

CREATING AND RESEARCHING SUSTAINABLE DESIGN OF CORRUGATED CARDBOARD FURNITURE WITH ADVANCED TECHNOLOGICAL MEANS

СЪЗДАВАНЕ И ИЗСЛЕДВАНЕ УСТОЙЧИВИЯ ДИЗАЙН НА ГОФРИРАНИ КАРТОНЕНИ МЕБЕЛИ СЪС СЪВРЕМЕННИ ТЕХНОЛОГИЧНИ СРЕДСТВА

Phd Tihomir Dovramadjiev, Prof. Phd Plamen Bratanov, Phd Kremena Cankova, Phd Ginka Jecheva
 Mechanical Engineering Faculty, Industrial Design Department - Technical University of Varna, Bulgaria.

tihomir.dovramadjiev@gmail.com, plamenbratanov@abv.bg, kremenacankova@abv.bg, ginkaava@yahoo.com

Abstract: Furniture made of corrugated cardboard is environmentally friendly, cheap and allow a construction of complex geometry in design and ergonomics of wide application. They may have functional value, art direction, etc. The application of advanced technological means which support the design process of furniture made of cardboard allows optimization of the complete process of creating a sustainable design.

Keywords: SUSTAINABLE, DESIGN, 3D, CARDBOARD, FURNITURE, SOLIDWORKS

1. Problem discussion

Furniture made of cardboard are ecologically clean, cheap and allow a construction of design with complex geometry of design, ergonomics and wide application in various aspects of daily life, interior and exterior. They may have functional value and art direction. For furniture made of cardboard new and/or already recycled materials can be used that contribute to the saving of timber (environmental and green protection), water saving (up to 99%), energy (up to 50%) and removal of waste (up to 90%) [1 - 3]. A very important point is the usefulness of the cardboard material referring to the environment and the advantage which is its quality to hold carbon emissions in the bulk structure. In order the relationship between cardboard material, its own volume and the level of carbon to be precisely examined it is necessary to use advanced technological means of Dassault System SolidWorks Sustainable [4, 5]. It allows analyzing the ecological impact on the environment of already constructed in SolidWorks CAD medium 3D models of furniture and optimizes their design compared to global environmental standards. Optimizing the process of creating furniture designs made from cardboard will help in improving the condition and quality of the production and optimization of the product life cycle [6 - 9]. The present work aims to explore the possibilities of direct advanced technological tools applied in the creation of sustainable furniture design made of cardboard and optimize the process.

2. Objective and research methodologies

The design of environmentally friendly furniture made of cardboard material is optimized by methods combining basic principles when constructing models through technological means, opportunities to study the quality of the material and market factors (Table 1).

Table 1. Creation sustainable design of cardboard furniture

| CREATION SUSTAINABLE DESIGN OF CARDBOARD FURNITURE | | |
|--|----------------------------|---|
| | PLM | SolidWorks Sustainable |
| Technological way of making cardboard furniture | CAD/CAM | Part, Assemblies and Drawings Design |
| Opportunities to study the quality of the material | CAE / empirical real tests | Database / in real time internet analysis |

| | | |
|----------------|--|--|
| Factors | Optimization of the design criteria and standards | <ul style="list-style-type: none"> Carbon footprint Water Eutrophication Air Acidification Total Energy Consumed |
| Market | <ul style="list-style-type: none"> Environment Equity / Society Economy | <ul style="list-style-type: none"> Material Production Transportation Distribution (LCA) |

The design of furniture from cardboard passes through ESW cycle (Fig. 1). The stages of the process support the optimization design based on specific features separated by criteria which contribute to the precise design from the conceptual idea to the finished product and its quality evaluation by SolidWorks Sustainable technological mean.

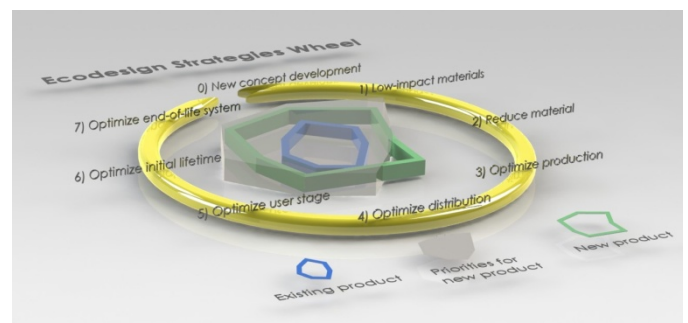
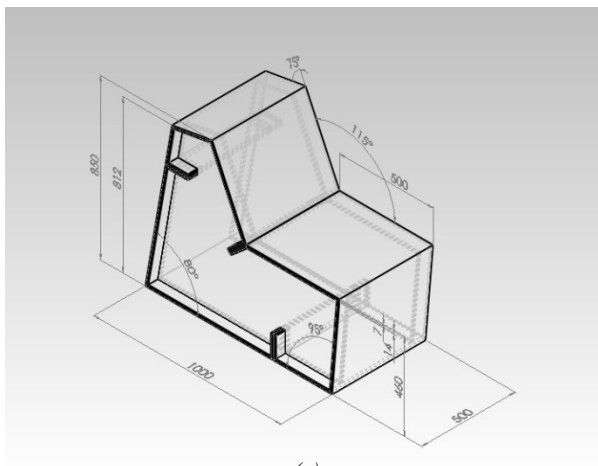
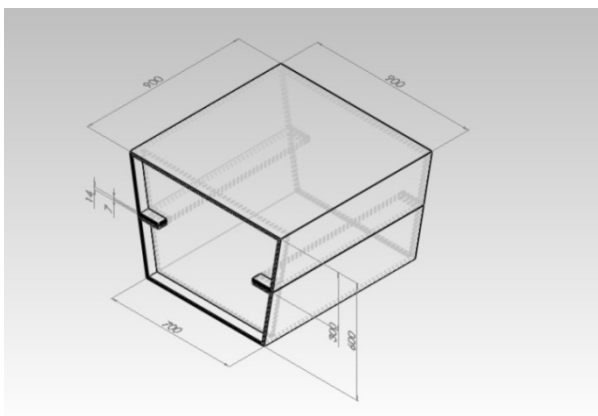


Fig.1. Ecodesign Strategies Wheel [1, 4, 9]

Using the methodology (Table 1) to create cardboard furniture and ESW cycle there have been developed variations of ergonomically streamlined design of interior and exterior furniture - chairs and table. Their design is fully optimized in terms of material and strength. Constructive appropriate options are selected of assembling in important areas providing stability. The thickness of a single sheet of cardboard is 7mm. The specific points, where are the supporting parts, are connected by three (7mm corrugated paper), providing the necessary reliability of the structure (Fig. 2).



(a)



(b)

Fig. 2. Dimensions of the models (a) ECOSEAT and (b) ECOTABLE

The concept of using eco furniture from cardboard implies the right atmosphere and setting. An exemplary application of the resulting patterns in the interior environment is shown in Fig. 3.



Fig. 3. Models of interior cardboard furniture

The sustainable design of the models is developed and optimized for the European region (Fig. 4).

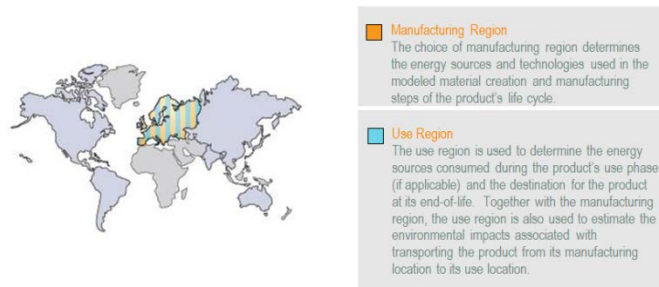


Fig.4. Manufacturing and use region

The information about transport, the sustainable design information, and environmental values of Carbon Footprint, Water Eutrophication, Air Acidification and Total Energy Consumed per unit model ecoseat and ecotable are shown in tables. 2 and 3.

Table 2. Properties

| PROPERTIES | ECOSEAT | ECOTABLE |
|---------------------------------|-------------------------|-------------------------|
| Material | Corrugated paper | Corrugated paper |
| Volume: | 4.99E+7 mm ³ | 5.84E+7 mm ³ |
| Surface Area: | 1.46E+7 mm ² | 1.70E+7 mm ² |
| Weight: | 7792.13 g | 9109.51 g |
| Primary Mode of Transportation: | Train | Train |

Table 3. Environmental impact

| ENVIRONMENTAL IMPACT | ECOSEAT | ECOTABLE |
|-----------------------|----------------------------|-------------------------|
| Carbon Footprint | 3.50 kg CO ₂ | 4.09 kg CO ₂ |
| Water Eutrophication | 9.33E-3 kg PO ₄ | 0.01 kg PO ₄ |
| Air Acidification | 0.02 kg SO ₂ | 0.03 kg SO ₂ |
| Total Energy Consumed | 109.51 MJ | 128.03 MJ |

3. Conclusion

Integration of advanced technological means in creating the design of eco furniture from corrugated cardboard material is a very good sustainable solution. The modeling of the ESW full cycle support both optimization of the design of the developed products and qualitative analysis of environmental values. These are necessary conditions for the protection of ecological environment combined with modern, sleek and available at cost price of products widely used in both the interior and the exterior environment.

References

- [1]. NCASI. Life cycle assessment of u.s. average corrugated product. Research Triangle Park, NC. USA, April 2014.
- [2]. Planet Ark Environmental Foundation. Sydney, Australia, 2014. <http://planetark.org/>.
- [3]. Corrugated Packaging Alliance (CPA). Corrugated Packaging Life-cycle Assessment. Summary Report. USA, 2010.
- [4]. Guide to Sustainable Design using SolidWorks Sustainability. Dassault Systemes SolidWorks. USA, 2014.
- [5]. Benjamin Tan. Green Design with SolidWorks. Dassault Systemes.
- [6]. Oltikar, akhil manohar. Computer-Aided Engineering of Plywood Upholstered Furniture Frames. USA, 2000.
- [7]. Michael Lee. Cardboard Chair Project. Research Report.
- [8]. Greg Saul, Manfred Lau, Jun Mitani, Takeo Igarashi. SketchChair: An All-in-one Chair Design System for End Users. TEI'11, January 22–26, 2011, Funchal, Portugal.
- [9]. Julija Jeganova. Product Life Cycle Design: Integrating Environmental Aspects into Product Design and Development Process at Alfa Laval. Lund University. Sweden, 20004.