DEVELOPING ENVIRONMENTALLY FRIENDLY FURNITURE THROUGH LIFE CYCLE ANALYSIS

Kamarulzaman Nordin, Mohd. Ariff Jamaludin, Mansur Ahmad and Ashari Abd. Jalil
Department of Furniture Technology, Faculty of Applied Sciences
Universiti Teknologi MARA, 40450 Shah Alam, Selangor

Abstract: The furniture industry is one of Malaysia's mainstays in economy and had gain reputation in industrial sector ever since the introduction of the first Industrial Master Plan (1st IMP). It has emerged from craftsmen's traditions specializing in customized, one-off production towards standardized batch production, often aimed at an international market. With the current development on environmental issues, Malaysian furniture manufacturers that rely or planning to venture into export markets need to re-organize their business strategy to accommodate this issue in order to enable them to penetrate global market as well as staying ahead of their competitors. As such, product developers, manufacturers, material and equipment suppliers, and those linked to the furniture industry, as well as public authorities need to analyze the industry's environmental status and made suggestions for ecological improvement initiatives in important areas. This paper aimed to give an overview on the steps that can be taken towards the development of environmentally friendly furniture. The procedures generally founded on the life-cycle analysis approach which focused on the cradle-to-grave environmental impact. It embodies environmental issues in the product development process by minimizing negative environmental burdens in furniture design and manufacture while upholding other requirements of the products such as function, usability, maintenance and service life, aesthetics and economy.

Keywords: Furniture, Environmentally friendly, Life-cycle analysis

INTRODUCTION

The furniture industry is one of Malaysia's mainstays in economy and had gain reputation in industrial sector ever since the introduction of the first Industrial Master Plan (1st IMP). From the craftsmen's traditions specializing in customized one-off production, it has emerged towards standardized batch production utilizing the latest manufacturing technology often aimed at the export oriented market. The bulk of total furniture exports from Malaysia comprised of wooden furniture. Wood, being a major industrial and engineering material from renewable resources often regarded as a material with many environmental advantages. Despite these, there is considerable debate about the environmental impact of wood products.

According to Kutscha [4], wood and the environment is one of the subject areas that are currently receiving top priority research and utilization efforts by the Technical Interest Group of the Forest Products Society. He outlined methods of life cycle analysis (LCA) to develop an objective process that can track the environmental burdens associated with a product, process, or activity as one of the major research that falls under this subject area. The concept of LCA is comparatively recent and has less awareness among researchers and policy makers not only in Malaysia but in the Asian region as well [1,3,5]. To date, LCA studies can be found for a number of wooden products like doors, windows, parquet, building element and a handful on furniture products [2]. However, there is no formal LCA study reported in Malaysia especially in the area related to wood based products perhaps due to non-existence of LCA expertise and lack of sufficient databases relevant to domestic conditions.

With the rise of current awareness of the world towards environmental issues or the eco-labeling programs particularly on products originated from tropical forest, Malaysian furniture manufacturers that rely or planning to venture into export markets need to re-organize their business strategy to accommodate this issue in order to enable them to penetrate global market as well as staying ahead of their competitors. As such, product developers, manufacturers, material and equipment suppliers, and those linked to the furniture industry, as well as public authorities need to analyze the industry's environmental status and made suggestions for ecological improvement initiatives in important areas. This aim of this paper is to give an overview on the steps that can be taken towards the development of environmentally friendly furniture based on LCA approach.

Furniture Industry Environmental Status

Wooden furniture comprised the bulk of total furniture exports from Malaysia. Malaysian Oak (*Hevea brasiliensis*), being the most important timber for the Malaysian furniture industry makes up approximately 80% of wooden furniture produced by Malaysia [6]. Other species of timber used for furniture includes kembang semangkok (*Scaphium spp.*), nyatoh (*Sapotaceae* and *Palaquim spp.*), sepetir (*Sindora spp.*), ramin (*Gonystylus spp*) and dark red meranti (*Shorea spp*).

As a raw material, sustainable timber such as Malaysian oak and the rest of the timber used for furniture affects the environment minimally. The actual utilization of wood for furniture cause no environmental effect since wood is a renewable resources. The impact therefore derives solely from logging machinery and transport and when wood is combined with other materials or has chemicals added to meet up specific functional or engineering requirements. Such activities deliberately change the environmental profile of the finished products.

For instance, it is necessary for Malaysian oak timber to be treated with appropriate preservatives for protection against the attacks of bio-deteriorating organism. Adhesive is used to create new product characteristics from the raw material of wood such as in the production of glued-laminated products, laminated veneer lumber, particleboard, and other composite wood products in order to obtain wider furniture components. Finishing, correspondingly improves both wear ability and easy-to-clean properties in addition to enhancing the aesthetic and economic values of furniture. All these products and their accompanying industrial system involved apparently can create an environmental impact from toxic substances or volatile organic solvents.

In addition to wood, the use of metal, plastic, glass and upholstery in furniture may add greater environmental impact to the furniture industry since the extraction and manufacture of these materials (i.e. glass and metal) are generally energy intensive and at the same time they are not renewable resources. In view of this, the stakeholders need to identify and evaluate the environmental burdens of the Malaysian furniture over their life cycle in order to suggest options for improvement of the environmental performance which can be incorporated into designing and development of furniture products that generates minimal effect to the environment.

MATERIALS AND METHOD

Life-cycle Analysis

In order to evaluate the environmental burdens of Malaysian furniture, a LCA approach can be used to make the overall assessment of all parameters, with the purpose of establishing a basis for making the right choices during the development process. The LCA approach which focused on the environmental impact from cradle-to-grave includes the impact on man and the environment caused by substances, material, energy and processes all the way from raw material acquisition via the production processes and use of the product to the final disposal. In the case of wooden furniture, the life cycle begins with material extraction (i.e. logging) and depletion (i.e. sawmilling, plywood processing, particleboard manufacturing, etc.) followed by all manufacturing process of the furniture product, through to product distribution, the use of the product, maintenance, and finally the end of life management Most wood based furniture products also contain other materials and sub-components such as metal fittings and frames, plastic components, upholstery materials, and glass. Therefore, such analysis of a product may be complex and may typically involve the life cycle of other products as well.

The results of a LCA will quantify the potential environmental burdens of the product system over the life cycle. A major part of the environmental burdens of a product is inherent in the product, depending on choices taken during the product development phase. The environmental burdens that are of major importance includes global warming, acidification, euthrophication, photochemical ozone formation, human toxicity, terestic toxicity, aquatic toxicity, resource depletion, land use impacts, biodiversity, water and soil stability, use of non-renewable materials, air quality and clean water availability. Thus, from the LCA results, the negative environmental burdens identified for the product must be reduced throughout the entire life cycle as close as possible to the source in order to produce an environmentally friendly product.

DISCUSSIONS

Environmentally Friendly Furniture

Environmentally friendly furniture is one that is less harmful to the environment than the next best alternative, having characteristics including but not limited to the following:-

- reduce wastes and make efficient use of resources
- are reusable or contain reusable parts
- are recyclable or contain recyclable material
- produce fewer polluting by-products and/or safety hazards during manufacture, use, or disposal
- have long service life and/or can be economically and effectively repaired or upgraded

In developing environmentally friendly furniture, the existing product first needs to be evaluated through LCA to identify the environmental burdens of the product. Resource consumption initially is mapped as far back as possible in the supplier chain to ensure that the timber used has been logged from sustainable forests that have minimum effect on the ecosystem and that are properly managed as indicated by an international forest certification system. As a raw material, sustainable timber affects the environment minimally. The actual consumption of wood generates no effect, since it is a renewable resource. The impact therefore derives solely from logging machinery and transport.

When wood is combined with other materials or has chemicals added to meet specific functional requirements, the environmental profile of the finished product changes. If the products can be separated, the wood per se can contribute large volumes of energy when incinerated at some subsequent point in the product life-cycle. Even minor metal and glass consumption affects a product's impact on the environment, since both raw materials are highly energy intensive to manufacture. Conversely, the energy consumed in producing glue, varnish and impregnating compounds rarely has any noticeable effect on the overall environmental impact. In the production of "clean" wooden furniture, the energy consumed on ventilation of production halls represents the greatest individual environmental impact.

Surface treatment results in various impacts on the environment. The vast majority of evaporation takes place during application and subsequent softening. However, a small proportion will not evaporate until the use phase, hence impacting on the indoor climate. Products used in an indoor climate release gaseous volatile organic compounds (VOC) to that climate. Clean wood products release clean odorants, in particular, which under normal circumstances do not cause irritation of the mucous membranes, eyes or the respiratory system. Glue and surface finishes, on the other hand, can contribute to degasification, which is less friendly to the environment. As such, the use of solvents must be restricted and efforts must be set towards changing over to other types of varnish and by controlling and improving the application technology involved. At the same time, it should be reminded that the quality of the finished products not be impaired when replacing "conventional" varnishes with water-based ones.

Other environmental impacts in the use phase originate from maintenance (e.g. repainting, impregnation or replacement of sub-components) and to a lesser extent cleaning. Wood with glue and varnish residues of up to one percent may be used to generate actual energy in the manufacturer's own approved incineration plant or in centralized systems. Wood with higher concentrations of glue and varnish must be disposed of by incineration in special, publicly approved plants. Impregnated wood must be dumped as hazardous waste. Plain glass would be recyclable if waste of this type were sorted into material fractions.

Glue and varnish residues from production are classified as hazardous waste and, together with metal and plastic waste must be disposed of according to the rules governing by the local authority. If the production waste and finished products are disposed of by means of recycling and/or incineration, environmental impacts can be substantially reduced. Obviously, then, it is environmentally advantageous to design and manufacture furniture products that can be stripped down and disposed of in the most appropriate fashion.

Based on the brief overview in the preceding paragraphs, a great number of conclusions can be drawn about the environmental conditions of a product. This will allow suggestions for improvement to be incorporated into designing and manufacturing of the future product development that will minimize the negative environmental burdens without affecting other requirements of the products such as function, usability, maintenance and service life, aesthetics and economy. A summary of material and product characteristics of a furniture with as minimum environmental burdens as possible which entails utmost consideration are given in Table 1 and Table 2 respectively.

Table 1: Material characteristics for furniture with minimum environmental burden.

Materials	Material characteristics
Solid wood	logged from sustainable forest no treatment with impregnating substances or other pesticides reusable and recyclable
Wood – based panels	logged from sustainable forest restrict use of hazardous substances in the production process limit to free formaldehyde in chemicals and glues used in production limit to contaminants in dry panel produced from recycled fiber control emissions to water limit to the emission of formaldehyde glue used for particleboard suitable for wet board recycling reusable and recyclable
Metal (aluminum & steel)	easy disassembly of parts of furniture recyclable
Plastics	no addition of certain hazardous additives (e.g. heavy metals) no use of certain flame retardants no use of chlorinated plastics, unless recycled requirement regarding the marking of plastic components of furniture for recycling recyclable
Glass	replaceability in case of damage or breakage
Surface treatment agents (wood based materials)	limit to the VOC contents of surface treatment agents limit to the contents of aromatic solvents no use of surface treatment agents with certain health risk classifications no addition to the chemical product of certain hazardous substances (incl. heavy metals and halogenated organic flame retardants) limit the emission of formaldehyde from agents of surface treatment limit the use of surface treatment agents classified as harmful to the environment
Surface treatment agents (metals)	limit to the VOC contents of surface treatment agents limit to the contents of aromatic solvents no use of surface treatment agents with certain health risk classifications no addition to the chemical product of certain hazardous substances (incl. heavy metals) no coating of metals with chromium, nickel, tin and their compounds (exceptions possible for chromium and nickel) control emissions from nickel or chromium surface treatment no use of halogenated organic compounds for degreasing or surface treatment
Overlaying materials	should not disturb board gluing if recycle into new products
Fittings and fixtures	easy removable use screw instead of gluing
Adhesives in the assembly of furniture	limit to the VOC content of adhesives used in furniture assembly limit to the use of additives and binding agents limit to the content of free formaldehyde

Table 2: Product characteristics for furniture with minimum environmental burden.

Product requirements	Product criteria
Durability	quality requirements of the materials used and surface treatment requirements on a product level: e.g. product guarantee maintenance: e.g. product information can contribute to correct maintenance to prolong the lifespan of the product personal taste, fashion and trends: the consumer might prefer to buy a new piece of furniture even if the old one is not outworn yet
Fitness for use	fulfils the expectations one objectively can have with respect to its function function related requirements on a product level
Reparability	ease of disassembly: this depends on the way the parts or materials are connected/assembled (the type of glue, the use of screws or welding, etc.) availability of spare parts technical possibility of reparation, e.g. a reparability service of the producer
Maintenance	the use of (cleansing) products
Recycling	variation in materials possibilities for take back of products/parts ease of disassembly marking of materials recyclability of the materials used
Reuse	ease of disassembly possibilities for take back of products/parts product information
Waste management of hazardous substances	take back obligations labeling of the product (product information) waste management systems
Ergonomics	product design contributes to a healthy work or living condition for the user
Safety	working conditions in production process the emission of hazardous substances in workplace the emission of hazardous substances: This could mean that for furniture for children, higher standards might apply with respect to the emission of VOCs and toxic substances, like varnishes and paint, than for other domestic furniture strength and stability of the product: this is dealt with under fitness for use special use of product: e.g. with respect to kitchen furniture, those parts near the stove may have to be fire resistant. Bed mattresses may have to be treated with flame retardants, etc.

CONCLUSION

As a conclusion, in developing environmentally friendly furniture, use more wood instead of other available material. In the designing phase, use less material as possible without affecting the quality requirements for use of the furniture and whenever possible reuse/recycling aspect of material and product must be taken into considerations. In the manufacturing phase, waste, energy, and emission must be minimized to the lowest possible levels.

REFERENCES

1. Chavan, A and Sharma, V.K. 2000. Overview of Life Cycle Assessment activities in India. Report on the International Conference on Eco Balance and Life Cycle Assessment in India. The International Journal of Life Cycle Assessment Volume 7 (3).

2. Fox, M., Kvist, K.E., and Kofoed, C.K. 2000. Analysis of environmental conditions in the wood and furniture industry. Environmental Project No. 561, Council for Recycling and Cleaner Technology, Danish EPA.

3. Inaba, A., Norris, G.A. and Grant, T. 2000. Activities on LCA in APEC Region. A Review and Update of the report of APEC/AIST Symposium on LCA for APEC Member Economies. November 2000.

4. Kutscha, N. 1999. Trends in Wood Research and Utilization. Forest Products Journal Vol. 49 (7/8): 12-17

5. Tan, R.B.H. 2000. Life Cycle Assessment for Green Productivity - An Asian Perspective. The International Journal Life Cycle Assessment Volume 7 (3): 179-190

6. Tong, K.H. 1995. Overview of the Rubberwood Industry. Paper Presented at the Rubber Growers' Conference in Kuala Lumpur, Malaysia. 17-19 July, 1995.