LAPTOP CASING AESTHETIC IMPROVEMENT

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ABSTRACT: This project is designed to take the advantage of additive manufacturing (AM) process in order to improve the aesthetic value of a laptop casing. The aesthetic value includes the overall form of the product, colour and surface of the product. The advantages of AM are able to produce complex shapes without need to consider the process-material-shape attribute. Literature review confirms that AM application in laptop casing particularly to improve the aesthetic aspects has not been done. Typically, laptop cases are poorly designed and do not integrate the cooler fan in the design. To overcome this, a new design of laptop case was proposed with improvement on the geometrical features and the prototype was fabricated directly via a Fused Deposition Modeling machine. A comparative study of the laptop produced by injection molding, handmade and AM was made. Based from a survey from the user, the design produced by AM are more aesthetically pleasing, more attractive and have complex shape compared with injection molded and handmade laptop case. The paper ends with the suggestion of the suitable AM system and the suitable material for the laptop casing.

KEYWORDS: *Additive manufacturing, Aesthetic improvement, Laptop casing.*

1.0 INTRODUCTION

This paper presents a study on application of AM in order to produce end use product to improve aesthetics value of a laptop casing. Aaesthetics' features are one way to increase a product value [1]. The value of product can be measured by how much a customer willing to pay for that product and it can be increase by reduce the production cost or raise the amount that the customer will pay. Aesthetics usually concern about sense responses to the object such as vision, hearing, touch, taste, and smell and emotions [2]. In this project, laptop case has been selected in order to improve the aesthetic value. Laptop case is a laptop accessory in order to protect the laptop from scratch and shock.

A. Additive Manufacturing (AM)

According to the American Society for Testing and Material (ASTM), AM can define as "the process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies, such as traditional machining". Subtracting material process is removing material from the stock such drilling, lathe, and milling out to material [3]. Figure 1 shows the different between subtractive and additive manufacturing. Beside the name of AM, this process also known as additive fabrication, three dimensional printing, solid freeform fabrication, direct digital manufacturing and layered manufacturing [4].

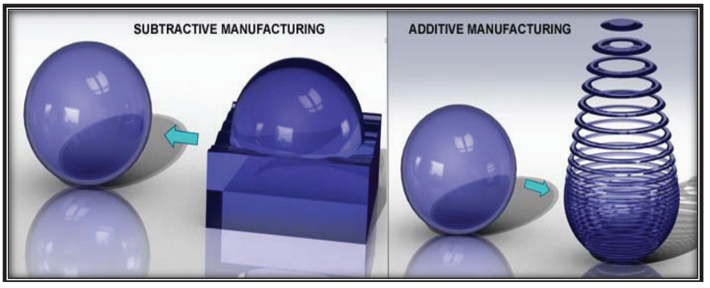

Fig. 1. The different between subtracting and AM concepts [5].

The first AM technology has emerged in 1977, when Swainson suggested a method of creating 3D objects directly by using two electromagnetic radiation beams and a sensitive polymer that solidifies in the presence of the beam and this method is considered to be the ancestor of modern stereolithography [6]. Although several AM techniques exist, all employ the same basic five-step process [6]. First step is CAD model of design are created. Then, convert the CAD model to STL format, slice the STL file into thin cross-sectional layers, construct the model one layer on another layer and last is clean and finish the model. Figure 2 shows the general step to step of AM process.

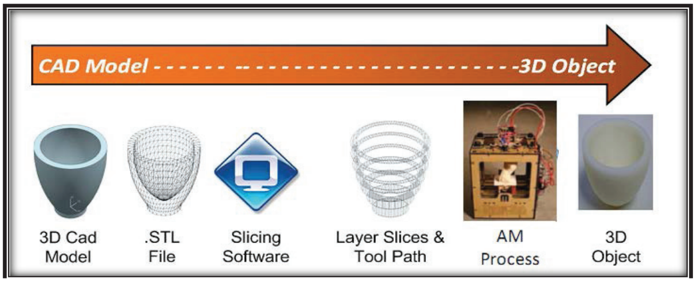

Fig.2. Step of AM process [5].

AM technology can be divided into three group based on the process, which are liquid based process, powder based process and solid based process. The examples of each categories of AM technology are shown in Table 1.

Table 1. AM technology based on the processes [6].

Liquid Based	Powder Based	Solid Based
Stereolithography (SLA) Jetting System High Viscosity Jetting Tn Maple process	3D printer Selective Laser sintering Direct metal Laser Electron Beam Melting	Fused Deposition Modeling Laminated Object Manufacturing Paper Laminated Modeling

AM offers some of benefits over traditional manufacturing techniques (injection molding, casting, stamping, machining) such as increased part complexity that requires a low level of operator expertise, reduced amount of human interaction needed to create an object, no additional cost to create complex shape, able to reduce material needs, reduced time to market and lower energy intensity [6]. However, AM process have limitations that keep this process from being solution for manufacturing problem such as limited for mass production, the material characterized weaker and material price for AM are higher [6,8,9]. The range of applications for parts made by AM has grown significantly over time [10]. AM are mostly suitable in applications such as small production runs, small part size, high-value products and products with high complexity. AM generally are applied in tool production, direct part manufacturing and maintenance and repair. Based on [11], direct part manufacturing category has grown from 4% of total AM revenues in 2003 to nearly 20% in 2010. AM process are also widely use in medical and aerospace application. The individual's unique requirements like shape and functionality, and the value of impact to drive research AM in medical application and they have large financial incentives [12].

Manufacturing practices have currently witnessed a shift in the way a product is designed and produced. The motivation of this research has come from an interest to support the aesthetic aspect of laptop particularly with additive manufacturing (AM) technology. Undertaking the literature review confirmed that little has been done in the area of supporting improvement of the aesthetic aspects of laptop cases via utilising AM. Laptop cases typically have poor design geometrically and do not integrate the cooler fan. To overcome this, this research proposed a new design of laptop case with improvement on the geometrical features and the prototype was fabricated directly via a Fused Deposition Modelling machine.

B. Aesthetic

There are five ways to add value of product through AM and improve the aesthetic value of them [1]. The product that is produced by conventional manufacturing processes, are limited in terms of freedom for design. Therefore, the value of aesthetics also are limited since each design done, the designer still have to consider the process constraint as well. The term aesthetics was coined by [13]. It based on the Greek word aesthesis example perception from the senses, feeling, hearing, and seeing. Then, Baumgarten subsequently defined aesthetics as "perfection of sensate cognition". Besides that, the aesthetics can define as "the formal study of art, especially in relation to the idea of beauty" [14]. Aesthetics can be defined as an artefact that the immediate feelings evoked when experiencing that artefact via the sensory system and it responses to be different from other cognitive responses in at least three ways [2]. First, it is rapid that usually exposure to the product within seconds and secondly is involuntary that requiring little if any expenditure of cognitive effort. Then, lastly is aggregate assessment biased either positively or negatively response.

The aesthetic value also related with the complexity of the product. One research to investigate the effect of stimulus complexity on customer aesthetic preferences has done by [15]. Based on the findings, the perceived level of complexity for complex design tends to move toward the optimal level of perceived complexity. The rating for simple design is moved away from the optimal level. Another result that is obtained from the experiment is the consumer's likings are higher for a more complex design and for simple design is otherwise. When customer wants to buy a product that have more than one alternative which is similar in the case of functioning and price, the customer will prefer the one that appeals the most to them aesthetically [16]. According to [2], most users will prefer a beautiful product to an ugly product, although in highly functional domains likes scientific instruments [2]. The aesthetic quality is an important factor in providing customer satisfactory.

C. Laptop Case

Laptop case is a carrying case designed to hold one laptop such as the hugging style and for visual appeal [17]. The purpose of laptop cases is to add another layer of protection for laptop and it also can help to keep any dust or scratch [18]. In the current market, it is known that laptop case are divided into four types based on their material form such ad rubberized, plastics, leather, synthetic fabric and vinyl. The current design of laptop case such as the sleeve like case, laptop skin sticker, and the newest design is the shell style case. Currently, laptop cases are developed by handmade (fabric) and injection moulding. Figure 3 shows the various designs from handmade laptop case while Figure 4 shows the laptop case which has been produced by injection moulding.

Fig. 3. Various handmade for the laptop case design.

Fig. 4. Laptop cases are produced by injection moulding.

II. METHODOLOGY

Figure 5 shows the final CAD model of the redesigned laptop case. All AM parts must start from a software model that fully describes the external geometry. SolidWork CAD modeling software was used to generate the 3D solid representation. The next process is to convert the CAD data into a STL file format. Nearly every AM machine accepts the STL file format, which has become a de facto standard, and nearly every CAD system can output such a file format. This file describes the external closed surfaces of the original CAD model and forms the basis for calculation of the slices. The STL file describing the part was then manipulated so that it is the correct size, position, and orientation for building. The FDM machine must then be properly set up prior to the build process. Such settings would relate to the build parameters like the material constraints, energy source, layer thickness and timings. Once the machine has completed the build the prototype part will be cleaned.

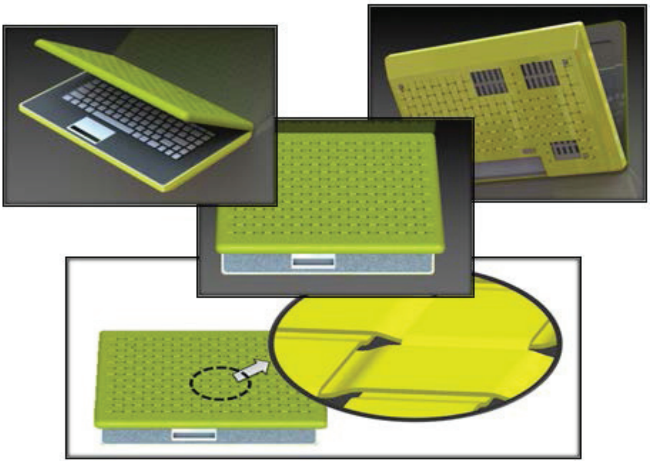

Fig. 5. CAD model using SolidWork.

III. RESULTS AND DISCUSSION

The key aspect is AM does not carry a heavy labour burden and therefore the production of components requires a minimum number of labour involvement and for much time machine can operate independently. Figure 6 shows the prototype produced from the FDM machine. The prototype would be impossible to produce by conventional manufacturing method. FDM machine was used to produce the model as this was the only machine available. A questionnaire survey was conducted with 30 final year students at UTeM to get their responses of the proposed laptop case prototype. Almost 95% respondent said the prototype are attractive, have complex shape and more aesthetically pleasing when compared with other casing. However, with FDM the accuracy is poor due to errors during tessellation and slicing, material shrinkage, restricted due the shape or diameter of filament form. Besides that, result of surface roughness of model shows that the surface was rough compared with the injection molded laptop casing.

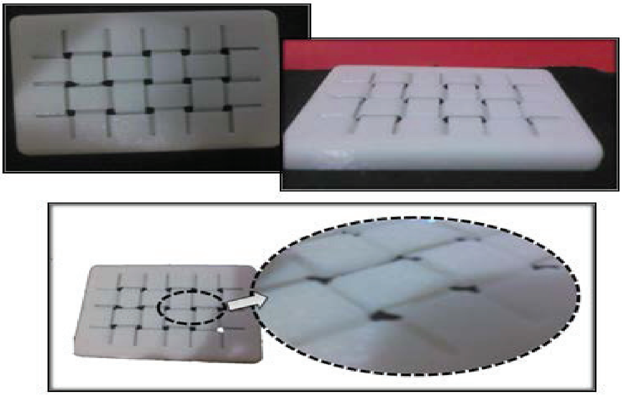

Fig. 6. Laptop casing model is developed using FDM machine.

Table 2 depicts the comparison between injection molding, handmade and FDM. It shows that for FDM the geometrical shape is complex, the embodiment and the surface features are easy to compare with injection mould and handmade casing. Due to FDM, the prototype has non uniform wall thicknesses that reduce the amount of material usage. However, the surface roughness of FDM prototype is poor compared to injection molded casing.

Table 2. Comparison between techniques in laptop casing design.

	Injection Molding	Handmade	FDM
Geometrical Shape	Mainly flat surface	Flat surface	Complex shape
Embodiment features	Hard to made	Non embodiment surface	Easy to made
Surface features	Hard to made	Non surface features	Easy to made
Wall thickness	Constant wall thickness	Constant wall thickness	Non uniform wall thickness
Visual	Usually non visual	Usually have visual graphic	Non visual graphic
Surface roughness	0.2 – 1.2μm	Depend on the material use: Cotton or leather.	Rough

IV. CONCLUSIONS AND FUTURE WORK

This project has successfully created a complex laptop casing prototype and took advantage of AM that enables the fabrication of complex geometrical features in order to improve the aesthetic value. Based on the user's perspective, the redesigned laptop case was found to be more attractive and have complex shape compare with injection molded and handmade laptop case. However, the surface roughness is rough compared to the injection molded laptop casing. Besides that, it was found that AM is not suitable to produce in mass production for the laptop. The material cost is higher compare with material for conventional machine. In addition, the project faced a few problems such as the limited availability of AM system. The recommended AM system that should be used is Selective Laser Sintering (SLS) due to its capability of improved surface roughness and has a better mechanical property. SLS able to process wide range of material include the elastomer material. SLS also does not require support structure while building the part. The material recommended for the laptop casing is flexible plastic material. It is recommended that Duraform® Flex plastic should be used to produce the prototype, as it is used with the SLS system. Duraform® Flex is a thermoplastic elastomer material that is durable with good tear resistance, easy-to-process, good powder recycle characteristics, good surface finish and feature detail. Third aspect that needs improvement is testing. Some mechanical testing such as impact test and tensile test should be done in order to ensure the laptop case can perform well.

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