DESIGN AND DEVELOPMENT OF AN AUTOMOTIVE SEAT FOR SAFETY

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Thesis submitted in accordance with the requirements of Universiti Teknikal Malaysia Melaka for the Bachelor Degree of Manufacturing Engineering in Manufacturing Design

By

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En. Shajahan Bin Maidin

Project Supervisor

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DECLARATION

I hereby, declared this thesis entitled “Design and Development of an Automotive Seat for Safety” is the result of my own research except as cited in references.

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ABSTRACT

The injuries from the impact of the face and chest towards airbags and the interior of the car in frontal collision have been issued by many researches. Car manufacturers have been trying to develop a seat to protect passengers from these injuries. In this report the study undergo the development process of an automotive seat that optimizes comfort with safety. The product is a Crash Restraint Safety (CRS) Seat that can minimize airbags related and body submarining injury. The conceptual design of CRS Seat is developed by studying related patents and is presented based on Functional Analysis, Morphological Chart and Pugh Method. In order to increase CRS Seat design sophistication, the embodiment design of CRS Seat is modeled in 3D using SolidWorks software. For CRS seat comfort evaluation, subjects' buttock-seat pressure distributions on CRS Seat are analyzed. Mathematical dynamic analyses on occupant motion in collision are analyzed to justify the mean of CRS Seat limiting occupant motion during collision does in fact reduced the occupants' possibility of injury.

ABSTRAK

Banyak kajian telah dibuat oleh penyelidik dan syarikat-syarikat pembuat kereta untuk membina satu kerusi kereta yang dapat melindungi pengguna daripada kesan kecederaan dari impak muka dan badan ke atas airbag dan permukaan dalam kereta semasa berlakunya pelanggaran. Kajian yang terkandung di dalam laporan ini menunjukkan proses pembikinan kerusi kereta untuk tujuan keselesaan dan keselamatan pengguna. Produk yang dihasilkan adalah kerusi kereta Crash Restraint Safety (CRS) yang dapat mengurangkan kecederaan yang disebabkan airbag dan pergerakan badan ke hadapan semasa impak. Konsep lukisan CRS Seat dibuat dengan merujuk kepada paten-paten yang berkaitan dan berdasarkan Functional Analysis, Morphological Chart and Pugh Method. Untuk meningkatkan kekemasan dan sofistikasi lukisan CRS Seat, setiap sudut lukisan CRS Seat dimodelkan dalam 3D menggunakan SolidWorks. Analisis tekanan subjek ke atas CRS Seat dilakukan bertujuan untuk menganalisa berkenaan tahap keselesaan pengguna CRS Seat. Secara kiraan matematik, kinematik pergerakan penumpang semasa pelanggaran dapat dianalisa dan sekaligus dapat membuktikan bahawa dengan keupayaan CRS Seat untuk menghadkan pergerakan penumpang semasa pelanggaran, kecederaan serius dapat dielakkan.

DEDICATION

A special dedication to my dearest dad, Ridzwan B. Abdullah, and mom, Masitah Md. Ali, whose countless sacrifices and positive mental attitude, inspired and empowered me. You are the best!

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LIST ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

"	-	Inch
°	-	Degree
C	-	Celcius
ft	-	Feet
M	-	Meter
N	-	Newton
Cm	-	Centimeter
QFD	-	Quality Function Deployment
PDS	-	Product Design Specification
CATIA	-	Computer Aided Three dimensional Interactive Application
CRS	-	Crash-Restraint Safety
CAD	-	Computer-Aided Design
DFM	-	Design for Manufacturing
DFA	-	Design for Assembly
g	-	Gram
mm	-	Milimeter
RM	-	Ringgit Malaysia
OOP	-	Out of Position
HIC	-	Head Injury Criterion

CHAPTER 1
INTRODUCTION

1.1 Background

The anti-submarine performance of an automotive seating system depends on many factors like seat characteristics, occupant position, impact speed and restraint systems. This project presents a product that optimized seat structure for anti-submarine performance.

The product is called Crash Safety Restraint (CRS) Seat that optimized comfort control mechanism with crash safety advantages. The main feature of this device is the arc-like path of motion of the seat that provides comfort adjustment and also acts as a safety restraint.

For comfort, the CRS Seat supports posture change. The movable backrest and lumbar offer continuous back support while driving. The seat, backrest, headrest and lumbar adjust to the posture and movements of the occupant.

For frontal crash safety, the CRS Seat utilizes the seat and lumbar cushions as a passive safety, crash restraint. It automatically increases seat angle to stop the occupant from submarining. The CRS Seat also actuates a backrest and headrest mechanism that increases rear crash safety.

1.2 Problem Statement

In a typical frontal impact, the occupant continues forward and is restrained by the belt with virtually no safety contribution from the seat pan. With the CRS Seat, effective deceleration has already begun. The driver's lower back, pelvis is still in contact with the lumbar support cushion and, more importantly, the face is not yet in contact with the airbag hence minimizing the airbag induced injury.

1.3 Objectives

The objectives of this project are:

i. To understand and implement the product design and development especially in concept development of CRS Seat.
ii. To emphasis on the aspect of designing and analysis of the factors affecting the safety of occupant in collision.
iii. To conduct static and dynamic test on CRS seat using CAE software and mathematical calculation.

1.4 Scope of Project

Scope of work for this project includes:

I. Develop the concepts for Crash-Restraint Safety (CRS) Seat

The concepts are developed by following the generic process of product design and development. After studying the useful patents and filling in the checklists of patent study, the conceptual design process is presented, which is based on Functional Analysis, Morphological Chart and Pugh Method.

II. Develop embodiment design of CRS Seat

At this stage CRS Seat is modeled in 3D using SolidWorks software in order to increase its design sophistication. SolidWorks software is chosen because it offers variable design tools and extensive built-in testing tools.

III. Conduct static analysis test on CRS Seat for comfort

At this stage it is important to analyze the factors that contribute to the occupant seating comfort. The pressure mapping tests for static evaluation are analyzed by COSMOSXpress system. The test was carried out to measure the buttock-seat pressure distribution. Subjects are tested with two different posture, CRS Seat normal and inclination posture.

IV. Conduct mathematical dynamic analysis on occupant motion in collision

In order to produce an automotive seat that can contribute to safety in time of frontal collision it is important to know how the occupant moves in a car during the collision. At this stage the purpose is to analyze what distance of the occupant motion from his/her sitting place in collision is the safest. Furthermore the calculation also assists in analyzing the occupant velocity and acceleration dependability to his/her safety in collision.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

This chapter covers the literature review of this project following eight lines of study.

- It begins by defining Safety Restraint System and followed by the trends of major cause of death and injury discussion.
- Following this, Product Design & Development are introduced prior a discussion of Product Design & Development tools
- Next, CAD/CAM and CAE are introduced before a discussion of the design and analyses tools, such as SolidWorks and COSMOSXpress.
- Lastly, various criteria of Material Selection Processes are introduced and discussed

Upon completion of the reviews for each line of study, the key findings are combined and summarized to explore their potential and applicability.

2.2 Safety Restraint System

In the field of automotive engineering, restraint systems refer to the safety devices in a vehicle that assist in restraining the occupant during a crash. Conventional restraint system design is largely oriented at car occupants of average height and weight for a set of standardized crash pulses. The restraint system is not able to adjust its characteristics during the crash event, so the occupant will not be optimally protected in every crash scenario. Hence, to achieve a satisfactory performance in all circumstances, the restraint system design is a tradeoff (Laan, 2006).

The restraints system can be categorized into two as shown in Figure 2.1. They are passive restraints system and active restraints system. For passive restraint systems, the purpose is to contribute to accident limitation & minimization of outcome. Examples of passive restraints system are passenger safety cell, deformation zones, seatbelts, airbags, laminated glass, correctly positioned fuel tanks, and fuel pump kill switches. Subsequently, active restraints system purpose is to contribute to accident avoidance and examples of active restraints system are good visibility from driver's seat, low noise level in interior, legibility of instrumentation and warning symbols, head up displays, good chassis balance and handling, good grip, ABS braking, all wheel drive, and secured luggage and passengers (cannot interfere with vehicle or driver) (Geisweid, 2000).

The most common safety devices that are supplied as a standard restraint system set to most Malaysian car buyers are seatbelts and airbags as shown in Figure 2.2 and Figure 2.3. Respectively, their key benefits are to restraint occupant from moving forward to prevent the second collision (human collision) and to protect the occupants from the 3rd collision (Internal collision). Airbags cushioned the passenger in an impact of a crash and kept the passengers from striking the steering wheel, dashboard or the windshield. Note that airbags supplement safety belts, they do not replace them (Whitehead, 2006).