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Design of Material Handling System for Process industry

Aarbaz Mutwalli[1], Jamil Dabir[2], Maruti Khot[3]

PG student, Department of Mechanical Engineering, Walchand College of Engineering, Sangli[1]

Assistant Professor, Department of Mechanical Engineering, Walchand College of Engineering, Sangli[2]

Assistant Professor, Department of Mechanical Engineering, Walchand College of Engineering, Sangli[3]

[1]Corresponding Author

Email: - aarbaz.mutwalli@walchandsangli.ac.in

Abstract: In case of industrial equipment there is a requirement of material to be transfer from one place to another place. This process may require the heavy load lifting and raw material movement etc. material handling is important to transfer the material at right place at right time for its good working environment. That's why requirement of the crane for the purpose of material handling from one place to another place is necessary. This work will helpful for the specific requirement of such application of material handling in case of process industry. Basically, such industries require more human interfere for proper completion of the work. We have designed material handling system for one of the industries where aluminum bars are manufactured using extrusion process.

Keywords: 3D model of material handling system, design of material handling system elements.

1.INTRODUCTION

A primary goal of a material handling system is to efficiently and safely transport material from one location to another, ensuring they are delivered to the right place at the right time. material handling system are essential in various industries, including manufacturing, construction and transportation. they can range from simple manual system to highly automated setups, depending on the complexity and scale of operation. Material handling equipment to a wide range of vehicle, tool and machinery used for the movement, storage, control and protection of material and product in various industries. The lifting capacity of these equipment can vary significantly depending on their type and design. The various cranes used in industry mainly are overhead cranes, mobile cranes, monorail crane, tower cranes, jib cranes. This are some common material handling equipment and their typical lifting capacities: mobile crane:10 to 1200+ ton, tower crane:2 to 20+ ton, overhead crane:1 to 500+ ton, gantry crane: 1 to 900+ tons, monorail crane:250kg to 10 ton. It was proposed to design an overhead monorail crane to overcome the problems faces by the existing method of working. In this paper, we include Design and its implement for particular load application. The proposed requirements of the project,

• Material of weight 720 Kg to be carry. • Maximum lifting height should be 5 feet.
• Minimum persons required to operate the crane. • Easily assembled on construction site.

2. LITERATURE REVIEW

The design of the runway beam, support positions, supporting structure, and connections are all part of the overhead monorail structure. The review covers the design and applications of material handling system elements.

A D Anjikar et al. (2013) examined the applications of seven various ratios to lower the cost of material handling activities and boost overall plant productivity. The issues raised under Design load rating or lift load are discussed. Useful safety, load, or impact factors Conveyor path, optimum support mechanism, and maximum lift design load. The work is not explicitly explained with an industrial applicability in this publication [1].

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Nenad Zrnićet al. (2022) I-beam runway beams were given loading capacity curves based on capabilities related to the strength of the bottom flange and lateral buckling of the top flange. For bottom flange bending, they followed the "Mendel" advice and checked with CATIA. The strength of a particular I beam relies on the beam's span and the I beam's wheel location. When creating the load capacity curve, the torsional impact brought on by lateral load is not taken into account [2].

K. M. Ozdemir et al. (2006) concluded that the location of the loading and supports is a key role in the lateral distortional buckling of overhanging monorails after analyzing the phenomenon. The buckling strength of overhanging webs decreases as web slenderness increases. Monorail trusses [3].

E. Mardani et al. (2011) Analysis of the beam under moving, continuously dispersed and focused stresses. The Euler-Lagrange Equation and the Hamilton's Principle are the sources of the vibration equations of motion. Calculations have been made in this work to determine the vibration's amplitude, circular frequency, bending moment, stress, and beam deflection. According to the study's findings, the resonance phenomena doesn't occur when the beam's material is thought of as physically nonlinear since there is no critical velocity. Analysis demonstrates that the vibration's amplitude increases with the speed of the moving weight [4].

Yong Lin Pi et al. (2000) examined the steel I beam's inelastic bending and torsion. They took into account minor axis bending actions for interaction ratio, which improves the design check for I beam strength [5].

Rajpandian R. Developed a system with 50 KN capacity EOT crane's structural analysis. He used ANSYS for structural analysis and the "Indian Standard Code for Steel Design" for his theoretical study. The buckling resistance moment must be greater than the gravity loads' calculated moments, including impact. The top compression flange is thought to be the only one to take on the horizontal bending moment. It applies the overall buckling check. The girder's web is examined for buckling and shear strength. It is also employed to check for local compression under the wheels. The crane girder is examined for fatigue as well as vertical deflection caused by static wheel loads and horizontal surge caused by crane surge. [6]

Previous researchers have reported works on the design of the entire monorail system for specific material handling problem. As a result, the entire system is broken down into many separate parts, such as the monorail straight I Beam, girder, and design of supporting beam and columns. The researchers have presented works in the area of monorail system and its components-parts. This will be useful to those working in this field.

3.METHODOLOGY

By referring various methodologies from the literature study. The methodology includes conceptual model, component list with end support beam, rail track and cantilever support beam. Next is calculation of end support beam, rail track and cantilever support. The results are given in Table.2. 3D model is developed in 3D modeling software is given in Figure 5.

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3.1 CONCEPTUAL DESIGN

The following fig.1 show the orthographic view of conceptual material handling system the overall dimension of the system is as per the process requirement in the industry.

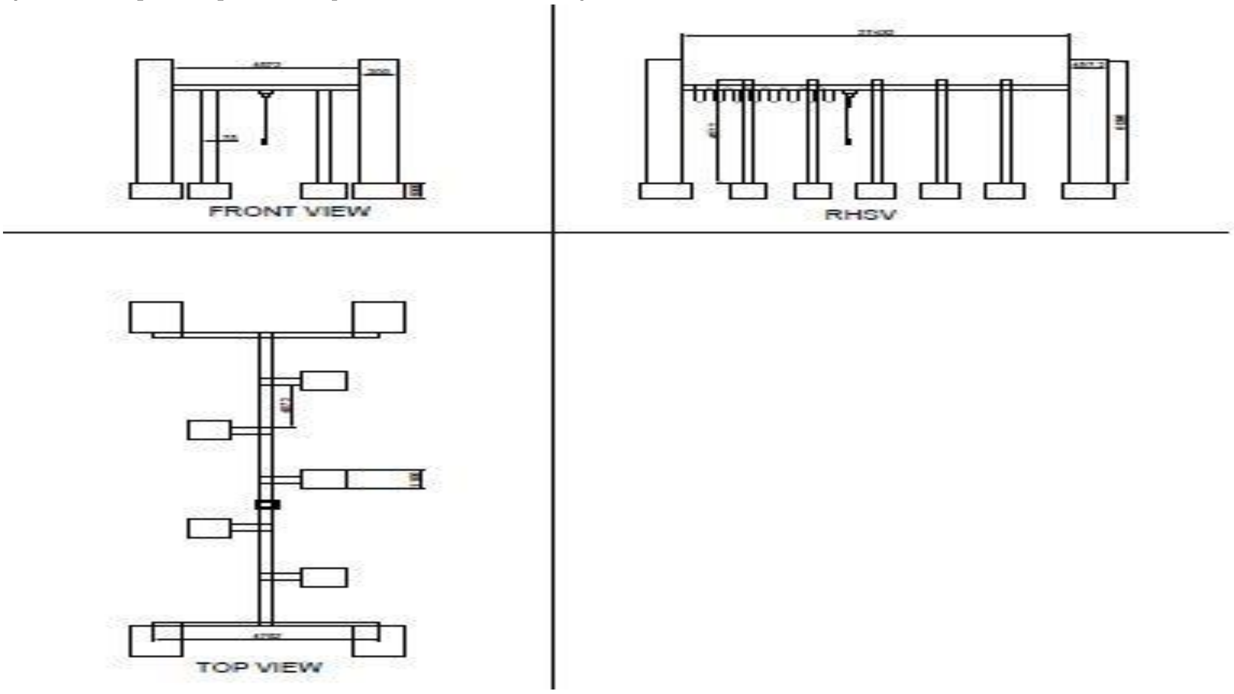

Fig 1. 2D Mode

3.2 COMPONENT LIST

The following table 1 shows the component list of material handling system with details.

Table.1 Part list

Sr no.	Component	Length	Quantity	Location
1	ISMB200	4.572 m	2	End support beam
2	ISMB200	4.572 m	6	Rail track/hoist track
3	ISMB150	1.067 m	5	Cantilever support beam

3.3 Therotical Design

The different components of material handling system are designed statically by considering the verious forces acting on elements of system.

3.3.1 Design of Overhead Monorail Crane parts

a) End support

all the dimensions of the parts select under safe limit.

Simply supported beam

L = 4.572M

Lifted load = 800kg E= 2.1×10^5N/mm^4

Hoist load = 150kg I= 66.66×10^6mm^4

Total load = 150 + 800 = 950 kg =9319.5N

For simply supported beam load acting at center

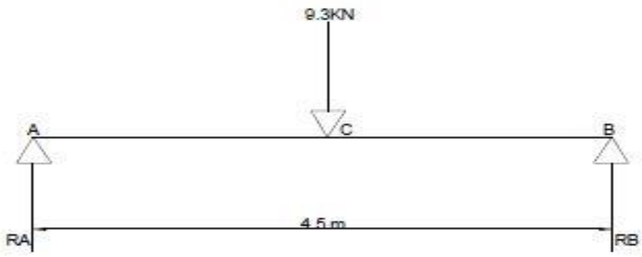

Fig.2 End support

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Bending moment (M_b)

$M_b = \frac{W \times L}{4} = 10.652 \times 10^6$ N/mm

Distance of outermost layer from N.A $y_{max} = {}^{d}/_{2} = {}^{200}/_{2} = 100$ mm

Bending equation $\sigma_{max} = \frac{M_b}{I_{xx}} \times y = 15.93$ Mpa $\therefore \sigma_{max} \leq Syt = 250$ Mpa

∴ So design is safe Max stress less than yield strength

Maximum Deflection at mid-point $\delta_{max} = \frac{WL^3}{48\,EI} = 1.32$ mm

∴ Max deflection at mid-point of beam = $\delta_{max} = 1.32$ mm

b) Cantilever support

all the dimensions of the parts select under safe limit.

W = 9.3 KN =9319.5N
Lifted load = 800kg
Hoist load = 150kg
Total load = 150 + 800 = 950 kg = 9319.5N
L = 1067 mm =1.067 m
$E = 2.1 \times 10^5$Mpa $I = 7264 \times 10^3 mm^4$

Deflection

Max Deflection = $\delta = \frac{WL^3}{3EI} = 2.59$mm

Slope $\theta = \frac{WL^2}{2EI} = 3.64 \times 10^{-3}$ rad

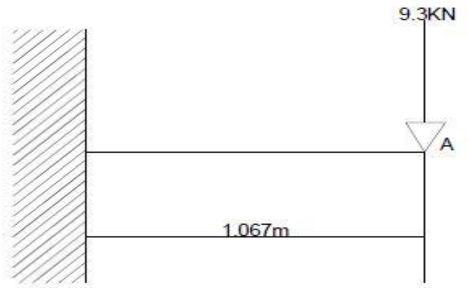

Fig.3 Cantilever support

Bending stress $\sigma_b = \frac{M_b}{I} \times y$

$M_b = P \times L = 9.3 \times 10^3 \times 1067 = 9.92 \times 10^6$ N/mm

$y = {}^{h}/_{2} = 75$mm

∴ bending stress of cantilever beam are $\sigma_b = 102.4$ Mpa

c) **Hoist track / Rail track**

All the dimensions of the parts select under safe limit.

W = 9.3 KN =9319.5N
L = 4.572 m = 4572 mm
$A=3233mm^2$ $E= 2.1\times10^5 N/mm^4$
Lifted load = 800kg $I= 66.66\times10^6 mm^4$
Hoist load = 150 kg
Total load =150 + 800 = 950 kg=9319.

U.d.l $W = \frac{w}{L} = \frac{9319.5}{4572} = 2.03$ N/mm

Stress $\sigma = \frac{F}{A} = \frac{9.3\times10^3}{3233} = 2.87$Mpa

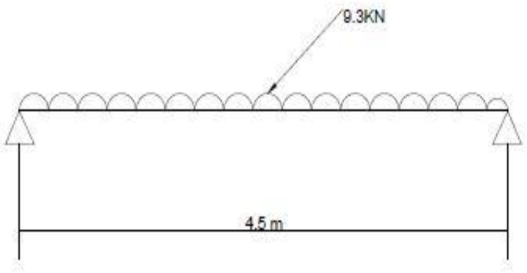

Fig.4 Uniformaly distributed load

Deflection $\delta = \frac{5wL^4}{384EI} = \frac{5\times2.03\times4572^4}{384\times2.1\times10^5\times66.66\times10^6} = 0.825$ mm

Bending moment $M_b = \frac{wl^2}{8} = \frac{2.03\times4572^2}{8} = 5.30 \times 10^6$ N/mm

Bending stress $\sigma_b = \frac{M}{I} \times y = \frac{5.30\times10^6}{66.66\times10^6} \times 100 = 7.95$Mpa

∴ bending stress of hoist track beam are $\sigma_b = 102.4$ Mpa

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Table.2 Results

Sr no.	Component	Symbol	Solution
1	ISMB200	Stress	$\sigma_{max} = 15.93$ Mpa
		Deflection	$\delta_{max} = 1.32$ mm
2	ISMB150	Stress	$\sigma_{max} = 102.4$ mm
		Deflection	$\delta_{max} = 1.32$ mm
3	ISMB200	Stress	$\sigma_{max} = 2.87$ mm
		Deflection	$\delta_{max} = 0.825$ mm

4. SOLID WORK MODEL

Following 3D model are design under solid work model as per design calculation.

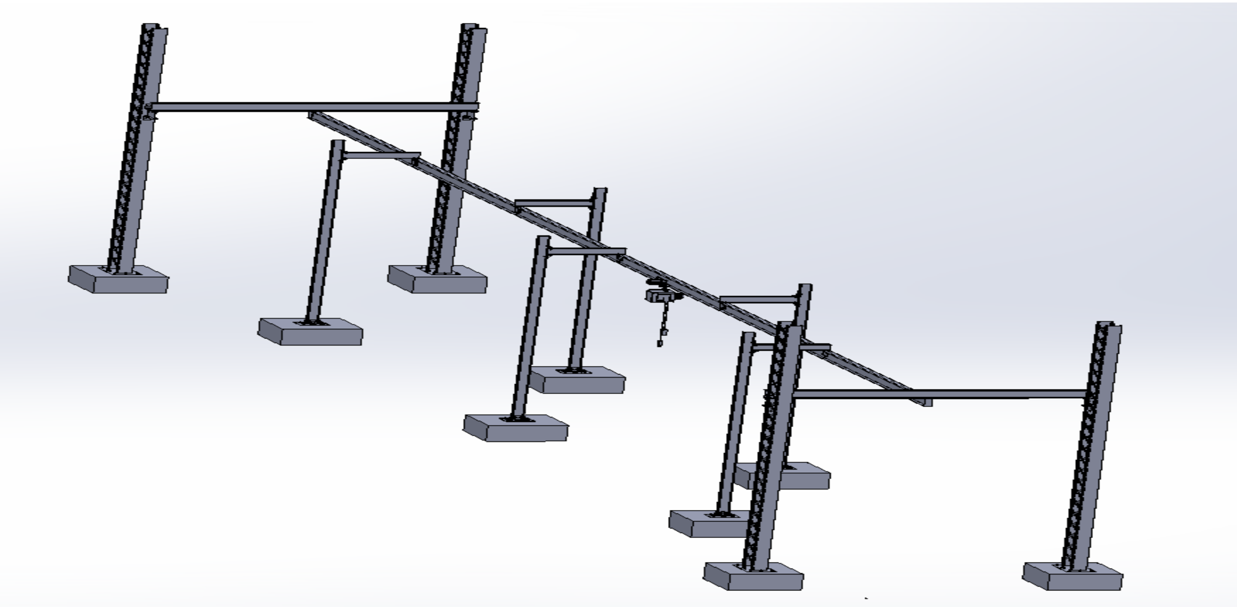

Fig 5. 3D Model

5. CONCLUSION

The material handling system for process industry manufacturing aluminum bar using extrusion process is design. The 3D model of material handling system is developed in modeling software. The designed material handling system will carry load 9.3 KN at a distance 27m. The different components of system are checked for stress and deflection. The all the components of designed material handling system within safe limit.

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