SUSTAINABLE DESIGN MANUFACTURING TO THE NEEDS OF INDUSTRY 4.0

This report is submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for Bachelor Degree of Manufacturing Engineering (Manufacturing Design) (Hons.)

by

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfilment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Design). The member of the supervisory committee are as follow:

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ABSTRAK

Pada masa kini, pertumbuhan ekonomi dan peningkatan daya saing dalam usaha meningkatkan kualiti, fleksibiliti, kelajuan dan produktiviti mewujudkan permintaan besar terhadap pendigitalan teknologi pembuatan. Kemajuan teknologi ini telah mendorong peningkatan permintaan bagi alat berasaskan komputer atau alat-alat bantuan komputer untuk memudahkan proses pembuatan dan meningkatkan produktiviti industri. Salah satu masalah dalam proses pembuatan adalah pengenalpastian atau pengekstrakan ciri-ciri produk. Kajian mengenai kaedah pengenalpastian ciri adalah penting untuk memudahkan pengiktirafan ciri untuk bahagian produk dan meningkatkan reka bentuk model produk. Di samping itu, kaedah ini adalah penting untuk integrasi antara reka bentuk dengan bantuan komputer (CAD) dan proses pembuatan dengan bantuan komputer (CAM) dalam industri pembuatan. Dalam kajian penyelidikan ini, kaedah pengecaman ciri interaktif digunakan untuk meningkatkan reka bentuk perumahan telefon mudah alih (penutup belakang). Tambahan pula, pelaksanaan pengiktirafan ciri akan membolehkan proses pertukaran maklumat produk yang diimport dari format yang berbeza ke dalam model yang boleh diubahsuai. Selain itu, penggunaan pengenalan ciri membantu meningkatkan reka bentuk model produk kerana masalah pada ciri model produk boleh dibetulkan secara langsung. Penambahbaikan penutup belakang telefon bimbit ini akan mempengaruhi ciri-ciri reka bentuk, keselamatan struktur dan prestasi penutup belakang. Analisis statik linear dengan menggunakan SolidWorks SimulationXpress dan Analisis ujian penjatuhan dalam pakej ANSYS “Explicit Dynamic” telah digunakan untuk kedua-dua reka bentuk perumahan telefon mudah alih (penutup belakang). Keputusan yang diperolehi daripada analisis statik linear menunjukkan pengurangan dalam tekanan *Von Mises* dan anjakan, justeru itu menunjukkan nilai faktor keselamatan adalah lebih baik. Ramalan mod keletihan boleh dicapai dengan menggunakan Newton interpolasi polinomial yang menunjukkan bahawa

reka bentuk penambahbaikan boleh menahan tekanan permulaan yang lebih tinggi dan akan mengalami keadaan kegagalan yand lebih perlahan. Sementara itu, keputusan daripada analisis dinamik (analisis ujian penjatuhan) menunjukkan bahawa reka bentuk penambahbaikan mempunyai nilai-nilai yang lebih rendah untuk jumlah anjakan, tekanan maksimum dan tekanan linear berbanding dengan reka bentuk yang sedia ada. Pengesahan kedua-dua model reka bentuk dilakukan berdasarkan pengiraan kecekapan reka bentuk dan pekali variasi. Berdasarkan keputusan, kecekapan reka bentuk (DE) untuk kedua-dua model melebihi 85% yang menunjukkan bahawa reka bentuk boleh diterima. Di samping itu, CV digunakan untuk mengesahkan kebolehan (cover belakang) reka bentuk perumahan telefon mudah alih. Berdasarkan CV yang dikira, reka bentuk penambahbaikan mempunyai peratusan yang lebih rendah berbanding dengan reka bentuk yang sedia ada, dengan itu reka bentuk penambahbaikan mempunyai kestabilan yang lebih baik, kebolehpercayaan dan kualiti. Oleh itu, kajian ini menunjukkan bahawa penggunaan kaedah pengenalpastian dan pengikhtirafan dalam mereka bentuk semula penutup belakang telefon bimbit telah meningkat kualiti permukaan, keselamatan struktur, kualiti produk dan prestasi penutup belakang telefon bimbit.

ABSTRACT

Nowadays, the growth of economy and increases of competitiveness in order to boost quality, flexibility, speed and productivity created significant demand of the digitization of manufacturing technologies. These technological advances have driven increases in demand for computer-based tools or computer-aided tools to facilitate the manufacturing processes and increase the industrial productivity. One of the problems in manufacturing processes is the recognition or extraction of product features. The study of feature recognition method is vital to facilitate the recognition of part feature and improve the design of product model. In addition, this method is significant for the integration between computer-aided design (CAD) and computer-aided manufacturing (CAM) in manufacturing industries. In this research study, interactive feature recognition method is used to improve the design of mobile phone housing (back cover). Furthermore, the implementation of feature recognition will enable the recreation of imported feature from different file formats into feature model that can be altered. Besides that, the use of feature recognition helps to improve the design of the product model as feature problems of the product model can be corrected directly. The improvement of mobile phone's back cover will influence the design features, structural safety and performance of the back cover. Linear Static Analysis using SolidWorks SimulationXpress and Drop Test Analysis in ANSYS Explicit Dynamic packages have been utilized for both existing and improvement designs in this research study. The results obtained from linear static analysis demonstrated the decrement in Von Mises Stress and displacement consequently, contribute of a good value of safety factor. The prediction of fatigue mode can be attained by applying the computation of Newton interpolation polynomial, which showed that the improvement design can withstand higher initial pressure and will experience slower

failure condition. Meanwhile, results from the dynamic analysis (drop test analysis) depicts that improvement design has lower values for total deformation, maximum stress and linearized stress intensity compared to existing design. Validation of both design models are done based on the computation of Design Efficiency (DE) and Coefficient of Variation (CV). Based on the results, design efficiency (DE) of both models exceeds 85% which indicate that the designs are acceptable. In addition, coefficient of variation (CV) is used to validate the consistency of mobile phone housing (back cover) design. Based on the computed CV, improvement design has the lower percentage compared to the existing design, hence improvement design has better stability, reliability and quality. Therefore, this research indicates that the utilization of feature recognition in redesigning the mobile phone's back cover has improved the surface appearance, structural safety, product quality and performance of mobile phone's back cover.

DEDICATION

Special dedicated to my beloved parents, Mr Halim bin Ali and Mrs. Suhaila binti Sulaiman who are being caring, understanding, supportive and patience in helping me physically and mentally. A million thanks to my lovely siblings, honourable lecturers and fellow friends for all the encouragements, guidance and patience in completing my final year project. My prayers upon all of you will be embedded in my heart whenever I go.

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LIST OF ABBREVIATIONS

2D	-	Two-dimensional
3D	-	Three-dimensional
AAG	-	Attribute adjacency graph
AFR	-	Automatic feature recognition
B-rep	-	Boundary representation
CAD	-	Computer aided design
CAM	-	Computer aided manufacturing
CAPP	-	Computer aided process planning
CE	-	Concurrent engineering
CIM	-	Computer integrated manufacturing
CPS	-	Cyber-physical systems
CSG	-	Constructive solid geometry
CV	-	Coefficient of variation
DE	-	Design of efficiency
ICT	-	Information and communication technology
IFR	-	Interactive feature recognition
IGES	-	Initial Graphics Exchange Specification
IOS	-	Internet of services
IOT	-	Internet of things
PC	-	Polycarbonate
PDM	-	Product data management
STEP	-	Standardized graphic exchange format
TET	-	Tetrahedral Element
t	-	Time
v_0	-	Input velocity
v_1	-	Output velocity

CHAPTER 1

INTRODUCTION

This chapter provides the general ideas of the research study, which are optimization of mobile phone's housing (back cover) design using Feature Recognition tool in SolidWorks software. The role of the feature recognition technology for design improvement related to Industry 4.0 or smart production processes is likely to be highlighted in this context. In this chapter, the background of the project, problem statements, significance of study, objectives and report organization are also depicted.

1.1 Background of The Research Study

Technological advances have driven dramatic increases in industrial productivity and created significant demand of the digitization of manufacturing technologies in order to boost flexibility, speed, productivity and quality. This emerging technology lead to the fourth stage of industrialization called as Industry 4.0 (Stock and Seliger, 2016). This development proceeds from the third industrial revolution which started in the early 1970s and was based on electronics and information technologies for realizing a high level of automation in manufacturing (Stock and Seliger, 2016).

The term Industry 4.0 is defined by Schlaepfer and Koch (2014) as further developmental stage in the organization and management of the entire value chain process involved in manufacturing industry. Another term for this process is the 'fourth industrial revolution'. Besides, according to German Chancellor, Angela Merkel, Industry 4.0 is the 'comprehensive transformation of the whole sphere of industrial production through the merging of digital technology and the internet with conventional industry' (Davies, 2015). The terms "Smart production" and "Smart factory" become the norm in Industries 4.0 where manufacturing is transform from single automated cells to fully integrated and the intelligent ICT-based machines, systems and networks are capable of independently exchanging and responding to information to manage industrial production processes (MacDougall, 2013).

Moreover, this development provides massive opportunities for the realization of the sustainable industrial value of all three sustainability dimensions which are economic, social and environmental. This literature is characterized as the contribution of Industry 4.0 to the economic dimension of sustainability. For example, the opportunities of sustainable manufacturing for the macro perspective can be seen in the approach of the sustainable design of products where it focuses on the realization of closed-loop life cycles for products by enabling the reuse and remanufacturing of the specific product or by applying cradle-to-cradle principles (Stock and Seliger, 2016).

One of the examples of the approach or technique that can be viewed as a solution in Industry 4.0 is feature recognition through SolidWorks software. Feature recognition enables the automated extraction of features from a CAD model and minimize loss of design intent from product models when translating CAD models from one computer system to another, or between computer programs (Jones et al., 2006). Feature based modeling is viewed as more suitable for modeling in manufacturing as it deals with shape attributes related to manufacturing. Tan et al. (2013) have highlighted that with feature based models, shape information and other information (such as functional and non-geometrical information) can be stored and associated with manufacturing process models.

In this research study, feature recognition will be used to facilitate data exchange between different file formats, extraction of data from mobile phone housing (back cover) model design and optimization of the mobile phone housing. Feature recognition also helps in facilitating the customization and optimization of the existing product design. This approach reduce the lead time of activities downstream of design process by minimising user interaction with the product model, eliminating the redesign step and allowing direct alteration of the product design from the extracted product model (Jones et al., 2006).

Furthermore, interactive mode of feature recognition technology is chosen as a method to extract the feature geometries where potential features are being recognized by a user and it allows a user to determine the build order of recognized features. Accordingly, in the interactive feature recognition system, the designer defines a set of features and sets a collection of recognition process parameters. Thus, individual features can be unambiguously identified in an automatic or semi-automatic way directly in a CAD system or in an external application to which the part model might be transferred. A user is able to define non-geometrical information such as overall dimensions and surface roughness (Grabowik et al., 2015).

1.2 Problem Statement

Recently, industries are facing a fierce competition in order to meet today's global market need requirements. According to Subrahmanyam and Wozny (1995), conventional method requires user's interaction to ensure that features are accessible, no collisions occur, and the parts is not over-cut or under-cut, though there is increased progress in automatic feature recognition. Conversely, automating extraction of features by using feature recognition approach lead to the reduced lead-time of activities downstream of engineering design analysis by minimising user interaction with the product model (Jones et al., 2006). These feature problems can be directly edited or eliminated from the extracted features of CAD model, and also the product and process information can be

retrieved from the feature-based model to support manufacturing activities such as machining, process planning, analysis, assembly and inspection (Ozturk, 2001).

In 2002, Chang et al. noted that the feasibility of integration between CAD and CAM, for the downstream applications such as process planning, can be achieved only when the manufacturing information can be obtained directly from 3D solid model and hence, automate the process planning functions. Similar finding can be seen from the studies by Nasr and Kamrani (2006), where it noted that the concurrent engineering concept can be facilitated by the automatic extraction of manufacturing information from CAD systems and the link between the design and manufacturing activities can be achieved.

On the other hand, difficulty in the transferring of data is also one of the problem faced in the industry. Within industrial systems, design and manufacturing of engineering products commonly involves the transfer of data or information between designers and manufacturers who may be located in different companies and, often, different countries. This interaction includes the extraction of data from different file formats of CAD model design which requires processes that take time, implies costs and cause loss of design data. This is due to the fact that each engineering companies has different requirements of its software and different standards of product data management (PDM), which include the software, modeling practices, version control and file naming strategies (Jones et al., 2006).

In addition, Natekar et al. (2004) also emphasized that there is a problem in transferring the data due to the lack of neutral formats as well as content to convey the CAD information from Computer Aided Design (CAD) data to a downstream Computer Aided Manufacturing (CAM) system. This is due to many vendors have their own particular suite of integrated software modules and data structures and the commercial CAD/CAM marketplace is still very much in its infancy (Tan et al., 2013). Tseng and Joshi (1998) also added that the information related to the design is store in their own databases for different CAD or geometric modeling packages and the structures of database are different