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Safety Lesson: Transferring of Patients in Hospitals using Rack and Pinion based Mechanism

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Abstract

As of now the wealth within the health care industry is being exported to Japan and the China for equipment that Pakistan can produce domestically. Our bed is just one step that will allow Pakistan to begin producing its own quality medical equipment. If this equipment is domestically produced it will allow quality healthcare to become more affordable and accessible to many Pakistanis citizens. The purpose of this paper is to give necessary infrastructure to understand design related to the comfort level of a patient healthcare quality. Different research articles from international journals have been studied to review patient satisfaction, comfort, and healthcare quality. Methodology has been developed for the design of modern hospital cot with 5-axis motion. This work will be useful for designing sliding motions in hospital beds to provide patients more comfort when they are already battling with the disease. Task of elevation and declination of head and legs at an angle of 56.3 degree have been achieved. It is concluded in this study that doctors can move patients without taking help of attending staff from one bed to another using sliding mechanism using rack-pinion and controllers. This full scaled bed structure can carry load of 250kg. The sliding mechanism used in this bed is a replacement of steward to move patient from one bed to another. These steps would a technological evaluation and that this bed design would help in expanded Pakistan's health care industry.

Keywords: Reverse switch (RS); Revolution per minute (RPM); Steward; Healthcare; Sleeping surface (SS)

Introduction

It is confirmed from studies that high quality services are directly linked to increased market share, profits, and savings [1]. But patients comfort and healthcare quality should always be the priority. In US, there have been made man modifications to increase healthcare quality factors for the patients. Pakistan also have started to adopt new modified hospital beds for patient satisfaction. Recently Pakistan engineers and machinist have worked together to furnish hospitals with modern beds. While the additional features of the beds are desirable, the quality and reliability of the Pakistan beds conversely are quite questionable. Because engineers have not been able to manufacture and market safe and reliable hospital beds internally, even the neediest of hospitals in Pakistan have turned away their native models. Patients may be unable to evaluate medical service technical quality accurately; hence, functional quality is usually the primary condition. Also, healthcare quality is more difficult to define than other services such as financial or tourism mainly because it is the customer himself/herself and the quality of his/her life being assessed [2]. A substantial research has appropriately focused that handling patients manually results into a risk factor of injury [3].

Different new ideas and techniques have been adopted in giving comfort to the patients but the transferring of patient from one bed to another except using stewards haven't been adopted. If we adopt this approach of using this modified hospital cot it will be great in terms of healthcare quality, giving satisfaction to the patients. Normally patients were shifted from one bed to another using steward and if one has just come out of the operation theatre and you need to move him/her to next room, patient will be shifted by ward boys using steward and that will hurt patient for sure. According to [4] China and American bed manufacturers have modified their beds but still they don't have this modification of shifting patient using sliding mechanism. The two biggest makers of clinical beds as of now in activity inside the United States, Stryker Medical headquartered in Portage, Michigan and Hill-Rom situated in Batesville, Indiana, are answerable for most of clinical beds gave to American emergency clinics. Two of the most normally utilized

kinds of beds are made by these two ventures; the most mechanically progressed just as the most expensive of these beds are those created explicitly for use in escalated care units, where the most mindful clinical consideration is given. The second sort of bed created is a Medical/Surgical bed or a Med/Surg bed for short. Prescription/Surg beds will be beds regularly found in emergency clinics and nursing homes for most restoration purposes. These are beds for patients who require standard clinical consideration and are less modern and more affordable than the beds utilized in the ICU. These beds come in models fueled electrically, physically or a mix of the two. Both ICU and Med/Surg beds share the normal obligation of filling a need to show restraint well-disposed and easy to use to suit the wiped out, harmed and emergency clinic staff From the above literature review, it can be concluded that shifting of patient from one bed to another really needs mechanism by which patient who is just operated not feels any discomfort unlike using steward to shift him. That's why this research is related to propose a rack and pinion-based mechanism which can easily shift patient using sliding mechanism.

Main purpose of current study is to

- Transfer of patient from operation table after being operated by means of sliding of the sleeping Surface to another bed with dual

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capability of doing it manually and automatically keeping the economical factor and requirement of the government and private sector in mind.

- Lifting of the sides of the bed (right and left) of the patient by inflation of the bed using vacuum technology for the purpose of providing ease to the patients back eliminating the use of any local traditional way of doing it reducing the pain factor.
- Control of the axis motion system and folding (components, part).

Material and Methods

Evaluating current designs

Our research started in Islamabad, where we visited the Quaid-e-Azam International Hospital to view beds currently being used in a Pakistan Hospital. We also reviewed existing hospital beds in books found at WPI's Gordon Library The library revealed some information regarding standards for hospital bed for patient entrapment. The FDA recently released reports that new models of hospital beds used in the Pakistan must have components which minimize the risk of patient entrapment including an emergency button for the patient to press and a warning signal if an entrapment takes place. The chief engineer of the biomedical department at Quaid-e-Azam international Hospital met with us where he reported that the largest setback of existing hospital beds from an engineer's perspective is the location of the gearbox for repairs to electronic beds. The engineer also gave us recommendations and standards regarding Imported American hospital beds. He told us several functions regularly included with even the most inexpensive hospital beds including an elevating mechanism, an incline to 60º for the back, collapsible safety rails and a requirement that all electronic beds are grounded. Lastly, he recommended to us that we use larger casters than many beds currently employ which reduces the vibration to the patient when traveling over grooves and allows for easier traversing of spaces between the elevator and the floor.

Selection of best bed design

By comparing current standards with already manufactured in US & china, we decided our design of bed.

To appropriately survey a bed structure for the requests of the Pakistan's medical clinic and an advancement of presenting sliding movement for dozing surface and furthermore for expansion of sides, we needed to create and fitting lattice for assessment. Industry Standards to constrain ambiguities between what the clinical centers used and the improvement we are endeavoring to compel. Sturdiness and prosperity gave the second most noteworthy parts for structure point on the grounds that the security of patients and staff is an irrefutable need. Poor quality of the beds grows their upkeep essentials thusly adding to additional costs, another huge idea in the bed structure. Manufacturability, cost and effortlessness of movement gave the accompanying greatest courses of action of data for relationship. Manufacturability or the opportunity to successfully make the bed inside Pakistan, is a critical part with the objective that a high number of beds will be mass- conveyed to fulfill the necessities. The cost of the beds is basic to put aside crisis facilities money from bed purchases just as to satisfy the necessities of the Pakistan economy which isn't so obvious as the United States economy. Adjusting the things for consolidation in the decision network were the straightforwardness of transportation, sliding for resting surface, expanding of sides, lower leg flexibility, electrically energized limits and other additional features. Joined, these five sections add to 16% of the bed structure and were used for additional execution and engaging quality in our own arrangement.

A summary and brief outline for each measure considered in the presentation and affirmation of a better than average bed is as:

- Industry Standards (20%)
- Long lasting-resistant (15%)
- Protection (15%)
- Ease of manufacturing (12%)
- Economic factor (12%)
- Ease of Working (10%)
- Leg Movement (5%)
- Electric Functions (4%)

Thus, for final basis of our design selection we adopted features of the two highest scoring beds, the Hill-Rom Century+ and the Stryker LTC, and added those features to the potential of the Paramount beds. While we did not convert our own design into an electronically powered design, the opportunity does exist to change the bed from manually cranked to electrically driven and the power required for all articulating parts can be found in subsequent sections.

Current study design

Although the primary focal point of our project was to design a bed that could be manufactured and distributed in Pakistan. So we needed to make certain alterations into American Beds. The beds currently used in America, manufactured by Hill room Ltd. provide only the basic entities of bed articulation and elevation changes. While our bed design focused primarily on these concepts, we found that it would be necessary to make a few changes so as to spark interest in our bed design.

Modelling: Modeling of the hospital cot was made using Solid Works

We have selected the angular restraints of the bed, we felt that an angle of at least 75 º and as high as 80 º would be ideal (Table 1). In order to establish a length for the entire hospital bed, we considered of data that we had researched.

The first consideration we wanted to deal with was the adjustment of sliding Mechanism for sleeping surface (Figure 7). Presently in the United States, beds that are electrically powered have been found to frequently is not using this technology [5]. So neglecting all factors whether it's an innovation we will use Rack gear Mechanism for current study.

To provide Structural support and to connect Headboard with Foot board we are using side Supports as shown in Figure 2.

Our final design combines the mechanics of the slider-crank mechanism with the Pneumatic/Hydraulics at the end of the lower leg portion In order to keep the manufacturing cost down, the lower leg mechanism of our bed is manually cranked to adjust the bed, same as the slider- crank lifting device. The crank lower legs our preliminary sketch, in (Figure 1). Bed Dimension shows in a simple manner how the bed will articulate. The only portion of the platform that rises is the two links where the wheels for the Sliding Mechanism are supported.

Figure-2: Modeling of bed parts (a) Bed Structure (b) Sleeping Surface (c) Knee Gatch (d) Sideview of the bed (e) Headboard (f) Supporting attachment (g) Frame with pins on headboard

Figure 1: Stryker Medical Bed.

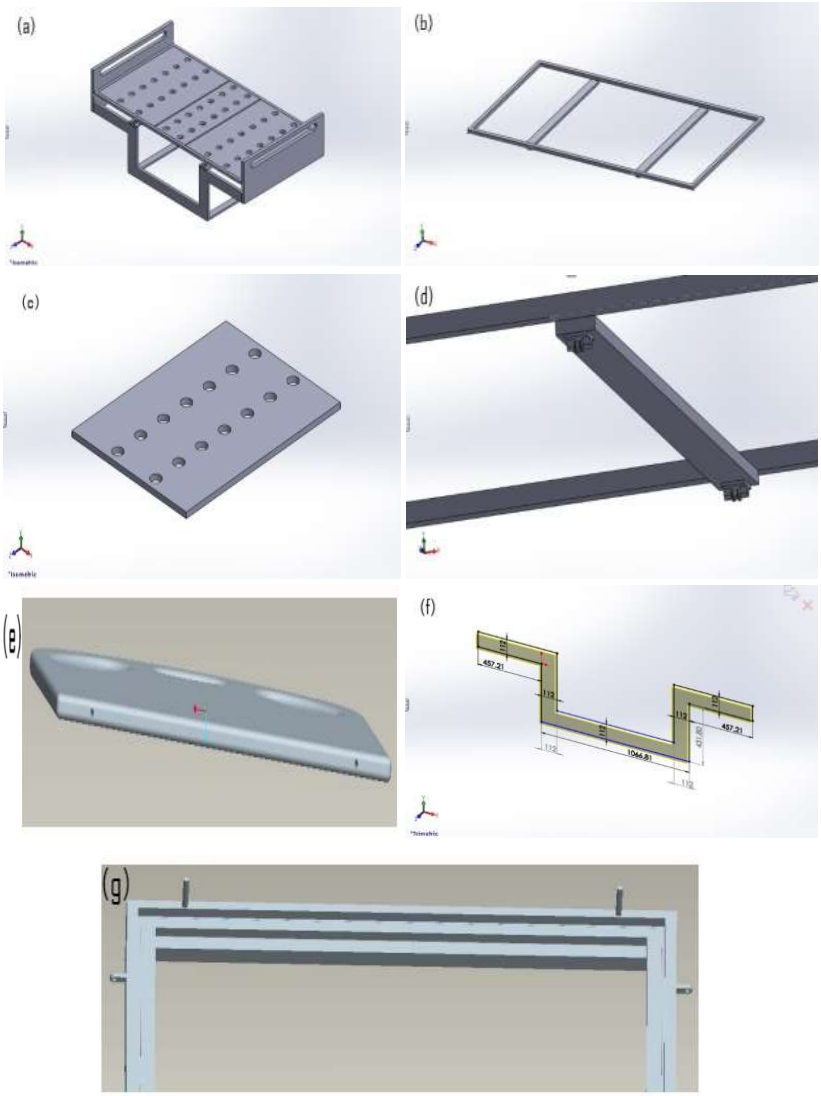

Figure 2: Modeling of bed parts (a) Bed Structure (b) Sleeping Surface (c) Knee Gatch (d) Sideview of the bed (e) Headboard (f) Supporting attachment (g) Frame with pins on headboard.

Fabrication

Few stages have been adopted to do the fabrication of the model. Like

- Material selection
- Dimension Parameters
- Selection of motors

Material selection

For material selection as shown in Figure 3, following are the parameters which should kept in mind

- Mechanical properties
- Physical Properties
- Manufacturability
- Cost

Properties of material are discussed in Table-2.

Caster

According to [6] one of the most popular medical casters is the revolutionary twin wheel caster by Steinco (Series 551D) specifically designed for hospital and electro-medical equipment. Because of its design, this medical caster makes it easy to enter and exit elevators in hospitals. It also may assist win compliance with the IEC/EN 60601-1 standard.

By keeping this in view, caster is choosed as mentioned in Figure 4 and its properties in Table 3.

Motors selection

Different sample of motors are available at reversible Motors [7]. We select motors based on its output power. This is a condenser-run type induction motor, intended for toughness in rehashed clockwise and counter-clockwise revolutions as in entryway actuators and lifts. This sort of model has high beginning torque and short increasing speed period (Figure 5). The most extreme ceaseless running time is 30 minutes. At the point when the engine is halted for a long enough opportunity, it very well may be utilized for a more extended period in a rehashed way. The yield is 6W to 120W. The evaluated voltages are 100V, 115V (UL Standard), 220V, and 240V (CE standard). It is prescribed to choose a suitable engine type that will fit the heap attributes and client's conditions.

Controller (Forward and Reverse Switch)

The motor will run just if each pushbutton switch is held down. In the event that we needed to keep the engine pursuing even the administrator takes their hand off the control switch (es), we could change the circuit in two or three unique ways: we could supplant the pushbutton switches with flip switches, or we could add some more transfer rationale to "hook" the control circuit with a solitary, fleeting activation of either switch (Figure 6).

Rack & Pinions

The Rack & Pinion block represents rack and pinion gear that converts between translational and rotational motion. The rotational-translational gear constrains the pinion (P) and rack (R) to, respectively, rotate and translate together in a fixed ratio that you specify. You can choose whether the rack axis translates in a positive or negative

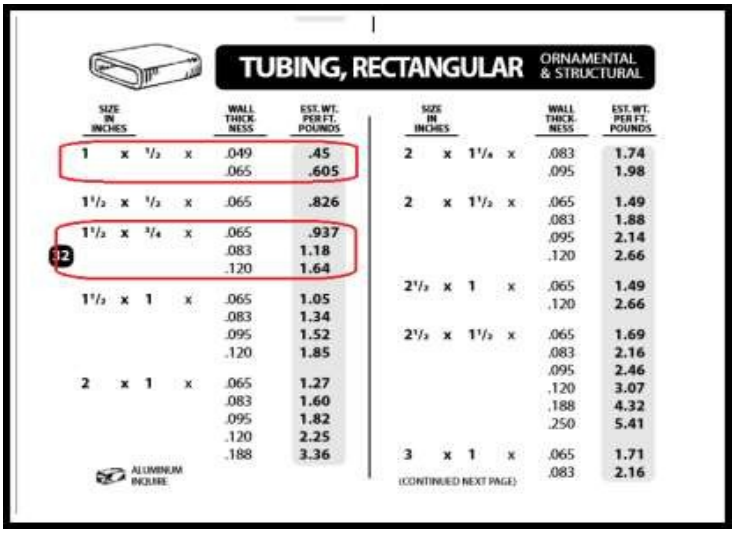

Figure 3: Material selection criteria.

Parameters	Maximum Value
Bed Length	254cm
Bed Width	101.4cm
Bed Height	40.01cm
Backrest (Inclination)	65º
Knee Gatch (Declination)	36º
Weight Capacity	Approx. 100kg

Table 1: Modeling Dimensions of the Hospital Cot.

Figure 4: Caster.

S. No.	Parameter	Dimension
1	Length	7ft
2	Width	3ft
3	Height	1.38ft
4	Elevation	75degree
5	Declination	20degree
6	Mattress	3ft *7ft
7	Weighing capacity	150kg
8	Maximum motor load	50kg

Table 2: Material general Parameters.

Figure 5: Motor.

S. No	Item	Description
1	Caster Type	Swivel
2	Wheel Width	25mm
3	Wheel Description	Solid Rubber on Nylon
4	Wheel Bearing	Plain bore
5	Load Rating (lbs)	154
6	Mount Type	Plug-in pin
7	Mounting Plate	43mm
8	Bolt Hole	11mm
9	Wheel Material	Solid Rubber
10	Wheel Diameter	100mm
11	Overall Height	121mm
12	Manufacturer	Blickle

Table 3: Specifications of a caster.

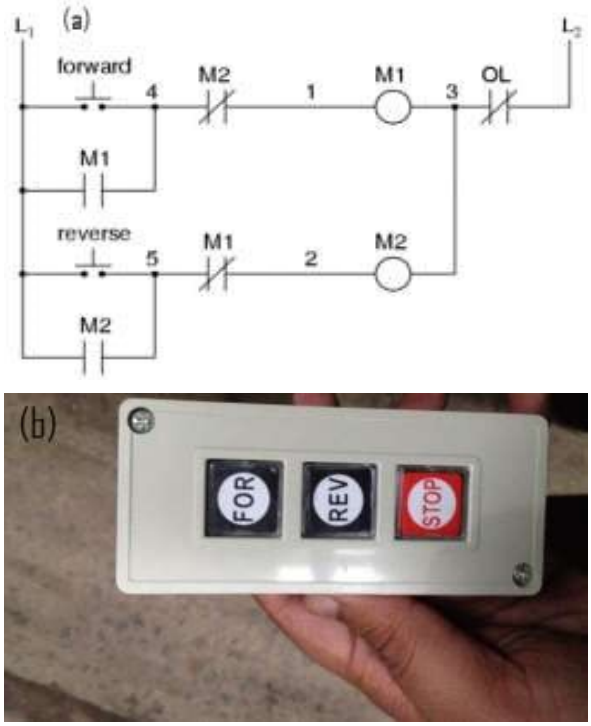

Figure 6: (a) Switch diagram, b) Controller remote (Forward/Reverse/Stop).

S. No	1st Rack	2nd Rack	Pinions
Width	0.7inch	0.7inch	0.7inch
Length	21inch	15.5inch	36inch
Teeth	79	59	34

Table 4: Rack and Pinion specifications.

Figure 7: Final full scaled Hospital Cot with Sliding Mechanism.

direction, as the pinion rotates in a positive direction, by using the Rack direction parameter (Table 4).

Conclusion

After completion of this model, it is concluded that Pakistan need a lot to do in field of healthcare quality. Pakistanis hospitals need to start buying domestically produced beds, so that Pakistan's wealth can be redistributed within the country. As of now the wealth within the health care industry is being exported to Japan and the China for equipment that Pakistan can produce domestically. Our bed is just one step that will allow Pakistan to begin producing its own quality medical equipment. If this equipment is domestically produced it will allow quality healthcare to become more affordable and accessible to many Pakistanis citizens.

This bed has been designed after consideration of current hospital bed products. Our bed offers additional features to the beds that are currently being used in Pakistanis hospitals or either manufactured in Pakistan. Our bed can easily affect the back, upper, and lower legs,

as well as adjust the bed height etc. Our bed has been shown to be of higher quality that what is currently domestically produced within Pakistan, and of the same quality as the Paramount Bed from Japan. Aside from having more features than the other beds it will allow rural, smaller, and less wealthy hospitals to afford and implement modern healthcare equipment.

Our team feels that with a minimal amount of additional work this bed design would be an economical and effective alternative to the beds that are currently being used in Pakistan. A working prototype of the lower leg mechanism must be manufactured and tested. Moreover, work is needed to be done in the manufacturing area of the design. Appropriate material must be selected for each part and several complete full fledge model of this bed design must be constructed. We felt that these steps would a technological evaluation and that this bed design would help in expanded Pakistan's health care industry.

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