DESIGN AND FABRICATION OF SOLAR POWERED OVER HEAD CRANE FOR LOGISTICS VEHICLE

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***Abstract*—**Material handling is a common challenge in many industries, leading to the use of cranes and Electric Overhead Traveling (EOT) systems. This project presents a solution by designing an overhead crane that is built into a truck trolley. This system helps move heavy loads from outside the truck to inside and also within the truck. The overhead crane extends beyond the truck's chassis, making it easy to lift nearby loads and place them inside. It can move in all three directions and runs on a battery-powered motor. To improve efficiency, a solar panel is also installed as a backup power source. This system reduces manual labor, speeds up loading and unloading, and lowers costs. This type of crane is especially useful in construction, the oil and gas industry, and railway logistics, where moving heavy loads is a challenge. By adding an overhead crane to a truck, this system makes material handling safer, faster, and more efficient.

Keywords: Gantry, Hoist, Boom, Carriage, Trolley, Bridge Cranes etc.

I. INTRODUCTION

An overhead crane is a machine used to lift, move, and lower heavy objects in places like factories, warehouses, shipyards, and construction sites. It has two main tracks called runways, with a bridge that moves between them. This allows the crane to lift and transport loads in different directions. The key parts of an overhead crane include the bridge, which spans the work area, and the runway, which supports the bridge. The hoist is the part that lifts and lowers the load, while the trolley carries the hoist and moves along the bridge. End trucks help support the bridge, and the crane is controlled either manually, with a remote, or automatically. Safety features like limit switches, overload protection, and emergency stop buttons help prevent accidents.

There are different types of overhead cranes. Single girder cranes have one main beam and are used for lighter loads, while double girder cranes have two beams and can lift heavier loads. Gantry cranes have legs and move on tracks or wheels, while jib cranes have a rotating arm for lifting objects in a small area. Monorail cranes use a fixed track for moving items in a straight line. Overhead cranes are very useful because they reduce the need for manual lifting, making work faster and safer. They also save space by using overhead areas and can handle very heavy loads with ease. This helps businesses improve productivity and reduce costs in the long run.

These cranes are used in many industries, such as manufacturing plants for moving materials, warehouses for storing and transporting goods, and steel factories for handling heavy metal items. They are also important in construction for lifting materials and in shipbuilding for assembling and maintaining large ships. Overall, overhead cranes help make work easier, safer, and more efficient. Regular maintenance and proper training are necessary to ensure they work well and last a long time.

1.1 Evolution of Mobile Cranes

Mobile cranes have changed a lot over time, becoming more powerful, efficient, and easy to use. They started as simple manual machines and have evolved into advanced, computer-controlled lifting systems.

• Early Mobile Cranes

In ancient times, people used wooden cranes with ropes and pulleys to lift heavy objects. The Romans built mobile cranes on carts to move materials for roads and buildings. During the medieval period, treadwheel cranes (powered by people walking inside a wheel) helped in construction, but they were still difficult to move.

• Steam-Powered Cranes (18th–19th Century)

The Industrial Revolution brought steam-powered cranes, making lifting easier and more efficient. These cranes were often mounted on railways for loading and unloading cargo. British engineer William Armstrong developed hydraulic and steam-powered cranes, improving lifting capacity.

• Diesel and Electric Cranes (20th Century)

In the early 1900s, diesel and electric engines replaced steam, leading to truck-mounted cranes. Hydraulic systems were introduced, allowing smoother and more controlled movements After World War II, rough-terrain and telescopic boom cranes were developed, making cranes more versatile.

• Modern Mobile Cranes (21st Century)

Today, mobile cranes use advanced technology like GPS, remote controls, and artificial intelligence to improve safety and efficiency. Hybrid and electric-powered cranes are being developed to reduce fuel use and pollution. Some companies are also exploring solar-powered cranes for a greener future.

1.2 Types of Over Head Cranes

Overhead cranes are widely used in industries to lift and transport heavy materials efficiently. They come in different types, each designed for specific applications based on load capacity, structure, and operational needs.

1.2.1 Bridge Cranes

Bridge cranes are the most common type, featuring a horizontal bridge that spans the width of a workspace. They are supported by either a building structure or freestanding columns. Single girder bridge cranes have only one main girder supporting the hoist, making them cost-effective and lightweight, typically handling loads up to 20 tons. They are commonly used in warehouses, small manufacturing plants, and assembly lines. Double girder bridge cranes, on the other hand, have two girders, providing increased strength and stability, and are suitable for heavy-duty applications, often exceeding 100 tons.

• Components of Bridge Cranes

Bridge cranes consist of several key components, including the bridge, girders, hoist, trolley, and end trucks. The bridge is the horizontal beam that spans the workspace, while the girders are the main structural members that support the hoist. The hoist is the device that lifts and lowers loads, and the trolley is the mechanism that moves the hoist along the bridge.

1.2.2 Gantry Cranes

Gantry cranes are another type of overhead crane, supported by legs that move on rails or wheels, making them suitable for outdoor and large open-space applications. Full gantry cranes have two vertical legs supporting the bridge and can handle extremely heavy loads, sometimes over 200 tons. Semi-gantry cranes, on the other hand, have one side supported by a leg on the ground, while the other side is attached to an existing structure, such as a wall or column.

• Types of Gantry Cranes

Portable gantry cranes are small, mobile cranes that can be easily moved and assembled, typically used for light-duty applications in workshops and maintenance areas, with a lifting capacity of up to 10 tons. Gantry cranes consist of several key components, including legs, bridge, hoist, trolley, and wheels or rails.

1.2.3 Jib Cranes

Jib cranes consist of a horizontal boom (jib) that rotates around a central point, making them ideal for localized lifting operations. Free-standing jib cranes are mounted on a vertical post and can rotate 180° to 360°, handling up to 15 tons. Wall-mounted jib cranes are attached to a wall or an existing column, saving floor space while providing lifting capabilities up to 5 tons.

1.2.4 Monorail Cranes

Monorail cranes feature a single rail along which the hoist moves in a fixed path, commonly used in assembly lines and manufacturing processes. They are simple in design, cost-effective, and suitable for linear lifting tasks.

II. Objective

The aim of this project is to design and fabricate a solar-powered overhead crane inside a truck, providing an efficient and eco-friendly solution for lifting, moving, and unloading heavy materials. The crane will be integrated within the truck to allow easy transportation and handling of loads without requiring external lifting equipment. This project will focus on determining the maximum load capacity the fabricated crane can safely lift and operate without causing structural failure or affecting the truck's balance. A detailed analysis of the normal reaction forces acting on the wheels of the truck will be conducted to ensure that the additional load does not compromise the vehicle's stability, maneuverability, or suspension system. Another critical aspect of the project is the calculation of the minimum torque required to lift a specific load, which is essential for selecting the right motor, gearbox, and pulley system. By optimizing these mechanical components, the crane can operate efficiently while minimizing energy losses. The study will also compare the performance and efficiency of the solar-powered crane with a traditional electrically powered industrial overhead crane, considering key factors such as power consumption, lifting speed, operational feasibility, and load-handling capability.

This comparison will help in understanding the advantages and limitations of using solar energy for material handling applications. Furthermore, the project will explore the structural design, material selection, and energy management system to enhance the durability and efficiency of the crane. The integration of solar panels, batteries, and electrical components will be examined to ensure a reliable power supply for continuous operation. The findings of this study will contribute to the development of a sustainable, energy-efficient, and cost-effective lifting solution that can be used in industries where mobility and flexibility are crucial.

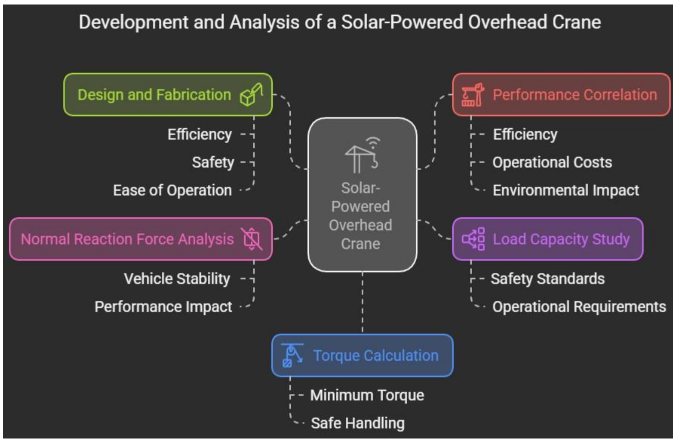

Figure 1.1: Development and Analysis of a solar-Powered overhead crane

The primary objective of this research paper is to design and develop a solar-powered overhead crane specifically for logistics vehicles. The aim is to create an efficient, cost-effective, and environmentally friendly solution for lifting and moving heavy loads. Traditional overhead cranes typically rely on electricity or fuel-powered engines, which lead to high operational costs and increased carbon emissions. By using solar energy, this study explores a sustainable alternative that reduces energy costs and minimizes environmental impact while maintaining high performance.

The research involves designing a sturdy and efficient crane system that can lift and transport heavy goods with minimal energy consumption. This includes selecting suitable materials, integrating solar panels for power generation, and implementing a reliable control system for safe and smooth operation. The fabrication process requires careful planning to ensure that the crane is lightweight yet strong enough to handle heavy loads. Factors such as weight distribution, structural stability, and energy efficiency are considered in detail to optimize performance.

Once fabricated, the crane is tested under real-world conditions to evaluate its lifting capacity, power efficiency, and operational reliability. The study also examines potential challenges, such as energy storage for nighttime operation and the durability of solar panels in different weather conditions. By addressing these factors, the research aims to develop a practical solution that can be widely used in warehouses, factories, and logistics hubs. Ultimately, this project contributes to the advancement of sustainable material handling systems by promoting the use of renewable energy in industrial applications. The solar-powered overhead crane offers a cleaner and more cost-effective alternative to conventional lifting systems, helping businesses reduce their carbon footprint while improving operational efficiency. This research highlights the potential of solar energy in industrial logistics and encourages further innovation in green technology for material handling.

III. Design and methodology

3.1 Introduction to design

In this chapter design of over head crane and logistic vehicle is performed. First we have developed a CAD model with the help of CATIA V5 software. For design, of various parts and components in this project, We have taken many design consideration such as selected material should be posses more strength by which it can be bear the load of complete model, a number of components attached with overhead crane should be light in weight, economical and durable.

3.2 Design Procedure

Ihe steps are describe in the flow chart.

1. Our first step was to design the vehicle's body. For the vehicle's body, we chose plywood that is strong, capable of carrying the weight of the complete crane assembly and the load it will lift.

2. In the second step we designed the vehicle cabin made up of a solid material, which will be assembled with the vehicle body. The cabin consists of two pockets for the windows and one for the front.

3. For running of the over head crane we designed rack and pinion gear using rectangular pattern. This will help in moving the over head crane on the rack in CATIA commands such as rectangle, pad, pocket, circle, arc, linear pattern and rectangular pattern. This will help in moving the over head crane on the rack in horizontal direction.

4. Our over head crane design includes the design of the spool on which a rope will wrap around, the shaft for connecting the pinion, the bed, the motor brackets, and the hook design. Assembling these parts will form a complete overhead crane.

5. In the last step all parts will be assembled together and shows the design of over head crane and the vehicle in we have to install the crane.

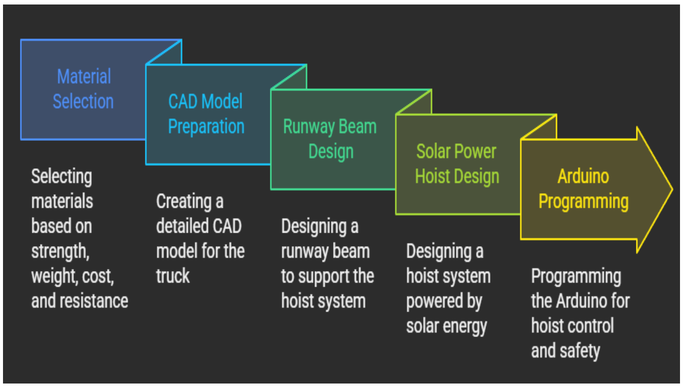

Figure 3.1: Design and methodology of Solar-Powered overhead crane

3.3 Part Design

3.3.1 Design of Cabin

First We designed a cabin for a vehicle in which the overhead crane will be installed. This cabin is designed with many commands such as line, circle, trim, shell, pocket, pad. The specifications of the cabin are : Thickness of wooden sheet used here for the fabrication of the cabin (4cm), Length of cabinet (22am), height of the cabinet (30cmn), width of cabinet(22cm).

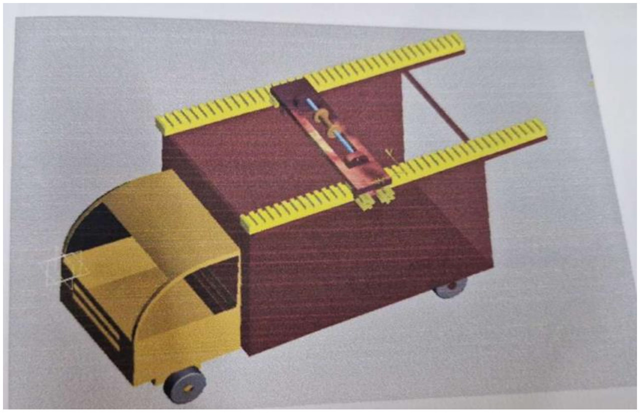

Figure 3.2: Design of Cabin

IV. Component of Over Head Crane

4. Basic Component of Over Head Crane

4.1 Hook

Lifting hooks are used to hold and lift loads using a forklift or crane. Lifting hooks are usually equipped with a safety device to prevent the rope, chain or cable to which the load is attached from becoming detached. A hoist lifts, holds, raises or lowers a load by steel rope or chain. Hoists can be operated either manually, electrically or with compressed air (pneumatic). The carriage supports the hoist and moves horizontally along the crane bridge to deploy the hoist and hook.

4.2 Hoist

A load-bearing beam that spans the building width. Ilt is the main structural component that connects the track and moves the forklift back and forth through the carriage. Bridges can consist of one or two beams, commonly referred to as single-girder or double-girder structures. The beam can be made of rolled steel by welding it to a steel crate.

4.3 Bridge

The bridge is the main structure of an overhead crane that moves along the length of the work area. It spans across the width of the space and supports the lifting mechanism. The bridge allows the crane to transport heavy loads from one point to another. A load-bearing that runs the width of the building. This is the primary structural component that connects the runways and moves the hoist forward and backward using a trolley.

4.4 Runway Rail or Tracks

A bridge can be comprised of one or two beams more often referred to as a single girder or double girder design Girders can be made of rolled steel or can be fabricated by welding the beams into a steel box design. Rail supported by the runway on which the crane travels. Top-running cranes typically run on ASCE/railroad rails. Gantry cranes can also utilize a rail or track system installed in the floor to move the bridge back and forth.

4.5 Controls

The controls are usually panel mounted on the crane or hoist and allow the operator to control the crane via an overhead or remote radio console. The control unit can drive a variable frequency drive (VFD) to control the drive and lift motors and adjust

the lift speed for accurate load sensing. Operates the crane and includes pendant controls, radio remote controls, or a cabin for an operator.

4.6 Electrification

Insulated conductor bars or festoon systems (flat cables) bring power to the crane from the building.

When we installed a crane before we must consider some parameters

- Motion of the crane structure.
- Weight and type of material /load.
- Location of the crane--indoors or outdoors.
- Required capacity.
- How often the crane will be used.
- Length or span of the crane.

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V. Fabrication Process

5. Fabrication Process

5.1 Introduction

Fabrication of overhead crane for logistics vehicle contains many steps which are following in this chapter. The complete fabrication is fitted as our design consideration. There are many materials are used in fabrication of solar powered overhead crane for logistics vehicle, which are listed below.

Sr. No.	Materials	Quantity
1	Wooden Sheet	11
2	Iron rod	4
3	Rack gear	4
4	Pinion	4
5	Wheel	4
6	Bearing	3
7	Stepper Motor & clamp	2
8	DC Motor & clamp	5
9	Spool & Pulley	1
10	Rope & hook	1
11	Arduino	1
12	Bluetooth Connections	1
13	Motor driver shield	1
14	Motor driver	2
15	Battery	1
16	Solar panel	1

Table 5.1: Materials used in fabrication

5.2 Fabrication Flow Chart

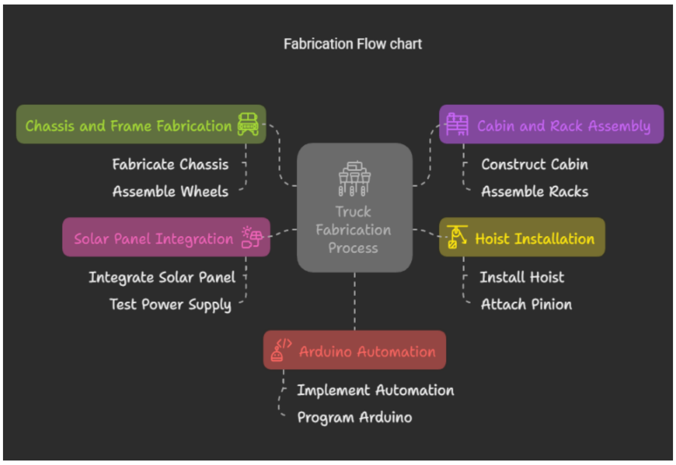


Figure 5.1: Fabrication Flow Chart

5.3 Fabrication Process

We fabricate a solar powered overhead crane for logistics vehicles using all the above materials. We prepared some parts and assembled them with prototype. Our complete fabricated prototype consists of many parts, and then all parts are fabricated together, and we prepare our prototype. In order to fabricate a solar powered overhead crane for a logistic vehicle, we plan to follow the following steps:

• First we prepare the chassis of the vehicle on which we mount the complete vehicle. This chassis is made from waste iron rods. Grinding, surface finishing and welding processes are used for the fabrication of the cassis of the vehicle.

•With the help of wooden plywood, we prepared a vehicle body that will hold the load of the overhead mounting A wooden ply is attached with adhesive, hardnar, and nails. It is used to carry goods and products.

• The cabin of the vehicle is prepared with wooden ply This wooden ply IS fixed with adhesive, hardner and the nails. Cabin has three slots for windows and front glass. Acrylic sheets cover these slots.

- In this step the fabrication of the overhead frame is done. A slot is given to the bed where the wire or the rope will be passed through. Under the overhead bed, there are four brackets for holding the shafts. Two brackets control the pinons, while two brackets control the pulley.
- The shaft on which the pulley will be mounted is prepared in this step. This shaft is prepared with waste iron rebers. There are many processes included in the preparation of the shaft such as drilling, turning and grinding for the surface finish.
- **Assembly of vehicle** Contains chassis, body, cabin, shafts, rack base, rack, gear and wheels. The chassis contains four wheels and DC motors which drive the vehicle. These all parts assemble together and build the vehicle. These parts are fixed together by nuts and bolts, nails and adhesives.
- **Assembly of overhead crane,** there are a number of components including a bed, shafts, spool, stepper motor and DC motor. The pinions are connected to the stepper motors. A DC motor is used to rotate the spool.

5.4 Fabricated Prototype

Figure 5.4: Fabricated Prototype

VI. Experimental Analysis

6.1 Experimental Setup

In this experimental setup, an overhead crane is used to handle material on a logistics vehicle. In this case, the rope extends to reach the location of the material. Automation controls the motion of the rope and overhead crane. In our experiment, various dead loads are applied on hook and material handling capabilities of vehicle is investigated. The fabricated overhead crane assembly can crawl on the guided rack base after lifting the load. We have considered some parameters such as load of material, motor torque, tension in rope and time taken for the complete process.

6.1.1 Experimental process

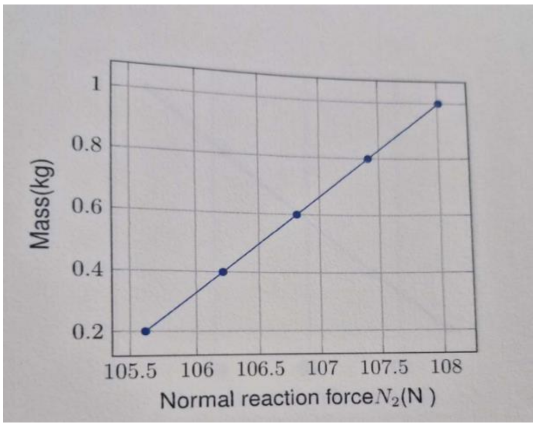
We followed many steps for experimental computation of various analysis such as experimental study of normal reaction force acting on the wheels of vehicle when the overhead crane is at the center of the vehicle or the overhead crane reaches its limits or center of the vehicle.

Experimental computation of force equilibrium equation:

- When overhead crane inside the vehicle.
- When overhead crane outside of the vehicle.

6.1.2 Experimental study on torque of the motor

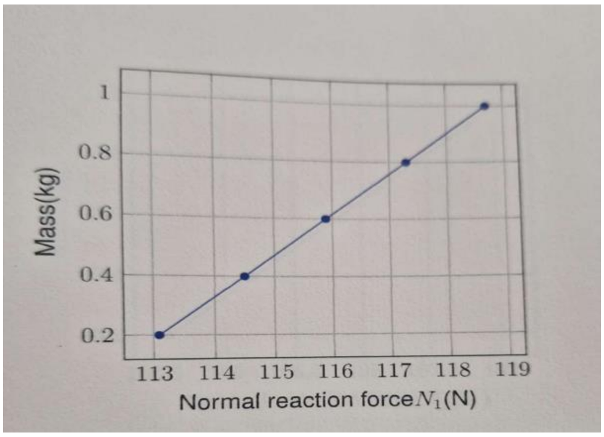
The torque of motor variate with respect to the hanging load on the over head crane. As our consideration the motor torque should be greater than the the product of moment of inertia and the angular momentum of the pulley.



Graph 6.1: Torque of the Motor

6.1.3 Experimental study on normal reaction force at wheels

Normal reaction force by means of a force acting perpendicular to two surfaces in con- tact with each other. Here we compute normal reaction forces, acting on front wheel of the vehicle while lifting the material by the various loads. Here we found that different reaction forces are acting in wheels while handling different types loads.



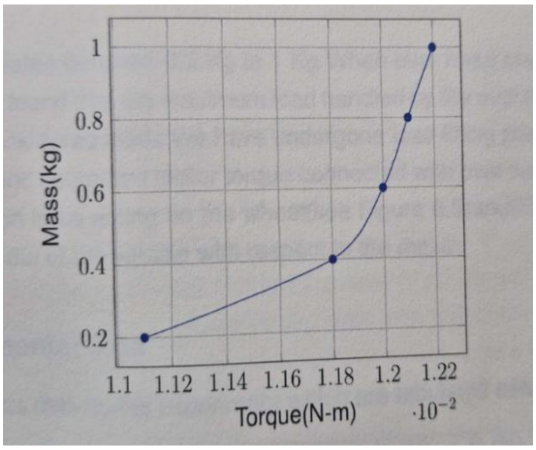
Graph 6.2: Normal reaction force at wheels

6.1.4 Experimental data

We obtain various data during experiment which are tabulated below:

Sr. No.	Load (kg)	Torque (N-m)	N1(N)	N2(N)	R1(N)	R2(N)
1	0.2	0.0111	113.09	105.61	92.52	126.18
2	0.4	0.0118	114.49	106.21	91.72	128.98
3	0.6	0.0120	115.89	106.81	90.92	131.78
4	0.8	0.0121	117.29	107.41	90.12	134.58
5	1	0.0122	118.69	108.01	89.32	137.38

Table 6.1: Experimental data



Graph 6.3: Normal reaction force at wheel

6.2 Result and conclusion

Upon performing a set of loading and unloading processes at over head crane based logistics vehicle, It has been observed that variation of lifting LSD may change the stability of vehicle. increasing the dead load increases the normal reaction at rear wheel which may tilt the vehicle backward if the normal reaction at front wheel vanishes hence appropriate stability dead load should be placed at front chassis of vehicle.

Further the operational capability of motor also depends upon (motor for lifting load) depends upon voltage supplied by battery or torque by engine. W With our experimental observation the prototype model is found satisfactory operate to load up till 1 kg. More generalized vehicle model can be devised for centering logistics load. Apart from these hydraulic rams should also be provided of the back side pf chassis to reduce higher normal load at rear wheel.

6.2.1 Future Outlook

Overhead cranes play an important role in logistics and material handling operations, allowing for efficient movement of goods and materials within a facility. The future Outlook for overhead cranes in logistics vehicles is positive, as the demand for faster and more efficient material handling continues to grow.

Many companies are looking to automate their material handling operations to increase efficiency, reduce costs and improve safety. This could lead to the development of more advanced overhead crane systems that are integrated with automated material handling systems, such as conveyor belts and robotic picking systems, Another trend that is likely to impact the future of overhead cranes is the increasing use of data analytics and loT technologies in logistics. By collecting and analyzing data on material handling operations, companies can identify areas for improvement and optimize their processes for greater efficiency. This could lead to the development of overhead crane systems that are equipped with sensors and other loT devices to collect data on their performance and usage, Overall, the future outlook for overhead cranes in logistics vehicles is positive, as they will continue to play an important role in material handling operations. As technology continues to evolve and logistics operations become more automated and data-driven, we can expect to see more advanced and efficient overhead crane systems being developed to meet the needs of the industry.

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