

Design Modification and Development of an Industrial Trolley

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Abstract

The work focused on the design and development of an industrial trolley, which could improve efficiency, productivity, cost-effectiveness, resource optimization, and industrial development. The aim of the work is to design and develop a reliable material handling device that could impact positively on the industrial operations and economic growth of the organization. The trolley was fabricated in the welding and fabrication shop. Measuring, marking out, and cutting operations were the first methods applied in the fabrication procedures. The cutting operation was done on the galvanized steel pipe and plate. A welding operation was used to assemble all the parts of the machine. The trolley was tested, and it was observed that its maximum load capacity was 2kN. The technology developed was to ensure easy movement of machine tools and other items from one place to another. Therefore, the developed trolley would be utilized for material handling to reduce fatigue, injury, waste of energy, and loss of time.

Keywords: Ergonomics, Productivity, Workforce, Safety, Load analysis

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I. Introduction

Industrial trolleys are essential equipment used in various industries for the efficient movement and transportation of material. They are design to carry heavy loads and provide ease of maneuverability, reducing the risk of manual handling injuries and improving productivity.

The concept of using wheel devices for transporting heavy loads dates back to ancient civilizations. The ancient Egyptians for example, used sledges ad wheeled platform to move heavy stones during the construction of the pyramids [1]. Primarily, the Greeks and Romans employed wheeled carts and wagons for transporting and materials. The industrial revolution, spanning from late 18th to early 19th centuries, marked a significant turning point in the development of industrial trolleys. The advent of stream power and the expansion of factories lead to an increased need for efficient material handling during this period, trolleys and carts with modern platforms and metal frames became common in factories and warehouse [2].

In the mil-19th century, the introduction of cast iron as a construction material revolutionized industrial trolley design. Cast iron provided enhancement strength and durability and allowing trolleys to handle heavier loads. It also facilitated more intricate and robust design [3]. The exceptional strength and rigidity of steel made it useful for heavy material handling applications. Moreover, advancements steel manufacturing techniques, such as welding and rolling, enables the production of more complex and customized trolley designed [4].

However, in recent decades, industrial trolleys have witnessed several innovations driven by technological advancements and changing industrial needs. Some notable developments include:

- i. **Introduction of lightweight materials:** The use of lightweight material such as aluminum and high-strength plastics, has gained popularity, particularly in industries that prioritize portability and maneuverability [5].
- ii. **Ergonomic Improvements:** The focus on ergonomics has led to the integration of adjustable handles, Cushioned grips, and anti-vibration components to reduce operator fatigue and minimize the risk of musculoskeletal injuries [6].
- iii. **Specialize trolley designs:** Industries with unique material handling requirements such as health care, retail and logistics, have witnessed the development of specialized trolley designs. These include medical equipment trolleys, order picking trolleys, and parcel handling trolleys, among others [7].

There are several types of industrial trolleys used in various industries. We have platform trolley, Hand truck, platform truck, pallet jack drum trolley, panel cart etc.

- i. **Platform Trolley:** This type of trolley usually has a flat platform made of steel or other durable materials. It is used to transport heavy or bulky items within a manufacturing or warehouse setting.
- ii. **Hand Truck:** Also known as a two-wheel or dolly, a hand truck is a small trolley with an L-shaped frame and two wheels. It is commonly used to move boxes, crates or other relatively light objects.
- iii. **Plat Truck:** Similar to a platform trolley, a platform truck is larger and sturdier often equipped with four wheels. It is designed to transport heavier loads over longer distances.
- iv. **Pallet Jack:** This is a specialized trolley used to lift and move pallet jacks typically have two forks that slide under that pallet and they are widely used in warehouses and distribution centres.
- v. **Drum Trolley:** This type of trolley is specifically designed for moving and handling drums or barrels. It usually has a cradle or platform to hold the drum securely while being transported.
- vi. **Panel:** A panel cart is commonly used in a load working or construction industries to transport large panels, sheets, or boards, such as plywood or drywall. It often features adjustable arms or clamps to secure the material.

Industrial trolleys can be made from a variety of materials, depending on their intended use and environment. Some common materials used in the construction of industrial trolley include:

- i. **Steel:** Steel is a popular choice for industrial trolleys due to its strength and durability. It can withstand heavy loads and rough handling. Steel trolleys maybe painted or powder coated to provide additional protection against corrosion [4].
- ii. **Aluminum:** Aluminum trolleys are light weighted yet strong making them ideal for applications where portability is important. They are resistant to corrosion, making them suitable for environments where moisture or chemicals are present [5].
- iii. **Plastic:** Plastic trolleys are lightweight corrosion resistant, and easy to handle. They are commonly uses in industrial setting where cleanliness is important, such as food and beverage industry. Plastic trolleys are available in various styles and load capacities [7].
- iv. **Wood:** Wood is often used for platforms or shelves on industrial trolleys. It provides a surely and cost-effective for holding materials.
- v. **Stainless Steel:** Stainless Steel is resistant to corrosion and stains, making it suitable for applications where hygiene is critical, such as in health care or pharmaceutical industries. A is also durable and can withstand heavy loads.
- vi. **Fiberglass:** Fiber glass reinforce plastic trolleys are lightweight resistant to corrosion, and non-conductive, making them suitable for use in environments with electrical equipment or other insulation is required.
- vii. **Rubber:** Rubber is commonly used for the wheels and handles of industrial trolleys. It provides fraction, shock absorption, and noise reduction. Rubber wheels can vary in hardness, depending on the intended surface and load capacity of the trolley.

When it comes to industrial trolleys, the load they carry can have various effects on their performance and operation. Here are some key effects of load in industrial trolleys:

- i. **Weight bearing capacity:** Industrial trolleys are designed to carry specific loads within their weight-bearing capacity. Exceeding this capacity can lead to structural damage, decreased maneuverability, and increased safety risk. It is important to adhere to the manufacturer's guidelines and not overload the trolleys [8].
- ii. **Maneuverability:** The local carried by an industrial trolley affects its maneuverability. Heavier load can make the trolley more difficult to steer and control especially in the tight space. Unevenly distributed or unbalanced load can cause the trolley to tack or become unstable [6].
- iii. **Traction and braking:** The weight of a load influences the traction and braking capacities of an industrial trolley. Heavier loads increase that downward force of the wheels, improving traction [5].
- iv. **Energy Consumption:** The load carried by an industrial trolley impacts its energy consumption. Moving heavier loads requires more power, which can increase energy cost. Additionally, the weight of the load affects the efficiency of the trolley's motor or propulsion system. It may require more energy to accelerate, decelerate, or maintain a constant speed with a heavier load.
- v. **Wear and tear:** The load placed on an industrial trolley can contribute to wear and tear on its components. The wheels, axis, bearing and other parts may experience increased stress and fatigue when carrying heavy loads over extended periods. Regular maintenance and inspections are important to identify and address any damages or signs of excessive wear.

The availability and efficiency of manpower can have a significant impact on material handling operations in industries. Manpower is required to physically handles and transport materials within a facility, such as loading and unloading trucks moving material from one location, and assembling or disassembling products.

The effectiveness of manpower in material handling can affect productivity, safety and overall operational costs with a skilled and sufficient workforce, material can be handled efficiently reducing the time required for task

and improving productivity on the other hand, a shortage of manpower or unskilled labor can lead to delays, errors and accidents, resulting in decreased efficiency and increased costs.

Here are some effects of manpower on material handling

1. **Efficiency:** The effectiveness and efficiency of material handling task largely depends on the manpower involved.
2. **Workforce Productivity:** The productivity of a material handling operation is directly influenced by the manpower involved. Skilled workers can handle materials safely, quickly and accurately, leading to high productivity level.
3. **Continuous Improvement:** Human involvement in material handling allows for continuous improvement of processes.
4. **Safety:** Material handling can involve physical labor and the use of heavy equipment. Adequate manpower ensures that the tasks are distributed among workers, reducing the risk of injuries and accidents.
5. **Productivity:** With the right manpower, material handling task can be performed efficiently, leading to increased productivity. Sufficient manpower can help in minimizing downtime and reducing delays during the handling process.

Industrial trolley plays a crucial role in material handling operations in industries. They are specialized carts designed to transport materials efficiently and safely within a facility. Here are some key reasons why industrial trolleys are important

1. **Increase efficiency:** Industrial trolleys enable the movement of large quantities of materials at once, reducing the number of trips required and saving time. This improves overall efficiency in material handling operations.
2. **Ergonomic benefits:** Trolleys are designed with ergonomic considerations in mind, making it easier for workers to load, unload and move materials. They typically have handles, wheels and other features that reduce physical strains and minimize the risk of injuries.
3. **Safety:** Industrial trolleys are designed to ensure the safe transportation of materials. They often have features like brakes, straps, or sides to secure the materials and prevent them from falling or shifting during transit. This reduces the risk of accidents, damage to materials and injuries to workers.
4. **Versatility:** Industrial trolleys come in various sizes, shapes, and configurations to suit different material handling needs. They can be customized or equipped with attachments to handle specific types of materials such as flatbed trolley for large and heavy items or cage trolleys for fragile or bulky goods.
5. **Cost-effective:** By enabling the efficient movement of materials, industrial trolleys help reduce labour cost and increase productivity. They also minimize the risk of damage to material reducing the need for replacements or repairs. Overall, industrial trolleys are essential tools for material handling industries, providing efficiency, safety, and cost-effectiveness in transporting materials within a facility.

Industrial trolley plays a crucial role in various sectors of the Nigerian economy. These versatile transportation tools are widely used in manufacturing, warehousing, logistics and other industrial settings. This note aims to explore the significant impacts of industrial trolleys in Nigeria, highlighting their contributions to productivity, safety and efficiency.

The impacts include:

1. **Enhanced Productivity**

Industrial trolleys have a direct impact on productivity within Nigerian industries. By facilitating the movement of heavy goods and material, they streamline workflow processes, reduce manual labour, and increase operational efficiency. A study conducted by Adeoti, A.I. et al. [9] titled "Assessment of material handling equipment in manufacturing firms in Nigeria" found that the introduction of industrial trolleys resulted in a 20% increase in productivity in surveyed manufacturing firms.

2. **Improved Safety:**

Safety is a paramount concern in industrial environments, and industrial trolleys contribute significantly to enhancing workplace safety in Nigeria. They are designed with features such as safety construction, ergonomic handles, and braking systems, which minimize the risk of accidents and injuries.

3. **Efficient Material Handling:**

Efficient material handling is crucial for the smooth operation of industries, and industrial trolleys play a vital role in this aspect. They enable the transportation of materials within factories and warehouses, ensuring timely delivery to production lines or storage areas. The article by Oke, S. A. et al. [10] also highlighted how the use of trolleys reduced the time required for material handling activities by 30% in a Nigerian manufacturing company, resulting in improved overall operational efficiency.

4. **Cost Savings**

Industrial trolleys contribute to cost savings for Nigerian industries by reducing labor requirements and minimizing the risk of product damage. As stated by Ochiaka, J. O. et al. [11] in their research paper,

“Economic Analysis of Material Handling Equipment in the Manufacturing Industry”, the implementation of industrial trolleys resulted in a 15% reduction in labor costs and a 10% decrease in product damage related expenses in surveyed Nigerian manufacturing firms.

5. Flexibility and Adaptability

The versatility of industrial trolleys allows them to adapt to various industrial settings and tasks. They can be customized with different load capacities, wheel types, and configurations to meet specific handling requirements. In Nigeria, where industries vary in size and operational needs, this adaptability is highly valuable: The study by Adeoti, A. I. et al. [9] also emphasized the ability of industrial trolleys to handle a wide range of materials, contributing to their widespread adoption across diverse sectors within the Nigeria economy. With the following impacts, it is now certain that industrial trolleys have significant impact on Nigeria’s industrial landscape. Their contributions to productivity, safety, efficiency, cost savings, and adaptability make them indispensable tools in manufacturing, warehousing and logistics sectors.

II. Materials and Method

2.1 Materials

The materials used for the fabrication were selected based on some design factors.

2.1.1 Material selection

The choice of material is vital to ensure that the parts that need to be produced have the appropriate performance criteria. Materials like galvanized steel, and alloy rubber were chosen because they have the required engineering properties for the product, since different machine components would be subjected to varying forms and the degree of stresses strains, torque, and frictional effect.

Table 1. The components of the system

S/No.	Component	Material	Specification
01	Frame and Structure - Base plate - Handle or push bar.	galvanized steel plate 2 Round galvanized steel pipe	1070mm x 470mm 1243mm x 35mm
02	Wheel and Casters	Four (4) Alloy rubber wheels	120mm x 200mm x 5mm
03	Handle or Push Bar	2 Round galvanized steel	1243mm x 35mm
04	Load Surface - base plate - The two (2) tools box carrier	A galvanized steel plate	1070mm x 470mm 1225mm x 180mm

2.1.2 Material selection criteria

Following a thorough analysis of the intended physical, mechanical, chemical, and even aesthetic properties of several suggested materials, the materials to be used for manufacture were chosen. High and medium carbon steel would be mostly utilized for body parts and chuck materials in this project because to financial concerns and raw material availability, while alloy rubber was selected for the wheels.

2.2 Method

The trolley was constructed in the welding workshop where marking and cutting was the first approach in the construction. The cutting of the steel galvanized pipe and plate will be used for fabrication. Metal welding was the next step, all parts were joined together using a welding machine and an electrode. Flat bar was bent to an appropriate angle and attached to the trolley.

2.2.1 Machine drawing

This is a line-based graphic representation of a machine assembly or component. It provides all the dimensional information needed to build the machine component. This will be done using AutoCad or Solidworks.

2.2.2 Testing of the machines

After the development and production of the machine were finished, it would be tested to ensure that its efficiency was up to standard. All design ideas and computed outcomes would be strictly adhered to and reached with minimal to no deviations.

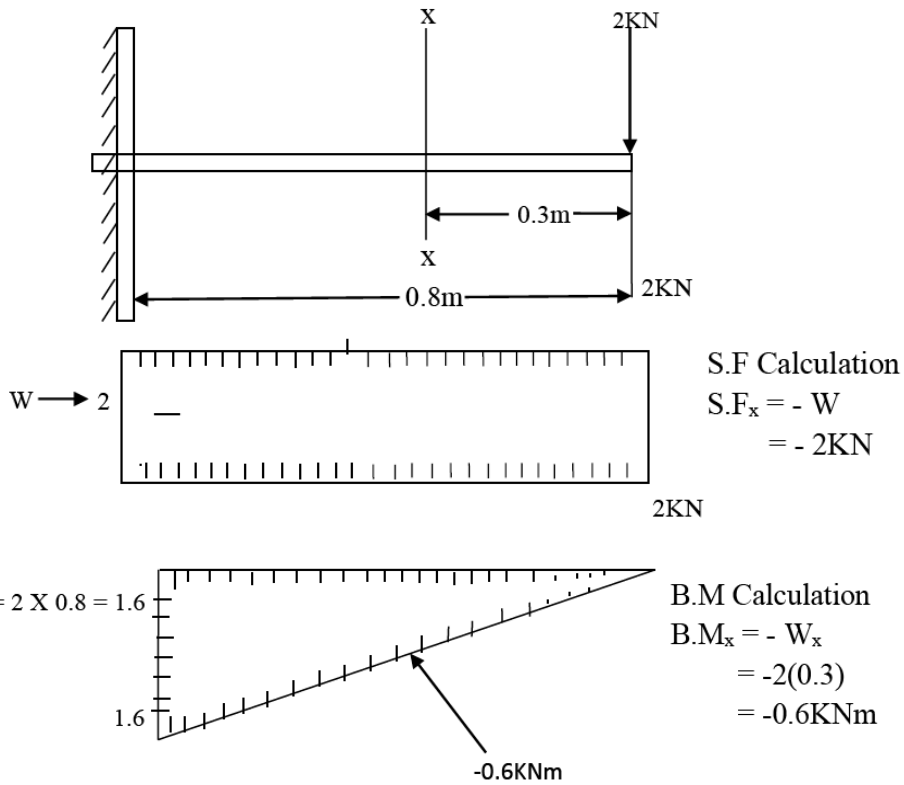
2.2.3 Performance evaluation

Series of test would be conducted using the machines. When evaluating the performance of the trolley, several key factors were considered. This includes load capacity, maneuverability, durability, and safety features.

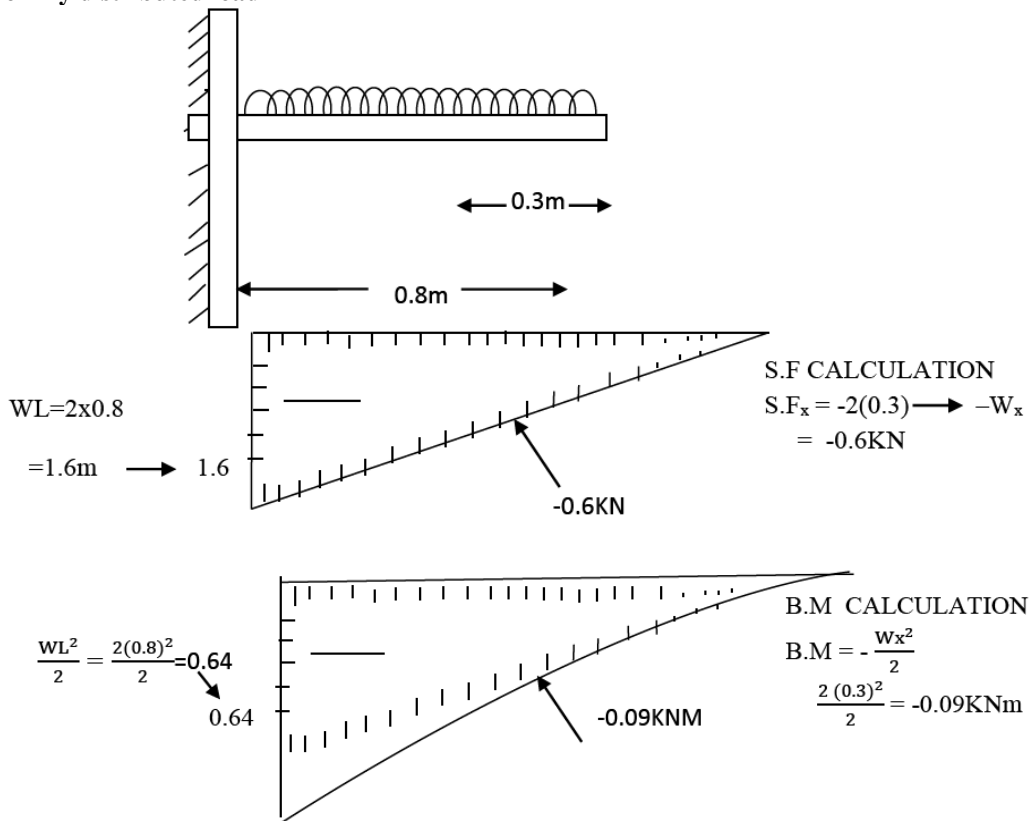
2.2.4 Installation of the machines

At this stage, we reassemble the fabricated machine, realign it, connect it to essential services, and conduct extensive testing to ensure optimal operating efficiency when it enters production.

Point load analysis



Uniformly distributed load



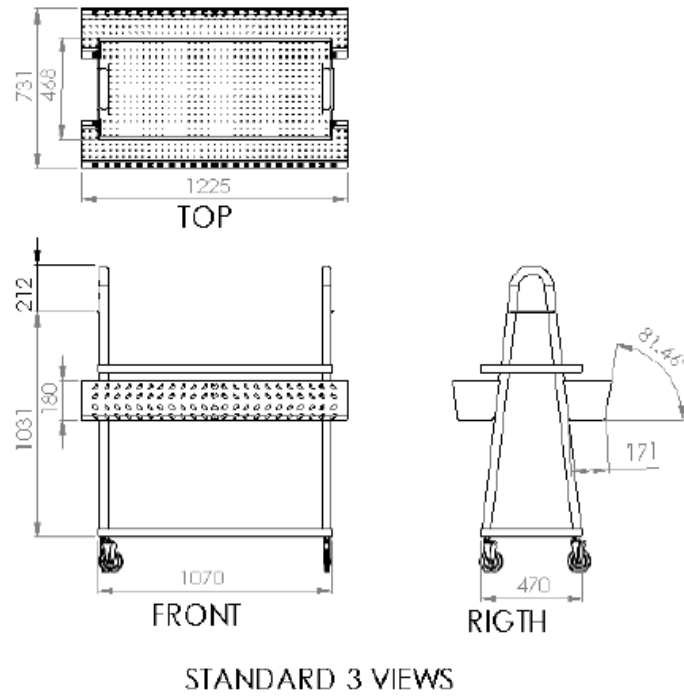


Fig. 1. The isometric views, of the machine





Fig. 2. The 3D model drawing of the machine

III. Performance evaluation and results

The maximum weight of the trolley was determined considering the physical dimensions of the trolley and materials used for the fabrication.

1. Load Capacity:

The load capacity of the trolley was determined based on the type of load applied on the trolley.

(a) Point Load on the Trolley:

When a 2KN point load was on the trolley 2KN shear force and 0.6KN bending moment were obtained. This showed that the trolley would be able to withstand the shear force at 2KN and 0.6KN or 61.18kg bending moment, therefore, the load capacity under point load should not exceed 61.18kg or 70kg to avoid breakdown of the trolley.

(b) Uniformly Distributed Load on the Trolley (UDL):

When uniformly distributed load (UDL), was considered it was observed that:

i. The trolley could only withstand the shear force of about 0.6KN or 61.18kg, when a load 2kN was on the trolley.

ii. The trolley could only bend at 0.009KN, or 9.18kg when a load of 2KN was on it.

(c) Uniformly Varying Load on the Trolley:

When uniformly varying load was applied on the trolley and the following result was obtained:

i. The trolley was able withstand the shear force of about 4.08kg, when 2KN load was applied.

ii. The trolley bending moment was at the rate of 0.0053KNm which is 0.54kg when a 2KN load was applied.

From the above results this work is good, trusted, reliable and recommended for use.

IV. Conclusion

This work was faced with a lot of teething problems, the objective which was to construct an industrial trolley for material handling was achieved. The construction of an industrial trolley holds significance importance in the field of material handling and industrial operation. The work carries several Key implications and benefits such as improved efficiency and productivity, enhanced workplace safety, customized solution for industry needs, cost-effectiveness and resources optimization and contribution to industrial development etc. Therefore, the out-come of this work will have a positive impact on industrial operations, supporting the growth and success of businesses in various sectors.

It is also hoped that all readers should find this work very useful, helpful and interesting.

It is recommended that the system should not be loaded over its limit of 2KN, and also, it should be used in small scale auto repair shops.

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