UNIVERSITI PUTRA MALAYSIA

DESIGN OF POLYMERIC BASED COMPOSITE AUTOMOTIVE BUMPER FASCIA

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UPM

Do you have time to pray?
God has time to listen

Abstract of thesis presented to Senate of Universiti Putra Malaysia in fulfilment of the partial requirements for the degree of Master of Science

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October 2003

Chairman: **Associate Professor Ir. Hj. Mohd Sapuan bin Salit, Ph.D.**

Faculty: **Engineering**

An automobile bumper fascia is a non-structural component, which contributes to vehicle crashworthiness during front or rear collisions. In the past, the fascia was made of plastic material. The weight reduction in bumper fascia without sacrificing the safety of the car passenger was extensively studied. In this research, the bumper fascia made of polymeric based composite material is designed in solid modelling software. The polymeric based composite material was selected because it can offer low weight, high specific stiffness, high specific strength, high-energy absorption and easy to produce complex shapes. Four conceptual designs of bumper fascia were developed in 3-D solid model. To decide the final design of bumper fascia the matrix evaluation method was used. The weight of bumper fascia was obtained through weight analysis that has been developed by using Pro/Engineer software. The fascia was successfully designed with less weight compared to the current fascia.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi sebahagian keperluan untuk Ijazah Master Sains

REKA BENTUK FASIA BAMPER AUTOMOTIF KOMPOSIT BERASASKAN POLIMER

Oleh

MOHD NIZAM BIN SUDIN

Oktober 2003

Pengerusi: **Profesor Madya Ir. Hj. Mohd Sapuan bin Salit, Ph.D.**

Fakulti: **Kejuruteraan**

Fasia bamper automotif adalah salah satu komponen bukan struktur yang menyumbang kepada kemusnahan kenderaan semasa perlanggaran dari hadapan atau belakang. Sebelum ini bamper dihasilkan daripada bahan yang berasaskan plastik. Pengurangan berat fascia bamper tanpa menjejaskan keselamatan penumpang telah dikaji dengan mendalam. Dalam kajian ini fasia bamper yang dihasilkan daripada polimer bahan rencam telah direka bentuk dengan menggunakan perisian permodelan padu. Bahan composite berasaskan polimer telah dipilih kerana ia menawarkan berat rendah, tegasan spesifik tinggi, kekuatan spesifik tinggi, penyerapan tenaga tinggi dan mudah menghasilkan bentuk kompleks. Empat konsep reka bentuk fasia bamper telah dihasilkan dalam model 3-D. Untuk menentukan reka bentuk akhir kaedah penilaian matrik telah digunakan. Berat bamper ini diperolehi daripada analisis berat dengan menggunakan perisian Pro/Engineer. Fasia yang kurang berat berjaya direka bentuk berbanding dengan fasia yang sedia ada.

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CHAPTER 1

INTRODUCTION

1.1 Background

The use of polymer-based materials in automotive industry has raised dramatically in recent years, as its offer low weight, corrosion free, easier to produce complex shapes, high specific stiffness (stiffness/weight), high specific strength (strength/weight), and high impact energy absorption characteristic over their metal counterparts. One of the important structural to absorb the collisions energy and the impact energy is bumper system. The bumper system consist of three components namely bumper beam, energy absorber and bumper fascia. There is an interest among the researcher to move from conventional material such as plastic, aluminium, or steel to cheaper materials such as polymeric based composites in bumper system. In this study, the use of polymeric based composite material for bumper fascia is proposed for the quest of high fuel efficiency in automobiles, cheaper, and having comparable properties to conventional fibres without sacrificing the safety of cars.

Substitution of the polymeric based composite material for bumper fascia is suggested mainly to improve the bumper system performance as it can offer lightweight as well as to reduce the energy consumption. Therefore, automotive bumper fascia made of polymeric based composites material will be designed and

analyzed to investigate the effect of weight as well as the overall performance of automotive bumper systems. The front-end bumper fascia of proton Iswara aeroback 1.3 is selected to be the subject of this study. It is selected mainly due to certain shortage in the current design such as attachment method of fascia to the body of the car, weight, and appearance of the bumper fascia. The study purposely to improve all the shortages arises.

1.2 Research Objectives

The major objectives are:

- to apply proper design method to design automotive bumper fascia.
- to design bumper fascia made of polymeric based composite material using solid modelling software
- to investigate the weight of bumper fascias made of polymeric based composite

1.3 Structure of the Thesis

Literature review in various relevant areas is presented in chapter 2. The review started with the brief description of the components and bumper system. The review than explain the manufacturing of bumper systems and polymeric based composite bumper system and it is end with the comparison between polymeric based composite material with conventional material. The structure and methodology of design process is described in chapter 3. It concentrates on the propose design methodology for the design system, tools required for the design,

and product design specification (PDS) of bumper fascia. The conceptual design of polymeric based composite for bumper system is described in chapter 4. It comprises on the generating, developing and design evaluation of automotive bumper fascia for achieving final design concept.

Chapter 5 deals with the detail design of the composite bumper system. This chapter comprises two main parts, the component design, and design analysis. The component design was developed using computer aided design software. Design analysis is mainly for design decision and verification. The weight analysis is performed using Pro/Engineer software. Final model was developed, which is in 3-dimensional (3D), to achieve the optimised weight of bumper fascia.

In the chapter 6, conclusion is made on the design aspect of fascia design and recommendations for the future improvement are identified and explained.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Automobile bumper is a structural component of an automotive vehicle, which contributes to vehicle crashworthiness or occupant protection during front or rear collisions. The bumper systems also protect the hood, trunk, fuel, exhaust and cooling system as well as safety related equipments. A brief description of bumper components and a critical review of polymer-based bumper systems with specific methodology are described. This chapter led to a proposal for proper bumper design and material selection, which provides better understanding of automotive bumper systems. The aim of this review is also to attempt to provide the information about scientific systems components and to offer a critical review of bumper materials. The advantages and disadvantages of polymer based composite materials compared with the traditional steel were also discussed.

A bumper is a shield normally made of aluminium, steel rubber, composite or plastic that is mounted on the front and rear of an automobile vehicle. When a low speed collision takes place, the bumper system absorbs the shock or energy to prevent or reduce damage to the vehicle. In some bumpers energy absorbers or brackets are used and others are made with foam cushioning material.

The car bumper is designed to absorb energy thus to prevent or reduce physical damage to the front and rear ends of an automobile at low speed collisions. Automobile bumpers are not usually designed to be structural components that would significantly contribute to vehicle crashworthiness or occupant protection during front or rear collisions at high speed. The bumper should be designed as safety feature since it is intended to reduce the magnitude of deceleration during impact. The bumper systems are only designed to protect the hood, trunk, frame, fuel, exhaust and cooling system as well as safety related equipments, such as parking lights, headlamps and taillight at low collisions.

Bumper systems have been changing drastically over the last 20 to 30 years. More demanding government safety regulations and different styling concepts have resulted in new designs. For example, reinforcing beams covered by plastic fascias were introduced in the early 1970's. Styling fashion has changed appearance values from almost 100% chrome-plated face bars to predominately fascia system that are colour coordinated with the body. The growth of light trucks, minivans and sport utility vehicles have created two classes of bumper systems in the eyes of the engineering world: one for passenger cars and another for the broad grouping of light trucks. Safety concerns have resulted in the bumper beam becoming a part of the structural load path (Kelman et al.,1990).

There are several factors to be considered when selecting a bumper system. The most important consideration is the ability of the bumper system to absorb enough energy to meet the original equipment manufacturers (OEM's) internal bumper

standard (Bernert et al., 2001). Another is the requirement to stay intact at high-speed impacts. Weight, manufacturing process ability and cost are also the factors that have to be considered during the design phase. Both initial bumper cost and repair cost are important. The formability of materials is important for high-sweep bumper systems. Another factor considered at the material selection stage is recyclability of materials, which is an advantage for steel, but yet the evolution of Carbon dioxide (CO_2) during recycling or re-melting of steel has to be taken into consideration.

2.2 A Brief Description of Bumper Systems and Components

There are four different types of bumper systems commonly used in the automotive vehicles as shown in Figure 2.1(Bernert et al., 2001). A brief description of each system is as follows:

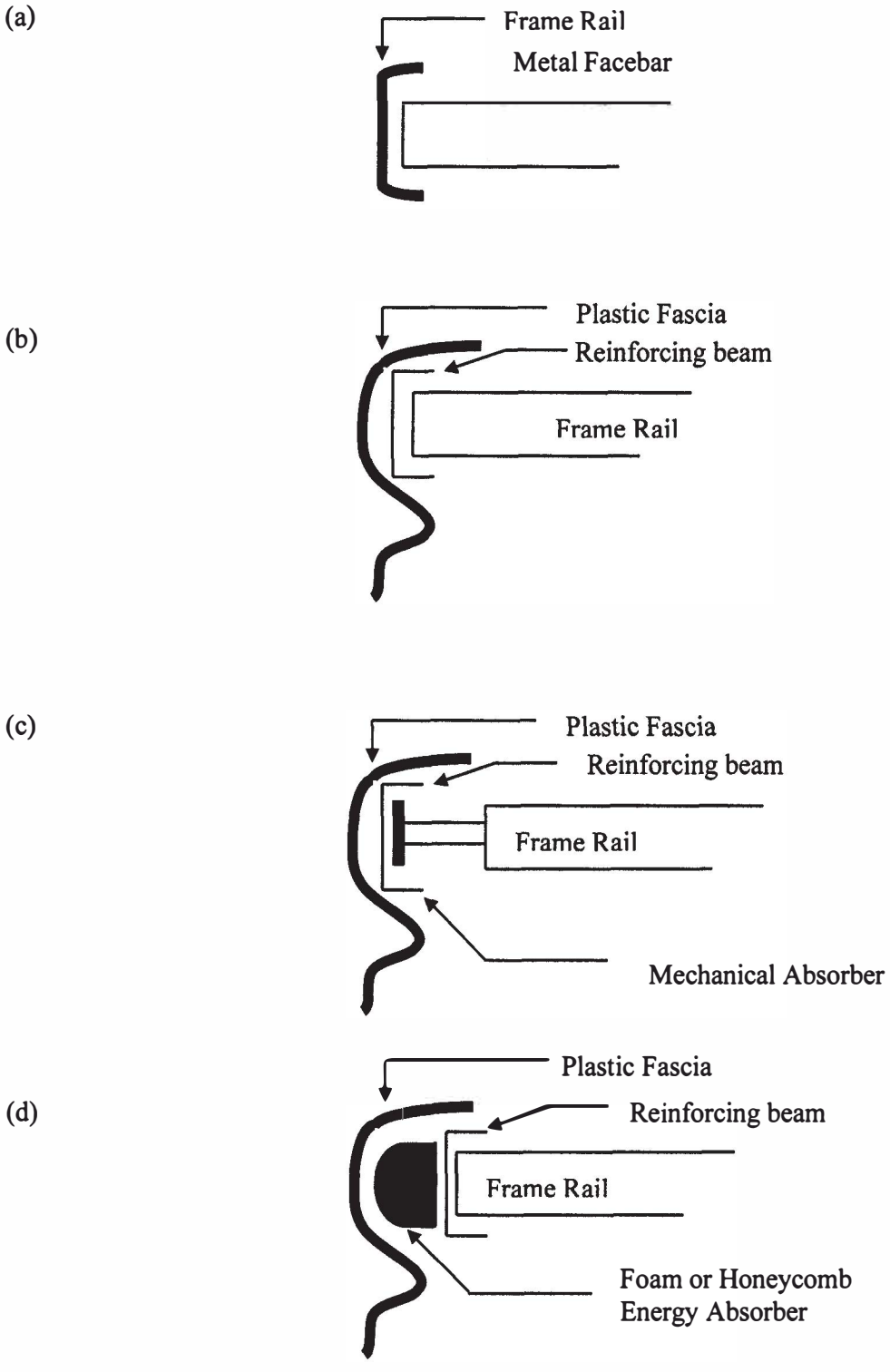

Figure 2.1: Four different types of automotive bumper systems: a) Metal facebar system, b) Plastic fascia and reinforcing beam system, c) and d) Plastic fascia, reinforcing beam and energy absorbers (Bernert et al., 2001).

2.2.1 Metal Face Bar System

A metal face bar system consists of a single metallic bumper that decorates the front or rear end of a vehicle and acts as the primary energy absorber in a collision. The bumper regulations in the United States require passenger cars to withstand a 4 km/h impact at the curb position plus or minus 50 mm with no visual damage and no damage to safety related items. The Canadian passenger car regulations call for an 8 km/h impact, however limited damage is permitted. The North American OEM's voluntarily design their passenger car bumpers to withstand a 8 km/h impact with no visual damage and no damage to safety items. Current face bar systems can only withstand a 4 km/h impact at the curb position plus or minus 50 mm with no visual damage and no damage to safety items. For this reason, the use of current face bar systems is restricted to light trucks. The aesthetics of face bars matches the styling trend for full size vans, pickups and sport utilities. Thus, most face bars are presently being applied to these vehicles.

If the design standard for light truck bumpers were to rise to the 8 km/h voluntary passenger car standard, then the face bar systems used on full size vans, pickups and sport utilities would have to be redesigned. For the reason of weight, such redesigns would likely revert to systems that employ a reinforcing beam (Bernert et al., 2001).

2.2.2 Plastic Fascia and Reinforcing Beam System

This system consists of a plastic fascia and a reinforcing beam, which is fastened directly to the vehicle frame or motor compartment rails (Figure 2.1b). It is primarily used in Europe and Japan, where bumper regulations are less stringent than those in North America. On many vehicles in Europe and Japan, the reinforcing beam in this system also serves as the first structural cross-member. While this arrangement leads to a small sacrifice in bumper performance, it increases vehicle crashworthiness. If the reinforcing beam is a part of the body-in-white, the favoured material is steel because of the structural requirements associated with a cross-member. Also, steel is fully compatible with the body in white E- coat and paint systems used by the OEM's plastic fascia, reinforcing beam and energy absorption system.

2.2.3 Plastic Fascia, Reinforcing Beam and Mechanical Energy Absorbers System

Bumper systems with a plastic fascia, reinforcing beam and energy absorption are shown in Figures 2.1c and 2.1d. These readily meet the 8 km/h voluntary bumper standard set by the North American OEM's. All passenger cars and most minivans around the world have this type of system with small variations of the method of energy absorption. Energy can be absorbed by a mechanical absorber (Figure 2.1c), foam or honeycomb (Figure 2.1d), or by the reinforcing beam itself (Bernert et al., 2001).

2.2.4 Plastic Fascia, Reinforcing Beam and Energy Absorption System

A bumper system consists of three components (as shown in Figure 2.2) such as, fascia, and energy absorber and bumper beam. A brief description of the components is furnished in the following sub-sections.

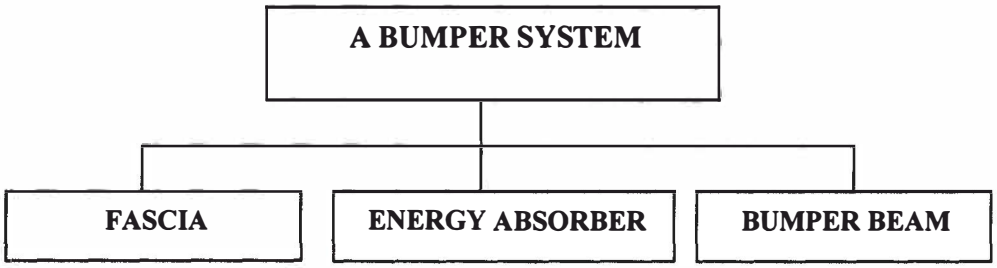

Figure 2.2: Automotive bumper system components

2.2.5 Fascia

Bumper fascia is designed to meet several requirements. It must be aerodynamic to control the flow of the air around the car and the amount of air entering the engine compartment. It should be aesthetically pleasing to the consumer. Typical fascia as shown in figure 4.3 is styled with many curves and ridges to give bumper dimension and to distinguish vehicles from competing models. Another requirement of bumper fascia is easy fabrication. It is also important for it to be light in weight. Virtually fascia is made from one of three materials: polypropylene, polyurethane or polycarbonate (Bernert et al., 2001).