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Original Research Article

Design and Development of Kenaf Fiber-Reinforced Polymer Composite Polytechnic Chairs

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Abstract

This study is carried out for the design and development of a kenaf fiber-reinforced polymer composite for chairs used in polytechnic institution of higher learning. Development of the furniture industry in the field of education has been increasing recently. This is due to the gained attention in composite materials for implementations in the field such as medical, industries, sports, aerospace, , and education such as polytechnic furniture. A systematic approach of a total design process is utilised for a better undertaking towards achieving the best conceptual design for the Polytechnic Chairs. The best conceptual design of the composite polytechnic chair was then selected where the design utilises kenaf fiber-reinforced polymer composite which is also described in this paper. The usage of kenaf fiber-reinforced polymer composite helps in reducing global warming

Keywords: Design and Development, Kenaf Fiber-Reinforced Polymer Composite, Polytechnic Chairs

Introduction

One of the most commonly used items in our daily lives are chairs. Chairs are an important product or item used in a variety of settings and situations in most work, study, and play situations. When designing chairs, designers and industrial engineers should ensure that chairs are designed by utilizing the correct anthropometric information (Castellucci et al., 2015). In a polytechnic institution of learning, classrooms, lecture halls and workshops, chairs and tables are widely used. The anthropometrics dimensions of a polytechnic student and the measurements are important design features of polytechnic furniture (Jung, 2005). A chair has an significant role in maintaining a good sitting posture (Panagiotopoulou et al., 2004). Ergonomic design of polytechnic chairs in classroom are closely tied to the anthropometric features of the students' population (Aminian and Romli, 2012). According to the guidelines provided by the Department of Safety and Health Malaysia, the Hazard Identification Risk Assessment and Risk Control (HIRARC) states that general factors that determine the occurance of musculoskeletal pain includes a furniture design that does not fit the dimensions of the human body, and imprecise sitting posture on the part of the students themselves (Syazwan et al., 2011). Anthropometry is now an important factor in the design and development process when creating an ergonomics product. Measurement size reference is inseparable from the human body based on the furniture design, in order to

enable the designers can meet user's requirements from the size of the furniture (Mohamad et al., 2010). For a polytechnic student, there is a incompatibility between the natural propensity for unimpeded physical movement and the need to sustain a sitting posture for a longer period of time (Troussier, 1999). This study is important as it concerns polytechnic students compared to younger children reported in most previous studies in Kuching, Sarawak and elsewhere. Composite materials utilising natural fibers have some additional advantages over conventional material. These natural fibers are environment friendly, reduced cost and renewable. Product development requires the design of component as well as ensuring that the manufacturing process is set by nature of composite at the early stage of design process in order it fits within the definition of concurrent engineering (CE) (Sapuan and Mansor, 2014), including design, development and fabrication of natural woven fabric reinforced epoxy composite products such as a household telephone stand (Sapuan and Maleque, 2005). These days, applications of natural fiber-reinforced polymer composites (NFCs) are being considered for various products. Sathishkumar developed a new model for a snake grass fiber-reinforced composites chair for commercial usage. The mechanical properties of the material such as cost-effective analysis, water absorption and flexural and compressive considerations were utilized in making the chair (Sathishkumar, 2016). Kenaf fibers usage is already increasing in the market throughout the world and including Malaysia due to the abundance source of natural materials (Saba et al., 2015). In order to design our kenaf fiber-reinforced polymer composite polytechnic chair, nine concepts (Table 1) were evaluated using criteria such as ease of transport, low set up time, ergonomic aspects, reliability of service, ease of manufacture, cost of production, and stability of the product (Sapuan, 1998).

Materials and Method

Total design process of kenaf fiber polymer composite polytechnic chair.

Total design process involves different phases/ stages that are distinguishable and is a progression of design activities from market needs to sale. A primary total design model is shown in Figure 1. In the design of the composite polytechnic chair, all the processes of total design (except for sale) was carried out. A brief conceptual design of composite polytechnic chair is described below. A detailed design is also presented in the form of final drawing.

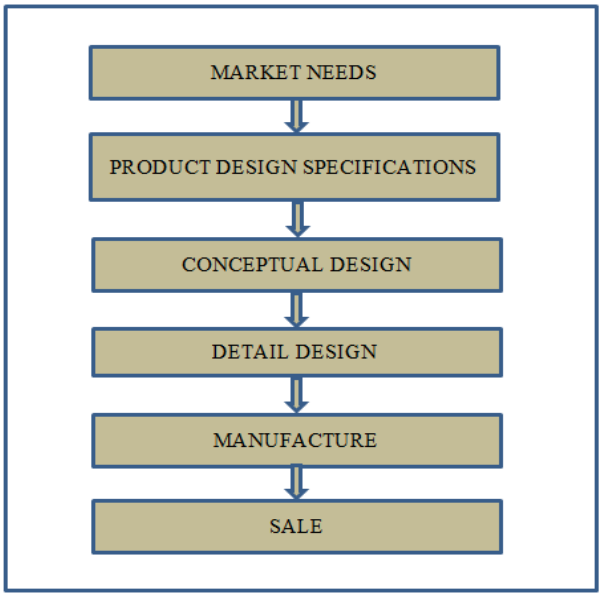

Figure 1: A fundamental total design model

Product design specification

A set of the prerequisites of the product that to be met at the end of the product development phase is called Product design specification. Figure 2 shows the elements of the Product design specification (PDS) was considered in designing the composite polytechnic chair.

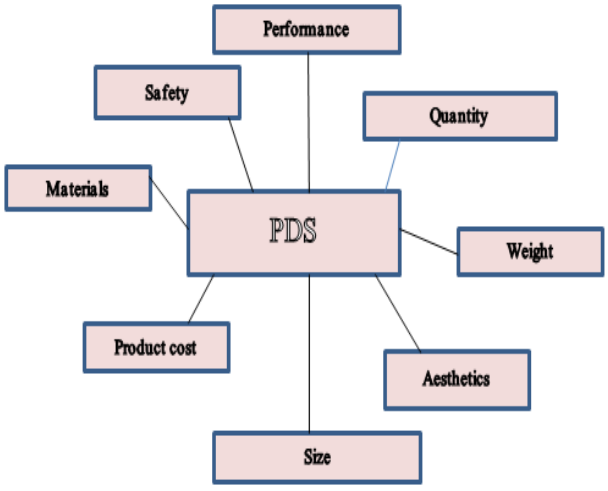

Figure 2: The PDS for composite polytechnic chair

The PDS can be summarized as:

- The resulting product will contain all relevant facts.
- Forecast results should be avoided.
- The restraints must be realistic.
- Product introduction process in all affected areas must participate in a generation.
- All involved parties can amend the document evolution with mutual consent.

This document must be written.

Results

Conceptual design

Nine concepts of composite polytechnic chairs were developed. These concepts were then analyzed based on certain design criteria taken from the product design specifications. The matrix evaluation chart for choosing the best concept is shown in Table 1. From this table, concept 2 is tabulated with the highest score compared to the other concepts and it was chosen as the best concept to be designed and developed further.

Table 1: Conceptual design chart, for selecting the best design of composite polytechnic chair

Concept		1		2		3		4		5		6		7		8		9	
Characteristic	C	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S
Stability	5	4	20	4	20	3	15	3	15	3	15	4	20	3	15	4	20	4	20
Cost effective and cheap	5	4	20	5	25	3	15	4	20	3	15	4	20	3	15	4	20	3	15
Ergonomic design	5	4	20	4	20	3	15	3	15	3	15	3	15	2	10	3	15	2	10
Low setup time	4	3	12	5	20	3	12	3	12	3	12	3	12	3	12	2	8	3	12
Less space needed	4	3	12	3	12	4	16	4	16	3	12	3	12	3	12	3	12	3	12
Less complex	3	3	9	4	12	4	12	4	12	4	12	2	6	3	9	3	9	3	9
Portability	3	3	9	3	9	3	9	3	9	3	9	3	9	3	9	3	9	2	6
Total score		102		108		94		99		90		94		82		93		84	

Note. C means the weightage for the characteristic. W means the score of the concept. S is the product of weightage and score of the concept.

Table 2: Properties of kenaf fiber (Saba et al., 2015)

Density (g/cm^3)	Tensile strength (MPa)	Tensile modulus (GPa)	Elongation (%)
-	692	10.94	4.3
-	930	53	1.6
1.45	930	53	1.6
1.4	284-800	21-60	1.6
1.5	350-600	40	2.5-3.5
0.75	400-550	-	-
0.6	-	-	-
0.749	223-624	11-14.5	2.7-5.7
1.2	295	-	3-10

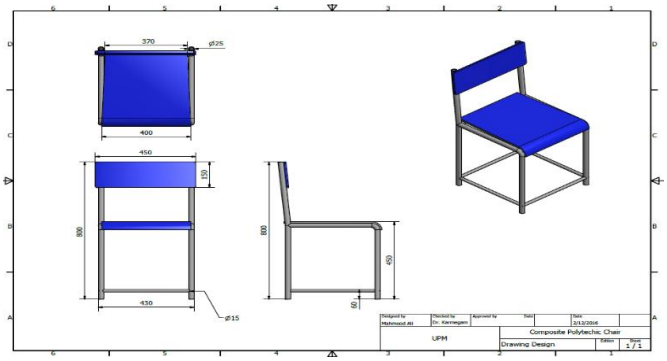

Figure 3: Detail design for composite polytechnic chair

Conclusion

This research was concerned with the design and development of composite Polytechnic chairs made from kenaf fiber-reinforced polymer composites. The total design approach was used in the development of kenaf fiber-reinforced polymer composite polytechnic chairs. During the market investigation stage of the design process, the results of the survey questionnaire indicated that there was a real need to develop a composite polytechnic chair for student. Product design specification (PDS) of the composite polytechnic chair was successfully prepared and the design complied with the PDS. Nine conceptual design chart were successfully developed using the weighted objective method and the best design of the composite polytechnic chairs was selected. Detailed design was presented in the forms of engineering and assembly drawings drawn using CAD software package Autodesk Inventor 2015.

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