



Study and Design of Foldable Bench

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Abstract

In this paper we have studied different concept of advanced smart furniture's through survey of the global technologies that is used to blend conventional design of furniture's into smart design by integration of latest technologies which we have implemented to propose a design blending common furniture's. First concept which we have cad modeled is TANCH which is single, smart and integrated design of bench and table which can be used as table, bench as well as dining table. Second concept is regarding SICTCD for office furniture's that is Smart Integrated Concept of Table Chair and Drawer which have been cad modeled. Both concepts are modeled by keeping certain comfort indexes in mind such as space, ergonomics, functionality, weight, cost etc. These designs have been compared with convention model and proved way ahead in term of smart technology and can be benignant in day to day life.

Keywords- TANCH, SICTCD, Smart furniture, Smart techniques, Integrated cconcept.

I. INTRODUCTION

Furniture's are simple structures which are used for human comfort. Furniture's are object intended to support various human activities such as seating (e.g., chairs, stools, tables and sofas) and sleeping (e.g., beds). Furniture is also used to hold objects at a particular height. It can be made up of many materials like plastic, aluminum, wood, steel etc. It's nice to see new and beautiful furniture's that has not only a practical use, but also looks aesthetically good and improves your interiors.

Trends of furniture are changing day by day as per the needs. In the ancient days the population was less and the furniture's used were very bulky. In the recent years population is continuously increasing which is resulting in less space for accommodation. The conventional furniture's which are used they are not adjustable and require a lot of space which is uncomfortable for humans. Therefore we need such furniture's which require less space and can be used for multiple purposes.

The furniture's which are used nowadays are very huge and bulky and require a lot of space. They cannot be used for multiple purposes as well. So we require many furnitures for different types of work.

Our main aim for this project is to design furniture's which are easy to use, aesthetically good, multi functional and require less space. We are going to study the design of two concepts in this paper, office table and tanch. These two products are very useful in daily life as they require very less space and are multipurpose and it reduces the inconvenience faced by the huge and bulky furniture's in our daily life. It can be used in various places like offices, restaurants, home interior etc.

1.1. Problem Statement

To tackle the issue of convention furniture's regarding feasibility and compactness and to study and design of space saving smart furniture's that can be used for multi - purpose task in offices premises, hotel, restaurants etc.

1.2. Objectives

- 1) Multi purpose
- 2) Space saving
- 3) Easily foldable
- 4) Good aesthetics
- 5) Cost reliable

II. LITERATURE REVIEW

Honghua Li, Ibraheem Alhashim et.al^[1] studied the foldabilization problem for space-saving furniture design. Their goal was to apply a minimum amount of modification to the object so that it can be folded to save space, the object is thus foldablized. They develop an automatic algorithm for foldabilization by formulating, solving a optimization problem operating at two levels of the input shape. Specifically, the input shape is first partitioned into a set of integral folding units. For each unit, a graph was made which encodes conflict relations, e.g., collisions between foldings implied by various patch foldabilizations within the unit. Furthermore, adding the time dimension to the search also increases the problem complexity.

Emil Varghese, Sudhindra Kumar et.al^[2] studied the present scenario of furniture's that occupies the majority of space in the home interior. This study is to design and develop a multipurpose modular flexible, space saving dining table for Indian middle class homes. User study was conducted to understand the lifestyle, need and comfort as well as different activities associated with specific home interior and furniture. Several furniture design stores were visited in order to understand the present market scenario, demand and needs of the customers. Existing dining furniture was analyzed in detail including its components and parts and their assembly and sub assemblies. The user needs were analyzed as per data generated and QFD was generated. Final concept was selected using weighted ranking method by evaluating all the concepts. Drawings were developed for final concept, ergonomic validation and a prototype was made. In stowed form, the proposed concept is found to occupy just less than 25% of its deployed area.

Chanda Nelofer Khanam, Mahalakshmi V. Reddy and A. Mrunalini et.al^[3] studied the opinion of Students on Seating Furniture Used in Classroom. Classroom furniture is an important facility that helps in providing a conducive and comfortable environment for students in an educational institution. The comfort and functional utility of the classroom furniture depends on its physical design and relationship to the physical structure, biomechanics of human body etc. Some of the features like seat pan width and height, backrest height, thigh clearance, footrest, lumbar support were found to be incompatible to the users. They preferred furniture height to be adjustable. Other recommendations were broad seat, lower back support, clearance space for thighs and legs, provision for footrest, wide work surface, and provision for books, bags and water bottle, strong and durable furniture with rubber bushes to prevent noise. Since ergonomic evaluation of the existing classroom furniture proved mismatch in many respects to the users, it is necessary to improve the furniture design and make it user friendly.

III. METHODOLOGY

In this project we are using various foldable techniques for space saving and multipurpose use. Our aim is to keep design and working simple and reliable comparing with various similar products available in the market. We have reduced the space required for a normal office table and dining table by modern design concepts using foldable mechanisms and space saving techniques which makes it cost reliable and very helpful in daily life.

3.1. Market Survey

First we completed market survey online and collected the information regarding the smart furniture available globally. India is lagging in this modern technology but with world's second largest population which is increasing rapidly, there is need of adjusting settlement in the office as well as other building premises.

Market survey helps to understand the idea as well as technology of smart furniture which give us an idea of how these technologies can be applied in integrated ways so that can be introduced in India. Some of the online survey is from leading global industries. Few of them are listed below.

3.2. Concept of Design

Second step was to integrate the concept we have collected during the market survey. The key issue was to blend two different models and to design smart furniture.

We have to design the furniture keeping our objective in contrast of multipurpose and space saving issue and at the same time it can be used in two different way eliminating the need of two different separate furniture and mould it into one at the cost of function of both. We have integrated the idea of Dining table with single sided bench which can be efficiently used in both public as well as private place at cost of reduced keeping space.

3.3. Preparation of cad model

After having the idea of design concept, we put it down on paper and hence prepared our first cad model using Ironcad Software.

IV. MODELLING AND DESIGN

After the market survey of different furniture's we designed a concept of table and bench. It can be used as a table as well as a bench. In this model we have integrated the idea of folding bench with dining bench.

4.1. Concept 1.TANCH

Tanch-Table and Bench

Tanch is basically a table which can be folded into a bench. It can withstand load upto 600-800kg and it is very useful for restaurants, hotels etc.

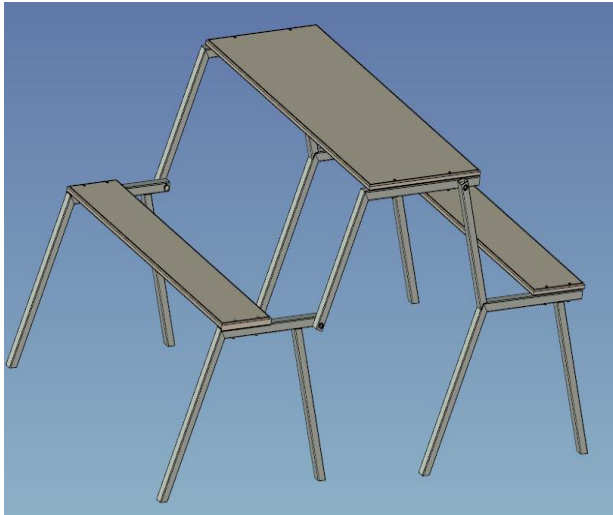


Fig. 1 Before Folding

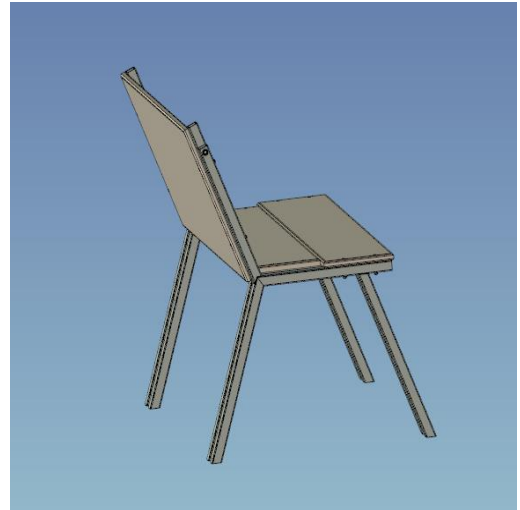


Fig. 2 After Folding

Initially the model had some flaws which in was observed after the market survey. The joint connecting the link between bench and table restrict the movement of a person sitting through sideways. This flaw was eliminated and model was redesigned providing an alternate way of folding process was provided as shown in figure below.

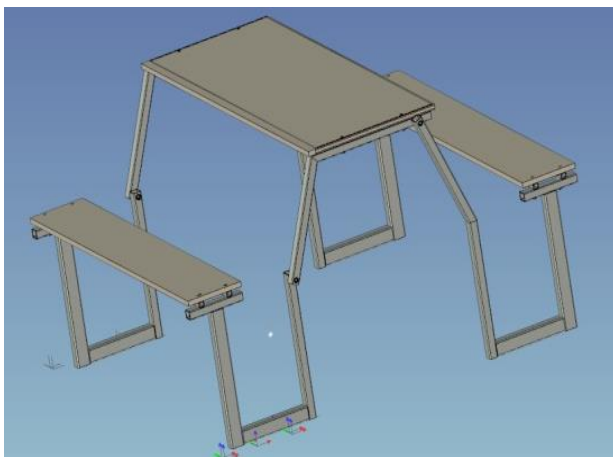


Fig. 3 Before Folding

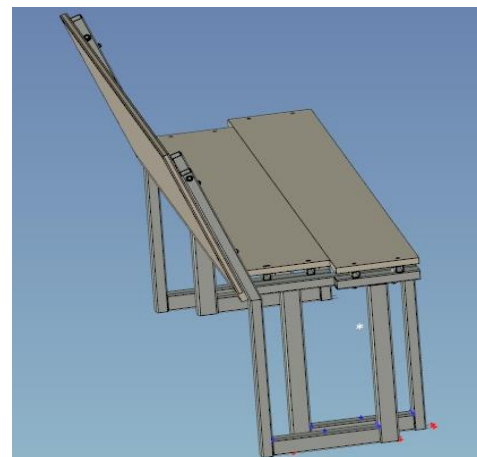


Fig. 4 After Folding

We can see that the link between the rods connecting bench and table which is responsible the flaw is eliminated. Now a person can slip sideways without restriction which makes the model more reliable and easy to use. It don't have any effect in after folding procedure to convert it as a single sided bench as you can see in figure below.

4.2. Materials used for the the TANCH are

4.2.1. Frame- Mild steel

Mild steel is a very popular metal and one of the cheapest types of steel available. It is found in almost each and every metal product. This type of steel contains less than 2% carbon, which makes it magnetize well. Because it is a soft material, mild steel is easy to weld, whereas high-carbon steel and stainless steel, require the use of specialized welding methods. Also, electricity can flow through mild steel easily without impacting its structural integrity. Mild steel is a variant of hard steels, which makes it much less brittle and enhances its flexibility. 30*30mm rods are used for the frame.

Types of mild steel

1. Low-carbon steel -Up to 0.3% carbon content.
2. Medium-carbon steel -Approximately 0.3–0.6% carbon content.
3. High-carbon steel- Approximately 0.6–1.0% carbon content. Very strong, used for springs, swords, and high-strength wires.
4. Ultra-high-carbon steel -Approximately 1.25–2.0% carbon content

4.2.2. Plywood

The support used for sitting is made from marine plywood. Plywood is a sheet material manufactured from thin layers of wood that are glued together with layers having their wood grain rotated up to 90 deg. to one another. Marine plywood is manufactured from durable face with few defects so it performs longer in both humid and wet condition and resists delaminating and fungal attack. Its construction is such that it can be used in environments where it is exposed to moisture for long periods. 15mm Plywood is used for sitting and table portion.

4.2.3. Primer paint

A primer or undercoat is a preparatory coating put on materials before painting. Priming gives better adhesion of paint to the surface, increases durability, and provides additional protection for the material being painted.

4.2.4. Sun mica

It is a decorative laminate sheet that is generally used as an overlay over wooden furniture.

V. DESIGN CALCULATIONS

5.1. Selection of Nut & Bolt Diameter

As there is clearance and washer in between the frames, hence tensile stress is not considered no nut & bolt. Therefore we have to consider shear and bending failure for selection of nut and bolt diameter.

5.1.1. Considering shear failure

Material Plain Carbon Steel ,
 $S_{yt} = 300 \text{ N/mm}^2$

$$\tau = \frac{P \sin \theta}{\frac{\pi d^2}{4}} \quad \dots(1)$$

But

$$\tau = \frac{0.5 S_{yt}}{f_s} = 50 \text{ N/mm}^2 \quad \dots(2)$$

From Eqn, (1) & (2),
 $d = 6.92 \text{ mm}$

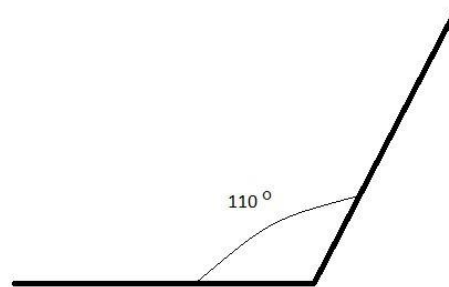


Fig. 5 Angle in between two links

5.1.2. Considering bending stress

$$\sigma_b = \frac{S_{yt}}{f_s} = 100 \text{ N/mm}^2 \quad \dots(3)$$

$$M_b = P \sin \theta * 15 = 28.2 * 10^3 \text{ Nmm}$$

$$I = \frac{\pi d^4}{64} = 0.049 * d^4 \text{ mm}^4$$

$$\sigma_b = \frac{M_b * y}{I} \text{ N/mm}^2 \quad \dots(4)$$

From eqn, (3) & (4),

$$d = 10 \text{ mm}$$

The diameter is larger in bending stress. Hence the design will be safe in bending and shear when diameter is 10 mm or under bending stress consideration.

5.2 Welded Joint Efficiency

Joint efficiency is concept which is found in API and ASME codes. It is a numerical value, which represents a percentage, expresses as the ratio of strength of a rivet, weld joint, etc to the strengthen the base material. It is a good way to introduce safety factor in welding of shells for containments and can be expressed as follows:

In other standard, values for Joint Efficiency in welds are assumed according to 2 traits

$$\text{Joint Efficiency} = \frac{\text{Strength of weld}}{\text{Strength of base material}}$$

- 1) Type of welded joint
- 2) Extent of NDE required for the welded joint
- 3) Joint efficiency varies with weld type. Various welding type and joint efficiency for them can be found in “Maximum allowable joint efficiencies for arc and gas welded joints”. That way, a butt welded joint will have a greater value of E than a fillet welded joint.
- 4) Joint efficiency also changes with the extent of NDE required for the joint. A value of 1 for E will make one joint go full radiography.

$$\eta_j = \frac{410}{500} = 0.82 \text{ or } 82\%$$

Electrod material E6011 and Base Material carbon AISI 1040 Annealed.

VI. ANALYSIS

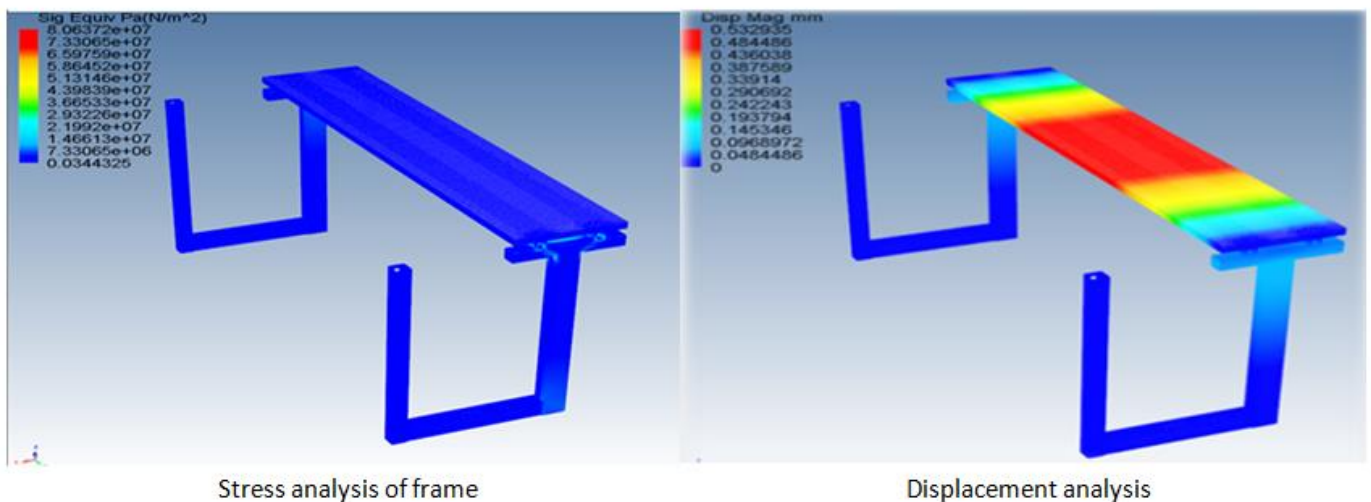


Fig. 6 Analysis

From stress analysis, max. stress = $8.0637 \times 10^7 \text{ N/m}^2$
 But the material yield strength is $3.7 \times 10^8 \text{ N/m}^2$

As Max. stress is less than yield strength of material, hence material will be safe under loading.

Displacement should be less than 1 mm as per standard design consideration. By analyzing the plywood in FEA software the results were recorded as,

Max. displacement = 0.5329 mm

The portion at center of plywood is more concentrated in displacement. But the max. displacement is less than 1 mm, hence design will be in safer side.

VII. CONCLUSIONS

Hence, we have made models of such integrated furniture's which can be very useful in our day to day life and it has solved many problems related to furniture which required large space, bulky, comfortness etc. The concept has developed by doing market survey, ergonomic design consideration, literature study, etc. Analysis of frame has done in Ansys software which provided stress and displacement values. These values were compared with the yield strength of material and design is safe under loading. Welded joint efficiency is 82%. M10 nut & bolt is selected for the mechanism on the basis of bending stress calculation.

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