ENVIRONMENTAL IMPACT ASSESSMENT OF COMFORTABLE AND STYLE FURNITURE PRODUCTION PROCESS USING LCA

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Abstract - This study focused on the collecting life cycle assessment data for furniture production process in two different types (comfortable and style) in Tehran, I. R. Iran, and analyzed the environmental impacts during the production process as gate to gate investigation. The results revealed that emissions in style furniture production process were higher than that of comfortable furniture production process, which is due to more solid wood utilization and therefore coating and painting processes. Moreover, the results showed that comfortable furniture production process has the highest effects on ecosystem quality, human health, and resources (fossil fuels and mines), and style furniture production process has the highest effects on resources (fossil fuels and mines), ecosystem quality, and human health, respectively.

Keywords - Life cycle assessment, comfortable furniture, style furniture, ecosystem quality, human health.

I. INTRODUCTION

Today, the migration of people to urban areas has increased the demand for furniture and overall growth of furniture industry [1]. In 2004, Iran's wood products industry represented 0.45 percent of the nation's GDP and accounted for 1.46 percent of total employment. Based on data from the Home and Office Furniture Exporters Union, in this year, there were more than 50,000 furniture manufacturing enterprises in Iran, accounting for 13.9 percent of the total number of enterprises across all industrial sectors in the country. Based on Central Bank data, of these, approximately 1,000 enterprises had more than 10 employees. There are 12 furniture manufacturers with more than 100 employees. In 2004, the production value of the furniture industry was US$1.2 billion, with an estimated 4 million m3 of wood raw materials consumed [2]. Furniture industry is essentially an assembly- based industry that employs several raw material including wood, metals, plastics, fabrics, leather, adhesives, paints etc., that maybe play a significant role in increasing the risks of human health and the environment pollution [3]. Attention to environmental issues is growing increasingly more and more in advanced societies and even developing societies. In recent decades, attention has been focused on reducing emissions to water, soil and air. But new attention to environmental issues is much wider and more complex, including sustainable resource management. In fact, reducing energy consumption, using renewable energy sources, optimum use of materials, reuse and recycling of materials and controlling pollutants are the things that can help to sustain an industry [4]. The World Commission on the Environment and Development (WCED), in a report entitled "Our Future," (1987), prepared and published a report for a unified strategy for sustainable development. Based on the results of this report, sustainable development is meeting current needs without compromising future generations' capabilities for meeting their needs [5]. Sachs and Warner believed that the great challenge of the 21st century would be sustainable development [6]. Since the importance of protecting the environment in modern societies is evident, the action and implementation of any program requires the necessary science and knowledge of the environment [7]. Today, the environmental promiser consumers have a special sensitivity to environmental indicators from production to consumption. In fact, the product is more acceptable, with less environmental impact. In addition, rapidly reduction of fossil fuel resources and the destructive effects of the use of these fuels on climate changes, display importance of the life cycle assessment (LCA) more than ever [8]. In life cycle assessment (LCA), the environmental indicators are carcinogens, Resp. organic, Resp. inorganic, climate change, radiation, Decreasing ozone layer, Toxic substances, acidification, land use, minerals and Fossil fuels. Yearly the furniture industry causes to release a large amount of unstable organic materials due to using types of adhesives, paints and coating materials, which, in addition to having a destructive impact on the environment, it is also harmful to human health. As mentioned, in the LCA technique, the term "cradle to grave" is used for a specific unit of furniture from getting wood from the forest, carried it to the manufacturing, manufacturing, utilization, recycling and final disposal. Wooden furniture in Iran is mainly produced using traditional methods and old machinery, which is usually expensive that accompanied by energy consumption, work and waste, and therefore has a high environmental burden for each unit of production. In general, due to the

economic, social and environmental importance of the furniture industry, it is necessary to moving towards sustainable development for this industry [9]. Life cycle assessment (LCA) has been identified as one of the most reliable methodologies for evidencing and analyzing the environmental impacts along the life cycle of a product and should be part of the decision-making process towards more environmentally friendly products.[10,11][ISO 14040 2006; ISO 14044 2006; Baumman and Tillman 2004].Any life cycle assessment studies proved that wood products usually have favorable environmental profiles compared to products from other materials with the same function [12, 12]. (E.g. Werner and Richter 2007; Glover et al. 2002). Tarantini et al. (2011) applied that the LCA methology is used to the definition of green public procurement (GPP) and product building [13]. Studies by Werner and Richter (2007), Gonzalez-Garcia et al. (2009) and Bovea and Vidal (2004) have proven that, in order to ensure the reduction of environmental impacts in furniture production, consideration of volatile organic chemicals (VOCs) and rates Greenhouse gas emissions are very important [13,15,16]. Federlegno Arredo (2010) in a survey among an Italian consumers group showed that one-third of consumers pay 10% more than the standard price for a piece of furniture with eco-friendly features [17]. Despite the strategic capabilities of LCA in assessing impact along the life cycle of a product, the LCA database regarding furniture is very rudimentary [14]. (Werner and Richter (2007)). Based on studies and assessments on the importance and position of the life cycle assessment technique in the furniture industry and the strategic capabilities of this technique in assessing the environmental impacts throughout the life cycle of a product and the weakness of the database on comfortable and style furniture this research was necessary.

II. MATERIAL AND METHODS

According to the amplitude of the life cycle assessment and the lack of availability of raw material data, as well as data related to the final recovery and disposal of the product, in this research, life cycle assessment is only gate-to-gate (from beginning to the end of production process including raw material and finished products warehouses). According to this, two style and comfortable furniture manufacturers in Tehran province were considered as a case to study. Comfortable and style furniture manufacturing process system boundary is shown in Fig. 1.The system boundary is the same for two process but the only difference between this two processes is amount of consumption of material, and Painting in style furniture is more than comfortable furniture.

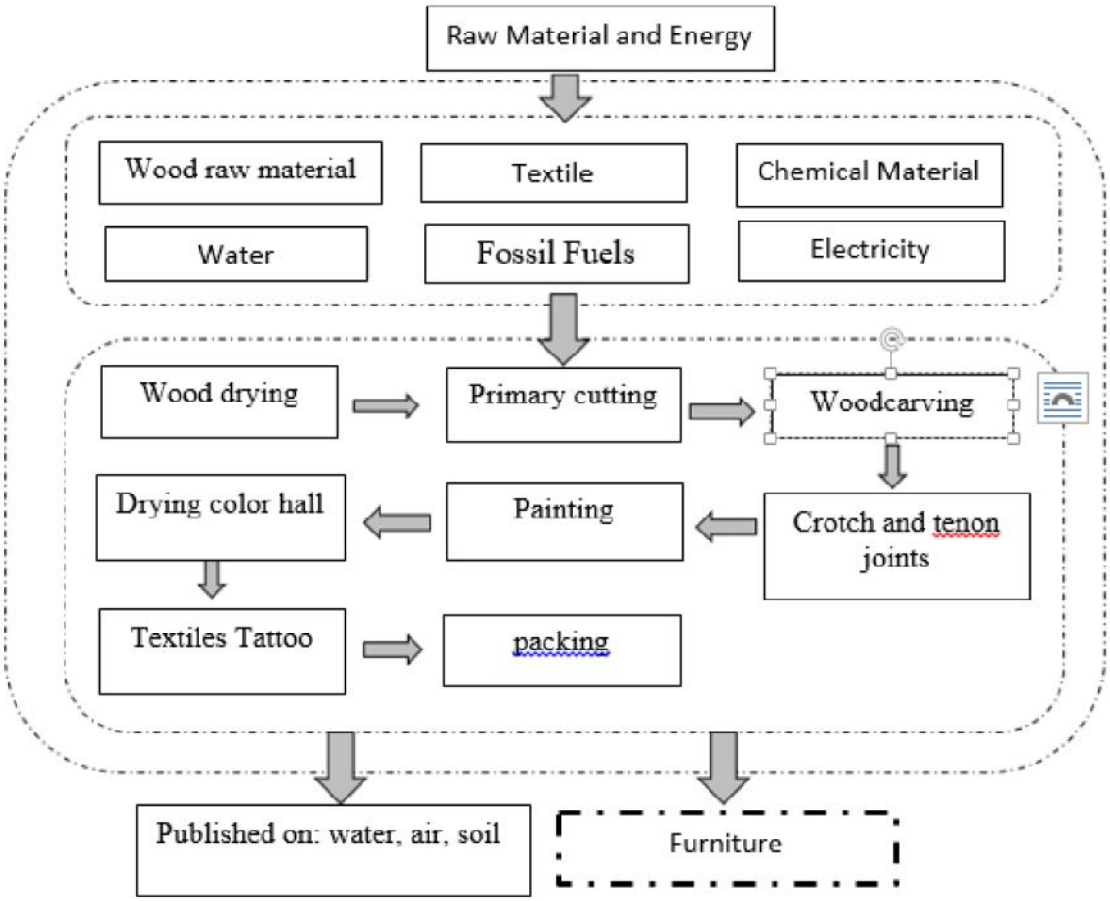


Figure 1: Comfortable and style furniture manufacturing process system boundary

III. DATA COLLECTING AND ACQUISITION

All data relating to the use of wood, sponge, fabric, water, chemicals, fossil fuels and electricity was obtained by measuring in situ (foreground). Ecoinvent databases were also provided for releases of pollutants from each of the inputs (background).
Many industrial life cycle studies have shown that the environmental burden associated with the production of capital goods is negligible compared to the operational stage of production [18, 15]. Therefore, capital products, maintenance them and transport personnel, at the system boundary are not considered.

Life Cycle Assessment

According to the ISO 14040 standard, life cycle assessment is a method in which all the environmental impacts associated with a product, its entire lifecycle, from the process of extracting or aggregating raw materials up to production, consumption and then recycling, resulting waste and ultimately its disposal is evaluated. There are four stages in the study of life cycle assessment [11]:

A) Define the purpose and scope
B) Log analysis;
C) To evaluation the outcome;
D) Interpretation.

In the goal setting and scope, a life-cycle assessment study is being discussed about how (scope) and why (the goal) is. Determine the purpose highlights the results of the study. And determine the scope of the description of the functional unit of the product under study, is the production system and its boundaries, the process of collecting and processing data and parts of environmental effects. In the stage of log analysis, natural resources and other inputs of the system, publishers and other outputs in each process are examined from the production system. In the process of assessment of impacts, inputs of natural resources and environmental publications are presented as their share in the range of selected parts of the effect, and in the final stage, the results of the previous stages will be subtracted [4]. Finnveden et al. (2009) stated that the functional unit is a small unit of performance of goods or services [19], which indicates how much this function is considered in the study [4]. The functional unit in the present study is based on the volume of production and is designated as a (7 persons) sofa. In the life cycle assessment, the term "cradle to grave" is used. In order to calculate the environmental impacts in this method, a specific unit of the product (functional unit) is considered as a computational and comparative basis. The parts of the effect used in this study can be seen according to the ECO-indicator method is shown in Table 1. In calculations, the conversion factors in each section of the effect will be taken from the ecoinvent database and the Simapro software.

Table 1: The parts of the effect and unit of measurement of each section

Unit of measurement	Sections of the work
DALY/kg	Carcinogenicity
DALY/kg	Resp. Organic
DALY/kg	Resp. Non-organic breathing
DALY/kg	climate changes
DALY/kg)	Radiation
DALY/kg	Decreasing ozone layer
PAF*m2*yr/kg	Toxic substances
PAF*m2*yr/kg	Acidification
PAF*m2*yr/kg	land use
MJ surplus	minerals
MJ surplus	Fossil fuels

DALY: The number of years of life is reduce
PAF: Percentage of potential impact

RESULTS AND DISCUSSION

Environmental Impact Assessment

This study carried out an environmental analysis of the production process of this product using a life cycle assessment method. Figure 2 shows the relative contribution of each part of the manufacturing process to the production of a comfortable and style furniture in each group.

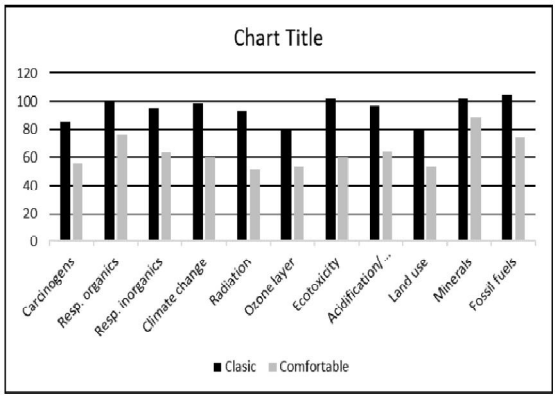


Figure2: Comparison of the relative contribution of the process of producing a comfortable sofa in different work group

The results of Fig. 2 are as follows:

1) In the carcinogenic effect group, style furniture contamination was more than comfortable furniture, which is due to more painting use
2) Style furniture had a larger share in the Resp. organic group than comfortable furniture
3) Style furniture in the group of Resp. non-organic effects has had more pollution than comfortable furniture
4) The share of style furniture in the climate change cluster was more than comfortable furniture

5) The greatest influence in the radiation was on style furniture
6) In the ozone-depletion group, the greatest contamination was related to style furniture 6)
7) In the toxic effect group, the style furniture contamination was more than comfortable furniture
8) The degree of pollution in the group of acidification in the classic furniture was more than comfortable furniture
9) Classic furniture was the main responsibility of publishing in the group the effect of land use relative to comfortable furniture
10) In the group of minerals - classic furniture was more effective than comfortable furniture, but the difference was small
11) The share of style furniture in the group of fossil fuels was more than comfortable furniture

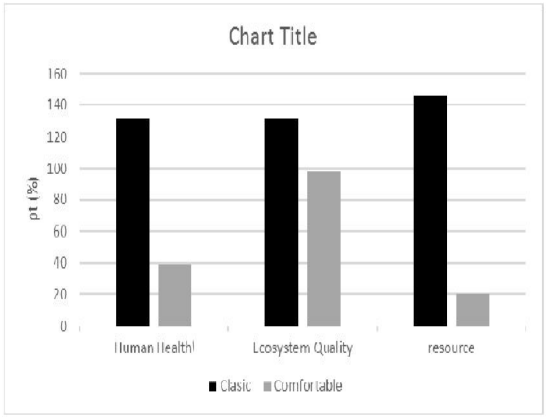


Figure 3: Comparison of the evaluation of the effect of two types of comfort and classic furniture on the damage classes according to the standard method

As shown in Figure 3, the production of comfort furniture has the greatest impact on the quality of the ecosystem and the least effect on resources, but the production of classic furniture on the resources has the greatest impact.

In the subgroup of human health, which includes climate change, decreasing ozone layer, carcinogenicity and exposure to radiation, resp. organic, and resp. non-organic. The greatest effect is because of style furniture. In the subcategory of ecosystem quality, which includes the land use, acidification, toxicity, the most effect is because of style furniture, but the difference is not so much between them.

The effect of producing comfort sofas on resources, including the reduction of fossil fuels and minerals, is low compared with other subgroups. According to the results, the destructive effects of style furniture manufacturing unit on the ecosystem quality, human health and resources are more than the damaging effects of the convenience furniture manufacturing unit on the criteria.

CONCLUSION

Based on the results of this research, it can be stated that the contamination rate of the style furniture production process is more than the comfortable one, which is due to the steps of cutting and assembling the furniture collar within the same unit. Also, the most effective factor was the production and use of the fabric, followed by the production of polyurethane foam. In addition, the comfort furniture production has the greatest impact on the quality of the ecosystem and, to a lesser extent, on human health and resources (reduction of fossil fuels and mines).

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