
SMART HOSPITALITY BED WITH REMOTE CONTROLLED TECHNOLOGY TO ENHANCE FLEXIBILITY AND COMFORT IN PATIENT CARE

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Abstract

Improving the quality of healthcare services is a top priority for hospitals, especially for patients with limited mobility, such as stroke patients, the elderly, and individuals with disabilities. These patients require specialized care, including beds that can assist them in changing body positions without fully relying on medical personnel. This study aims to design a Smart Hospitality Bed powered by electric actuators, controllable via a remote. The bed is designed with dimensions of 2000×1000×600 mm and equipped with a control system that allows automatic adjustments to the backrest, legs, and body positions. Additionally, an integrated container for urination is provided to enhance the bed's functionality. The research methods include a preliminary study involving an analysis of patient needs, design development using Solidworks software, and the selection of components such as electric linear actuators. The next stage involves performance simulation to verify the device's functionality. This smart bed is designed to facilitate five main movements: backrest elevation, leg elevation, and lateral body movements to the left and right sides. This innovation is expected to improve patient comfort and the efficiency of medical care in hospitals. The study contributes to the development of more inclusive and effective healthcare technologies for patients with limited mobility.

Keywords: Electric actuators, Healthcare, Healthcare technology innovation, Limited mobility patients, Smart hospitality bed.

INTRODUCTION

The Merdeka Curriculum is a new curriculum introduced by the Ministry of Education, Culture, Research, and Technology (Kemendikbudristek) in 2022. This curriculum was developed in response to the results of the Program for International Student Assessment (PISA), which revealed that 70% of Indonesian students aged 15 and above had not reached the minimum competency in literacy, numeracy, and science. The Merdeka Curriculum aims to create a curriculum that is more relevant to students' needs and provides teachers and lecturers with the freedom to develop learning approaches tailored to the context and needs of their students. This curriculum also emphasizes the development of students' character and skills, encouraging them to become lifelong learners.

As part of the learning recovery effort, the Merdeka Curriculum (previously referred to as the prototype curriculum) was designed as a more flexible framework, focusing on essential materials and the development of character and competencies in students. The main characteristics of this curriculum that support learning recovery include:

- Project-based learning to develop hard skills, soft skills, and character aligned with the Pancasila Student Profile.
- A focus on essential materials, allowing sufficient time for in-depth learning of foundational competencies such as literacy and numeracy.

- Flexibility for teachers to provide differentiated learning based on students' abilities and adapt to local contexts and content.

In support of Kemendikbudristek's Merdeka Curriculum program, the Department of Mechanical Engineering at Semarang State Polytechnic implements project-based learning. One of these initiatives is the design and construction of a Smart Hospitality Bed, aimed at enhancing students' skills in design, engineering, and construction. Through this project, students are required to design a bed that meets healthcare facility standards and subsequently construct the Smart Hospitality Bed according to their design.

Technological advancements in healthcare have seen significant progress in the Society 5.0 era, introducing numerous innovations to improve the quality and accessibility of healthcare services. Many advanced tools have been developed for diagnosing, treating, and preventing diseases. The healthcare sector remains vital, as its technology will continue to be essential as long as humanity exists (Lintang Pramita & Wibawa, 2022).

However, these advancements are yet to align with the availability of adequate healthcare facilities in Indonesia. According to research, in 2018, the hospital bed ratio in Indonesia was recorded at 1.17 per 1,000 residents. This figure is far below countries like South Korea, which has around 11 hospital beds per 1,000 residents. The region with the highest number of hospital beds in Indonesia is Jakarta, with two hospital beds per 1,000 residents. The lowest ratio is found in West Nusa Tenggara (NTB), with only 0.71 beds per 1,000 residents, meaning NTB has only 71 hospital beds per 10,000 people (Jayani, 2020).

This lack of facilities poses challenges for Indonesian hospitals, particularly in providing optimal care for patients. One critical aspect of patient care is the prevention of pressure sores, or decubitus ulcers. Decubitus is a skin injury caused by prolonged pressure, forming ischemic lesions on the skin and underlying tissues. This condition can obstruct blood and lymphatic flow, potentially leading to tissue necrosis and ulceration (Purwantini *et al.*, 2023). Purwantini also noted that bed rest is a primary trigger for decubitus ulcers, as patients remain bedridden for nearly 24 hours a day to minimize organ system function.

Studies on pressure sore incidents report high prevalence rates, such as in Europe: Ireland 16%, Denmark 15%, Norway 17%, Iceland 8.9%, and Sweden 25% (Agustina *et al.*, 2023). According to the Global Burden of Disease Study 2019, the prevalence of decubitus ulcers in Southeast Asia in 2019 was 32,237 cases per 100,000 population, with 120,615 new cases per 100,000 annually (Zhang *et al.*, 2021). Agustina also stated that Indonesia's prevalence is between 15%-38.18%, comparable to several European countries.

Given these high rates, decubitus ulcers are a critical aspect of healthcare requiring medical attention. One technological innovation addressing this issue is the Smart Bed, designed to provide flexibility for patients, allowing them to move more freely and avoid prolonged stationary positions. Based on the description above, the following problems can be formulated: How can a smart bed be designed to prevent decubitus ulcers in patients with limited mobility; the advantages of smart bed technology in improving patient comfort and care, particularly in hospitals with limited facilities; the mechanism of a smart bed provide flexibility of movement for patients without compromising their comfort, and tools and materials are required to realize this smart bed innovation.

LITERATURE REVIEW

Technology in the World of Health

Health technology continues to develop to meet the need for better health services. According to Lintang Pramita & Wibawa (2022), technological developments have made it possible to create sophisticated medical tools that are used to diagnose, treat and prevent disease. In era *Society 5.0*, the focus on the integration of smart technologies into people's lives is growing, including in healthcare systems. This technology aims to improve the quality of patient care, especially in hospitals.

Indonesia has varying scores in various aspects of health services, with an overall Health Care Index score of 42.99. In the Medical Infrastructure and Professionals category, Indonesia recorded a score of 64.37, indicating progress in providing health facilities and medical personnel. However, in terms of Availability and Cost of Medicines, Indonesia's score is lower, namely 54.02, which indicates challenges in ensuring the accessibility and affordability of medicines for the community. In addition, the government's readiness in dealing with health problems is reflected in a score of 55.79, which indicates the need for improvements in health policies and programs. Overall, although Indonesia is showing some progress in health infrastructure, there are still many aspects that need to be improved to achieve a better and more efficient health system.

Currently, Indonesia is facing major challenges regarding health facilities. Jayani (2020) revealed that the ratio of hospital beds in Indonesia is still low, namely only 1.17 per 1,000 population. This ratio shows that the need for innovation, such as smart beds, is increasingly urgent to support patient care.

Implementation of Smart Beds in Indonesia

In Indonesia, the implementation of technology such as *smart bed* still faces various challenges, including high production and distribution costs. However, with the high prevalence of pressure ulcers, this technology has great potential to improve the quality of health services. In addition, the use of smart technology is in line with the vision *Society 5.0* which prioritizes human welfare through the integration of technology.

Development *smart bed* It is hoped that this can be an effective solution to overcome the limitations of health facilities in Indonesia, while improving overall patient care.

Power Supply

A power supply is an important component in an electronic device such as a computer. This component functions as a provider of certain current and voltage according to the load requirements of existing electrical resources (Nurlana, Murnomo. 2019). To meet the DC load requirements of the grid, a power supply circuit is needed that converts AC voltage to DC voltage (Istataqomawan, Zuli. 2002).



Figure 1. Power supply 12v DC

Relay Module

The relay module is a device that functions to move the contactor to move the on to off position or vice versa. Relays are needed in electronic circuits as executors as well *interface* between loads and electronic control systems with different power supply systems (Turang, 2015). According to Ramady *et al.* (2020) The relay consists of 2 main parts, namely the electromagnet (*Coil*) and Mechanical (Switch Contacts/*Switch*) and works with electromagnetic principles that regulate the movement of switch contacts that allow small electric currents (*low power*) capable of transmitting electricity at a higher voltage.



Figure 2. Relay module

Electric Linear Actuator

Working principle of *electric linear actuator* is by changing the rotational movement of the electric motor into linear motion (forward/backward). *Actuator linear* has the function of moving or controlling a mechanism or system. Apart from that, linear actuators can convert analog electrical energy into other quantities, such as rotation speed, and also function as an electromagnetic device that produces a moving force (Poesoko *et al.*, 2024). *Electric linear actuator* chosen as the main driver *Smart Hospital Bed* because the mechanism is quite simple and can lift loads as needed.



Figure 3. Electric linear actuator

Arduino Mega 2560

The Arduino Mega 2560 is a device designed for quite complex projects. This device functions as a microcontroller/integrated circuit (IC) which is designed to regulate certain operations in embedded systems. Arduino Mega 2560 is a microcontroller board based on the ATmega2560 (datasheet) which is programmed using *software* Arduino and can run both online and offline and consists of 54 digital I/O pins, 16 analog inputs, 4 UART, USB connection, ICSP header, reset button and larger sketch space, making it suitable for projects that require a lot of input/output and memory (Siswanto *et al.*, 2019).



Figure 4. Arduino Mega 2560

Remote IR & IR Receiver Module

Remote IR & AND Receiver Module are two interconnected devices. In simple terms the working principle of *Remote AND* is to send signals and *IR Receiver Module* as a signal receiver. According to Thaha (2020) the button pressed on the remote is a *keypad* which produces a *dual tone multiple frequency* then encoded into a hexadecimal value. The data is in the form of a square signal which is emitted by the transmitter and received by the transmitter *receiver infrared* and then outlined as a binary data package (Thaha, 2020).



Figure 5. Remote IR and IR Receiver

Bearing

Bearing or bearings are machine elements that are used to reduce friction between two components so that they can move according to their purpose. The component in question is more specific to the shaft (*shaft*) and the hole where the shaft rotates. Bearings must be strong enough to allow the shaft and other machine elements to work properly (Mursyid *et al.*, 2020).



Figure 6. Bearings

Castor Wheel

Castor wheel or caster wheels are a type of wheel consisting of small wheels mounted on an axle that can rotate 360 degrees. Caster wheels are used on equipment and tools that require high maneuverability, such as office chairs, shopping trolleys and industrial equipment.



Figure 7. Castor Wheels

Hollow Iron

The selection of hollow iron as a material for the manufacture of the Smart Hospitality Bed frame is more affordable than *stainless steel*. Some of the advantages of hollow iron include fire resistance, anti-termite, anti-rust, fast installation process, and the price is quite affordable (Tasliman, 2022).



Figure 8. Hollow Iron

Welding Joint Strength Planning

Welding is a connection method that can be used besides bolts and rivets. According to Fahrudin (2018) Welding is a technique for joining metals by partially melting the parent metal and filler metal with or without pressure and with or without additional metal and producing a continuous connection. In selecting there are several factors that must be considered, such as: welding classification, welding type, and welding strength.

Welding Classification

From Fahrudin's statement (2018), welding classification can be divided into several parts in the process, namely:

- Liquid welding
This is a welding method where the joint is heated until it melts with a heat source from an electric arc or a burst of burning gas
- Press welding
This is a welding method where the joint is heated and then pressed so that it becomes one.
- Desoldering
That is a welding method where the joints are bonded and joined together using a metal alloy that has a low melting point. In this case the parent metal does not follow melt.

Shielded Metal Arc Welding (SMAW)

Shielded metal arc welding or welding with a wrapped arc is often found in small workshops around. According to Azwinur et al. (2017) SMAW is a metal joining process using electric power as a heat source and using electrodes as additional material. SMAW welding is mostly chosen because the process is easy, economical and the welding results are also seen from good mechanical and physical properties, as well as low costs (Azwinur, 2017).

Weld Strength

Weld strength needs to be considered when designing the frame, this is because the frame needs strength to withstand the load when used. According to Muku (2009), to determine the tensile strength of welded joints, a tensile test is carried out. In the test, the test rod is loaded with increasing loads little by little until the test rod breaks. The tensile strength is calculated by the formula:

$$\sigma = A_o/F \text{ (kg/mm}^2\text{)}$$

Where:

σ = tensile strength (kg / mm²)

F = maximum load that the specimen can withstand (kg)

A_o = Initial cross-sectional area of the specimen (mm²)

RESEARCH METHOD

Research Methods

The method used is to create a framework. The framework outlines the implementation sequence.

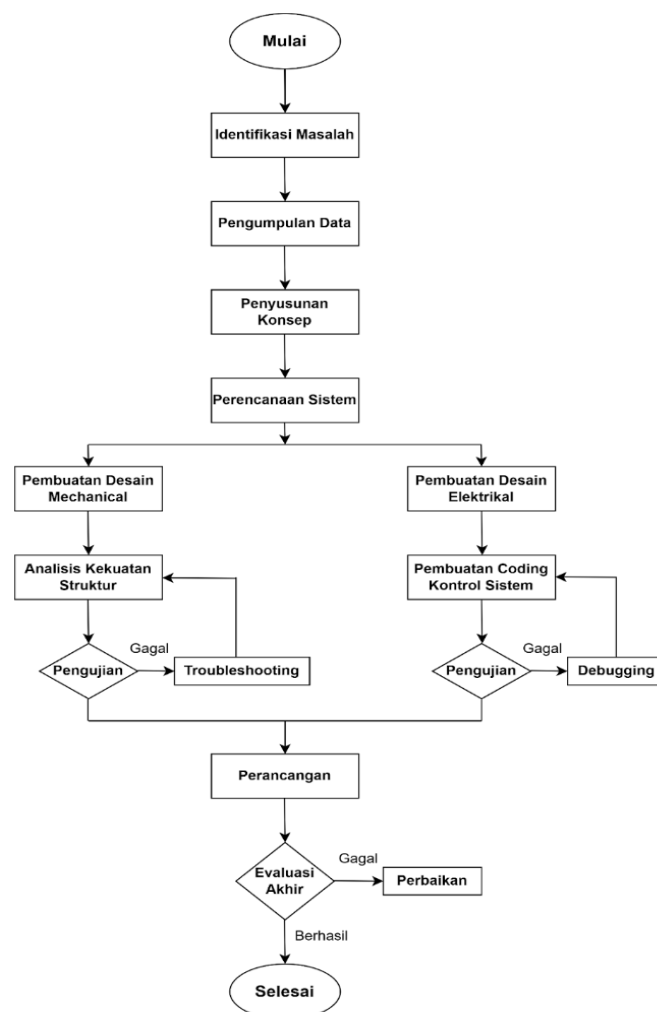


Figure 9. Research flow diagram

This research uses a mechanical design system design method to develop *Smart Hospitality Bed* which is specially designed for patients with special needs, such as stroke sufferers, the elderly, paralyzed, and pressure ulcer sufferers. The research stages involve a systematic process, starting from problem identification to preparing the final design. This entire process is designed to ensure research results can effectively address user needs.

Problem Identification

The initial step in this research is to identify the problems faced by patients with special needs in the hospital or care environment. The main problem found was the need for patient beds that not only provide comfort, but also support optimal patient care. Current beds are often limited in function and do not provide sufficient flexibility to support automatic changes in patient body position.

Based on this problem, *Smart Hospitality Bed* designed using an electric actuator that allows automatic bed position adjustment via remote control. The dimensions of the bed were determined to be 2000 × 1000 × 600 mm to ensure ergonomic suitability to the patient's needs. This bed is also designed to be sturdy, safe, and able to support the patient's weight without reducing the flexibility of the actuator movement.

Data Collection

Data collection was carried out to obtain in-depth information regarding the components needed to manufacture the tool, including frame material, type of actuator, and remote-based control system. Data was obtained from various sources, such as research journals, final assignments, as well as observations in the field regarding previously existing products.

In addition, a study of literature was conducted to understand the characteristics of patients who will use this bed, including their specific needs, such as body positioning and increasing comfort during treatment. The collected data becomes the basis for determining tool specifications and features that will be integrated into the design.

Concept Preparation

Based on the results of problem identification and data collection, initial concept *Smart Hospitality Bed* prepared in the form of a CAD design. This concept involves positioning electric actuators on certain parts of the bed to support up-and-down movements and changes in position. The remote-based control system is designed to ensure users can easily control the movement of the bed without requiring much physical effort.

Apart from that, this concept considers aspects of ergonomics, material strength and design aesthetics. The bed is designed to resemble a standard hospital bed with additional innovation in the form of an automation mechanism based on an electric actuator.

System and Software Planning

The next stage is designing systems and software to support automation functions on the bed. The control system is designed using a platform *Arduino*, where the program created will regulate the operation of the electric actuator based on input from the remote controller. Planning process *software* includes programming of key functions, such as actuator speed settings, maximum movement limits, and safety features to prevent operational errors.

Making 3D Designs

After the system is designed, the next step is to create a CAD design using Solidworks software. This CAD design provides an accurate visual depiction of the shape and dimensions of the bed. Key components, such as the frame, electric actuators and control panels, are strategically placed to ensure stability and ease of access.

The design dimensions, namely $2000 \times 1000 \times 600$ mm, were selected based on ergonomic standards to ensure patient comfort and safety. This 3D model is also used to analyze the strength of the structure and evaluate possible problems before the manufacturing process *prototype* done.



Figure 10. 3D Smart hospital bed design

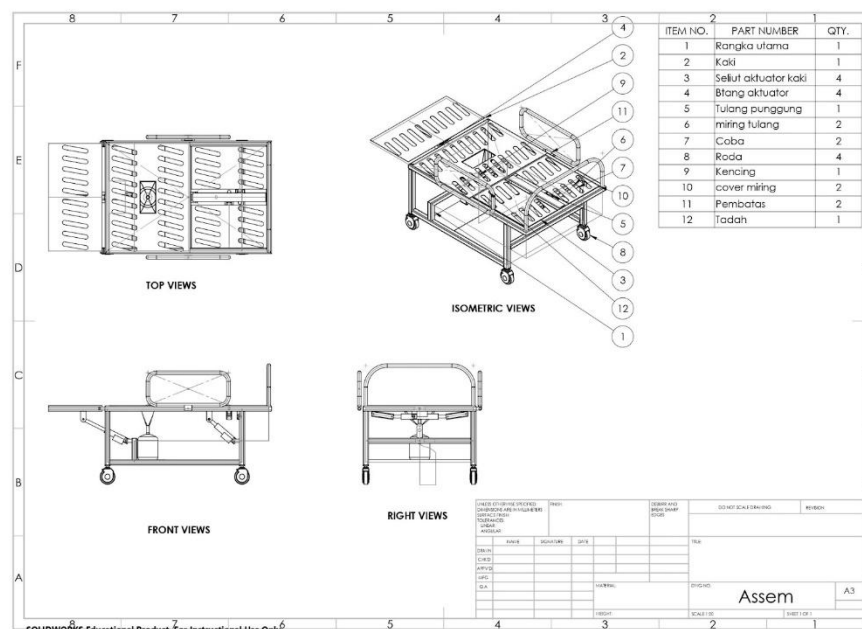


Figure 11. Drawing hospital bed design

Design Strength Analysis

Design strength testing focused on bed frames designed to support loads of up to 150 kg, according to the needs of patients with that maximum body weight. Simulation using *Solidworks* carried out to identify the stress distribution, deformation, and safety factors of the frame structure. The process is carried out using features *simulation* from *Solidworks*. Analysis is carried out to determine the stress distribution, maximum deformation (displacement) and safety factors, which ensure the design is able to withstand the patient's load without exceeding the permitted material limits.

Tool Working Mechanism

How the electrical components work *Smart Hospitality Bed* starting from the infrared (IR) remote control, which is used to send commands in the form of infrared signals. When the button on the IR remote is pressed, this signal is received by an IR receiver module, such as a TSOP1738 or VS1838, which is connected to the *Arduino Mega 2560*. This IR receiver module is tasked with converting infrared signals into digital data, which is then processed by *Arduino Mega 2560*. *Bluestoneo*, as the system control center, will translate the data into commands to move the electric linear actuator.

Power supply 12V DC is used to provide power to the entire system, incl *Arduino Mega 2560*, *module relay*, and electric linear actuators. *Power supply* This ensures stable voltage to keep system performance optimal. *Arduino Mega 2560* controls *module relay* which functions as an electronic switch to regulate the flow of electricity to the linear electric actuator. *Module relay* this is possible *Arduino* turns power to the actuator on or off according to commands from the IR remote.

The electric linear actuator, which is the main mechanical element, receives power and instructions from the relay module. When the relay is active, electrical current flows to the motor inside the actuator, producing linear movement (push or pull) through its internal screw mechanism. Cables are used to connect all electrical components, ensuring stable power and signal transfer. With this coordination, commands from the IR remote can be easily translated into mechanical movements of the bed, enabling efficient and precise position adjustments to patient needs.

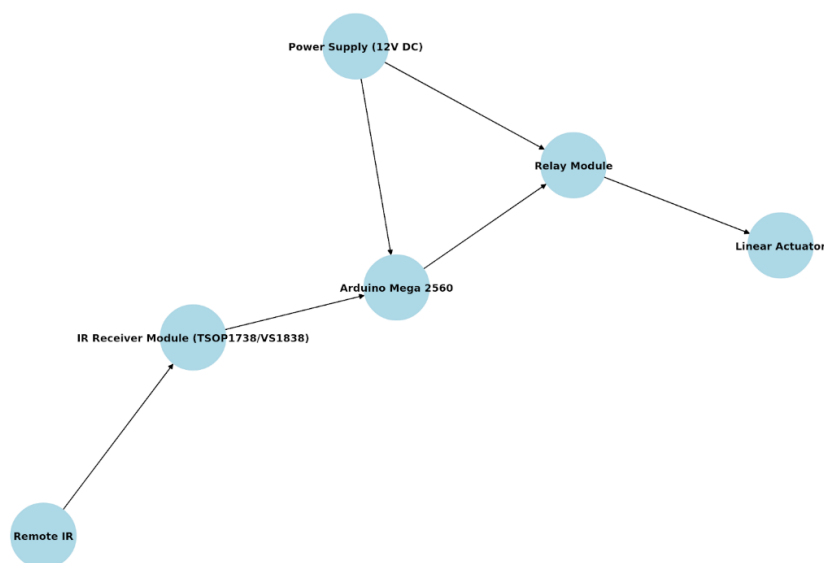


Figure 12. Diagram of how electrical components work

ANALYSIS AND DISCUSSION

Analysis of Displacement and Stress in Frames

Displacement and stress analysis of the frame is carried out using software *Solidworks* to ensure that the design meets safety and functionality criteria. The simulation is carried out by providing loads according to the actual conditions expected to occur when using the tool. The value of the loading force given is 1500 N. The analysis results show that the maximum value *displacement* is at 0.2 mm, which is still within the design tolerance limit. Meanwhile, the maximum stress that occurs is 1.52×10^7 N/m², much lower than the stress *yield*. The material used is 2.82×10^8 N/m², so the frame is declared safe to withstand operational loads. With these results, the frame design meets the mechanical requirements and can function optimally in accordance with the objectives of the tool development. The following are the results of the analysis carried out using software *Solidworks*.

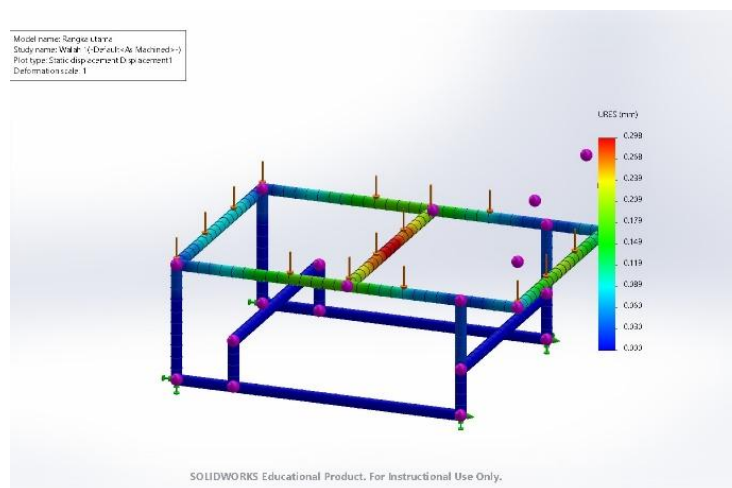


Figure 13. Displacement analysis

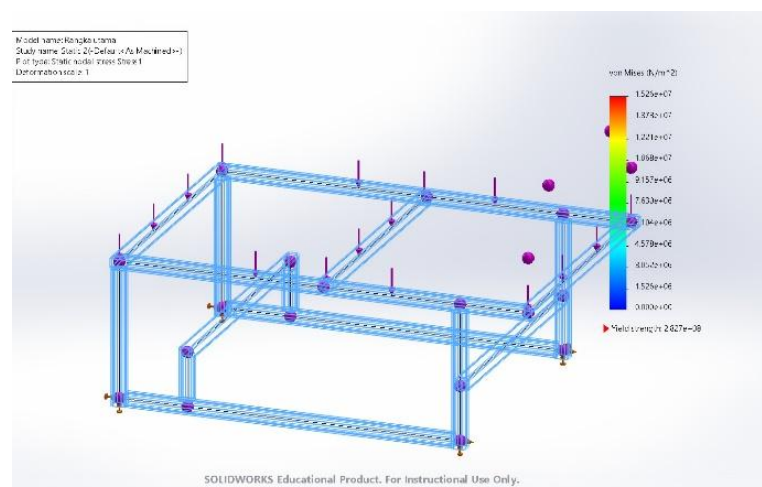


Figure 14. Stress analysis

Weld Strength Analysis

The material used is hollow iron with dimensions of 40 mm×40 mm×3 mm, so:

- Yield voltage (y) on hollow iron: $282 \cdot 10^6 \text{ Pa}$
- Allowable shear stress (allowable) calculated as 60% of the yield stress: $\text{allowable} = 0,6 \cdot 282106 = 169,2106 \text{ N/m}^2$
- The maximum load on the welded frame is identified as the patient's weight with a mass of 150 kg so that the forces acting on the weld are as follows:
 - $W = mg = 150 \text{ kg} \cdot 9,81 \text{ m/s}^2 = 1471,5 \text{ N}$
 - This means that the welded joint will withstand a force of 1,471.5 N of the patient's weight
- The thickness of the weld joint is 3 mm and the welding length is 40 mm for :
 - $A = t \cdot L = 3 \cdot 10^{-3} \cdot 40 \cdot 10^{-3} = 120 \cdot 10^{-6} \text{ m}^2$
- The maximum strength of the welded joint (Shear Strength) is calculated using the formula:
 - $\text{Shear Strength} = A \cdot \text{allowable} = 12010 - 6169,2106 = 20304 \text{ N}$
- The safety factor (SF) is calculated by comparing the weld strength to the maximum force:
 - $\text{SF} = \text{Shear Strength} / W$
 - $\text{SF} = 20304 / 1471$
 - $\text{SF} = 13,8$

Calculation of Power Requirements for Hospital Bed Electrical Systems

To calculate the total power requirements for running a hospital bed, you need to know the power required by the four linear actuators and the control panel. The basic formula for calculating electrical power is:

$$P = VI$$

Where:

- P = one (watt)
- V = voltage (volts)
- I = arus (amps)

a. Power Required by Linear Actuators

The operating voltage of each actuator is 12 V DC, with a current of 4 A. So, the power required by one actuator is:

- $P_{\text{actuator}} = V \cdot I = 12 \text{ V} \cdot 4 \text{ A} = 48 \text{ W}$
- Since 4 actuators are used, the total power for the actuators is:
- $P_{\text{total actuator}} = P_{\text{actuator}} \cdot 4 = 48 \text{ W} \cdot 4 = 192 \text{ W}$

b. Power Required by the Control Panel

It is assumed that the power required by the control panel to operate the hospital bed control system is 20 W.

c. Total Power Requirements

Total system power is the sum of the power for the actuators and control panel:

- $P_{\text{total}} = P_{\text{total of actuators}} + P_{\text{control panel}}$
- Value substitution:
- $P_{\text{total}} = 192 \text{ W} + 20 \text{ W} = 212 \text{ W}$

So, the total power required to run the hospital bed electrical system is 212 watts. Assuming that no voltage or power is lost during the conversion process from AC to DC, this value becomes a reference for determining the specifications of the power supply used.

Analysis of Voltage Drop in Electric Actuators

In some cases, the power supply and linear actuator can be located quite far apart, requiring long cable runs. This can cause a voltage drop in the cable due to the internal resistance of the wire. The basic equation for calculating the voltage drop in a cable is as follows:

$$V=I \cdot A$$

where:

- V = voltage drop (Volts)
- l = cable length (meters)
- I = electric current (Ampere)
- ρ = cable resistivity ($\Omega \cdot m$)
- A = cross-sectional area of the cable (m^2)

In the developed tool, the cable length between the actuator and the power supply panel varies depending on the configuration. The voltage drop due to cable resistance is calculated and presented in the form of the following table.

In this calculation, it is assumed:

- Electric current (I) = 4 A
- Copper resistivity (ρ) = $1.68 \times 10^{-8} \Omega \cdot m$
- Cable cross-sectional area (A) = $1.5 \times 10^{-6} m^2$ (assuming cable diameter 1.38 mm²)

Table 1. Voltage drop in cables

Cable	Cable Length (m)	Voltage Drop (V)
Cable 1	0.5	0.0224
Cable 2	2	0.0896
Cable 3	2	0.0896
Cable 4	2	0.0896

Based on the calculation results, the value of the voltage drop on the cable is very small, which is below the safe limit for the voltage requirement on the electric actuator. Therefore, this voltage drop value can be ignored in designing the hospital bed electrical system.

CONCLUSION

Based on the results of research and analysis that have been carried out in the Smart Hospitality Bed proposal with Remote-Based Control Technology to Increase Flexibility and Comfort in Patient Care, it can be concluded that the Smart Hospitality Bed design was successfully designed with the main aim of helping patients who have limited mobility. This design integrates remote-based control technology to increase flexibility and patient comfort during treatment. This smart bed offers

various advantages, such as the ability to adjust body position automatically, minimizing the need for assistance from medical personnel, and increasing the efficiency of care in hospitals with limited facilities.

The bed frame uses hollow iron material $40 \times 40 \times 3$ mm which has adequate mechanical strength and affordable cost. Mechanical analysis shows that the frame is able to withstand loads of up to 150 kg with appropriate safety factors. The Arduino Mega 2560-based control system, relay module and electric linear actuator ensure that equipment operations can be carried out effectively and efficiently. An infrared remote is used to provide easy control for users.

This project provides real experience for students in developing technological innovations based on community needs. In addition, the results of this research have the potential to improve the quality of health services, especially in areas with limited medical facilities. Thus, this research shows that the development of the Smart Hospitality Bed is an innovative step that is relevant to the needs of modern society, while also supporting the integration of technology in the health sector. Recommendations for further research include testing the prototype in a real patient care environment and developing additional features to improve the device's functionality.

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