International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No.04, April 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

A REVIEW ON BODY IN WHITE SOLUTIONS FOR IMPROVING LIGHTWEIGHT AUTOMOTIVE STRUCTURES

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ABSTRACT

Body in White refers to the components assembled in the frame structure of any vehicle before painting. Lightweight vehicular body may be produced by development of novel body constructions using lightweight materials and implementing structural optimizations. In this research, an effort has been made to enhance the strength of vehicular body structure using different materials for weight reduction. The present paper focuses towards automotive structure enhancement by the application of B.I.W. materials with different manufacturing methods by optimizing lightweight design of the vehicular structure for weight reduction to reduce emissions to prevent environment from pollution.

Keywords: vehicular structure, automotive material, design, weight reduction, multi material.

I.INTRODUCTION

Body in White (B.I.W.) explores that phase of automotive manufacturing in which a car body's sheet metal parts have been joined together through welding. B.I.W. refers to the components of a vehicle before painting and before moving the components such as doors, hood and fenders assembled in the frame structure.

Lightweight vehicular body can easily be produced by developing new body constructions with the use of lightweight materials and implementation of structural optimizations. New body construction uses High Strength Steel, Aluminium, Magnesium and Carbon Fiber Reinforced Plastic as lightweight materials for the reduction of overall weight of an automotive body.

II. LITERATURE REVIEW

Linli Tian and Yunkai Gao[1] have proposed topology optimization design flow for a B.I.W. exposed to various representative legislative crash loads, including frontal impact, side impact, roof crush and rear impact and expanded the optimization process up to multiple load cases design by employing the compromise programming method in which the strain energy has been treated as the stiffness evaluation index of the B.I.W. and the relative displacements have been employed as the compliance index of the components and parts. The topology optimization problem of crashworthiness design could be changed into maximizing structural stiffness of the design space while constraining the relative displacements of the passenger cabin lower than a certain value to guarantee the stiffness of passenger cabin and constraining the relative displacements of the front and rear cabin greater than a certain value to increase the energy absorption during the crash process. The results provided a conceptual design, which emphasizes the most efficient load paths and served as an effective guidance to the next-step B.I.W. detailed design.

Pranav Shinde et al.[2] have reviewed the solution for improvement of functional properties of a light weight body in white and explained automobile functional characteristics, influence of parameters on light weight body in white, comparison of various solutions for the problems related to light weight body in white structures.

Dinesh Munjurulimana et al.[3] have focused on the development of reinforcement solutions for body in white by using engineering thermoplastic materials which were mounted at appropriate locations on a vehicle's body in white for achieving significant weight savings without compromising crash performance. Several design and material configurations including plastic, metal-plastic and composite-plastic structural members mounted on the body in white were evaluated through CAE studies for various crash scenarios like high-speed frontal crashes, side impact, pole impact and rollover. The computer-aided engineering studies were performed by using generic vehicle models for quantifying the potential weight-savings in a vehicle by either replacing the existing reinforcements using a lighter system or by incorporating additional reinforcements in the B.I.W. by down-gauging the existing body in white.

Elena Cischino et al.[4] have presented a project for reducing the number of parts by using innovative lightweight materials and technologies. They considered high performance aluminium alloys for providing the opportunities to obtain components with complex geometries and low thickness, merging different parts into one unique element.

Ashish Kumar Sahu et al.[5] have optimized the mass reduction in body in white by carried out experiment on the body in white of a Sports Utility Vehicle (SUV). This optimization was carried out by considering all the basic performance parameters required for the reduction in mass of the body. In the initial phase of development of body in white, the optimization helped for ensuring the minimum B.I.W. weight rather than carrying out mass reduction post vehicle launch.

III. OBJECTIVE

The main objective of the present review was to emphasize the enhancement of automotive body structures for the reduction in weight of the vehicle for making it lightweight and for the further improvement in vehicular emissions using Body in White for prevention of environment from pollution.

IV.REQUIREMENT FOR DESIGN OF BODY IN WHITE

The functional requirements of Body in White include sealing for acoustic body structure, noise, vibration and harshness along with materials requirements of safety for crash performance such as frontal crash, rear crash, side-crash and rolling. The performance and technical requirements of body combines for geometry and dent resistance, fatigue and antirust for some typical parts with protection requirements of B.I.W. for rolling and relational requirements of body for the profile difference, torsional stiffness and bending stiffness for improving performance.

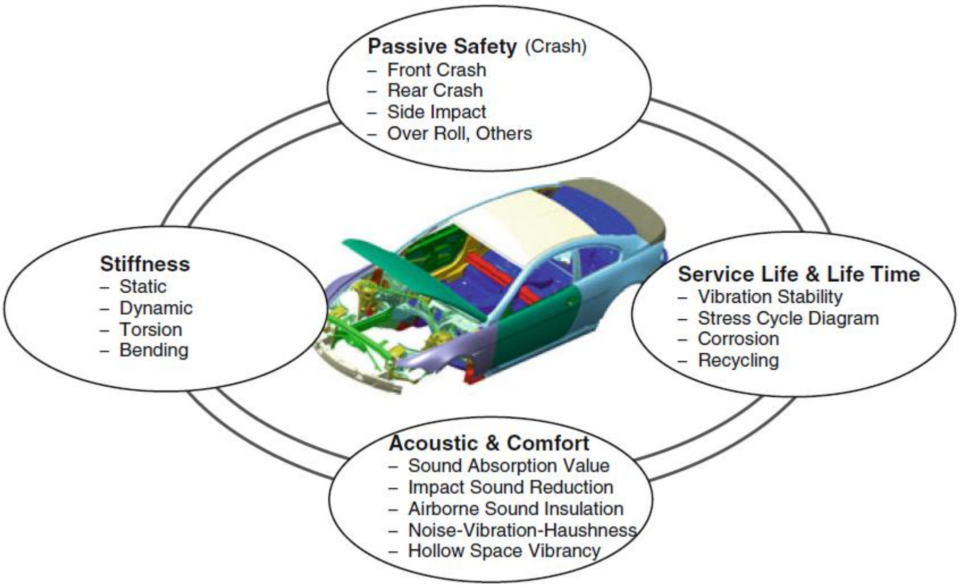

Fig. 1. Functional Requirements for the Body in White Design[13]

V. CONCEPT OF AUTOMOTIVE LIGHTWEIGHT DESIGN

Lightweight design and weight reduction of the Body in White can only be achieved by correct dimensioning of the vehicle and by proper functional requirements. The three aspects are used to expand the concept of automotive lightweight design. First, an automotive lightweight design has been performed to reduce the mass by direct lightweight. Second, an automotive lightweight design has been performed for improving the performance by keeping the mass constant. Third, an automotive lightweight design has been performed for the reduction of mass with the improvement in performance.

5.1 Factors Influencing Weight

The weight of an automobile depends directly upon the material type along with the material quantity used for manufacturing. The durability of Body in White depends upon the selection of above mentioned two factors. So, it is necessary to add-up more material for achieving more durability. Hence, the material has been considered as the major factor for addition in weight.

5.2. Influence of Materials

The process of making novel designs for lightweight applications using advanced materials depends upon the knowledge of interaction between different manufacturing processes, material science and metallurgy, and properties of materials. Magnesium may be utilized in lightweight structures having high strength through integration of design, manufacturing methods and material properties. The analytical model plays a vital role in building the relation between structure and metal-matrix composite characteristics. Martensitic stainless steel has difficult joining process and machining process too which can be used with knowledge of advanced and specialized techniques of welding.

5.3. Influence of Constructional Design

The lightweight structure of an automobile ensures the outstanding driving dynamics. Furthermore, the weight distribution must be maintained uniform throughout the frame. Utilization of elegant strategy for material selection regarding primary structures in B.I.W. results in weight reduction with decrement in static bending strength and torsional stiffness.

VI. MULTI MATERIAL LIGHTWEIGHT VEHICLE B.I.W. STRUCTURE

The vehicular parts of B.I.W. structure have been optimized for their particular application by selecting the best features from steel and aluminum for the different applications. The components have been designed either with high pressure-high vacuum die casting and formed to extruded profile or used as an aluminum sheet having varying wall thickness.[7]

Table 1. Materials and Manufacturing Process for Several Parts of B.I.W. Structure[9]

BIW Part	Recommended Material	Processing Route
Front bumper	Low-grade carbon fiber composite	Fabric stamping or RTM
Front rails	Low-grade carbon fiber composite	Fabric stamping or RTM
Upper radiator support	Magnesium	Cast
Lower radiator support	Magnesium	Cast
Shock towers	Steel	Stamp
Wheel housings	Steel	Stamp
Cradle / front cross member	Aluminum	Cast
Toe pan	Steel	Stamp
Firewall	Steel	Stamp
Plenum	Magnesium	Cast
Floor pan	Steel	Stamp
Sills	Low-grade carbon fiber composite	Fabric stamping or RTM
A-pillars	magnesium inside/carbon outside	SMC
B-pillars	Low-grade carbon fiber composite	SMC
Roof	Steel	Stamp
Roof rails	Low-grade carbon fiber composite	SMC
Front & Rear header	Magnesium	Cast
Roof bow	Steel	Stamp
C-pillars	magnesium inside/carbon outside	SMC
Shelf panel	Magnesium	Cast
Rear kick-up	Steel	Stamp
tire tub	Steel	Stamp
Rear shock towers	Steel	Stamp
Rear cross member	Aluminum	Cast
Rear rails	Low-grade carbon fiber composite	Fabric stamping or RTM
Rear bumper	Low-grade carbon fiber composite	Pultrusion
Rear deck opening	Steel	Stamp

RTM = Resin Transfer Molding
SMC = Sheet Molding Compound

The improved casting stiffness permits thinner gauge steel applications with reduced mass which saves the overall weight of the body structure. This body structure has superior engineering implementation to use various structural materials, forming operations and techniques of joining.

VII. PROCESSING METHODS FOR LIGHTWEIGHT BODY STRUCTURE

The increment in rigidity of the car's body has been experienced through improvement of connected components of a car body structurally with a less increment in weight by applying ultra high strength steel along with thin-walled steel hydroforming and roll forming methods.

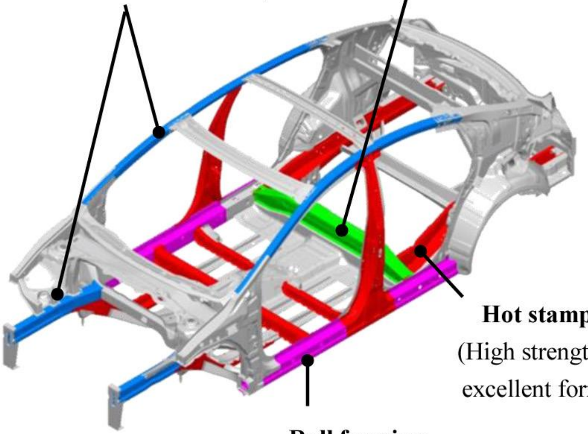

Fig. 2. Processing Method for Lightweight Application[8]

VIII. CONCLUSION

The present study emphasizes the enhancement of automotive structures by applying ultra high strength steel as a B.I.W. material with thin-walled steel hydroforming and roll forming methods by improving lightweight design through optimization of different parts for their particular application for the reduction in weight of the vehicle due to which the vehicular emission reduces and prevents the environment from pollution.

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