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Design and Development of Multi-Featured Medical Stretcher

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Abstract:- The multi-featured medical stretcher represents a significant leap forward in patient care and hospital operations. Its innovative design combines various features aimed at enhancing both patient comfort and healthcare worker efficiency. At the core of its design is a commitment to making patient movement easier and safer. Through its adjustable height mechanism, the stretcher can be tailored to individual patient needs and seamlessly integrated into various medical procedures. This adaptability not only enhances patient comfort but also facilitates smoother transitions between different stages of care. Furthermore, the inclusion of storage compartments ensures that essential medical supplies are readily accessible, minimizing disruptions during patient transport and treatment. This organizational feature not only saves time but also contributes to a more efficient workflow for healthcare workers. Importantly, the stretcher's ability to move patients from stretcher to bed with minimal human assistance is a game-changer. By reducing the reliance on manpower for transfers, it streamlines hospital operations and minimizes the risk of patient discomfort or injury during movement. Overall, the multi-featured medical stretcher represents a significant advancement in hospital equipment, offering a comprehensive solution to the challenges associated with patient transport. Its integration of comfort-enhancing features and efficiency-boosting functionalities marks a substantial improvement in patient care delivery and contributes to a smoother and safer hospital environment for both patients and healthcare workers alike.

Keywords:- *Multi Features, Height Adjustable, Safety.*

I. INTRODUCTION

The healthcare industry is characterized by physically demanding tasks, particularly those related to stretcher and patient handling. Manual patient transfers, which often involve lifting and lowering patients, pose a significant risk of work-related musculoskeletal disorders (WMSDs), with back pain being a prevalent issue. Studies indicate a high prevalence rate of such injuries, with healthcare workers experiencing 34.6 injuries per 100 workers annually, surpassing rates in other industries. Nursing assistants, in particular, are vulnerable to overexertion injuries [1]. These WMSDs can lead to chronic health problems, impacting both the quality of life for healthcare workers and the economic well-being of healthcare organizations.

Moreover, research highlights that manual lifting of stretchers often exceeds recommended safety limits, especially in the lower back region, further exacerbating the risk of musculoskeletal issues. Recognizing the pressing need to address these challenges, there has been a growing interest in improving stretcher design to alleviate the physical stresses on healthcare workers. Multi featured stretchers, in particular, have garnered attention as potential solutions to mitigate concerns associated with conventional methods [2]. However, current stretcher designs still necessitate emergency medical workers to manually lift patients from the ground, limiting their automation.

Therefore, the primary objective of the project is to develop a stretcher capable of performing lateral patient transfer operations with minimal human intervention. By enhancing automation in this aspect, the aim is to improve efficiency and reduce the physical strain on medical personnel. This innovative approach seeks to revolutionize patient handling practices, offering a solution that not only prioritizes worker safety and well-being but also enhances overall operational efficiency within healthcare settings.

➢ *Related Work*

We have referred certain papers having objective of designing a multifunctional foldable stretcher aims to streamline patient handling tasks while reducing the need for multiple medical personnel. This concept synthesizes various features from existing stretcher designs to create a versatile solution. The stretcher consists of a soft platform supported by a frame, allowing for compact storage and easy deployment and enhances patient comfort during transport, while safety belts minimize the risk of falls and additional injuries [3]. By combining these elements, the design maximizes efficiency and mobility, empowering caregivers to safely and effectively transfer patients between surfaces with minimal physical strain [4]. This innovative approach represents a significant advancement in stretcher design, offering a comprehensive solution to enhance patient handling processes and improve overall healthcare outcomes.

II. MATERIAL

We choose cast iron for manufacturing our multi featured medical stretcher. Choosing cast iron as a material offers several advantages:

Cast iron is renowned for its exceptional strength and durability, making it capable of withstanding heavy loads and

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frequent use. This robustness ensures that the stretcher can endure the rigors of patient transport within healthcare settings without compromising structural integrity. Cast iron provides excellent stability, which is crucial for ensuring patient safety during movement and transfer. The inherent weight and solidity of cast iron minimize the risk of tipping or instability, especially when navigating uneven surfaces or during emergency situations. Cast iron exhibits high resistance to fire and heat, making it suitable for use in environments where fire safety is paramount, such as hospitals and emergency response settings [5]. This fire resistance enhances the overall safety of the stretcher and mitigates the risk of damage in case of fire incidents. Cast iron surfaces can be machined to achieve a smooth finish, which is beneficial for patient comfort and ease of cleaning. A smooth surface minimizes the risk of abrasions or discomfort for patients during transport and simplifies the disinfection process, helping to maintain optimal hygiene standards. Despite its exceptional properties, cast iron can be a cost-effective material option for manufacturing medical stretchers, particularly when considering its long lifespan and minimal maintenance requirements. The initial investment in a cast iron stretcher may be offset by its durability and longevity, resulting in potential cost savings over time.

Overall, the advantages of cast iron, including its strength, stability, fire resistance, smooth surface finish, and cost-effectiveness, make it a compelling choice for manufacturing medical stretchers. By leveraging these properties, cast iron stretchers can contribute to improved patient safety, comfort, and operational efficiency within healthcare facilities.

A. Hydraulic Jack

A hydraulic jack is a device that is used to lift heavy loads by applying a force via a hydraulic cylinder [6]. Hydraulic jacks lift loads using the force created by the pressure in the cylinder chamber. In a hydraulic jack, fluid pressure multiplies force in a cylinder to lift a heavy load. These jacks have many applications: machine shops, the automobile industry, material handling equipment, lifting platforms, railroad work, and hydropower plants. This article examines how hydraulic jacks work, how to use them properly, different types of jacks, and what to consider when selecting a hydraulic jack.

Fig 1: Hydraulic Jack

➢ *Hydraulic Jack Operating Principle:*

Hydraulic jacks operate based on Pascal's Law. This law states that a pressure change at one point in an enclosed incompressible fluid leads to the exact pressure change at every point. This law also governs the hydraulic jack press and the braking system for most vehicles. According to the law, pressure equals force divided by area. Therefore, force equals pressure multiplied by area [7]. If pressure is constant and area increases, force also increases. Figure 2 illustrates Pascal's Law and how hydraulic jacks work. A person operates the lever to push down the plunger piston (Figure 2 labeled A). This downward movement creates a change in pressure. The fluid in the larger hydraulic cylinder (Figure 2 labeled B) equally changes in pressure, applying it to the ram piston (Figure 2 labeled C). Since pressure is the ratio of force to area, the ram piston's larger surface area will distribute a larger lifting force. The larger force lifts the load above the ram cylinder. To raise the load to a reasonable height, the plunger piston has to move a greater distance than ram piston.

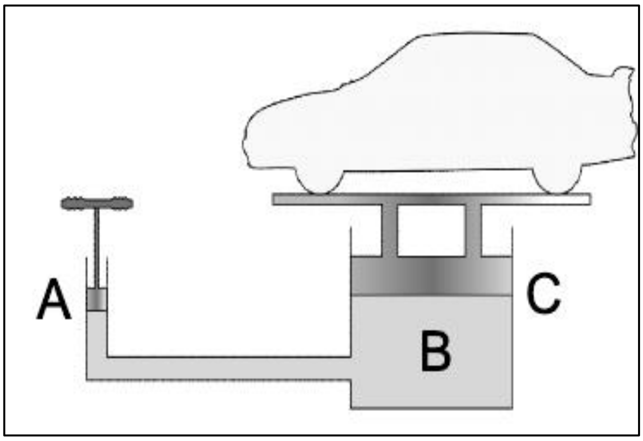

Fig 2: The Principle of Hydraulic Lifting Devices (Pascal's Law): A Small force (A), Incompressible Fluid (B), and A Large Lifting Force (C).

➢ *Components of a Hydraulic Jack*

There are seven primary hydraulic jack parts:

- **Reservoir:** The reservoir stores the hydraulic fluid for a change in pressure.
- **Plunger piston:** The plunger piston pushes the hydraulic fluid from the reservoir through a check valve to the ram cylinder.
- **Check valve:** The check valve prevents fluid return from the ram cylinder to the plunger cylinder. Therefore, the ram cylinder maintains the rising pressure.
- **Ram cylinder:** The ram cylinder transfers the pressure of the hydraulic fluid to the ram piston.
- **Ram piston:** The ram piston lifts the load.
- **Release valve:** The hydraulic jack release valve returns pressurized fluid to the reservoir.
- **Handle:** The hydraulic jack handle provides leverage to operate the plunger piston easily.

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➢ *How to use a Hydraulic Jack*

Using a hydraulic jack correctly depends on the specific application. This section details the similarities between using a hydraulic jack in any situation.

- Before: There are important considerations to make before using a hydraulic jack.

✓ Ensure the jack is on level ground.
✓ Check the jack for any damage or leaking.
✓ Prepare jack stands to hold the load's weight after lifting.

- During:

✓ Insert the handle into the plunger piston's socket to pump the jack and raise the load to the desired height. Ensure the ram piston contacts the load at a proper lift point. For example, the axle of a vehicle.
✓ Insert the jack stands beneath the load next to the hydraulic jack and lower the load's weight onto the jack stands.
✓ Perform any necessary work.
✓ Use the hydraulic jack to lift the load once again and remove the jack stands.
✓ Open the hydraulic release valve to lower the load slowly.

B. *Helical Spring*

A coil spring is a helical shaped mechanical device made of wound metal. They store potential mechanical energy and release the energy to absorb shock. Coil springs are made by winding a strand of wire using continuous turns to form a helical coil. The process transforms a strand of wire into a helix that is capable of storing energy. The varying sizes of coil springs are used to reduce shock and stress on a surface by allowing extra give. They change their shape when an external force is applied to them but return to their original shape when the force is removed. The energy of a coil spring is stored and recovered when the spring returns to its normal shape, which depends on the amount of force applied. When coil springs are holding weight, they shrink in size under the applied force [8]. It stores mechanical energy due to the compression. As the force is removed, the coil spring expands and releases its stored mechanical energy [9].

Three main types of coil springs are compression, extension, and torsion, each of which performs a different function. Of the three main types, compression springs are the most common, which are produced by hot or cold winding of spring steel. They are capable of absorbing force and offering resistance when they are compressed [10].

Fig 3: Helical Spring

III. CALCULATIONS

Spring Calculation

We know that,

Deflection of spring
$\delta = 64WR^3n / Cd^4$

Where,
R = radius of coil
d = diameter of wire of the coil
C = modulus of rigidity
n = no. of coils or turns

Given: n = 18 turns
R = 13.5mm = 0.0135m
D = 3.5mm = 0.0035m

Consider W = 25kg (There are 4 springs and as we consider the average weight of patient is 100kg, so the weight on each spring is 25kg)

W= 25kg = 25* 9.81 = 245.25 N

Take C = 45 GPa (range 40 – 45)

$\delta = 64WR^3n / Cd^4 = 64*242.25*(0.0135)^3*18 / 45*10^9*(0.0035)^4 = 0.1029$ m

➢ *Buckling Stress*

One end fixed, one end hinged
We know that,
$P = \Pi EI / Le^2$ and $Le = L / \sqrt{2}$

Where,
L = original length
Le = effective length
P = crippling load
E = modulus of elasticity
I = moment of inertia

Given: L = 609.6mm
b (width) = 50mm
h (height) = 25mm
t (thickness) = 2mm

E = 210 GPa

$Le = L / \sqrt{2} = 609.6 / \sqrt{2} = 431.05$ mm

For hollow rectangular section

$I = \frac{1}{12}* [b*h^3 – (b – 2t) * (h – 2t)^3] = \frac{1}{12}* [50*25^3 – (50 – 2*2) * (25 – 2*2)^3] =29603.66\ mm^4$

$A = b*h – (b – 2t) * (h – 2t) = 50*25 – (50 – 2*2) * (25 – 2*2) = 284\ mm^2$

P = ΠEI / Le2 = P = Π*210*103 *29603.66/ 431.052 = 330224.39 N = 33662.01 Kg = 330224.39 N

$\sigma = \frac{P}{A}$ = 330224.39 / 284 = 1162.76 N/mm2 = 118.52 kg/mm2.

- *CAD Model*

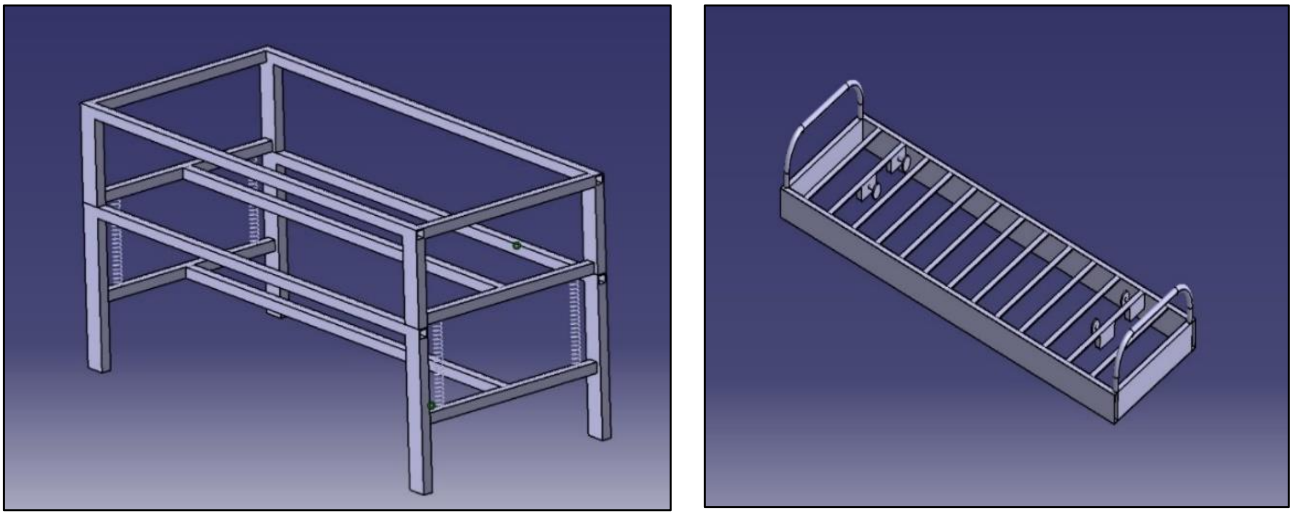

Fig 4: CAD Model of Stretcher

IV. CONCLUSION

The development of a multiple features stretcher with adjustable height, safety belt, moveable plate, and accessories arrangement represents a holistic solution catering to the complex needs of transporting patients with minimal human assistance. By incorporating adjustable height, the stretcher accommodates varying patient requirements, enhancing comfort and reducing strain on caregivers. The inclusion of a safety belt ensures patient stability during transit, mitigating the risk of falls or injury. The movable plate offers versatility in positioning, facilitating easier transfers onto and off of the stretcher. Additionally, a thoughtfully arranged accessories setup streamlines access to medical equipment, further optimizing efficiency and patient care. These innovations collectively aim to elevate patient comfort, improve facility logistics, and bolster overall safety standards, aligning with the overarching goal of enhancing the patient experience while minimizing reliance on manual assistance.

REFERENCES

[1]. Mete, Dipak, and Sanket Tanaji Patil. "DESIGN & FABRICATION OF AUTOMATIC LEVEL ADJUSTABLE STRETCHER."
[2]. Hiray, A.A. and Kulkarni, N.L., 2020, December. Design and Development of Automatic Position Adjustable Bed cum Stretcher to Improve Patients Comfort and Safety. In 2020 IEEE Bombay Section Signature Conference (IBSSC) (pp. 74-78). IEEE.
[3]. WEN, L.S., 2022. POWERED STRETCHER FOR PATIENT TRANSFER (Doctoral dissertation, Universiti Sains Malaysia).
[4]. Lim, S.H. and Ng, P.K., 2021. Synthesisation of design features for multifunctional stretcher concepts. Journal of medical engineering & technology, 45(2), pp.145-157.
[5]. Fande, A.W., Taiwade, R.V. and Narayane, D.C., 2024. Experimental investigation of the flux-assisted TIG weldment of super duplex stainless steel. Materials Today: Proceedings, 98, pp.21-27.
[6]. Kajol, H., Junaid, S., Jain, S., Chaudhary, A. and Prajwal, K.T., 2019. Design and development of a voice actuated hospital bed for patient care. Int J Recent Technol Eng, 8(4), pp.1751-1757.
[7]. Hiray, A.A. and Kulkarni, N.L., 2020, December. Design and Development of Automatic Position Adjustable Bed cum Stretcher to Improve Patients Comfort and Safety. In 2020 IEEE Bombay Section Signature Conference (IBSSC) (pp. 74-78). IEEE.
[8]. Fande, A., Ziya, S., Navghare, D., Tumble, G., Admane, G., Patil, S. and Khan, S., To Reduce Driving Effort of Tricycle by Implementing Changes in Brake and Radius of Wheel Combination.
[9]. He, S. and Adar, E., 2020, July. Plotting with thread: Fabricating delicate punch needle embroidery with xy plotters. In Proceedings of the 2020 ACM Designing Interactive Systems Conference (pp. 1047-1057).