STUDIES ON DYNAMIC BEHAVIOUR OF THE AUTOMOTIVE DOOR LOCKING SYSTEM DURING IMPACT

MUHAMMAD RIDHWAN BIN MOHD TALIB

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Faculty of Mechanical Engineering

Universiti Teknikal Malaysia Melaka

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VERIFICATION

"I hereby verify that I have read through this report entitle "STUDIES ON DYNAMIC BEHAVIOUR OF THE AUTOMOTIVE DOOR LOCKING SYSTEM DURING IMPACT" and found that it has comply the partial fulfilment for awarding the degree of Bachelor of Mechanical Engineering (Design and Innovation)"

Signature : ……

Supervisor's Name : En. Razali B Mohd Tihth

Date : ……

DECLARATION

"I hereby declare this thesis is result of my own research except as cited in the references"

Signature : ……

Author's Name : Muhammad Ridhwan B MohdTalib

Date : ……

DEDICATION

Dedicated to

My Mother (Rahmah Bt Mahmud)

My Father (Allahyarham Mohd Talib B Othman)

And My Beloved Family

ACKNOWLEDGEMENTS

Peace Be Upon You…

I am Muhammad Ridhwan Bin Mohd Talib a student from Faculty of Mechanical Engineering (Design and Innovation) of Universiti Teknikal Malaysia Melaka (UTeM) would like to grate acknowledgement for who peoples that willing to collaborate with me to finish my Final Year Project.

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Thank you.

ABSTRACT

Automotive door locking system is one of the most important things to be considered in safety precaution of vehicle. During crash test, the components of the door locking system that consists of latch, striker, cylinder key, lock knob, inside/outside door handle and linkages must sustain it position and function which is to ensure that the door did not open and keep the occupant safely inside the vehicle. By studies the theoretical of dynamic behavior of the system during impact, it helps to solves and minimizes the probability of passengers being ejected from a vehicle in order to fulfill the requirements of standards and regulations that had been established (FMVSS, 2004). In this case studies had been refer on the United States of America Federal Motor Vehicle Safety Standard No. 206, Door Locks and Door Retention Components (FMVSS No.206). By using dynamic inertia calculation, 30g load exerted vertical (worst rollover) and lateral (side) directions. In assumption, the door considered pass both impact directions when got the result in positive value unless got negative value, it considered fail. The results showed that, the door locking system pass the 30g impact test in lateral direction which is +3.105Nm. However, the continuous action has been taken on vertical direction but obtained the fail result which is -0.0734Nm. For the other method by using CAE simulation, applied conditions still same as 30g load will be exerted vertically and laterally. The result obtained show that the value of angular velocity of every part equal to zero means that there have no rotation motion during impact. Hence, the test considered passed for both directions. Both methods are correct and follow the requirement of FMVSS No 206 and UNECE Regulation No 11.

ABSTRAK

Sistem penguncian pintu automotif adalah salah satu perkara yang paling penting untuk diambil kira dalam langkah-langkah keselamatan kenderaan. Semasa ujian kemalangan, komponen sistem penguncian pintu yang terdiri daripada latch, striker, cylinder key, lock knob, inside/outside door handle dan linkages mesti mengekalkan kedudukan dan fungsi utamanya iaitu untuk memastikan bahawa pintu tidak terbuka dan memastikan penumpang dalam keadaan selamat di dalam rangka kenderaan. Daripada kajian yang dijalankan secara teori, tingkah laku dan kesan system dinamik boleh menyelesaikan dan mengurangkan kebarangkalian penumpang daripada terhumban dari kenderaan ketika kemalangan sejajar dengan keperluan piawaian dan peraturan-peraturan yang telah ditetapkan. Dalam kes ini, kajian telah merujuk pada Amerika Syarikat Federal Motor Kenderaan Keselamatan Piawaian No 206, Pengunci Pintu dan Pengekalan Komponen Pintu (FMVSS No.206). Dengan menggunakan pengiraan inersia dinamik, beban 30g dikenakan pada arah menegak dan arah sisi . Dalam andaian, pintu dianggap lulus untuk kedua-dua arah apabila mendapat keputusan dalam nilai positif melainkan mendapat nilai negatif, ia dianggap gagal. Hasil kajian menunjukkan bahawa, sistem mengunci pintu lulus ujian 30g kesan ke arah sisi ialah +3.105 Nm. Walau bagaimanapun, tindakan yang berterusan telah diambil atas arahan menegak tetapi mendapat hasil gagal iaitu -0.0734Nm. Bagi kaedah lain dengan menggunakan simulasi CAE, Keputusan yang diperolehi menunjukkan bahawa nilai halaju sudut tiap-tiap bahagian bersamaan sifar bermakna bahawa tidak ada pergerakan semasa impak. Oleh itu, ujian dianggap lulus untuk kedua-dua arah. Kedua-dua kaedah adalah betul dan mengikut keperluan FMVSS No 206 dan UNECE Peraturan No 11.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Crash test or impact test are the most important procedures to be applied on any vehicles. It is compulsory to pass all the vehicle safety standards and regulations before it is ready and proceeds for manufacturing process. There are hundreds kind of standards listed that need to be followed for all components and parts. Crash tests including such frontal-impact test, offset test, roll over test, and side impact test. Hence, every components and parts of the vehicle will be tested and analyzed for any possibilities occurred during accident (Portillo, 2008).

One of the components that must be highlight here is doors of the vehicle. The testing of vehicles is considered failed if the door cannot hold on it position and open during crash test in any direction (FMVSS, 2004). Hence, the door locking system is related to and it must function successfully as the requirement of certain standard and regulation. Door locking system consists of several mechanical and electrical parts such as door handle, linkages, latch, striker, actuator, door hinge, etc. and many concepts and technologies has been developed by the engineers to improve the vehicle door locking mechanism.

1.2 Objective

The objective of this project is to studies the dynamic behavior of the automotive door locking system components during impact by application of dynamic analysis. Analysis will be conducted in both way, theoretical calculation and CAE simulation.

1.3 Scopes

There are lots of things can be found and discovered during the researches about automotive door locking system. For this research, focuses will be concern on below scopes of works;

a. Understand the concept of automotive door locking system design and its safety standard requirement.
b. Research focus on dynamic behavior of automotive door locking system component by selecting the existing product as case study
c. Application of both theoretical calculation activities on dynamic inertia and dynamic analysis simulation using MSC Adams software
d. Application of CAD in the process of case study data development (reverse engineering)

1.4 Problem Statements.

The function of automotive door locking system is to keep the passengers inside the vehicle safe during impact and minimize the probability of passengers being ejected from a vehicle as a result of impact. The system including latches, hinges, door handle, striker and linkages. The United States of America provided data on the magnitude of the door ejections and door openings based on 1994-99 National Automotive Sampling System (NASS) and Fatal Analysis Reporting System (FARS) annual estimates. The United States of America data shows that (Economic Commission for Europe, 2004, pg.5):

- There are approximately 42,000 door openings, or failures in the United States per year;
- Complete and partial ejections cause 9,864 fatalities & 9,767 serious injuries in the United States of America each year;
- Door ejections constitute 19 per cent (1,668) of ejection fatalities and 22 per cent (1,976) of ejection serious injuries;
- 94 per cent of serious injuries and fatalities attributable to ejections through doors involve unbelted occupants; and
- Hinged side door openings account for 90 per cent of door ejection fatalities and 93 per cent of ejection serious injuries.

The components inside the mechanism can hold a certain force only. The connections between them will effects the performance of the mechanism. In the report on The Development of a Global Technical Regulation Concerning Door Locks and Door Retention Components by UNECE is stated that "*Door openings are frequently caused by a combination of forces occurring during a crash, which simultaneously subject door retention components to either compressive/tensile lateral and longitudinal forces*" *(Economic Commission for Europe, 2004)*. Hence, by using dynamic inertia calculation and simulation of dynamic analysis software, the behavior of the part during impact can be shown. Hence, development activities on the locking system by following the international safety standard are very important aspect for passenger safety concern.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The function of automotive door locking system is to keep the passengers inside the vehicle safe during impact. The systems including latches, hinges, door handle, striker, and the linkages. The parts inside the mechanism can hold a certain force only. The connections between them will effects the performance of the mechanism. By using dynamic inertia calculation and simulation of dynamic analysis software, the behavior of the part during impact can be shown. Hence, developing on the locking system by followed the international safety standard is very important in order to minimize the probability of passengers being ejected from a vehicle as a result of impact.

The National Highway Traffic Safety Administration has determined that 75 percent of accident victims were thrown completely from their vehicle during a car crash, died *(Parker, 1999-2011)*. Based on a review of National Automotive Sampling System (NASS) and Fatal Accident Reporting System (FARS) data from 1995-2003, there were 54,082 vehicle occupants were ejected from their vehicle. 59 percent of ejections occur through side glazing and 26 percent of the ejections occur through openings other than side glazing or doors and 15 percent of ejections occurred through a vehicle door *(FMVSS, 2004)*. Hence, locking the doors while driving is an important safety feature that helps keep passengers inside the safety cage of the vehicle.

2.2 History of Invention

Automobile industries have been around since the beginning of the twentieth century. Owning a car in that time was like owning a private plane today. The invention of the car has certainly shaped the way of life around the world (America‟s Car Museum). Nowadays, the invention of vehicle especially cars are equipped with modern technologies and high-tech system. There are lot of parts and system attached inside a car. Hence, there must be many developments and improvements had been made until today (Wise, 1960). But car locks have taken a bit longer to catch on after safety precaution been considered. However, by the late 1920s that ignition locks came standard on most cars and closed vehicles had door locks as well. Current models can be secured with various locks (Parker, 1999-2011).

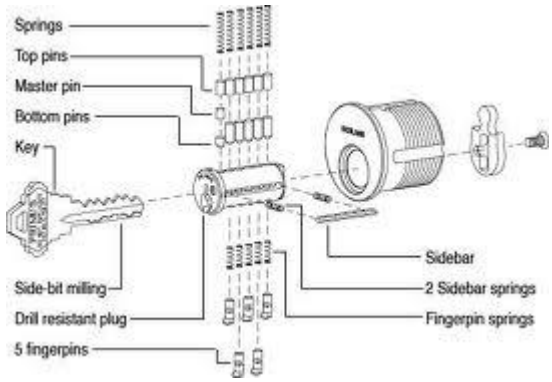

Figure 1: 6-cut sidebar locks. (Google image)

GM introduced its 6-cut sidebar locks (Figure 1) in 1935. In 1959, Chrysler began using sidebar locks on their trunks, but dumped the design in favor of pin tumbler locks on both trunks and doors in 1966. From the 1960s to the present, car lock technology has advanced significantly to include keyless entry, combination keypads and even bio-tech recognition devices (Parker, 1999-2011).

Child safety locks are built into the rear doors of most cars to prevent rear seat passengers from opening the doors both during transit and while the vehicle is

stationary; vehicles have been built with this feature since the early 1980s. They provide the vehicle driver with a simple, safe & secure method to prevent unauthorized exit from the car. Although called a child lock it is equally effective for adult passengers. The lock is typically engaged via a small switch on the edge of the door that is only accessible when the door is open. Some cars implement the locking mechanism as a rotary device which must be engaged with the vehicle key, this design prevents "sticky fingered" passengers from disabling the lock as they enter the vehicle. In both designs the lock is completely inaccessible, especially to the passenger, when the door is closed. When the child lock is engaged, the interior handle is rendered useless. Usually the insides handle just moves freely without unlatching the door. In this state the passenger cannot open the door from the inside and is effectively locked in, the passenger can only be released by someone lifting the outside handle. The child proof locks can be made considerably more secure if they are engaged on both rear doors and the power windows are also locked, this prevents the passengers from exiting on the other side or rolling down the window to reach the outside handle.

2.3 Type of Door Locking System

Different automotive manufacturer might have their own design and concept of door locking system. Engineers put the best concept of door locking system after they ran a research and done a lot of tests regarding the capabilities of the design to fully function at optimum condition. Most cars come equipped with numbers of different locks, including the ignition lock, door locks, glove compartment lock, trunk lock, hood lock and child safety lock. Some cars come with separate keys for the ignition and doors respectively. Others use a master key which will operate all locks, and a sub-key that will only open the doors and glove compartment. The hood lock is frequently not fitted with a key, but is actuated by a lever or button inside the vehicle. Car locks may be powered or manual (Parker, 1999-2011).

Until now, there are many type of how the door is open and close. Hence, the design of the door locking system also different such as for sliding doors (Figure 2), suicide doors (Figure 3) and scissor doors (Figure 4) have different latch design. For butterfly doors, gull-wing doors (Figure 5, and canopy doors (Figure 6) almost same as conventional doors latch.

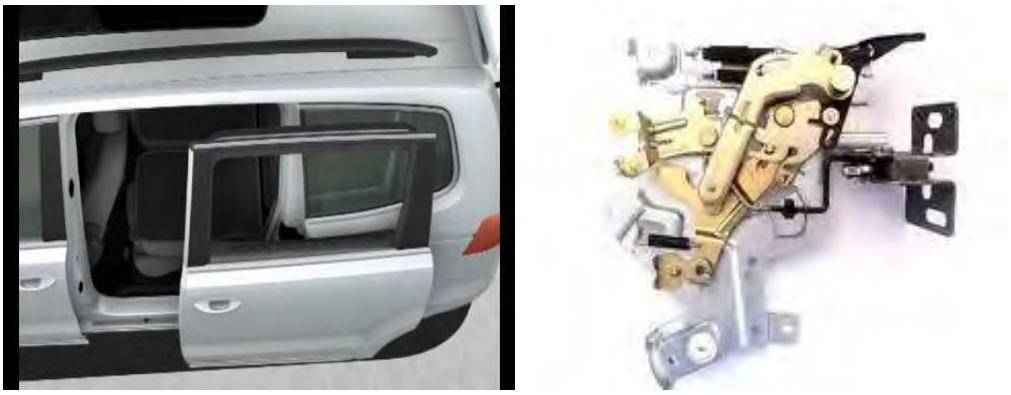

Figure 2: Sliding door latch (Google image)

Figure 3: Suicide door latch (rolls-royce.vehiclemechanics.net)

Figure 4: Scissor door hinge (www.boldride.com)

Figure 5: Gull-wing door (www.carsrevolution.com)

Figure 6: canopy door (priceofhistoys.com)

2.4 Technology Development In Automotive Door Locking System

There have many of technologies had been developed since the invention of automotive begin. Engineers competed to each other to make improvement on design and the performance in many aspects inside the vehicle. Technology development on door locking system is one of the most important aspects in safety precaution. There lot of patterns regarding the development of the door locking system. Such as central locking system, remote keyless entry system, pneumatic central locking system, superlocking vehicle door lock/unlock system, and deadbolt locking system.

The present invention relates to a central locking system for motor vehicles and more particularly to a central locking system comprising a plurality of electric locking drives and a time control means which can be triggered by at least one manually switchable control switch on setting of a predetermined switch position, wherein the time control means switches on the locking drives for a determined time duration in a drive direction allocated to the predetermined switch position (Fey, 1983). Figure 7 show the parts of the central locking system.

Figure 7: Central door locking system (Google image)