

# Factors of Successful Wooden Furniture Design Process

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## II. METHODOLOGY

**Abstract**—This study systemizes processes and methods in wooden furniture design that contains uniqueness in function and aesthetics. The study was done by research and analysis for designer's consideration factors that affect function and production. Therefore, the study result indicates that such factors are design process (planning for design, product specifications, concept design, product architecture, industrial design, production), design evaluation as well as wooden furniture design dependent factors i.e. art (art style; furniture history, form), functionality (the strength and durability, area place, using), material (appropriate to function, wood mechanical properties), joints, cost, safety, and social responsibility. Specifically, all aforementioned factors affect good design. Resulting from direct experience gained through user's usage, the designer must design the wooden furniture systemically and effectively. As a result, this study selected dining armchair as a case study with all involving factors and all design process stated in this study.

**Keywords**—Furniture Design, Function Design, Aesthetic, Wooden Furniture.

## I. INTRODUCTION

FOR wooden furniture industry, the designer or product manager must try to understand the nature of raw material, which may say that wood has unique mechanical properties such as swelling shrinkage warping depending on atmospheric moisture. Moreover, each type of wood has different property or even the same wood from different location also has different property as well as the wood of the same tree from different location will have different property, too. In addition, the designer must additionally concerned about factor of user such as dimension of the user, safety, and user feeling because of the furniture is the product that directly or indirectly contact with the user.

Generally, furniture can be divided as follow: appearance (leg-type, box or cabinet-type, upholstery-type), function (home, office, public, specific-purpose), placement (out-door, in-door), assembly (built-in, free standing) and materials (solid wood, panel board, steel sheet, steel rod, alloy-casting, plastic, natural material, concrete-casting) [1].

This study presents processes in furniture designing and concerning factors in both function and aesthetics factors for further benefits in wooden furniture industry.

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The study in furniture designing has various objectives such as to develop new product, to improve manufacturing process, to improve present product and process, to find extra benefit on present or rejected product, to find technical data for main division in the organization, to analyze the competitor's product, and to find and extend the knowledge which is the main reason of furniture research as well as this study. The study processes are as follow [2]:

- 1) Collecting information about product design
- 2) Collecting information about manufacturing and usage of furniture to analyze the design
- 3) Collecting specific information about wood for furniture manufacturing
- 4) Analyze the design process of solid wood furniture
- 5) Effectively analyze the risk factor affecting furniture design
- 6) Design follows results
- 7) Conclusion

## III. RESULTS

### 1) Process Design

1.1) Planning for Design; is the initial process of wooden furniture design. The designer must identify customer group which leads to customer needs then plans for expected product to answers the demand of the marker. Thus, the designer may plan for the product that already has its demand in the market then finalize the decision and conclude the expected design as well as plan the guideline (list) for the task.

1.2) Product Specifications; begins with specific feasibility study of related wooden furniture in target customer group. The designer must obviously state about production technology level, and basic information preparation.

1.3) Concept Design; is concept presentation of the wooden furniture which comprised of concept generation based on basic information, experience, and skill of the designer then will be concept selection and concept testing.

1.4) Product Architecture; is involving with various parts including design development, costing, prototype construction and prototype testing.

1.5) Industrial Design; in real wooden furniture industrial design, designer must start with a process in design revision. The designer and manufacturer must verify the design then the designer will begin production drawing and tendering for manufacturing and drawing again specially for manufacturing. Thus, this process must concern about design for manufacture and assembly for efficiency in manufacturing process. In addition, for longer furniture's life, the designer may apply robust design with the wooden furniture works.

1.6) Production; for production process, the designer should cooperate with manufacturer as well as examine the product in every process with engineer [3].

## 2) Design Evaluation

A good furniture design must answer to the main objective of effective creative design in various ways such as ease in use, ease in manufacturing [4]. And ease in distributing using these following evaluation criterions.

- 2.1) Good function and aesthetics
- 2.2) Durability
- 2.3) Economy
- 2.4) Appropriated material
- 2.5) Appropriated structure
- 2.6) Personality/Identity
- 2.7) Beauty causing positive response by consumers [5].

Design analysis and evaluation is not necessary to perform only in the last process. In the other hand, the designer and involved people should evaluate such design in other processes to made effective and accurate decision in each process [6]. Therefore, furniture design presentation provides better understanding to involved people in various level i.e. directors, department managers, or employer [7].

## 3) Factors Affecting the Design of Wooden Furniture

### 3.1) Art

3.1.1) Art Style: Furniture History; There are said that exterior architecture affects interior architecture and the furniture is the part of such interior architecture [8]. The furniture has been used in church, temple ceremonies and activities. Therefore, this furniture has been crafted with exquisite craftsmanship and functional support for the king and his royal family, peerage, and merchants, which the state that has the influence on such architecture is France [8]. This was markedly since the early 11th century which also influenced furniture design throughout Europe and around the world today. The furniture designs on the history are as follow:

- 3.1.1.1) GOTHIQUE (1150 A.D.-early 16<sup>th</sup> century)
- 3.1.1.2) RENAISSANCE (16<sup>th</sup> century)
- 3.1.1.3) LOUIS XIII (1590 A.D.-1661 A.D.)
- 3.1.1.4) LOUIS XIV (1661 A.D.-late 17<sup>th</sup> century)
- 3.1.1.5) REGENCE (early 18<sup>th</sup> century)
- 3.1.1.6) LOUIS XV (1735 A.D.-1760 A.D.), the same art period of ROCOCO
- 3.1.1.7) TRANSITION (1760 A.D.-1780 A.D.)
- 3.1.1.8) LOUIS XVI (1780 A.D.-1795 A.D.), affected by Greek-Roman, full of NEO-CLASSIC
- 3.1.1.9) DIRECTOIRE&CONSULAT (1795 A.D.-1804 A.D.) after French Revolution
- 3.1.1.10) EMPIRE (1804 A.D.-1815 A.D.)
- 3.1.1.11) ART NOUVEAU (late 19<sup>th</sup>-early 20<sup>th</sup>), new era arts in International Style
- 3.1.1.12) ART DECO (early 20<sup>th</sup> century-present)

3.1.1.13) MODERN (early 20<sup>th</sup> century-present); this design was in the concept of increasing in population, development in industry. Therefore, mass production is unable to achieve by craftsmen so that the machine was used. As a result, the design must be simple but strong and function as well as beauty in shape, color with acceptable price [9].

### 3.1.2) Form

Compactness; overall shape of the product must be unified and the exterior must be paralleled or systemically unparallelled. Therefore, the best design for wooden furniture is geometric form because of consistency in shape of the material finished in wood industry as well as ease to produce such shape with machine.

Simplicity; the design of wood products used in daily life should not looks unpleasant. Therefore, it should be a shape that blends in with its surrounding environment. Usually, the geometric form is a simple shape. Originality / Identity; the product is designed to represent a unique shape.

### 3.2) Function

3.2.1)The strength and durability; Structural concept shapes the wood product depending its expected function. Normally, wooden furniture structure will comprise of 4 types i.e. structural forming by column & beam or frame structure, structural forming by hand board on plains, structural forming by frame and panels, and structural forming by curved board. Moreover, the designer must consider about surface protection to present humid or insect or stain to enter the wood causing the product to spoil.

3.2.2)Area Place; appropriate shaping for a specific environment depends on the surrounding of the product when it was used. Even the designer was not sure about it final placement, the designer must design the furniture to suit its surrounding environment providing its main expected function. According to the nature of the furniture, it must be placed in an environment which has human as a part of such environment. This may divided into 2 main categories i.e. environment and built environment which the furniture will be designed having 2 basic concepts of function and aesthetics. For function, the furniture will produce ergonomics according to activity and activities & human's behavior depending on various environment factors [10].

3.2.3)Using; Form design of the wooden product can be divided into 2 categories which are design with inner space such as drawer, cupboard and design without inner space such as chair seats.

### 3.3) Material

3.3.1) Appropriate to Function; appropriate wood hardness selection must be related with the function of the furniture. Therefore, the designer should know about specific gravity or mass density which directly related with hardness of each type of wood. This is crucial since the hardness of the wood will affect the furniture's assembly process, load bearing, textures, and colors.

3.3.2) Wood Mechanical Properties; some mechanical properties dramatically affects manufacturing process and function of the furniture. Therefore, the designer should consider these following factors:

3.3.2.1) Moisture; moisture in the wood is critical factor in wood usage. This can be divided into 2 parts as bound water and free water. Bound water affects shrinkage, warping, and raised grain [11]. Therefore, the moisture must be controlled to be equal to atmospheric moisture at 12-14%, approximately.

Moreover, inappropriate wood moisture can reduce furniture life because of fungi. Fungi is the great threat by causing the wood to decompose which can be divided in to 3 type as; 1. Wood decaying fungi such as Brown Rot, White Rot, Soft Rot; 2. Color bleaching fungi such as Botryodiplododia, theobromae Pat.; and 3. Stained fungi that can be removed but sensitize to people with respiratory problems such as Aspergillus, Penicillium [12]. As a result, wood moisture should be considered in production and export because of difference in relative humidity in each continent [13]. Specifically, the wood fungi promoting humidity is 35-50% so, as prevention, the humidity must be kept at 20-35%.

3.3.2.2) Shrinkage and Swelling; wood shrinkage and swelling, as mentioned above, caused by wood moisture changes. However, the importance in this section is non-uniform shrinkage and swelling. Wood shrinkage and swelling depends on density, specific gravity, and, most importantly, direction of wood structure which causes the wood to shrinkage and swelling differently as follows; radial 3-6%, tangential 6-12%, and longitudinal 0.1-0.3% [12]. Therefore, processes wood selection with longer radial length and shorter tangential length will give better quality furniture called <sup>[14]</sup> quarter sawn furniture. This sawing pattern provides less quantity of wood and process slower but yield better quality as well as higher selling price [14].

3.3.2.3) Sapwood and Heartwood; difference between sapwood and hard wood has 2 conditions which are difference in color and durable of heartwood will be more than sapwood. However, for soft wood, the color between sapwood and heartwood will not observable. Moreover, for both soft wood and hard wood, the difference in hardness of sapwood and heartwood is also not observable [13].

As a result, the designer should consider this limitation for the designed furniture can has shading or different colors as well as durable.

#### 3.4) Joints

According to wooden furniture industry, the designer should extremely try to understand the nature of wood joints to be able to provide a design which is easy to produce and cost saving. Wood joints can be divided into 4 types including literal jointing to expand the width, jointing to expand the thickness, jointing to extend the length, and cornering. In addition, the factors that affected the strength of wood joints are grain pattern, wood moisture, shrinkage and warping direction, wood joints pattern as well as jointing material and method [15]. Cornering is common in multi pattern furniture including upper, middle, and lower cornering as well as corner supporting using wood as an enhancement and warping

prevention at upper, middle, and lower part. Therefore, this cornering will be done by full piece cornering which can be fixed with nail, pivot, tusk tenon joint, dovetail wedges, dovetail full joint, and dovetail.

#### 3.5) Cost

Cost of wooden furniture is mostly from raw material (Fig. 1). Therefore, manufacturing design will helps in efficiency of the manufacturing reducing material waste. Moreover, the labor is the second cause of the cost so optimal laboring can be reduces the cost in both labor cost and others. Product development cost was included in overhead cost. Normally, the good development in furniture design should focused on design and develop. It is obvious that the development in new product is an investment so that the resources requirements should be observed for further cost reducing measures [16].

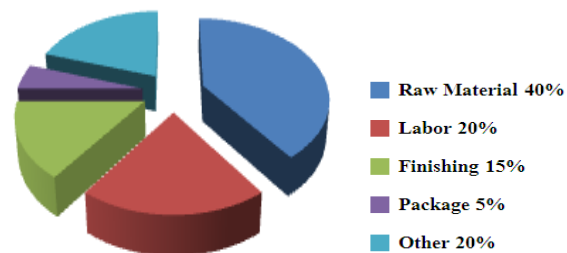


Fig. 1 Cost of wood furniture manufacturing

#### 3.6) Safety

Form design suiting behavior or activity in usage provides balance for the product when placed or with the environment especially for furniture design of chair, high closet, or high shelf. Therefore, the designer must concern about balance in consistent with usage behavior and size of the base of the furniture that can be place safely as well as the users' convenience for manipulating, convenience for hygienic cleaning and convenience for maintenance. Proportion design provides appropriate shape that gives good feeling in usage behavior, environment, desirable shape, and dimension of raw material in order to reduce the waste.

#### 3.7) Social responsibility

For wooden furniture industry, the important factor is "Material requirements planning" because of supply shortage may occurred in some period of time. To permanently preserving of forest, big voice of customers in various country in North America such as Canada and USA; Europe such as England, Netherland, Denmark, Sweden; and Asia such as Japan, China, Hong Kong including Australia as natural conservatives required that wooden furniture source must not come from conserved forest or forestry plantation that causing damages to the ecosystem. This includes soil damages, community affected insect borne disease, laboring in planting, etc. which standardized with FSC (Forest Stewardship Council). Therefore, the manufacturer formed an organization to answers this needs which ITTO (International Tropical Timber Organization) is having tropical forestry as members with main regulation in raw material usage that the wood must be approved by Forest Certification. As mentioned before, the social responsibility is the factor and may be the main factor

for the designer or wooden furniture manufacturer must concern about.

#### 4) Design Follow Step

From data calculation and analysis in furniture design process and affecting factors in solid wood furniture design in various aspects, the study designed a chair as a case study which is a MODERN style chair (early 20<sup>th</sup> century –present). MODERN style design was base on the concept of mass production with machine. Therefore, the design must be simple but strong and function as well as beauty in shape with acceptable price. The design process begins with original concept design from kangaroo using distinctive point of 2-legged standing behavior of the animal as the concept of the 2-legged chair as shown in Fig. 2.

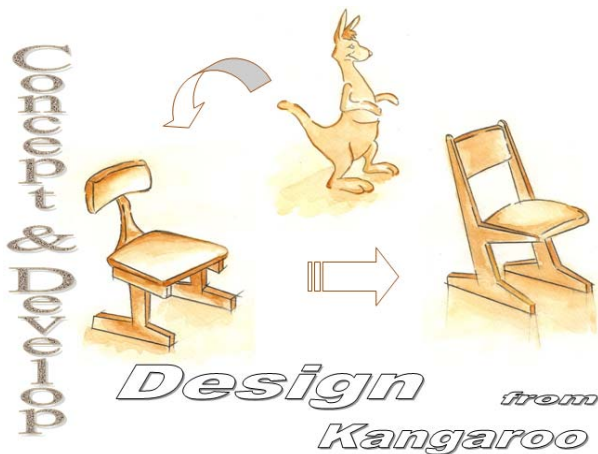


Fig. 2 Original concept design and develop shape

After that, the chair was developed again under studied factors to create a functional and cost saving chair. Therefore, concept design and development for manufacturing of 2-legged chair can reduce material cost as well as steps manufacturing process.

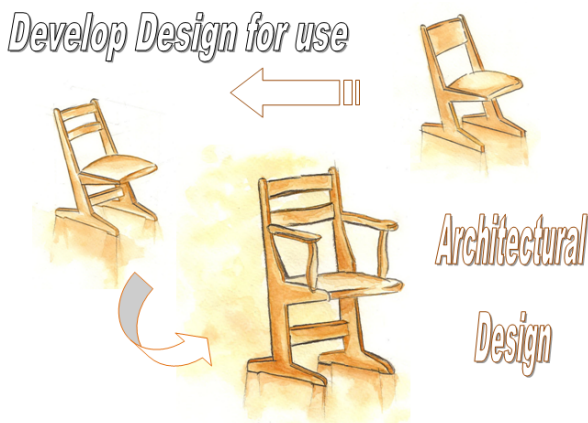


Fig. 3 Improved study case's chair

However, the design must concern about strength and function so the design was developed further as shown in Fig. 3 which adds arm supports to comfort the user as well as

increase the strength between side flap and backrest since the flap has only one joint. Therefore, the arm supports and pole of arm supports will helps distribute the load and increase the durability when used.

From developed chair, the design was concerned as industrial design since chair is furniture product that directly contact with the user. Therefore, human scale or dimension was considered. As a result, the improved design for producing prototype chair is shown in Fig. 4, Fig. 5.

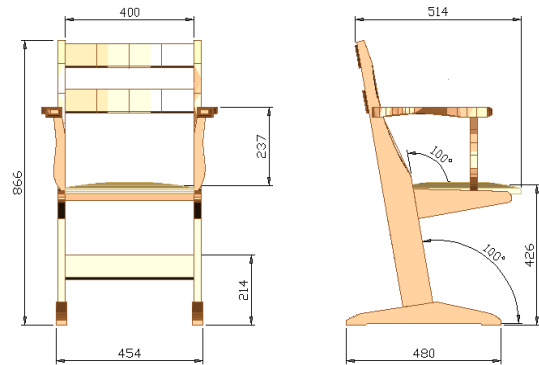


Fig. 4 Dimension of the chair considering human scale



Fig. 5 Case study's chair that passed processes of planning for design, product specifications, concept design



Fig. 6 Analysis for center of gravity using computer aided engineering (CAE)

According to concept design & development on 2-legged chair, there is a basic hypothesis on prototype chair that it will whether passed the stability test. The stability test is the test for balance and steadiness while use so that the analysis for balance in center of gravity will be used as shown in Fig. 6 [17].

## IV. DISCUSSION

As a consequence, solid wood furniture design highly depends on special skills of the designer who understand the nature of wood material which affects the usage of the customer or efficiency in manufacturing process. Besides, factors affecting the furniture design are art (art style; furniture history, form), function (the strength and durability, area place, using), material (appropriate to function, wood mechanical properties), cost, safety and social responsibility.

## V. CONCLUSION

Moreover, in order to be perfect, wooden furniture design must contain function and aesthetics which require systematic design including planning for design, product specifications, concept design, product architecture, industrial design, and production. In addition, for quality during and after design process, there is extremely necessary for the designer to evaluate their wooded furniture design. In the future, in-depth research in wooden furniture design should be further performed in design for manufacturing and assembly since the wooden furniture industrial manufacturing and assembly process produce more than 40% waste, averagely. In the purpose of that, design process can be a tool to increase the efficiency of such processes.

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## REFERENCES

- [1] Karl T. Ulrich and Steven D. Eppinger, *Product Design and Development*. Third Edition, The McGraw-Hill companies 2003
- [2] Youdhagarn Archary, *Product Design and Production*. King Mongkut's Institute of Technology North Bangkok., 2007
- [3] The Bossiness and Technician Education Council, BTEC; <http://www.edexcel.com/quals/btec/Pages/default.aspx>
- [4] Olson Delmar Walter, *Design in Woods and Woodworking for Industrial Art*. Englewood Cliffs, N.J. : Prentice-Hall, 1965
- [5] Jariya wattanakun, *Furniture History*. The paper for teaching, King Mongkut's University of Technology North Bangkok, 2000
- [6] Boonsanong Ratanasoontragul, *generally knowledge into the furniture and wood products*. Nation Science and Technology Development Agency Ministry of Science and Technology, June 2010
- [7] Pawin rujikiatkamjorn, *Design methodology*. Nation Science and Technology Development Agency Ministry of Science and Technology, June 2010.
- [8] Torwong Puipantawong, *Creativity for design*. Nation Science and Technology Development Agency Ministry of Science and Technology, June 2010.
- [9] Pasit leeniwa, *The relationship between man and area use*. Nation Science and Technology Development Agency Ministry of Science and Technology, June 2010.
- [10] Boonsanong Ratanasoontragul and Pasit leeniwa, *Research of design*. Nation Science and Technology Development Agency Ministry of Science and Technology, June 2010.
- [11] Motana sittipitak, *Presentation of design furniture*. Nation Science and Technology Development Agency Ministry of Science and Technology, June 2010
- [12] Teera Veenin and Songklod Jarusombuti, *Wood Structure and properties*. Nation Science and Technology Development Agency Ministry of Science and Technology, February 2006
- [13] Teera Veenin, *Wood Protection*. Nation Science and Technology Development Agency Ministry of Science and Technology, February 2006
- [14] Franz F.P. Kollmann and Wilfred A. Cote, *Principles of Wood Science and Technology*. Springer-Verlag New York Inc. 1968
- [15] W. Gwyn Davies and Heikki O. Rissanen, *Workshops on Sawmill Productivity Improvement*. Asia Pacific Forest Industries Development Group, 1988
- [16] Jamjun tummasujarit., *Wood Joints*. King Mongkut's Institute of Technology North Bangkok., 2008
- [17] Bifma Standard., *Business and Institutional Furniture Manufacturer's Association*. ANSI/BIFMA X 5.1, 2011