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Modelling and Fabrication of Tri-Head Gantry Crane Model

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***Abstract:** During the manufacturing process, various raw materials and finished goods have to be handled in manufacturing industries. As the shapes and material properties of each raw material / finished good to be handled are different, it gets difficult for a single-head crane to handle diverse materials. At present forklifts and hook-headed cranes are being used for this purpose, but it requires a lot of labor and time to handle the materials and finished goods due to miscellaneous work associated with this equipment. Looking at the present day's industrial requirements, it becomes inevitable for every manufacturing company to use the least manpower to offer competitive prices to customers without compromising the timely completion of projects. Tri head gantry crane is one of the best solutions to handle various raw materials and finished goods with the least manpower & time. The tri-headed gantry crane head consists of electromagnets to hold flat surfaces of magnetic materials, where the grab helps in holding the cylindrical, square, and rectangular materials finally if the material or a finished good is not in the shape that can be handled by using grab or magnetic heads, then we can use hook arrangement. The project involves study of various types of handling equipment being used in manufacturing industries, modeling and fabrication of tri-headed gantry crane model and testing of mechanisms of the model for handling diverse shaped materials [3].*

***Key Words:** Gantry Crane, Tri-head, Trolley Travel, Winch based Lifting, Head Rotation*

I. INTRODUCTION

A. Problems Associated with Material Handling

Handling plates in a thermal power plant can be challenging, particularly when managing large quantities of plates and the limitations imposed by relying heavily on manual labor. While overhead cranes are often utilized to handle plates to a certain extent, they have their own set of constraints. They may not have the capability to tilt plates as per specific requirements, and they are not designed for outdoor operations. This presents difficulties that need to be addressed in plate handling processes.

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In a heavy manufacturing industry, plates are crucial components used in various applications, such as boiler construction, heat exchangers, and storage tanks. These plates are typically large, and heavy, and often need to be precisely positioned during installation. The conventional method of plate handling often involves a significant amount of manual labour, which can be time-consuming, labor-intensive, and prone to human errors.

When relying on manual labour, handling plates requires a large workforce and poses challenges in terms of efficiency and productivity. Manually moving and positioning heavy plates can be physically demanding for workers, leading to fatigue and potential safety risks. Additionally, the manual handling of plates can be time- consuming, causing delays in project timelines and increasing overall project costs.

While overhead cranes are commonly used in thermal power plants for material handling tasks, they have their limitations when it comes to handling plates. Overhead cranes may have weight capacity restrictions that limit the size and weight of plates they can handle. Furthermore, tilting plates to specific angles or orientations may not be feasible with standard overhead cranes, which can be crucial in certain plate installation scenarios. The inability to tilt plates as required can hinder the precise positioning of plates during installation, impacting the overall quality and functionality of the installed components.

Another challenge is that overhead cranes are primarily designed for indoor operations within the confines of a warehouse or factory. They are not optimized for outdoor material handling tasks, which can be necessary during plate handling in a man-power plant. The terrain outside the ware house may be uneven or inaccessible for overhead cranes, making it difficult to transport plates to their designated locations. This limitation can significantly impact the efficiency and effectiveness of plate handling operations, causing logistical challenges and potentially increasing the risk of damage to plates or surrounding equipment.

To overcome these difficulties, alternative solutions can be employed. Specialized equipment, which can provide more precise control and allow for tilting plates as needed.

These devices can be operated by a smaller workforce and reduce the physical strain on workers during plate-handling tasks. Additionally, considering the use of mobile cranes or other outdoor lifting equipment can facilitate the handling of plates outside the warehouse, enabling smoother logistics and efficient installation processes.

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II. LITERATURESURVEY

A. A Study on Challenges Faced in Material Handling Management at Manufacturing Industries Chennai - Mohan Bala B.A. (MAY 2022) [1][7][8][9]

The conclusion drawn from the term paper is that material handling plays a vital role in the operations of any industry, be it government, private, or organizational. It is emphasized that material handling is essential for increasing the efficiency and effectiveness of manufacturing organizations, ultimately leading to a reduction in production costs. The benefits of material handling include saving time, reducing labor requirements, optimizing space utilization, and improving working conditions.

To achieve these objectives and enhance organizational performance, organizations must establish appropriate principles and guidelines for material handling processes. By doing so, organizations can enhance production levels while reducing production costs. The impact of material handling extends beyond improving efficiency and cost reduction; it also contributes to the overall improvement of industries in a country. This, in turn, leads to increased government income through the growth and success of these industries, ultimately fostering economic development.

To summarize, the term paper highlights that material handling is indispensable for the functioning of any industry, and its successful execution leads to enhanced efficiency, cost reduction, improved industry performance, and overall economic development.

B. Review of Overhead Crane and Analysis of Components Depending on Span - omkar k. Sakurikar (may 2016) [6][7]

The primary objective of this paper is to investigate the various components of electric overhead cranes, explore different types of overhead cranes, compare single-girder and double-girder cranes based on various parameters, and analyze the impact of increasing the span on crane components. In certain situations, planned or unplanned requirements may necessitate adjustments in the span of the crane. For instance, during the construction of a factory shed, the distance between two gantries may need to be modified, or a crane in one bay may have to be relocated to another bay with a different span. In such cases, modifications must be made to the existing crane to align it with the required parameters.

Specifically, we will focus on an electric overhead crane with a capacity of 10 tons and a pan of 20 meters. The objective is to modify this crane to accommodate 22-meter span. During this study, we will examine the effects of increasing the span on various components, such as the long travel wheel, long travel motor, and long travel brake [2][4].

When it comes to handling materials outside the warehouse, relying solely on overhead cranes becomes impractical and difficult. Factors such as uneven terrain, limited space, and the absence of a structured crane infrastructure outside the warehouse pose significant obstacles. Overhead cranes require a controlled and predefined environment to operate safely and efficiently. Taking them outside of these controlled settings can compromise safety, stability, and the crane's ability to handle materials effectively.

In situations where material handling tasks extend beyond the warehouse or factory premises, alternative equipment and solutions must be considered.

This may involve the use of mobile equipment, such as forklifts, reach stackers, or specialized outdoor cranes, which are designed explicitly for outdoor operations and equipped to handle varying terrains, weather conditions, and heavier loads. These types of equipment offer the necessary versatility and adaptability to navigate the challenges presented by outdoor material handling tasks.

By addressing these objectives, we aim to gain insights into the modifications required for adapting the span of an electric overhead crane, particularly examining the impact on crucial components.

This analysis will contribute to a better understanding of overhead crane design and assist in making informed decisions when modifying cranes for specific span requirements.

III. DISCUSSION

Plate handling in heavy equipment manufacturing industries poses challenges due to the limitations of relying solely on manual labor and the constraints of overhead cranes. The large size and weight of plates, along with the need for precise positioning and potential outdoor operations, require specialized solutions. By incorporating advanced plate handling equipment and exploring alternative lifting solutions in heavy machinery manufacturing industries can improve efficiency, reduce reliance on manual labour, and ensure safe and accurate handling.

A. Present Project

Tri-head gantry crane mainly consists of the gantry, traveling trolley, Head rotation arrangement, gantry travel wheels, head tilting arrangement, holding arrangement, and magnetic holding arrangement as shown in Fig.1.

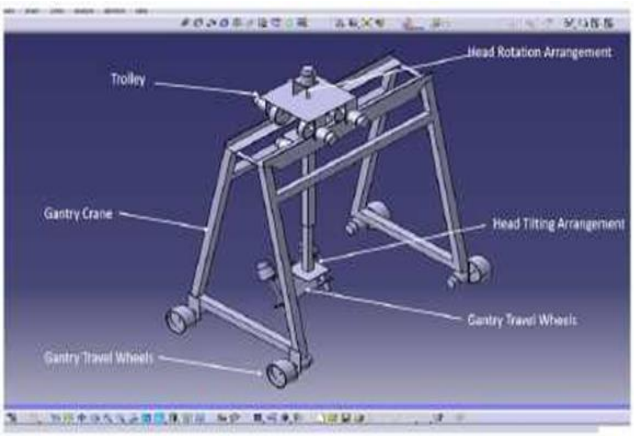

Fig. 1: Tri-Head Gantry Crane

CALCULATIONS

TILTING MAGNETIC ARM

Tilting EM(Electromagnetic) arm mass (M_t)	=	0.45 kg
Material mass to be handled (M_{mh})	=	1 kg
Total Mass (M_t)	=	M_t+M_{mh}
	=	0.45 +1
	=	1.45 Kg
The radius of the motor shaft (r_s)	=	0.003m
Force (F_t)	=	M_tx g
	=	1.45 x 9. 81
	=	14.22 N
Torque of Tilting magnetic Arm (T_t)	=	14.22 X 0.003
	=	0.042N-m
Speed of the motor (N_t)	=	10rpm
Power for tilting EM arm (Pt)	=	2 x 3.14 x 10 x 0.042/ 60
	=	0.0156 Watts

GANTRY CRANE MOVEMENT

Mass of Gantry Crane(mg)	=	8 kg
Force (Fg)	=	m x g
	=	8×9.81
	=	78.48N
Gantry Crane motor speed (Ng)	=	10 rpm
Speed of gantry wheel motor (Ng)	=	10 rpm
Diameter of the wheel (D)	=	70mm =70/1000
	=	0.07m
Radius of wheel(r_w)	=	0.035m

Gantry crane travelling speed (V)=2x 3.14 x10 x0.035/60 = 0.0366m/s

Gantry Crane Power (P_g)	=	FxV
	=	78.48 x 0.0366
	=	2.87 Watts
Power Consumption of each gantry motor	=	2.87/4
	=	**0.718 Watts**

TRAVELLING TROLLEY MOVEMENT

Mass of traveler trolley (Mt)	=	4.2 kg
Acceleration due to gravity(g)	=	9.81m/s^2
Force (F_t)	=	4.2 x 9.81
	=	41.202 N
Speed of traveling trolley wheel motor	N = 10 rpm	
Diameter of the wheel (D)	=	70mm =70/1000 = 0.07m
Radius of wheel(r_w)	=	0.035m
Trolley travelling speed(V)	**=2 x 3.14 x 10 x 0.035/60 = 0.0366m/s**	
Travelling Trolley Power (P_{tr})	=	FxV
	=	41.202 x 0.0366
	=	1.509Watts 1.509/4
	=	**0.377Watts**
Power Consumption of each trolley motor	=	

MATERIAL LIFTING

Total mass to be lifted (M_t)	=	2.95kg
Radius of motor shaft (r_s)	=	0.003m

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Force for lifting (F_l) = mg = 2.95 x 9. 81 =28.93N

Lifting Torque (T_l) = 28.93 X 0.003

= 0.086N-m

Speed of the lifting motor (N_l) = 10rpm

Power for lifting (P_l) = 2 x 3.14 x 10 x 0.086/ 60

= 0.0908 Watts

IV. RESULTS AND DISCUSSIONS

Part modelling and assembly of the Tri-Head Gantry Crane is performed using CATIA V5 R21 as shown in Fig.2

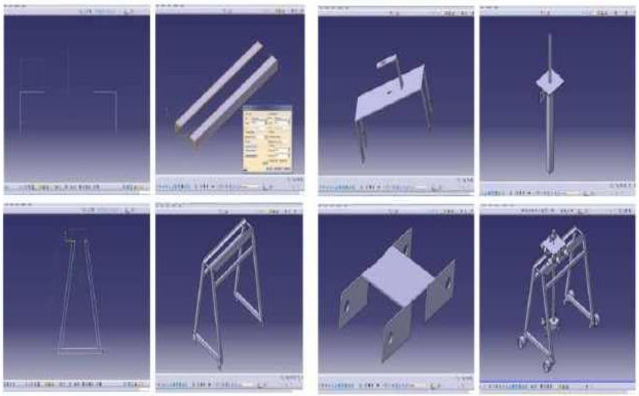

Fig. 2: Part Modeling and Assembly of Tri Head Gantry Crane

Fabrication of components of the Tri Head Gantry Crane is fabricated using mild steel material and the operations performed to fabricate the components are abrasive cutting, grinding, welding, drilling, etc., as shown in Fig.3

Fig. 3: Fabrication of Tri Head Gantry Crane Components

Assembly of components is performed to make Tri-Head Gantry Crane as shown in Fig.4

Fig. 4: Assembly of Tri-Head Gantry Crane

- The following results were found while testing the tri-head gantry crane

Operation	Result
Time required for Gantry to travel 300mm	8 Sec
Time required for Trolley to travel 500mm	10 Sec
Time required for Grab's arm for 90 degrees of rotation	1.5 Sec
Time required for Tri head rotation for 90 degrees	1.5 Sec
Time required for Lifting object from the ground (210mm)	3.5 min
Time required for Placing objection ground (210mm)	2.1 min
Object dimension that can be handled with arms	30mmx40mmx100mm
Object mass that can be handled with Electromagnet	1000gm
Object mass that can be handled with a hook	1000gm

Final Project

V. CONCLUSION

Conventional cranes cannot handle different-shaped materials like plates, pipes, and finished goods with precision using less manpower and less time. To overcome these problems, it is good to implement new technologies like tri-head gantry cranes. The tri-headed gantry crane's head consists of electromagnets to hold flat surfaces of magnetic materials, where the grab helps in holding the cylindrical, square, and rectangular materials finally, if the material or a finished good is not in the shape that can be handled by using grab or magnetic heads, then we can use hook arrangement. This crane requires less manpower and time to handle materials like Plates, Pipes, and Differently shaped objects and also low initial investment as it is indigenous technology.

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DECLARATION STATEMENT

After aggregating input from all authors, I must verify the accuracy of the following information as the article's author.

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Shaik Kafeel, M. Tech Degrees from JNTUA College of Engineering (Autonomous) in Ananthapuramu in Advanced Manufacturing Systems, B.Tech specialized in Mechanical Engineering. My academic journey reflects a deep passion for mechanical engineering. I did the project on "Modeling and Fabrication of a Tri-Head Gantry Crane". I aim to contribute meaningfully to the industry by developing advanced solutions and enhancing manufacturing practices.

Prof. B. Durga Prasad, M. Tech, Ph.D, Professor & Head of the Mechanical Engineering Department, brings 20 years of expertise in teaching and placement excellence. Known for his dedication and passion, he motivates students to achieve academic and personal growth. He hassupervised50M.Tech dissertations and Ph.D research at Sathyabama University and JNTUA, with 14 Ph . D students currently under his guidance. Additionally, he serves on doctoral committees at several universities, consistently exceeding expectations for his position**.** Vice-President of Teaching Staff Association in JNTUA College of Engineering, Anantapur. At present President of the Teaching Staff Association in JNTUA College of Engineering, Anantapur. Currently as President. His leadership extends to the Teaching Staff Association, where he has served as Vice-President and is now the President.