DESIGN,COSTRUCTION AND PERFORMANCE STUDY OF A PORTABLE JIB CRANE USING HAND WINCH

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Declaration

It is declared hereby that this Thesis paper or any part of it has not been submitted to anywhere else for the award of any degree.

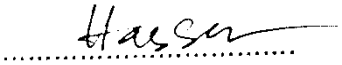
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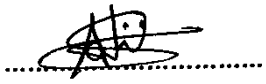
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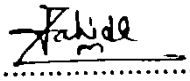
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Certification

This is to certify that this project entitled ‘’Portable Jib Crane‘’ is done by the above students under my direct supervision.
This project work has been carried out by them in the laboratories of the Department of Mechanical Engineering under the Faculty of Engineering , Sonargaon University (SU) in partial fulfilment of the requirements for the degree of Bachelor of Science in Mechanical Engineering.

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ABSTRACT

This research investigates the design, analysis, and optimization of a portable crane. The focus is on enhancing the crane's structural integrity, load-bearing capacity, and ease of assembly and disassembly. Finite Element Analysis (FEA) techniques are employed to simulate the crane's behaviour under various loading conditions, allowing for the identification of critical stress points and potential failure modes.

To optimize the crane's design, a multi-objective optimization approach is adopted, considering factors such as weight, strength, and cost. The optimization process involves the use of genetic algorithms to explore a wide range of design parameters and identify the optimal solution.

The findings of this research contribute to the development of safer, more efficient, and cost-effective portable cranes. The optimized designs can be used to guide the manufacturing process and improve the performance of portable cranes in various applications, such as construction, manufacturing, and logistics.

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MATHEMATICAL SYMBOLS

L=Length

A=Area

D=Diameter

d = Nominal Diameter

m =Mass

g= Gravitational Acceleration

v=Volume

M =Moment

S = Stress

I = Moment of inertia

P = load

ρ = Density

Chapter-01

INTRODUCTION

1.1 Introduction

A jib crane is a versatile lifting device that features a horizontal beam, known as a jib arm, which is used to lift and move loads. This type of crane is highly adaptable and can be utilized in various settings such as manufacturing plants and warehouses. The jib arm extends from a vertical pillar (or column) allowing for a wide range of motion and flexibility in lifting operations. Whether it requires to lift heavy materials, equipment, or other loads, a jib crane provides an efficient and reliable solution for lifting needs.Small portable cranes are compact, lightweight lifting machines designed for various applications where larger cranes are impractical or unnecessary. These cranes offer a flexible and efficient solution for lifting and moving heavy loads in confined spaces, construction sites, warehouses, and workshops.Small portable cranes come in various lifting capacities, ranging from a few hundred pounds to several tons, allowing them to handle a wide range of loads.

1.2 Literature Review

The Classical Greek period marked a significant advancement in lifting technology. By the 6th century BCE, the Greeks developed cranes with winches and compound pulley systems. This innovation allowed workers to lift heavier loads using reduced human effort. The jib arm, a horizontal beam capable of rotating around a pivot point, began to emerge during this time.[1]

The Industrial Revolution (18th–19th century) was a transformative period for crane technology[4]. The demand for efficient material handling in factories, shipyards, and warehouses spurred innovations in crane design. Key advancements included:
Introduction of gears and lever systems to improve mechanical efficiency[5].
Use of durable materials such as iron and steel, enhancing crane capacity and lifespan[7].
Development of manual chain hoists and winches, making lifting easier with human power.
During this period, the manual jib crane emerged as an essential tool for localized lifting tasks. Its ability to rotate and lift loads within a specific radius made it highly adaptable for workshops and small-scale operations.

By the 20th century, the manual jib crane had become a staple in material handling processes, particularly in small industries and workshops[8]. While electrically powered and hydraulic cranes gained. Modern manual jib cranes incorporate features such as manual chain blocks, slewing mechanisms, and adjustable mounts, making them efficient and user-friendly[13].

Ancient Egypt (3000 BCE): Early evidence of lifting mechanisms can be traced to the construction of the pyramids[16]. Workers utilized ropes, sledges, and ramps to lift and transport heavy stone blocks. Similar lifting methods were adopted in irrigation systems and ziggurat construction. These early tools laid the groundwork for crane technology, providing foundational knowledge of mechanical advantage through ropes, pulleys, and counterweights[18].

The Romans adopted and improved crane technology, incorporating treadwheel mechanisms. These cranes were widely used in constructing temples, aqueducts, and monumental structures. During the Middle Ages, crane designs became more sophisticated[12]. Treadwheel Operated by workers walking inside a large wheel, providing greater lifting capacity. Jib-Style Cranes Early versions of jib cranes allowed loads to be lifted and moved horizontally, improving versatility on construction sites and docks. Cranes during this period were primarily used in the construction of cathedrals, castles, and bridges, marking a transition from fixed lifting systems to rotational designs[19].

A jib or jib arm is the horizontal or near-horizontal beam used in many types of crane to support the load clear of the main support.[1][2] An archaic spelling is gib.
Usually jib arms are attached to a vertical mast or tower or sometimes to an inclined boom. In other jib-less designs such as derricks, the load is hung directly from a boom which is often anomalously called a jib.

A camera jib or jib arm in cinematography is a small crane that holds nothing but the camera.
James T. Frane Craftsman's Illustrated Dictionary of Construction Terms 1572180080 1994 p83 "crane jib -an extension at the top of a crane tower that gives the crane additional lifting or moving capabilities[14]. There are different types of jibs. A saddle jib is a horizontal extension, at a right angle to the tower, with a hook attached to a trolley."

Jib cranes are versatile material handling equipment widely used in various industries, including manufacturing, construction, and warehousing[13]. They offer a cost-effective solution for lifting and moving heavy loads within a limited workspace.

1.3 Research purposes

Portable Jib cranes are compact, versatile lifting machines designed for various applications where larger cranes are impractical or unnecessary. They are ideal for construction sites, warehouses, workshops, and other locations with limited space.
Future Research Directions:
1.Advanced Materials: The exploration of advanced materials, such as composite materials, could lead to lighter and stronger jib cranes.
2.Intelligent Control Systems: The development of intelligent control systems, such as artificial intelligence and machine learning, can further optimize jib crane operations.
3.Human-Robot Collaboration: The integration of robotic arms with jib cranes can improve productivity and flexibility in manufacturing processes.

1.4 Objective

The primary objective of a jib crane is to '' facilitate the efficient and safe lifting, lowering, and horizontal movement of heavy or bulky loads within a limited workspace.''[3][6]

Here's a breakdown of how jib cranes achieve this objective:

1.4.1 To design and construct an optimized boom of jib crane to increase its strength.

1.4.2 To analyse the performance of construct boom.

Chapter-02

MATERIALS SELECTION

2.1 General criteria for materials selection

A general procedure that could be used for identifying the most appropriate material for a specific portable jib crane application would consist of the following the jib crane requirements-Establish a strategy for evaluating candidate materials, Identify candidate materials-evaluation ,materials in depth special considerations which affect materials selection. When selecting materials for a specific application, engineers and designers consider several factors to ensure optimal performance, durability, and cost-effectiveness.[4]

2.2 Physical Properties of a Jib Crane

A jib crane is a type of lifting equipment featuring a horizontal or near-horizontal arm (the jib) that extends from a vertical support (the mast). This configuration allows for efficient lifting and moving of loads within a limited workspace. The maximum weight the jib crane can safely lift. This is typically indicated by the manufacturer and should never be exceeded. The horizontal distance from the mast to the end of the jib arm. This determines the crane's coverage area. The vertical distance from the ground to the hook or trolley at full extension. The angle of the jib arm relative to the horizontal. This can be fixed or adjustable depending on the crane design. The degree of rotation the jib arm can make around the mast. This is often 360 degrees for maximum flexibility. Can be floor-mounted, wall-mounted, or freestanding. Typically a chain hoist or wire rope hoist, which may be manual or powered. A movable carriage that runs along the jib arm, allowing the load to be positioned precisely.[6][9]

2.3 Mechanical Properties of a Jib Crane

Mechanical properties are crucial for ensuring the safe and efficient operation of a jib crane. These properties relate to the crane's ability to withstand loads and stresses without deformation or failure. The capacity of the crane to resist deformation or fracture under load. The stress at which the material begins to deform plastically. The maximum stress a material can withstand before breaking. The resistance of the crane to elastic deformation under load. It is quantified by the modulus of elasticity (Young's modulus). A higher modulus of elasticity indicates greater stiffness. The ability of the crane to withstand repeated loading and unloading cycles without failure. The ability of the crane to withstand sudden shocks or impacts. The ability of the crane material to deform plastically before fracturing. This is important for absorbing energy during impact. The choice of materials (typically steel) significantly influences the mechanical properties of a jib crane. High-strength steels are often used to enhance strength and stiffness. Proper design and manufacturing processes, including welding and heat treatment, are essential for achieving optimal mechanical properties. Regular maintenance and inspections help to identify and address any issues that could compromise the mechanical integrity of the crane.[8][11]

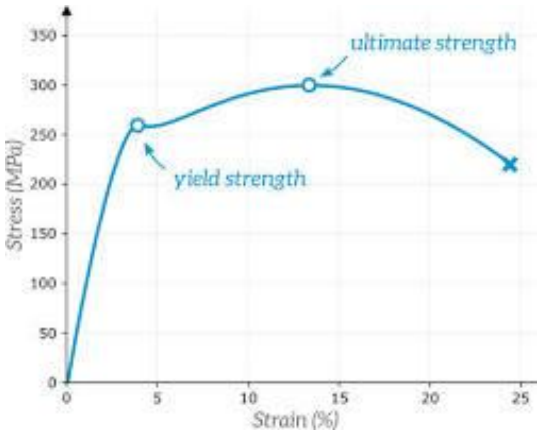


Fig-2.1: Stress-Strain Diagram (MS)

2.4 Methodology of the study

Creating a portable jib crane at home can be a challenging task, especially for those without welding and metalworking expertise[17][19]. However, there are simpler alternatives that can be considered:

1. Purchase a Pre-Assembled Portable Jib Crane: This is the easiest option, but it can be expensive. You can find a variety of portable jib cranes online or at hardware stores. Consider factors like weight capacity, boom length, and mobility when choosing a pre-assembled crane.
2. Use a DIY Jib Crane Kit: Some companies offer DIY kits that include all the necessary components and instructions. These kits often require basic assembly skills and tools like a wrench and screwdriver.
3. Create a Simple Jib Crane Using Existing Materials: If you have some basic woodworking skills and access to sturdy materials, you can build a simple jib crane using wood beams and a pulley system. However, this option is limited in terms of weight capacity and durability

2.5 Classification

Portable jib cranes can be classified based on their mounting type and mobility:

Mounting Type:

1.Wall-Mounted Jib Cranes
2.Pillar-Mounted Jib Cranes
3.Free-Standing Jib Cranes

Mobility Type:

1.Fixed Jib Cranes
2.Mobile Jib Cranes (Portable)

Based on load capacity:

Light-duty: 500-1000 lbs
Medium-duty: 1000-2000 lbs
Heavy-duty: 2000+ lbs



Fig-2.2: Free-Standing Jib Cranes

Chapter-03

EXPERIMENTAL DESIGN

3.1 Working Principles

A portable jib crane is a versatile lifting equipment that operates on a relatively simple yet effective principle. It consists of a boom, a mast, and a hoist.[2][5]

Here's a breakdown of its working principle:
1.Boom and Mast: The boom is a horizontal arm that extends from the mast. The mast is the vertical support structure that holds the boom in place. The boom can be rotated around the mast, providing a wide range of motion.
2.Hoist :The hoist is the mechanism that lifts and lowers the load. It's typically an electric or manual chain hoist. The hoist travels along the boom, allowing for precise positioning of the load.

Key Advantages:
1.Versatility: Can be used for a wide range of lifting tasks.
2.Mobility: Can be easily moved to different locations.
3.Efficiency: Improves productivity by reducing manual handling.
4.Safety: Reduces the risk of injuries associated with manual lifting.

Key Components and Principles:
1.Leverage:The long arm of the crane acts as a lever. The point where the boom pivots and applying a smaller effort (force) to the longer end of the boom, a larger load can be lifted at the shorter end.
2.Pulley System: Grooved wheels that guide a rope or cable By using multiple pulleys, the required effort to lift a load is reduced and Pulleys can change the direction of the force applied.
3.Counterweight: A heavy weight positioned opposite the load to prevent tipping and Ensures the crane remains stable during lifting operations.
4.Power Source: Hand-cranked winches or levers and Hydraulic fluid is used to generate force.

How it Works:
1.Setup: The crane is positioned and stabilized.
2.Hooking the Load: The load is attached to the hook.
3.Lifting: By applying force to the lever or activating the power source, the pulley system lifts the load.
4.Positioning: The boom can be adjusted to position the load.
5.Lowering: The power source is reversed to lower the load.

3.2 Structure Measurement

Elements

1.Caster Wheel
2.Steel Structure
3.Wire Rope
4.Rope Pulley
5.Lifting Huck
6.Hand Winch
7.Hydrolic jack

1. Key Parameters and Assumptions

Load Weight (W): 90 kg
Boom Arm Length: Variable, depending on the desired reach.
Safety Factor: Assume 2 (ensures the design can safely handle 100 kg).
Material Strength: Use steel lightweight strength.
Hydraulic Jack Force (F): Use a 1-ton jack with a 200–250 mm stroke.

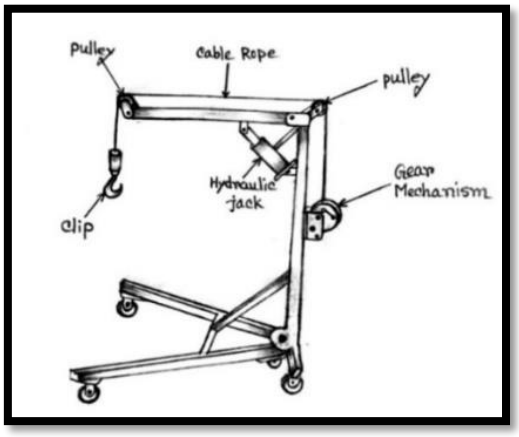


Fig-3.1: Project Sketch

3.3 Caster Wheel

A caster (or castor) is an undriven wheel that is designed to be attached to the bottom of a larger object (the "vehicle") to enable that object to be moved.

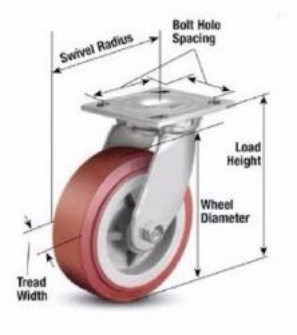


Fig-3.3: Caster Wheel

Caster wheels come in all shapes, sizes and materials for different applications, environments and industries. Peruse some high-level differences between different wheel types here.

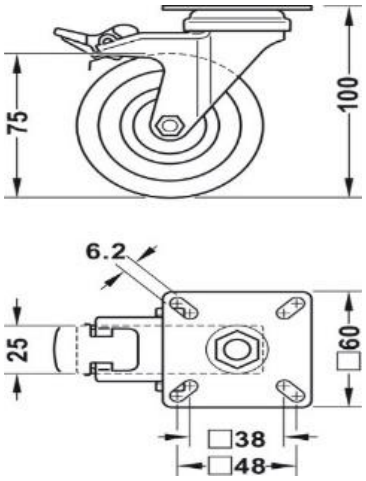


Fig-3.3.1: Caster Wheel Drawing & measurement

The size of caster wheels depends on the weight of the load and the type of floor. For lightweight, seldom used equipment on smooth floors, use caster wheels with a diameter of 75mm (3").For trolleys wheeled quickly, or on uneven floors, use caster wheels with a diameter of 125mm (5") or larger. There are 3 different castor wheel ratings depending upon the strength, durability and manoeuvrability required for the load capacity:

1.Light duty supporting weights of up to 75kg
2.Medium duty supporting weights of between 76 kg and 140 kg
3.Heavy duty supporting weights of over 141 kg

3.4 Steel Hole Bar (MS)

This square steel bar is a mild solid steel bar with radius corners and is manufactured using the hot-rolling method. It is most suitable for general fabrication, manufacturing, repairs, and structural applications.



Fig-3.4: Square bar

Mild steel is a type of carbon steel with a low carbon content, typically between 0.05% and 0.25%. It is also known as low-carbon steel. Mild steel is a versatile and widely used material due to its combination of properties:

Important Considerations:
1.Strength: Mild steel has good strength, but it is not as strong as high-carbon steel or alloy steels.
2.Corrosion: Mild steel is susceptible to corrosion, especially in harsh environments. It is important to protect it with appropriate surface treatments.
3.Welding: Mild steel is easily weldable, but it is important to use the correct welding techniques and materials to ensure good quality welds.

Common Shapes and Sizes:
Mild steel is available in various shapes and sizes to suit different applications. Some common forms include:
1.Sheets and plates
2.Bar (Solid and hole)
3.Angle
4.Pipe
5.Channels

3.5 Wire Rope

Wire rope is a type of rope made from twisted metal strands that are wound together to form a strong and flexible cable. It's commonly used in industries like construction, mining, and shipping for lifting, pulling, and supporting heavy loads.



Fig-3.5: Wire Rope

Wire rope is composed of as few as two solid, metal wires twisted into a helix that forms a composite rope, in a pattern known as laid rope.

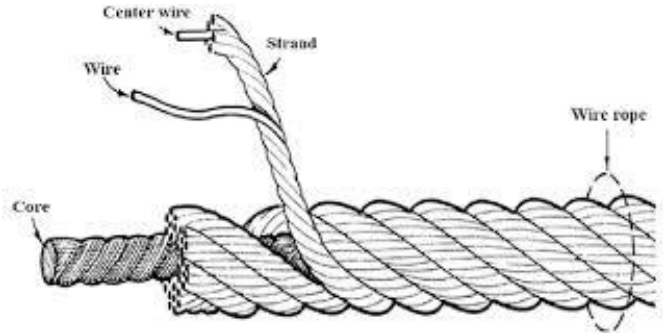


Fig-3.5.1: Wire Rope Structure

Construction

Wire rope typically consists of three main components:

1.Core: The core provides the rope's structural integrity and flexibility. It can be made of hemp, fiber or steel wire strands.

2.Strands: These are bundles of wires twisted together to form the rope's main strength element.

3.Wires: Individual wires make up the strands. They are usually made of high-tensile steel for maximum strength.

3.6 Rope Pulley

A pulley is a wheel on an axle or shaft enabling a taut cable or belt passing over the wheel to move and change direction, or transfer power between itself and a shaft. A sheave or pulley wheel is a pulley using an axle supported by a frame or shell (block) to guide a cable or exert force. A pulley may have a groove or grooves between flanges around its circumference to locate the cable or belt. The drive element of a pulley system can be a rope, cable, belt, or chain.

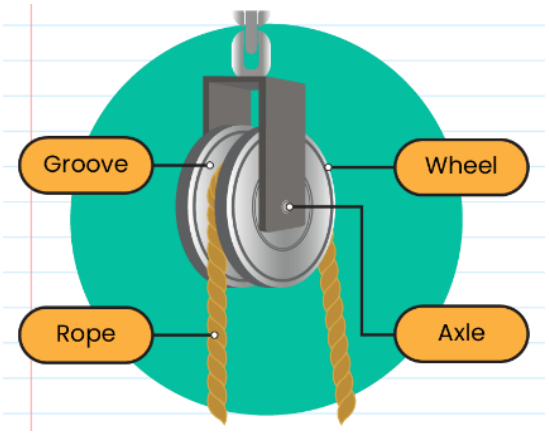


Fig-3.6:Rope Pulley

Rope pulleys are engineered to be used with fastenings and serve as the perfect way to deflect wires or synthetic ropes in a safe but effective manner. They're ideal for ensuring you can lift heavy objects safely off the ground, making them a great item to have on construction sites, large-scale event venues and festivals where heavy equipment is used.

Safety Considerations

1.Use the correct rope and pulley system for the load.
2.Inspect the rope and pulleys for wear and tear before each use.
3.Ensure the load is evenly distributed.
4.Use proper lifting techniques and wear safety gear.
5.Never exceed the rated capacity of the pulley system

3.7 Crane hooks

Crane hooks are essential components in the heavy-lifting industry, designed to hold and lift loads securely. Crane lifting hooks come in various types, each designed for the crane they are used with for specific lifting tasks and applications.



Fig-3.7: Crane hook

Crane hooks are essential components of lifting equipment, used to securely attach loads to cranes and hoists. They come in various shapes and sizes, designed to handle different load capacities and specific applications.

Key features and considerations:
1.Material: High-strength steel or alloy steel for durability and safety.
2.Capacity: Rated load capacity, which should not be exceeded.
3.Safety latch: A locking mechanism to prevent accidental release of the load.
4.Inspection and maintenance: Regular inspections are crucial to ensure the hook's integrity.

Potential Misinterpretation:
There might be a misunderstanding related to the term "huck" in the context of cranes. It's possible that you might be referring to a specific brand or model of crane hook, or a particular technique or operation related to crane usage.

To get more specific information, please provide additional context or details, such as:
1.Brand or manufacturer: If you know the specific brand or model of the crane hook.
2.Application: The industry or specific use case where the crane hook is being used.
3.Image or diagram: A visual representation can help clarify the query.

3.8 Hand Lever Winch

A winch is a mechanical device that is used to pull in (wind up) or let out (wind out) or otherwise adjust the tension of a rope or wire rope (also called "cable" or "wire cable"). In its simplest form, it consists of a spool (or drum) attached to a hand crank.



Fig-3.8.1 Hand Lever Winch

Lever winches are winches that use self-gripping jaws instead of spools to move rope or wire through the winch. Powered by moving a handle back and forth, they allow one person to move objects several tons in weight.

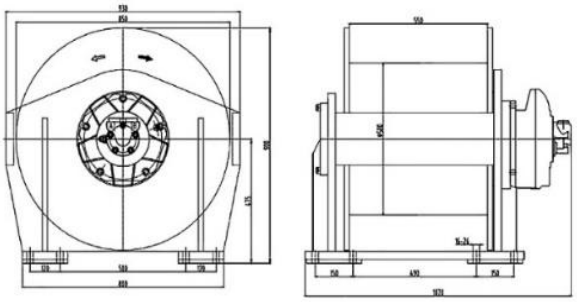


Fig-3.8.2: Hand Lever Winch Drawing & measurement

Key Components:

3. Frame
4. Cable
5. Brake

2. Drum
4. Hand Lever

How it Works:

Attach the Load: The cable is securely attached to the load to be lifted or pulled.

Engage the Lever: The user grips the hand lever and applies force in a circular motion.

Gear Reduction: The gear system within the winch reduces the speed of the cable's movement while increasing its pulling force.

Cable Winding: The rotation of the drum caused by the gear system winds or unwinds the cable, lifting or pulling the load.

Brake Engagement: When the lever is released, the brake mechanism engages, preventing the load from slipping or falling.

3.9 Hydraulic jacks (Bottle Type)

A hydraulic jack is a mechanical device that utilizes the principle of Pascal's Law to lift heavy loads. It's a compact and powerful tool commonly used in automotive repair, construction, and various industrial applications.



Fig-3.9: Hydraulic jacks (Bottol Type)

Components :

1. Extension Screw
2. Saddle
3. Ram
4. Filler Plug
5. Socket
6. Piston Assembly
7. Release Valve

Main principle

The hydraulic press depends on Pascal's principle. The pressure throughout a closed system is constant. One part of the system is a piston acting as a pump, with a modest mechanical force acting on a small cross-sectional area; the other part is a piston with a larger area which generates a correspondingly large mechanical force. Only small-diameter tubing (which more easily resists pressure) is needed if the pump is separated from the press cylinder.

Safety Tips:
1.Never exceed the jack's rated capacity.
2.Always use jack stands to support the load.
3.Avoid lifting the load too high.
4.Inspect the jack for any damage or leaks before use.
5.Wear appropriate safety gear when using a bottle jack.

3.10 Introduction of component:

SL NO	PARTICULAR	SPECIFICATION	QTY	REMARKS
01	Caster Wheel (Nylon)	60mm	04 pcs	
02	Steel Structure (MS Hole Bar)	2''x2''x3mm 1.5''x1.5''x3mm	22 Feet 8 Feet	
03	Wire Rope	6x19 (6mm OD)	10 M	
04	Rope Pulley (MS)	60 mm (OD)	02 pcs	
05	Hand Winch	180 mm	01 pcs	
06	Hydraulic jack (Bottle Type)	1 Ton (capacity)	01 pcs	

Fig-3.10: List of components



Fig-3.10.1: Project Photo

Chapter-04

APPLICATION AND BENEFITS

4.1 Benefits and Applications

Jib cranes offer numerous benefits, making them an invaluable asset in various industries:
Increased Productivity and Efficiency By streamlining lifting operations, jib cranes help boost productivity and reduce downtime.[13]
Common applications of jib cranes include:
Manufacturing: For handling parts and machinery in production lines.
Warehousing: For efficiently moving equipment within storage facilities.
Shipping and Receiving: For loading and unloading items in warehouses.
Overall, jib cranes are a reliable and efficient lifting solution that enhances productivity and safety across various industries.
Portable jib crane systems are used in a variety of industries, including:
1.Manufacturing
2.Construction
3.Warehousing
4.Automotive
5.AerospaceAnd more.
Key Features and Benefits:
1.Mobility: Portable jib cranes are designed to be easily moved around your workspace, allowing you to adapt to changing needs and optimize your workflow.
2.Flexibility: They can be used in a wide range of applications, including lifting, positioning, and transferring heavy loads. Their compact design makes them suitable for both indoor and outdoor use.
3.Safety: Portable jib cranes provide a safer way to handle heavy loads, reducing the risk of strain injuries and accidents
4.Cost-Effective: Compared to traditional overhead cranes, portable jib cranes are often more affordable and easier to install, making them a cost-effective solution for many businesses.

4.2 Safety Considerations

Safety Standards: Adherence to industry standards, such as OSHA and ANSI, is crucial for ensuring the safety of workers and preventing accidents. Regular inspections and maintenance are essential to maintain the reliability and safety of jib cranes.
Load Capacity and Stability: Accurate load capacity calculations and stability analysis are critical to prevent overloading and tipping. Proper balancing of loads and careful operation are essential for safe use.
Load Capacity: Never exceed the crane's rated capacity.
Stability: Ensure the crane is properly balanced.
Operator Training: Proper training is essential.
Regular Inspection: Regular maintenance is crucial.
Safe Work Practices: Follow all safety guidelines.

4.3 Making process

There are several options for how and where to mount a Jib Crane XS. Depending on the structural layout and supporting elements in the working environment, a Jib Crane XS can be either mounted directly on a wall or onto a pillar. A wall-hung jib crane frees up floor space, while a pillar-mounted crane will fully optimize on rotation.[14]

Tools:

1.Welding equipment
2.Cutting tools (grinder, saw)
3.Drilling machine
4. Wrenches
5.Measuring tools
6.Vice and Work table

Frame Construction:
1.Base: Weld the base frame to the desired shape and size.
2.Boom: Weld the boom to the base, ensuring it can pivot smoothly.
Winch and Pulley System:
1.Mount Winch: Secure the winch to the base or boom, depending on your design.
2.Install Pulleys: Position pulleys strategically to maximize lifting power and cable length.
3.Route Cable: Route the cable from the winch to the load hook, using the pulleys to change direction.
Mobility (Optional):
1.Wheels: Attach wheels to the base for easy movement.
2.Locking Mechanism: Consider a locking mechanism to secure the crane in position.

Load Capacity: Determine the maximum weight you'll need to lift.
Boom Length: Calculate the required boom length based on your workspace and load capacity.
Base Size: Ensure the base is large enough to provide stability.

Testing and Safety:
1.Static Load Test: Load the crane with the maximum weight it's designed to lift and check for stability.
2.Dynamic Load Test: Lift and lower the load to test the winch and pulley system.
3.Safety Features: Implement safety features like overload protection and emergency stop buttons.

Chapter-05

DATA ANALYSIS AND DISCUSSION

5.0 Calculation

5.1 Key Parameters and Assumptions

- **Load Weight (W):** 50 kg
- **Boom Arm Length:** Variable, depending on the desired reach.
- **Safety Factor (FoS):** Assume 2 (ensures the design can safely handle 100 kg).
- **Material Strength:** Use steel or aluminium for lightweight strength.
- **Hydraulic Jack Force (F):** Use a 1-ton jack with a 150–200mm stroke.

5.2 Boom Arm Dimensions [17][21]

The boom arm length depends on the **moment balance**. The crane must remain stable even when the load is extended outward.

Step 1: Calculate the Torque (Moment) Produced by the Load

Torque due to load = W×L arm

- W = 90 kg
- Larm= Length of the boom arm (assume 1–1.5 m initially for calculation).

Step 2: Counterbalance Torque from the Base

For stability, the counterbalance or base weight must resist the torque. This is done by ensuring the base frame is wide enough to shift the center of gravity back towards the support.

Base Width(B)≥W×Larm / Wbase

Wbase: Weight of the base/frame itself or additional counterweight.
Assume Wbase = 25 kg.

Example: Boom Arm and Base Width

- Let Larm= 1.5 m (maximum extension).
- Torque due to load: T=90kg×.5 m= 135 kg\cdotpm
- Base width calculation: B ≥ 90 / 25 = 3.6 m

This implies we need to either reduce the boom arm length or increase the base weight to maintain a practical base width.

5.3 Adjusted Boom Arm and Base Dimensions:

- Boom Arm Length (Larm): **1.5 m** (to keep the base width manageable).
- Base Width (B): **0.**5 **m**.

5.4 Hydraulic Jack Force and Placement

The jack must be positioned to provide enough force to lift the boom arm and the load.

Step 1: Calculate Required Force

The force Fjack needed to lift the load depends on the angle (θ) between the jack and the boom arm:

$$Fjack = W \times Larm / Ljack \times \sin(\theta)$$

Where:

- W : Load weight = 90 kg.
- Ljack: Length of the jack stroke (assume 200 mm = 0.2 m).
- sin(θ): Assume 45° ($\sin(45°) \approx 0.707$) for optimal force transmission.

Example:

$$Fjack = 90 \times 1.5 / 0.2 \times 0.707 = 954.74 \text{ N} = 97.00 \text{ kgf}$$

A 1-ton hydraulic jack (10,000 N capacity) easily exceeds this requirement.

5.5 Structure Dimensions

The vertical support and base structure must provide sufficient stability and height.

Step 1: Vertical Support Height

The support height should accommodate the boom arm's lifting range:

$$Hsupport = Hload + ClearanceH$$

- Hload=1.3 m (desired max lift height).
- Clearance: Add 0.2 m for pulley and hook.

$$Hsupport = 1.3 + 0.2 = 1.5 \text{ m}$$

Step 2: Base Length

The base length (Lbase) must prevent tipping when the load is fully extended:

$$L_{base} \geq W \times L_{arm} / W_{base}$$

Using Larm=1.5m, Wbase=25 kg:

$L_{base} \geq 90 \times 1.5/25 = 5$ m

For practicality, a **counterweight** can be added to reduce this.

5.6 Final Dimensions

Component	**Value**
Boom Arm Length	1.5 m (adjustable)
Vertical Support Height	1.5 m
Base Length	1.4 m (adjustable)
Base Width	0.3–0.5 m
Hydraulic Jack Stroke	150–200 mm

5.7 Jack Specifications

5.7.1 Dimensions

- **Collapsed Height:150–200 mm**
  - This is the height of the jack when fully retracted.

5.7.2 Load Capacity

- **Rated Load:** 1 ton
- **Safety Factor:** The jack is designed to lift 1000 kg but can handle higher loads due to built-in safety margins, making it ideal for lifting a 90 kg load with a high factor of safety.

5.7.3 Stroke (Lifting Range)

- **Stroke Length (Travel Distance):150–200 mm**
  - This is sufficient to provide a vertical lift range of ~300–400 mm in the crane design.

5.7.4 Pressure and Effort

- **Operating Pressure:150–200 bar**
    - Common for manual hydraulic jacks, achievable with standard hand-pumping effort.
- **Input Effort (Pump Force):** Typically requires **<15–20 kg of force** to operate, ensuring ease of manual use.

5.7.5 Approximate Weight of the Jack: 3–5 kg

- Lightweight enough to integrate seamlessly into the crane's design.

5.8 Pulley Specification

5.8.1. Load Capacity

The pulley should be capable of handling the **90 kg load** with a safety factor (FoS) of at least **3** for durability and safety.

- **Load to be supported:** 90 kg×9.81 m/s2=882.9 N
- **Safety Factor:3**.

Rated Load Capacity (Minimum)= 882.9 N×3=2648.97 N (∼265 kg).
Recommended Pulley Load Capacity:265 kg or more.

5.8.2. Material

The pulley must be made from a material capable of withstanding wear and tear while lifting.

- **Sheave Material (Wheel):** Alloy steel or cast iron with corrosion resistance.
- **Frame/Body:** Steel or aluminium for lightweight durability.
- **Bearing:** Ball bearings or bushings to reduce friction during operation.

5.8.3. Pulley Sheave Diameter

The sheave diameter depends on the **rope/cable** used. A larger diameter minimizes bending stresses on the cable, extending its lifespan.

- **Cable Diameter (d):** Assume **6 mm** for lifting 90 kg.
- **Recommended Sheave Diameter:** At least **10–12 times the cable diameter**.

Sheave Diameter (Minimum)=6 mm×10=60 mm.
Recommended Pulley Sheave Diameter:60–80 mm.

5.8.4. Pulley Type

- **Fixed Pulley:** For changing the direction of the force only (e.g., top of the boom arm).
- **Movable Pulley:** Provides mechanical advantage if used (not necessary in this design but optional).
- **Swivel Pulley:** Ideal for this design as it allows movement and rotation for alignment during lifting.

5.9 Wire Rope

- Type: 6x19 steel wire rope with 6 mm diameter.
- Load Capacity: Safe working load (SWL) of 288 kg; breaking strength ~1,200 kg.

Rope Type	Nominal Dia (mm)	Av. Weight (kg/cm)	Strength (1000-12500 kg/cm^2)	Remarks
6x19	6,8,10,12,14, 16,18,20,22,25	$.39d_r^2$	$3925d_r^2$	

Table:5.3.1 Rope Strength

<u>Calculation Of safe working Load of Wire Rope Sling</u>

Formula: SWL of Wire Rope Sling (KG) = D^2(mm) x 8 *D=Diameter of Wire Rope*

= 6^2 x 8

= 288 KG

Diameter: 6 mm
Type: 6x19 Construction (Steel Wire Rope)
Six strands, each with 19 wires.
Why: Provides a good balance between flexibility, durability, and load capacity. Ideal for lifting as it resists kinking and wear during operation.

Breaking Strength:
For galvanized steel: Typically between 1,000–1,200 kgf (kilograms-force) depending on manufacturing quality.
This provides as 90 kg load, which is excellent for lifting operations.

5.10 Performance Evaluation

Mobility:
The use of nylon caster wheels provides easy movement even under heavy loads, ensuring portability across workshops.
Strength and Durability:
Material selection (mild steel and galvanized steel wire) ensures long-term durability.
High safety factors in design minimize risks of failure.
Energy Efficiency:
Hydraulic jack offers smooth operation with minimal manual input.
The winch mechanism reduces human effort, improving productivity.
Cost-Effectiveness:
The portable design minimizes material use without compromising strength, lowering costs compared to traditional fixed cranes.

5.11 Performance Test

Lifting capacity (Kg) at different base Length, boom height & angle

Lifting capacity (Kg) at Initial base Length (42 inch)

Boom length (inch) / Boom angle (Degree)	Initial length (44 inch)	½ length (51 inch)	Final length (58 inch)
0^0	80 kg	60 kg	45 kg
30^0	90 kg	75 kg	50 kg
45^0	120 kg	90 kg	65 kg

Fig-5.11.1 Performance Table

Lifting capacity (Kg) at half base Length (48 inch)

Boom length (inch) / Boom angle (Degree)	Initial length (44 inch)	½ length (51 inch)	Final length (58 inch)
0^0	90 kg	80 kg	60 kg
30^0	100 kg	85 kg	75 kg
45^0	130 kg	110 kg	90 kg

Fig-5.11.2 Performance Table

Lifting capacity (Kg) at Final base Length (54 inch)

Boom length (inch) / Boom angle (Degree)	Initial length (44 inch)	½ length (51 inch)	Final length (58 inch)
0^0	100 kg	90 kg	80 kg
30^0	110 kg	100 kg	90 kg
45^0	140 kg	130 kg	120kg

Fig-5.11.3 Performance Table





Fig-5.11.4 Performance Test Photos.

Chapter-06

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Jib cranes have proven to be indispensable tools in a wide range of industries, from manufacturing and construction to maintenance and repair. Their versatility, efficiency, and relatively compact design make them a preferred choice for many material handling tasks. Will further enhance the capabilities and safety of jib cranes, making them even more valuable assets in modern industries. In conclusion, jib cranes are a cornerstone of efficient and safe material handling. Their continued evolution, driven by technological advancements and a focus on safety and sustainability, ensures their continued relevance and importance in the years to come.

The jib crane is designed and analysed in accordance with industry standards using he modelling programme UG-NX and the finite element solver Ansys.
The job is done by modifying the model's design and using different materials.
In the analysis section, the model was analysed at two loading conditions: mid-span and end-of-span, with the findings compared.
The deformation values of the reinforced jib crane are lower than the actual jib crane, indicating that the deformation values are lower, implying that the jib's life time will be extended and the project's goal will be met.
As part of the present project's expansion, the models are analysed while the materials are changed.
After comparing the data, we found the ASME A36 steel deformation values were lower than the structural steel. As a consequence, we believe that the reinforced jib with ASME A36 steel is a superior choice for industrial jib cranes because it will last longer and require less maintenance.

6.2 Recommendations for Future Work

In the event that any future experiments take place to further assess the performance of portable gib crane, Here are some key recommendations for the future of jib cranes:

By pursuing these research directions, we can further advance the design, operation, and application of jib cranes, making them safer, more efficient, and more sustainable tools for industries worldwide. Jib cranes have a long history of serving industries, and their evolution continues with advancements in technology and design.

6.2.1. Advanced Materials and Manufacturing:

Lightweight Composites: Explore the use of advanced composite materials like carbon fibre reinforced polymers (CFRP) to reduce the weight of jib cranes while maintaining or improving Additive Manufacturing: Investigate the potential of additive manufacturing (3D printing) for the production of complex and customized jib crane components. This could enable the creation of optimized designs and reduce material waste.

6.2.2 Enhanced Safety and Ergonomics:

AI-Powered Safety Systems: Develop AI-powered systems that can predict potential hazards, such as collisions or overloading, and automatically adjust crane operations to prevent accidents.

Ergonomic Design Optimization: Conduct research to optimize the design of jib crane controls and operator interfaces for improved ergonomics, reducing operator fatigue and the risk of musculoskeletal disorders.

6.2.3 Smart Technology Integration Develop predictive maintenance systems that utilize sensor data and machine learning algorithms to anticipate maintenance needs and minimize downtime.

Block chain Technology: Explore the use of block chain technology to enhance the traceability and authenticity of jib crane components and ensure compliance with safety and quality standards.

6.2.4. Human-Robot Collaboration:

Collaborative Robotics: Explore the integration of collaborative robots with jib cranes to enhance flexibility, precision, and safety in material handling operations.

REFERENCES

1. Gere, J. M., & Goodno, B. J. (2012). *Mechanics of Materials*. Cengage Learning. [stress]

2.Hibbeler, R. C. (2015). *Engineering Mechanics: Dynamics*. Pearson Education. [torque]

3. Crane Manufacturing objects Technical. (2005). *Wire Rope User's Manual* (4th Edition).

4. Shigley, J. E., Mischke, C. R., &Budynas, R. G. (2004). *Mechanical Engineering Design*. McGraw-Hill.[base width]

5. Parr, A. (2011). *Hydraulics and Pneumatics: A Technician's and Engineer's Guide*. Elsevier.[hydraulic jack]

6. Young, W. C., &Budynas, R. G. (2002). *Roark's crane details & Objects*. McGraw-Hill.[Objects]

7. Citation: CMAA (2020), Chapter 2.1.6: Pulley and Sheave Dimensions.[sheave diameter]

8. Merryfield, F., & Happell, J. (1980). *Hydraulics for Engineers*. Prentice Hall.
(A practical guide to hydraulic jack systems, including Pascal's law and stroke optimization.)

9.Gere, James M., and Barry J. Goodno. *Mechanics of Materials*. 9th ed., Cengage Learning, 2012.*(Covers stress-strain relationships, bending moments, and deflection equations.)*

10.Young, Warren C., and Richard G. Budynas. *Roark's Formulas for Stress and Strain*. 7th ed., McGraw-Hill, 2002.*(Comprehensive formulas for stress, strain, and deflection, including beam and shaft design.)*

11.Shigley, Joseph E., Charles R. Mischke, and Richard G. Budynas. *Mechanical Engineering Design*. 8th ed., McGraw-Hill, 2004.*(Includes formulas for torque, safety factors, and material selection criteria.)*

12.Hibbeler, Russell C. *Engineering Mechanics: Dynamics*. 14th ed., Pearson Education, 2015. *(Offers dynamic load calculations, including torque and force equilibrium.)*

13.Parr, Andrew*: A Technician's and Engineer's Guide*. 3rd ed., Elsevier, 2011.
(Applications & Benefits Discusses hydraulic jack force calculations and pressure formulas.)

14. Parr, Andrew :Crane manufacturing process &*User's Manual*. 4th ed., 2005.
(Explains safe working Process)

15.Crane Manufacturers Association of America. *Specifications for Top Running & Gantry Type Multiple Girder Electric Overhead Traveling Cranes*. CMAA, 2020.
(Focuses on pulleys, sheaves, and load testing guidelines.)

16.Callister, William D., and David G. Rethwisch. Materials Science and Engineering: An Introduction. 10th ed., Wiley, 2018.(Details properties of materials, including steel, for load-bearing applications.)

17. Gerdemeli I., K. Kurt S., Tasdemir B. "Design and analysis withfinite element method of jib crane", Faculty of Mechanical Engineering Istanbul Technical University, Turkey.

18.Timoshenko, Stephen, and J. Norman Goodier. Theory of Elasticity. 3rd ed., McGraw-Hill, 1970.(Useful for stress and strain analysis, including modulus of elasticity.)

19.ASME. ASME B30.2-2018: Safety Standard for Overhead and Gantry Cranes. American Society of Mechanical Engineers, 2018.(Covers safety, design, and testing standards for jib and portable cranes.)

20.Crandall, Stephen H., Norman C. Dahl, and Thomas J. Lardner. An Introduction to the Mechanics of Solids. 3rd ed., McGraw-Hill, 2012.
(Covers the fundamentals of mechanical design and stress-strain relationships.)

21.Reynolds, Terry S. Strong Men and Heavy Lifting: The History of Cranes. Harvard University Press, 1983.(Discusses the evolution of crane technology.)

Web Link

1. https://gemini.google.com
2. Homemade A Small Mobile Crane For Workshop - YouTube
3. https://www.dgcrane.com/jib-cranes
4. https://www.researchgate.net/publication/352553415_Design_and_Analysis_of_Wall_Mounted_Jib_Crane