IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 13, Issue 3 Ver. II (May- Jun. 2016), PP 57-63
www.iosrjournals.org

Conceptual Design of a Floor Travelling Jib Crane for Modern Workstations

Joseph Kiran Hamilton. C[1], R. Sumithra Nandhan Hari[2],
T. Shanmuganathan[3]
[1]Department OfAutomobile Engineering, IV Year,
[2]Department OfAutomobile Engineering, IVYear,
[3]Assistant Professor, Department OfAutomobile Engineering,
Hindustan Institute OfTechnology &Science, Padur, Chennai-603103

Abstract: *Cranes Are Complex Combinations Of Simple Machines. The Advancement Of Technology In Overhead Cranes Finds Itself Difficult To Capture In An Automotive Workstation Due To Several Space Constrains. To Offer The Best Service Facility In An Automobile Workshop, A Concept Of Providing Jib Cranes Impelling On A Guide Track To Reach All Desired Stations In An Automotive Workshop Is Achieved. In Order To Cater At Different Areas, A Well-Planned Tack System With Longitudinal Travel (LT) And Cross Travel (CT) Is Installed On The Floor With Turntables, Which Acts As A Junction Platform For The Crane To Change Its Direction Of Motion. An Alternate Solution To The Existing Counter Weight Of A Crane Is Developed, Which Is Made To Prevent The Tipping Over Of The Crane During Its Operating Conditions. Hence, A Mobilized Crane Is Achieved By Improving The Design Wherein A Rotating Mechanism Is Achieved By Introducing A Gearing System, Electric Motor, Solid Shaft With Flange, Sleeve Bearing And A Support Bearing. Since The Use Of Cranes Is Indispensable In The Industry, The Design Will Aid Productivity, Safety Of Workers, Ergonomics, Efficiency, Effectiveness And Versatility Of The Crane For Which They Are Designed And Manufactured. However, This Design Is Made To Handle Loads Up To 500kg Only.*
Keywords:*Jib Crane, Counter Weight, Wide Flange Beam, Trolley, Bearing.*

I. INTRODUCTION

This Project Deals With A Conceptual Proposal To Mobilize A Jib Crane, Satisfy And Achieve Its Intended Application Requirements In A Modern Workstation By Sating The Following Objectives

- To Ease The Material Handling System
- To Eradicate Arduous Man Labor
- Time Consuming Practices, Which Needs To Be Improved For Better Efficiency
- To Improve The Performance Of The Overall Work And Also To Increase Production Rate

II. SELECTION OF CRANE

The Workshop Requires The Usage Of A Movable EOT Structure To Carry And Transport Various Heavy Parts/Tools. Most Importantly, The Crane Should Be Such That It Should Neither Be A Wall Mounted Nor An Overhead Crab Because Of Low Roof And Space, Targeted Load Application, Presence Of Pillars, Complex Structure Etc.

Key Requirements Are As Follows:

- Height Constrains – 15ft.
- Presence Of Pillars
- LT And Extended CT Motion
- Access Across Shops/Rooms
- Loading And Unloading Of Goods
- Service At Desired Location
- Cost Efficient
- Higher Production Rate

The Above Key Nodes Are The Requirements That Are To Be Met By The Crane For The Desired Application.

Based On The Above Analytical Procedure, It Is Found That The Jib Crane Has Better Advantages And Can Handle The Loads Easily. However, A Column Mounted Jib Crane Wouldn’t Be Suitable For The Workstation, As It Doesn’t Meet All The Demands Out Forth By The Workshop. Hence There Is A Demand To

Design A System To Make The Jib Crane Portable In Order To Offer Long Travel (LT) And Cross Travel (CT) Motions. This Can Be Achieved By Laying A Guide-Track That Will Guide The Movement For The Crane To Travel With The Help Of A Trolley On Which It Has To Be Mounted. Also A Turntable Needs To Be Installed At The Specific Locations Where LT Shifts To CT.

Existing Work

The Pivoting Head Is Supported Either By A Floor-Mounted Mast Providing 360-Degree Boom Rotation Or By An Existing Building Column, Which Provides 180 Degrees Of Boom Rotation. Also, Jib Cranes Most Often Handle Lighter Loads At Lower Duty Cycles Than Their Bridge And Gantry Crane Counterparts. The Major Disadvantage Is That It Is Stationary And Cannot Be Moved Easily From One Work Area To Another. It Is Designed For Positioning A Work Piece Or Tool, Rather Than For Moving A Product Along In The Workflow Like An Overhead Crane. It Is Also Unsuitable To Use When There Is A Need For Precise Locating Of Heavy Loads, A Large Area Of Hook Coverage, Or Frequent Use For Heavy Loads. Another Disadvantage Is That The Hook Coverage Is Limited To The Boom Length (Typically A Maximum Of 20 Ft). The Hook Operates Along A Boom, Which Rotates About A Fixed Point.

III. METHODOLOGY ADOPTED

The Methodology Follows A Series Of Sequence Whereby The Primary Target Problem In A Modern Day WorkstationIs Identified And The Possible Solutions To It Were Discussed And Analyzed. The Need To Mobilize A Jib Crane Is Very Essential And Hence It Can Meet The Requirement(S) Stated. Apparently, This Requires The Need To Design A Suitable Trolley, Which Can Actually Bear The Entire Load And Move The Jib. Best Possible Design Of The Trolley Is Done And Accordingly, Its Analysis Is Also Carried Out. The Resulting Factors Are In Accordance With The Calculated Ones And Certainly Fall Under The Safe Zone. Moreover, The Jib Design Has Been Slightly Modified As The Swivel Arrangements Are No Longer Required. Also, The Guide Track Has Also Been Included In The Design To Demonstrate The Actual Working Of The Project.

Description ofthe Tote

This Drawback Was Mainly Due To The Cantilever Structure Of The Jib Crane, Which Could Potentially Affect Its Stability And Balancing. It Also Determines The Center Of Gravity Of The Jib Depending On The Load. Hence, A Good Jib Crane Should Be Equipped With A Strong Base And Foundation So As To Counter The Lifting Load Stress. Here, The Greater The Length Of The Boom, The More Stress Acts On The Column And Base. I.E.Stress A Length

A Jib Crane Normally Has A Hollow Column, Which Is Fixed To The Foundation With The Help Of A Base Plate. This Base Plate Bears The Entire Weight And Provides The Structural Foundation. In Addition, Ribs Serve The Purpose To Provide Structural Support To The Column And Eliminate Any Principal Stress, Strain(S). Furthermore, In Order To Withstand A Heavy Cantilever Structure, M-16 Bolts Are Normally Used For The Foundation To Make It Sturdier.

In Order To Make It Mobilize And Serve The Purpose Of Transportation In An Automotive Workshop, It Should Be Equipped A Trolley System, A System Where The Wheels Bears The Entire Load. For Better Safety And Balancing Concerns, An Eight-Wheeled System Is Adopted; Where The Drive Is Given To Two Pairs Of Wheels And The Second Set Of Pairs Of Wheels Are Dead. This Drive Is Produced By An Electric Motor, Which Is Connected To A Pinion Shaft. This Pinion Eventually Rotates A Bull Gear To Which Its Corresponding Wheel Is Attached. Squirrel Cage Crane Duty Motors And Slip Ring-Wound Rotor Crane Duty Motors Are The Normal Two Categories Of Motors Used For Crane Applications. Here, To Obtain The Long Travel Movement, We Use Wound Rotor Crane Duty Motors Of 0.5HP Capacity.Wound Rotors Are Used In Applications Where High Starting Torque Is Required. External Resistances May Be Added To These Rotors Via Slip Rings Shaft. These Resistances Serve To Increase The Starting Torque And Ensure Smooth Starts. However, These Rotors Are More Expensive Than Induction Motors. In The Wound Rotor, The Rotor Windings Are Insulated To The Ground. The Slip Rings And The Brushes Also Require Maintenance. The Starting Current Drawn By A Wound Rotor Machine Is Lesser Than That That Of A Squirrel Cage Motor. The Wound Rotor Is Designed To Have The Same Number Of Poles As The Stator Winding Of The Motor. The Windings Are Designed To With Stand High Mechanical Forces As These Motors Are Used For High-Torque Applications. Wound Rotors Are Used For Applications, Which Require Soft-Starts And Adjustable Speeds

Squirrel Cage Rotors Are The Most Common Type Of Rotors Found In Induction Motors. These Rotors Are Simple To Construct, Robust And Relatively Inexpensive. They Are Particularly Suited For Low Inertia Loads. Their Easy Construction Enables Lower Rotor Weight And Lesser Centrifugal Force And Windage Losses. These Motors Are Often Exposed To Extreme Weather Conditions As Well As Being Subjected To High

Operational Requirements. They Have To Withstand High Humidity; Salty Air And High Wind Speeds While Ensuring A High Overload Capacity And A Wide Speed Control Range.

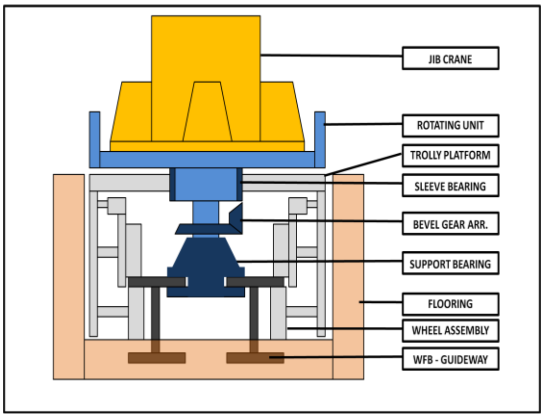


Fig 5.1 Concept Description Diagram

The Most Important Aspect Of This Trolley System Is The Wheel Position And The Rail Beam. The Wheels Should Be Positioned In Such A Way That The Jib Upon Carrying The Load, Due To Its Cantilever Structure Should Not Topple, As It Is Not Bolted To The Ground. This Is Done In Such A Way That The 200x200 Wide Flange Beam (Rail) Is A Semi-Submerged Type I.E. The Lower Half Of The Rail Beam Is Submerged Under The Ground, And Only The Top Half Is Visible. This Is Done To Ensure That The Beams Can Withstand This Operation And Also To Eradicate Any Structural Deformation(S). Therefore In Total There Are Two Rails, Which Are Positioned Apart From Each Other Based On The Width Of The Trolley. The Major Disadvantage Of Using A Monorail Is That, During The Rotation, There Are High Risks That The Entire System May Collapse Due To Improper Load Distribution And Imbalance.

This Two-Rail System Is Laid Along The Required Coverage Area Of The Workshop. On The Other Hand, The Eight-Wheeled System Is Positioned Such That A Pair Of Wheels Are Positioned In Such A Way That One Rests And Moves On Top Of The Wide Flange Beam While The Other Wheel Rests And Moves On Bottom Of The Wide Flange Beam. By Doing So, The Uplift Of The Trolley Can Be Prevented. Each Wheel Has The Capacity To Withstand Three Tons Of Loads. One Of The Most Distinguishing Specification Of This Trolley Based Mobilized Jib Crane Is That It Does Not Require The Presence Of A Counter Weight As Many Think It Would Be An Essential Factor. This Is Because Of The Load Carrying Capacity Of The Wheels. As Said Above, Each Wheel Has Got The Capacity To Carry Loads Well Over Three Tons Of Which Is Greater Than The Sum Of The Weights Of The Load (Greater Than 0.5T), Jib, Trolley And Other Peripherals. This Ensures Better Stability Even Without The Presence Of Counter Weight As The Bottom Wheel Bears The Entire Load Over The Wide Flange Beam.

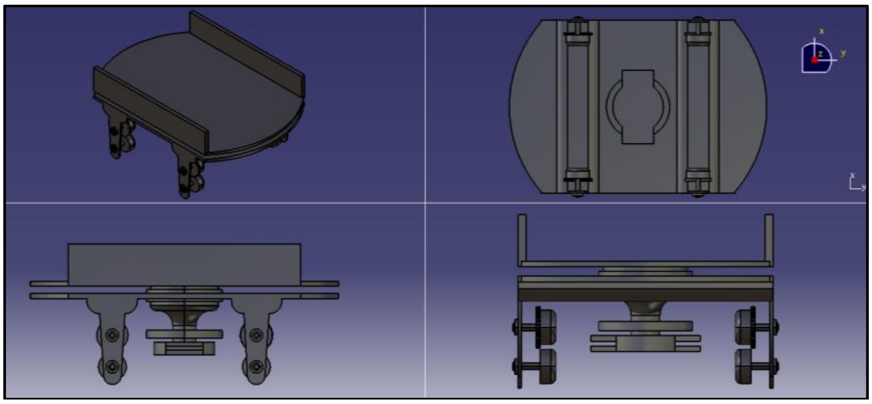


Fig5.2DesignOfTheTrolley

The Key Feature Of A Jib Is Its Ability To Turn Its Arm/Boom And Cover The Circumference Area For Loading And Unloading Purposes. A Normal Jib Has The Swivel Arrangement To Ensure This Operation. Here, The Main Drawback Of The Swivel Arrangement Is That Upon Rotation, The Axis Of The Boom And The Wheel, Which Should Be Perpendicular, Gets Disturbed And Becomes Parallel During 45o. In Other Words, The Wheels Which Acts As The Pivot, Gets Its Position Changed Upon The Rotation Of The Boom

Which Increases The Risk Of Instability And Could End Up In Toppling.The Design Should Be Made Such That The Jib Should Cover 180o Instead Of 360o As The Later Is Not Necessary For The Application. Hence, To Maintain The Stability, The Jib Is Made To Rotate As A Whole. This Is Done By Creating A Platform Above A Trolley To Which The Jib Is Bolted With The Help Of Its Base Plate. To Make This Rotation Happen, The Column Is Extended Downwards Beneath The Trolley. Contact Is Not Made Between The Rotating Column And The Trolley By Means Of A Taper Roller Bearing. The Bearing Arrangement Is Such That A Ball Bearing Is Present In Between The Taper Roller Bearing. Now, The Drive For Rotation Is Given By The Desired Motor, Whose Shaft Is Indeed Connected To A Bevel Pinion. This Bevel Pinion Is Connected To A Crown Wheel Whose Diameter Is Equivalent To The Diameter Of The Column, Follows A Three-Stage Reduction Mechanism And Is Welded Together.

Further Down, To Give An Additional Lock-Up With The Rail, Another Sleeve Bearing Is Present At The Bottom Of The Column And The Bearing Is Extended On Either Sides So As To Cover And Lock Up The Top And Bottom Of The Flange Beam. On Doing This, We Can Ensure 1. Safety Of The Column 2 Lower Half Is Staunch

On Top Of The Platform, On Either Side, The Two Motors Can Be Placed. One Is To Ensure The LT And CT Movements While The Other Is To Make The Jib Rotate. The Rotation Here Is Only Upto 180o. This Is Because Of The Need And Requirement As Stated In Chapter 5.

The Boom Length Being 3000mm Does Not Mean That The Length Of Travel Of Hoist Is The Same. The Jib Head To Which The Frame And Tension Plate Are Attached Takes Up About 600mm. The Remaining 2400mm Is The Length Of Travel Of The Hoist. An Important Part In The Boom Is The Stopper. A Stopper Does The Action To Prevent The Hoist From Travelling Further. Hence It Is Very Essential To Have The Presence Of Two Stoppers On Either Sides Of The Boom. The Boom Cover Is Placed On Top Of The Flange And Is Normally Used To Strengthen And Counter The Load Stress Acting On The Lower Flange Due To The Hoist and the lifting Load.

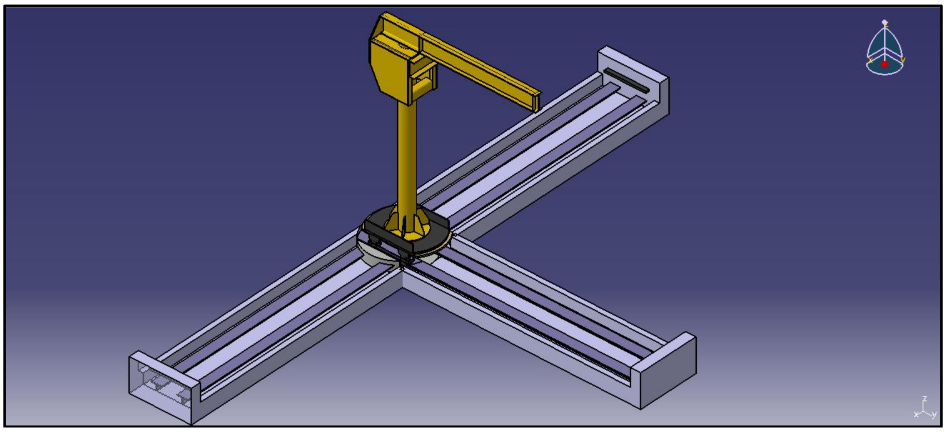


Fig5.3 Fully Assembled Jib Crane Installed On The Guide Way.

JIB CRANE SPECIFICATION

1. Capacity MH	**-**	**0.5Tonnes**	
2. Jib Radius (Hook Reach)	**-**	**3.0**	**Metres**
3. Lift (Total)	**-**	**3.00**	**Metres**
4. Duty	**-**	**2.0**	
5. Swiveling	**-**	**Electric**	
6. Application	**-**	**Automobile Workshop**	
7. Mean Height	**-**	**3.60**	**Metres**
8. Lifting Tackle	**-**	**EWRH**	

Crane Duty Variations

	Duty 2.0	**Duty 3.0**	**Duty 4.0**
D. Factor	**0.95**	**0.90**	**0.85**
Fraction	**0.05**	**0.67**	**0.1**
Im. Factor	**1.3-1.1**	**1.4**	**1.5**

Two Types Of Lifting Tackles Can Be Installed Depending Upon Operation:

EWRH - Electric Wire Rope Hoist(Electrically Operated)

CBP - Chain Block Pulley (Manually Operated)

IV. CALCULATED RESULTS

IMPORTANT FACTORS INFLUENCING JIB CRANE DESIGN

- Ixx
- Slenderness Ratio Yy
- Bending Stress
- Jib Arm Deflection
- Ixx= Iyy
- Combined Axial Compression And Bending
- Actual Deflection

X-Section Properties (Ixx):

Ixx= *[Area Of C.C (M.B Ht/20 + C.C Web Thk/10 - C.C Cxx- C.G Of X–Prop)* ^{2}*] + [T.P Area (M.B Ht/20 + T.P Dt/10 - C.G X–Prop)* ^{2}*] + [M.B Area (C.G X–Prop)* ^{2}*] + [B.P Area (M.B Ht/20 + B.P Dt/10 – C.G X–Prop)*^{2} *] + [M.B Ixx+ T.P Ixx+ C.C Ixx+ B.P Ixx]*

$=[28.21\ (300/20 + 6.1/10 - 2.17 - 4.49)^2] + [0\ (300/20 + 0/10 - 4.49)^2] + [56.26\ (4.49)^2] + [0\ (300/20 + 0/10 - 4.49)^2] + [8603.6 + 0 + 102.3 + 0]$

=**12099.80 cm**^{4} **SAFE**

[When Value>= Jib IxxDesired]

Where, Jib Ixx Desired $= \frac{Live\ load\ (Jib\ crane\ \times 100)^3}{3 \times 2100000\ \times Assumed\ Jib\ deflection}$

$= \frac{700\ x(3 \times 100)^3}{3 \times 2100000\ \times 0.0033\ meters}$

= 9090.91 Cm^4

X-Section Properties (Slenderness Ratio Yy):

Slenderness Ration Yy

$= \frac{200 \times Hooke\ reach}{Ryy}$

$= \frac{200 \times 3}{0.0519}$ Meters

= 115.66

= **SAFE**

[When Value < = 150]

Where,

Ryy $= \left(\frac{Iyy\ Whole\ section}{Total\ Area}\right)^{0.5}$

$= \left(\frac{I2273.20}{84.47}\right)^{0.5}$

= 5.19cm

Stress Acting On Jib Arm (Bending Stress):

Total Bending Stress = Vertical Stress + Horizontal Stress

= 45.02 + 3.24 Mpa

= 48.26 Mpa

All Bending Stress = Sigma Bc X D.Factor

= 141.55 Mpa X 0.9

= 134.48 Mpa

BENDING SAFETY = **SAFE**

[All Sigma Bc>= Total Bending Stresses]

Deflection OfJib Arm:

All Deflection = Jib Deflection Assumed X 10

= 0.330 Cm X 10

= 3.30 Mm

Actual Deflection $= \frac{Live\ Load\ \times (Hook\ reach \times 100)^3}{3 \times 2100000\ \times (Ixx\ \times 100)}$

$= \frac{700\ kg \times (300\ cm\ \times 100)^3}{3 \times 2100000\ \times (12099.80\ cm^4 \times 100)}$

= 2.48 Mm

DEFLECTION SAFETY = **SAFE**

[When All Deflection >= Actual Deflection]

Column Pipe Section (Ixx=Iyy):

Outer Diameter = 270 Mm

Inner Diameter = 242.02mm
Thickness = 14 Mm

Ixx= Iyy = $\frac{(Zxx = Zyy)}{64} \times \left[\left(\frac{OD}{10}\right)^4 - \left\{\frac{(OD - 2\times thickness)}{10}\right\}\right]^4$

= $\frac{(685.28)}{64} \times \left[\left(\frac{270}{10}\right)^4 - \left\{\frac{(270 - 2\times 14)}{10}\right\}\right]^4$

= 9251.34 cm^4 **SAFE**

[When Value >= Mast Ixx Desired]
Where,

Zxx= Zyy = $\frac{(Ixx = Iyy)}{OD \times 20}$

= $\frac{(9251.34)}{270 \times 20}$

= 685.28 Cm^3

Mast Ixx Desired = 9230.77 Cm^4

Column Pipe Section: (Combined Axial Compression &Bending)

Total Bending Moment = 264946.34kg-Cm Bending Stress =37.94Mpa
Axial Compressive Force = 1370 Kg
Ac. Cal = 1.19 Mpa
Ratio OfAxial Comp. Force=0.01 [< 0.15]
Combined Axial
Compression &Bending = *(Ratio Of Axial Comp. Force) + 2 (Bending Stress)*
= *(0.01) + 2 (37.94* Mpa*)*
= 0.50 **SAFE**

[When Value <= 1]
Actual Deflection Calculation:
Actual Deflection = Deflection Due To Jib + Deflection Due To Mast
= 0.2479 + 1.1674 Cm
= 1.4153 cm **SAFE**
[Value <1.5]
Where,

Deflection Due To Jib = $\frac{Live\ Load \times (Hook\ reach \times 100)^3}{3 \times 2100000 \times (Ixx)}$

= $\frac{700\ kg \times (300\ cm \times 100)^3}{3 \times 2100000 \times (12099.80\ cm^4)}$

= 0.2479 Cm

Deflection Due To Mast = $\frac{Live\ Load \times (Hook\ reach \times 100)^2 \times (Mean\ Height \times 100)}{2100000 \times (Ixx = Iyy)}$

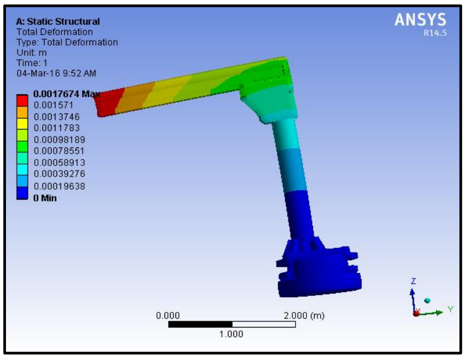
= $\frac{700\ kg \times (3.00m \times 100)^2 \times (3.60m \times 100)}{2100000 \times (9251.34\ cm^4)}$

= 1.1674 cm

V. RESULTS

ACTUAL DEFLECTION (EXISTING MODEL)
1. Deflection Due To Jib = 0.2479 cm
2. Deflection Due To Mast = 1.1674 cm
3. Overall Deflection = 1.4153 < 1.5 **SAFE**

ACTUAL DEFLECTION (MODIFIED MODEL)
1. Deflection Due To Jib = 0.2479 cm
2. Deflection Due To Mast = 1.1844 cm
3. Overall Deflection = 1.4323 <1.5 **SAFE**



VI. Conclusion

A Floor Travelling Jib Crane Of 0.5T Load Capacity Was Designed, Modeled In CATIA V5R20 And Analysis On Stress, Strain And Deformation Characteristics Was Performed Successfully Using ANSYS 14.5. The Result Of Which, Is Proclaimed Safe And Is In Accordance With IS(Indian Standards).

The Concept Involved In The Above Designed Trolley System Can Be Widely Used For Many Commercial Purposes. This Prospective Design Also Ensures Us The Nonobligatory Requirement Of A Counter Weight In A Jib Crane. The Mobility Provided To The Jib Can Ensure The Realization Of The Desideratum In A Modern Workshop. This Facile Mechanism Elucidates Us How A Fixed Structure Can Be Maneuvered And Serve Its Purpose More Effectively In A Material Handling System.

References

[1]. V.JoseAnanth Vino, "DESIGN AND FABRICATION OF A HYDRAULIC FLOOR CRANE", Bharath University, Andhra Pradesh, India, IJBTT – Volume2 Issue 1 Number1–Jan 2012
[2]. Adzimah Stephen Kwasi, "IMPROVEMENT IN THE DESIGN OF JIB CRANES FOR MODERN INDUSTRIES", University Of Mines And Technology, Tarkwa, Ghana, ISSN (E) 2278 – 4721 Volume 2, Issue 9, April 2013, Pp. 01-09.
[3]. Indian Standard, "HOT ROLLED PARALLEL FLANGE STEEK SECTIONS BEAMS, COLUMNS AND BEARING PLIES – DIMENSIONS AND SECTION PROPERTIES (First Revision)", Bureau Of Indian Standards, ManakBhavan, Bahadur Shah ZafarMarg, New Delhi, IS 12778, CED 7, September 2004
[4]. Indian Standard, "JIB CRANES – CODE OF PRACTICE", Bureau Of Indian Standards, ManakBhavan, Bahadur Shah ZafarMarg, New Delhi, IS 15419, MED 14, February 2004
[5]. James Fisher, Et.Al, "DESIGN CONCEPT FOR JIB CRANES", Paper Discussion By Michael Hemstad, TKDA, Minnesota, Engineering Journal, Fourth Quarter, 2003, Pp. 235-236
[6]. GORBEL, Inc. "INTRODUCTION TO JIB CRANES", United States 1/12, 2012

Referred Links

1. Http://Www.Singlegirdereotcrane.Com/
2. Http://En.Konecranes.Ca/
3. Http://Ispatguru.Com/Tag/Jib-Crane/
4. Http://Www.3benefitsof.Com/
5. Http://Www.Sahilcrane.Com/Default.Aspx