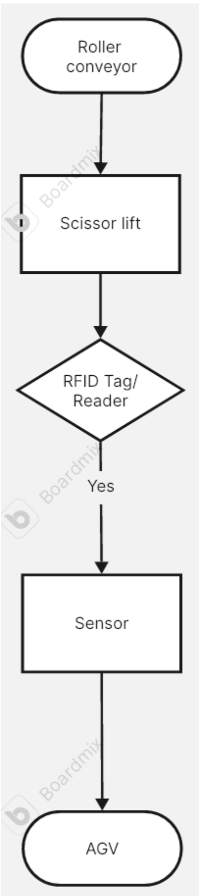

Fig-6(Process flow)

III. CONCLUSION

A revolutionary move toward more intelligent, flexible, and highly effective logistics operations is represented by the incorporation of (AGVs) into material handling systems under the Flexible Convolife concept. AGVs improve material flow, decrease human interference, and increase efficiency in warehouses and manufacturing facilities by utilizing sophisticated navigation, AI-driven automation, and seamless connection. They are essential to contemporary supply chains because of their versatility in managing a range of loads, negotiating changing conditions, and integrating with Industry 4.0 technology. AGVs are becoming more affordable and scalable because to ongoing developments in robotics and the Internet of Things, despite obstacles like initial investment and infrastructure compatibility. In the future, Flexible Convolife sees AGVs moving beyond strict programming to dynamically adjust to needs in real time, guaranteeing material handling operations' sustainability, safety, and agility.

One of the most important aspects of the design process is component availability.Every component might or might not be accessible locally. The budget for the local industries that are interested is increased when the necessary components are imported from other nations. As a result, the PCB design is a multifunctional circuit that can be enhanced and adjusted to satisfy industrial needs using parts found in nearby electronics stores. Additionally, the components employed are readily available, reasonably priced, and offer the highest performance. The coding is versatile and easy to use, and it is shown in a more straightforward manner. so that anyone with rudimentary programming knowledge of the Embedded C language can edit it. Additionally, you don't need to know this programming language to operate the AGV. The best coding and simulation software has libraries that can be expanded to work with any microcontroller. With a few tweaks, the code can be utilized in a variety of applications. This technique can also be employed with sonar and magnetic sensors. Additionally, the system can be set up to follow wired or unwired guide pathways. This system's TSOP sensors will enable it to move even under direct sunlight.

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