Hybrid Chair

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Abstract **The importance for flexible solutions that can suit a range of body shapes and weight ranges has been brought to light by the increased demand for ergonomic sitting. The design and structural analysis of a hybrid chair with movable seating and adjustable armrests that is intended for people weighing between 80 and 120 kg are shown in this project. For heavier users, traditional seats frequently don't offer enough support, which causes discomfort and bad posture. Our creative chair design solves this problem by including moveable seating that improves user comfort and adaptability, as well as adjustable armrests that may be adjusted for width. The structural and dynamic analysis of the chair is a primary emphasis of this study in order to guarantee its longevity, stability, and safety under a range of stress scenarios. The chair's resistance to static forces is evaluated using static structural analysis. Dynamic analysis, on the other hand, models' actual usage situations to assess how resilient it is to changing loads and effects. Advanced simulation techniques and material testing are integrated into the design process to maximize user experience and structural integrity. This hybrid chair fills an important need in ergonomic furniture design for heavier weight categories by providing an affordable and all-inclusive solution. Personalized comfort is encouraged with the addition of flexible seating and adjustable features, which help users maintain ideal posture. This study advances our understanding of adaptive ergonomic design and opens the door to more adaptable and supportive *chair options that can accommodate a range of physical requirements.***

Index Terms **Adjustable Armrests, *Ergonomic Design,* Hybrid Chair, Movable Seating, Posture Support, *Structural Analysis.***

INTRODUCTION

Ergonomical chairs are currently a considerable consideration in modern chair design, as customers are requiring flexible choices that provide support and comfort to different body shapes and weights. Average chairs are built for the most part with users weighing up to 90 kg; therefore, they do not have structural support and adjustability for heavier users. Such limitations have an effect on discomfort, posture, and an increased risk of long-term musculoskeletal disorders. To combat these adversities, this project provides an adjustable hybrid chair with movable armrests and seating position for users weighing 80 to 120 kg. The multipartite innovation of this chair comes from its features customized by the user: height, width adjustment of the armrests, and sitting position for optimum ergonomic support. In other seating systems, little to no flexibility exists; however, this one tries to improve users' comfort by seating adjustments according to personal preferences. Besides ergonomic design, the chair is also taken care of from structural and dynamic performance. A static structural analysis is carried out to know its capability of supporting static loads; thus, promoting durability and stability. Whereas dynamic analysis helps to recreate real-life usage conditions under which the chair faces variable load and impulse forces and tests its strength against those factors. Advanced simulation tools with material testing techniques validate design, while taking a balance between structural integrity, functionality, and user comfort. The hybrid design of the chair is an ergonomic solution to a gap in existing chair offerings for higher weight ranges cost-effectively, inclusively, and with maximum support.

This chair will provide posture supports by moving and adjusting features, thus reducing physical strain while enhancing the overall sitting experience. This work contributes to the adaptive ergonomic design, forming a pathway toward a more flexible and supportive kind of seating for the wider base. The transformation of cantilever chair from design innovation to everyday commodity is governed by intellectual property rights (IPRs), branding, and market forces. Branded copies and originals are worth more in perceived value, while mass-market copies command bigger markets. 500 Bangladeshis were interviewed by researchers to collect anthropometric data for ergonomic chair design. They established dimensions that fit an extensive body size range, enhancing usability and comfort. This research sets the importance of region-dependent ergonomic design in developing countries like Bangladesh. An experiment also investigates hybrid sit-stand postures, perching, which decrease discomfort but also requires lower limbs. It was discovered that perching requires 15% of a person's body weight and has typical muscle activity.

Variations in postural adjustments between genders also contribute to the need for ergonomic designs that accommodate this posture. A Sensor Chair tracks individuals' posture and gives them real-time feedback towards healthier behavior. Studies showed that feedback participants corrected their posture significantly, while instructional participants did not. However, feedback improvements declined over time, so repeated strategies are needed for long-term ergonomic benefit. School ergonomic chairs play an important role in providing comfort and concentration to the students. Evidence supported the need for certain designs to accommodate the students' size. The proposed chair includes adjustable height, working area, and air circulation, balancing functionality and design to promote comfort and concentration. This paper explores case-based reasoning for office chair customization. It builds an intelligent model using a weighted K-nearest neighbours' method, improving matching similarity and matching designs with customer requirements. The research addresses the problem of transforming imprecise customer requirements into precise design specifications. his study assesses the structural strength of cantilever handrail joints in solid wood armchairs. Three joint designs—dovetail tenon, cross-stepped tenon, and rear plug corner tenon—were recommended for improved structural strength. Finite element analysis demonstrated that the cross-stepped tenon was more excellent than others for stiffness and aesthetic appeal.

MATERIAL SELECTION

304 stainless steel is one of the most used austenitic stainless steels, recognized for its excellent corrosion resistance, strength, and versatility. Made from 18% chromium (Cr) and 8% nickel (Ni), this alloy gives a good balance of mechanical properties and corrosive stability, so it can be widely applied in food processing, medical equipment, aerospace, and structural components. Below are some important features of 304 stainless steel:

Tensile Strength: 304 stainless steel is generally very strong, with values between 505-720 MPa, depending on its processing and treatment, helping it deal with severe stress and mechanical loads without failing.

Yield Strength: The yield strength of 304 stainless steel is only some 215 MPa, which meant it was starting to undergo some plastic deformation. Although it is lower than that of high-strength steels, it does allow for great formability.

The hardness: a range usually from 140 to 200 HB (Brinell). It may not be as hard as some tool steels, but it has a good balance of strength and ductility to resist wear and impact.

Toughness: 304 stainless steel is its high toughness at any temperature, including cryogenic. It makes it particularly ideal for applications that require great endurance in extreme environments.

Ductility: 304 stainless steels has an excellent ductility property allowing it to form, bend and stretch without breaking. Such kind of quality works to its benefit in some processes of manufacturing, for example, in deep drawing, welding, and machining. Weldability:

Weldability: Owing to its low carbon nature, 304 stainless steel is very weldable with minimum risk of cracking or embrittlement in heat-affected zones. It is often used in fabrication, piping, and structural works that require extensive welding.

DESIGN CALCULATION

The following analysis evaluates the structural integrity and deflection characteristics of a chair leg designed to support a load of 120 kg (1200 N) with a factor of safety of 1.5. Using beam theory and material properties of 304 steel, we assess load distribution, bending stress, and deflection to ensure the leg meets strength and comfort criteria.

ASSUMPTIONS

To simplify calculations and focus on the structural analysis:

- Overall Chair Height: 900 mm
- Seat Width: 520 mm
- Seat Height from Ground: 510 mm

- Leg Length: 500 mm
- Applied Load: 120 kg (equivalent to 1200 N)
- Factor of Safety (Fos): 1.5

LOAD DISTRIBUTION

Assuming uniform load distribution, the total load is divided equally among the four legs of the chair.

$$\text{Load Per Leg}=\frac{1200N}{4}=300\text{N}$$

MOMENT OF INERTIA FOR A RECTANGULAR CROSS-SECTION

If each chair leg is modelled as a hollow rectangular steel tube, we can calculate the moment of inertia (III) for the cross-section. For a rectangular section:

$$I=\frac{bh\hat{}3}{12}$$

Width of Cross-Section (b): 20 mm = 0.02 m
Height of Cross-Section (h): 500 mm = 0.5 m

$$I=\frac{0.02.(0.5)\hat{}3}{12}=2.083*10^{-4}m^4$$

BENDING MOMENT CALCULATION

For a leg of the chair subjected to a load at the top, the bending moment (MMM) can be calculated as:
M=F·L

- Load per Leg (F): 300 N
- Leg Length (L): 500 mm = 0.5 m

M=300×0.5=150 N.m

BENDING STRESS CALCULATION

The bending stress (σ) in the leg can be calculated using the formula

$$\sigma=\frac{M.c}{I}$$

where:

Bending Moment (M): 150 Nm
Distance from Neutral Axis to Outer Fiber (c): 0.25 m
Moment of Inertia (I): 2.083×10^{-4} m^4

$$\sigma = \frac{150*0.25}{2.083*10\hat{}-4} = 180\text{MPa}$$

COMPARISON WITH YIELD STRENGTH

The calculated bending stress of 180 MPa is compared to the yield strength of 304 steel, which is 215 MPa. Since the bending stress is less than the yield strength, the design is deemed safe. Additionally, applying the factor of safety:

$$\sigma_{SAFE} = \frac{\sigma}{FoS}=\frac{180MPa}{1.5}=120\text{MPa}$$

The design satisfies safety criteria under the given loading conditions.

DEFLECTION CALCULATION (USING BEAM THEORY)

To ensure the chair remains stable and comfortable, we calculate the deflection (δ) of the leg under load. Using the beam deflection formula:

$$\delta=\frac{F.L\hat{}3}{3.E.I}$$

where:

- Applied Load (F): 300 N
- Leg Length (L): 0.5 m
- Modulus of Elasticity (E): 205×10^9 Pa
- Moment of Inertia (I): 2.083×10^{-4} m^4

$$\delta = \frac{300*(0.5)\hat{}3}{3*205*10^9*2.083*10\hat{}-4}=0.000126\text{m}=0.126\text{mm}$$

The combination of low deflection, acceptable bending stress, and a factor of safety of 1.5 confirms that the chair leg design meets the structural requirements for users weighing up to 120 kg.

METHODOLOGY

RESEARCH

It is all about learning about the market for hybrid and ergonomic chairs through market surveying, trend analysis, and considering ergonomic requirements. This involves examining existing chair models, gaps in users with a weight capacity of 80-120 kg, examining consumer trends for adjustable and multi-functional chairs, and researching body posture requirements for comfort.

LITERATURE REVIEW

Use scientific studies and industry trends to enhance your chair design. Research ergonomic design requirements, material life, load-carrying capacity, and fatigue life analysis. Industry publications contain information on trend materials and manufacturing techniques. Looking for existing patents on ergonomic or hybrid chairs avoids intellectual property problems and encourages innovative modifications.

DESIGN

Based on the ergonomic needs and according to the users' needs, 3D models of chair components are created by utilizing CAD software like SolidWorks and CATIA. The aim is to provide support for the optimal sitting posture, sitting comfort, and effortless adjustment for the preference of various users with the guarantee of an ergonomic comfortable chair.

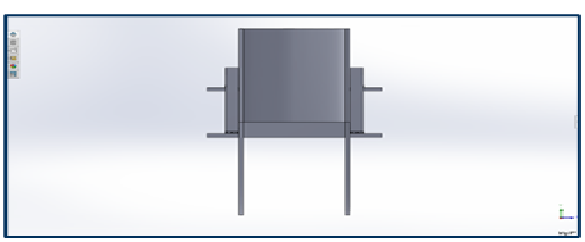
DESIGN VALIDATION

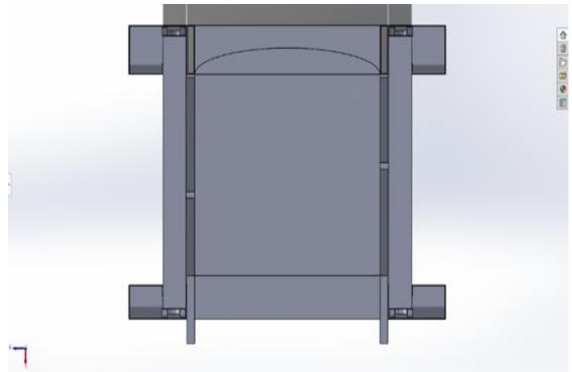
Design validation is conducted through static and dynamic structural analysis by employing simulation tools to verify the resistance of the chair against various loads and stresses. Mesh has 1,239,531 nodes, a fine element size, and a fine span angle. Dynamic analysis through Adams simulates real conditions and yields data regarding vibration, oscillation, and stability. Strength and stability verification validates chair strength in the case of specified loading conditions

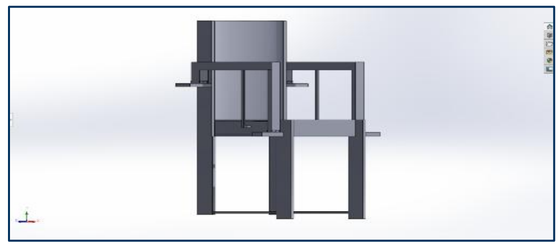
MANUFACTURING PROCESS

The production process is executed by employing appropriate techniques and maintaining quality through controlled processes. Methods such as injection molding or welding are selected depending on materials, providing durability, cost savings, and accuracy in design. Quality checks are maintained throughout to provide consistency and reliability in output.

DESIGN

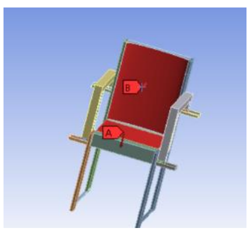


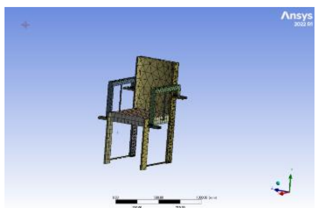


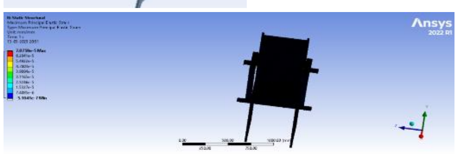


With the increased demand for ergonomic seating solutions, hybrid chairs have been developed that offer comfort and adaptability. The primary function in this research includes an adjustable armrest and seat width mechanism which is intended to accommodate users according to their body sizes or postures. Furthermore, the use of customizable dimensions for the seat ensures improved ergonomic support thereby minimizing discomfort and fatigue when used for longer times. The modular adjustment mechanism for armrests and the seat itself forms the main feature of the system under discussion. A. Armrest Adjustability Horizontal Movement: Armrests are to be extended outward or inward depending upon the user shoulder width. Vertical Movement: Adjustable height armrests for function to give better forearm support thus relieving shoulder and wrist strain. Locking Mechanism: Spring-loaded pin or ratchet lock system for assured secure positioning. B. Seat Width Capacity Had the base of the seat to widen for the offering loads of accommodation for the users of bigger frames. Sliding Nature: Rail system dependent on extrusion technology of adjustable stops accessed for controlled changes in the width. Structural Integrity Still uses high-strength steel or aluminium material warrants with stability despite width adjustment. To check the mechanical reliability of the articulated parts, FEA such as static load testing could be one method, done in SolidWorks Simulation: A range of user weight from 80 to 120 kg is applied for static load testing while even stress distribution is guaranteed. Dynamic load resistance of the chair is tested, imitating a keas tome impacting load such as the user suddenly sitting down. Material selection is done, and it is based on high-strength alloys 304 Stainless steel to reach a compromise between durability and weight efficiency. Ergonomic Benefits and Practical Application Provides a custom fit for diverse users, improving comfort and reducing musculoskeletal strain. Ideal for office, medical, and high-end seating applications, where prolonged sitting requires adaptable support. The modular design allows cost-effective scaling for commercial production.

ANALYSES







Nodes-1239531: The number of nodes in the mesh refers to the finite element method points where displacements, stresses, and other results are computed. The higher the number, the finer the mesh will be, which is usually the case for accurate results.

Element Size-25 mm: This defines the size of individual elements in the mesh. It means that the mesh is reasonably fine since one element is sized at 4 mm, balancing accuracy versus cost of computation.

Mesh Type-Tetrahedral type: This means that tetrahedral elements with triangular faces were used in the mesh, usually applicable in cases of complex geometries because they can adapt better to irregular shapes.

Span Angle Centre-Fine: Fine indicates how well the meshing quality has been; this means that the mesh is quite refined to give a good answer in the critical region of interest, such as junctions or supports. To fix the chair, the legs are fixed, and no movement is allowed at those locations. They are common boundary conditions to simulate realistic constraints. A load of 1200N on the seat, 600N on the backrest, and 200N on the armrest: The loads which are applied on various parts of the chair. The seat takes up quite heavy load while backrest and armrests take comparatively light loads. Results of Deformation: Max Deformation: 0.067054 mm: This is the maximum displacement of the chair structure due to applied loads. Since it is a small value, the structure is fairly stiff and resilient. Min Deformation: 0.00 mm: Minimum displacement which occurs normally at the fixed support points where no movement ever occurs. Color Gradient: The color gradient visually indicates levels of deformations; in theory, red represents areas under maximum deformation (that is, bending or stretching), while blue represents less deformed areas, which are close to the fixed support.

CONCLUSION

It is a significant contribution to the development of ergonomic furniture, the development of a hybrid chair for a person weighing between 80 and 120 kg. An excellent solution involving the use of movable seating and adjustable armrests has been found to correct some shortcomings of chairs. It increases the convenience, adjustability, and support for people with different weights. The movement of the seating and the adjustable width of the armrests have been designed by mechanical means. The durability, stability, and safety of the chair under loads have been checked by the analysis of the mechanics of the structure and the dynamics of the process of the chair's use. This approach allowed to confirm the reliability of the chair during its real use. The simulation of the design process of chairs and testing of the materials used helps to optimize the user experience while maintaining the strength. The development of the chair design for a person weighing between 80 and 120 kg is a significant contribution to a significant gap in the equipment of an ergonomic office in a weight category. It creates a basis for the development of universal adaptive furniture. For the first time, a hybrid chair has been proposed as an adaptive and inclusive design solution. The hybrid chair is a cost-effective and comprehensive solution that can be a good basis for the development of office chairs for other weight categories. The design approaches developed here help design more versatile and supportive chairs for people in need.

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