Reconfigurable Body Exterior Panels: A Review

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ABSTRACT: Automobile industry has always considered the exterior body of the automobile as their main concern. Automobile sector advancing and developing the exterior panels of the vehicle giving the vehicle an advantage of the reduction of the weight, improvement in fuel efficiency, improvements in aerodynamics, etc. In this paper we have discussed the researches and findings regarding the advancements and reconfigurability of the external panels of the vehicle. Considering the advancements and reconfigurability into the different exterior panels, aerodynamics and materials have been discussed. Aiming the research towards the advancements and re-configurability of the exterior panels, aerodynamics and material used.

KEYWORDS: Exterior panels; drag reduction; aerodynamic enhancements; vehicle efficiencies; smart materials.

INTRODUCTION

Automobile industry is the quickest growing industry today. In the competitive automobile industry must take care of the cost of vehicle, its performance and service [1].

The developing trend for vehicles with mid-range weight to allow better efficiency for fuel, reduction of emissions like CO₂ and consumption of energy constitute an opportunity with task for automobile sector [2].

Optimization of weight is based on the lightweight engineering, 8 % to 10% of increase in fuel economy can be possible with decrease of 10% vehicle weight. Steel is the most used alloy in maximum segments of automotive industry, materials having light weight like high strength aluminum alloys which in comparison to alloy steels have high weight ratio of stiffness to strength, higher corrosion resistivity, recycling ability and joining ability [2] [4] [3].

Lightweight design of the auto frame is a powerful way to reduce vehicles’ weight for reduction of fuel consumption and exhaust emissions or enhancement of the battery power of electrical automobiles [5].

Designing lightweight vehicles is an important task and strategy for increasing fuel economy and reducing CO₂ emissions [6].

There were tremendous modifications inside the use of materials in extraordinary fields internationally. Fiber reinforced polymer composite (FRP) materials constitute a unique class of advanced substances with scientific and industrial applications [7].

The applications of composite materials in the automobile industry creates the requirement for obtaining complex systems that have advanced traits to the traditional substances regarding their mass reduction. Selecting materials appropriately results in optimization of lightweight vehicles. The material behavior under high temperature conditions of composite substances is not like that of traditional materials [3,7].

Customer demand for alternatives which include power windows, power steering, heated seats, and in latest year’s complicated facts and entertainment structures has cause a steadily growing variety of components, and mass [4].

As there is increase in the amount of mass in an automobile, the basic legal guidelines of physics dictate that you ought to increase the amount of energy essential to move the car. Combustion engines are more efficient than their
systems with Vehicle of better high effect

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advanced increase Exterior functionality, Automobileute Automobile PROBLEM [12]

Improving led the predecessors, to these automobiles.

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To increasing in number of vehicles on the road. Increasing number of people have been the cause for growth in annual mileage of vehicles [8-11].

Improving the materials used improves many aspects like Improves down force and traction, provides stability to the vehicle at excessive speeds, improves braking overall performance, Improves tyre overall performance in cornering [12].

PROBLEM DEFINITION

Automobile industry has always considered the exterior body of the automobile as their main concern which contributes to vehicle efficiency, aerodynamic efficiency, weight of the vehicle.

Automobile exterior panels usually used are the passive exterior panels which cannot be reconfigured and contribute mostly on weight, which can be improved by using active aerodynamics which would give an advantage of multi functionality, reduction of the weight, improvement in fuel efficiency and improvements in aerodynamics.

Exterior panels traditionally used in an automobile industry include aluminum, metal, glass, iron, steel, rubber, petroleum products, copper, and others. Optimization of weight is based on the lightweight engineering, 8 % to 10% of increase in fuel economy can be possible with decrease of 10% vehicle weight which could be achieved by use of advanced composite materials, smart materials which can be reconfigured and can even be multifunctional.

OBJECTIVES

1. To study and know the possibilities of reconfigurable exterior body panels for automobiles.

2. To study and know the advancements of materials which can be used for reconfigurable panels.

3. To study the developments which can be made to achieve reduction of the weight, reduction of emissions, improvement in fuel efficiency, improvements in aerodynamics for an automobile.

4. To study and know the research gaps due to which the advancements in exterior panels of an automobile cannot be achieved.

5. To make the study useful for new researches and researchers.

EFFECTS OF AERODYNAMICS AND AERODYNAMIC ENHANCEMENT ON DIFFERENT AUTOMOBILE PARTS

The subject “Aerodynamics” studies with air flow passing over the automobile and the behavior of air flow. The effect of aerodynamic design is increasing fuel efficiency, reducing drag and improving the stability of automobile in high speed [13].

With growing of automobile industry, people begin to be aware of dynamic performance of cars [14-15].

The aerodynamic forces appearing on an automobile significantly reduces its efficiency. The vehicle can produce better effects if redesigned to optimize those forces. Active aerodynamic surfaces (AAS’s) to improve the trip comfort of automobiles. AAS’s are constituted by way of air foils which can be mounted on vehicle chassis with modulated change in angle of assault [14-15].

Vehicle dynamics control (VDC) system offers manufacturing industries a way to symbolize the control and comfort with offering more performance with their models and safety of passenger. As such, VDC ha became a logo-defining feature, these structures have good impact on the dynamic conduct of vehicle depending on distinct lively aerodynamic systems [15].
Effect Of Spoiler On Aerodynamic Performance

The drag force is produced by way of relative motion between air and vehicle with about 60% of total drag at the rear end. A spoiler is tool which is locate in sedan-based automobile model at rear end for improving aerodynamic performance. Spoiler means the “ruin adverse air motion throughout a car body in movement” it is whenever effect on aerodynamic overall performance. Spoiler installed on the front end of the car is known as Air Dams whereas the spoiler on the rear end is called rear wing [13,16-18].

Rear wing (spoiler) is a tool used inverted role on the rear end of vehicle model for generating negative lift and improving aerodynamic performance. Wing is very effective for producing proper amount of down force is very important for improving aerodynamic overall performance. As the Bernoulli’s effect states, the downward force is provided with the inverted wings aerodynamics. The generated downward force results in the growth in vertical pressure of the tyre on ground [19-21].

With inverted wing configuration downward pressure distribution can be changed and result, plays a big role in crucial impact due to distribution and affects the driver’s protection and handling of race vehicles. In a passively operating aerodynamic device, the wings configurations are decided on according to the type of circuit, race vehicle dynamic behavior, tyre houses and the climate situation. The active inverted wings potential has been tested in various applications of automobile for increasing the experience for comfort, control of the pitch movement, improving the vehicle management, and enhancing its brake. The lift forces were managed by means of changing the perspective of attack angles momentarily and decided to mount the spoiler on the automobile frame. Important factors like lift and drag should be considered while designing a vehicle [19, 22-24].

Discussion of Different Experimental Strategies: -

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<td>AERODYNAMIC PARTS</td>
<td>Change in angle of elevation for reducing lift is 80, 100, 150 coefficients. With an addition of a wing with 8° diffuser helps in reducing the lift considerably (34% reduction in lift coefficient Cl) with slight increase in the drag coefficient (0.5% increase in drag coefficient Cd)</td>
<td>[18]</td>
<td>Providing active rear wing with different angels at different speeds can be effective in reducing lift and drag.</td>
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<td>The diffuser angle for optimum drag reduction of sedan based and wagon-based model is 8° and 5° respectively. The improvement for the sedan was approximately 4%, from 13 % reduction of the drag coefficient Cd.</td>
<td>[25]</td>
<td>Considering sedan and wagon shaped automobiles, having active aerodynamics can suggest a proper angel at which the car can experience reduction in lift and drag.</td>
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<td>Change in diffusers with angles of 0°, 3°, 6°, 9° and 12° on a sedan type car model. The outcome of CFD investigation is the drag coefficient first reduced from 0° to 6° and then improved from 9° to 12° whereas the lift coefficient every time reduced from 0° to 12°.</td>
<td>[27]</td>
<td>The researcher experimented on different angels of diffuser for sedan shaped car and got results for reduced lift and reduced drag, by which we can say that having an active diffuser and rear wing would help at different speeds and handle cornering effectively.</td>
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Working on the flap combination for improving the performance. The drag reduction related with reducing the back angle from 30° to the most favorable of around 12°. The test velocity was 40m/s. Aerodynamic drag reducing up to 25% with best combination of flaps, improving efficiency as well as stability of model in higher speed.

Numerous studies and experiments have shown that the dominant fluid motion over the rear area of an automobile and its wake are highly correlated with the flow coming through its underbody. This dynamic implies that it may be possible to modify the flow behind the passenger vehicle by controlling the flow through the underbody. Considering the rear under configuration of the automobile itself, passenger cars have a diffuser shape between the road and the rear underbody.

Control techniques applied to the forebody, such as the passive approach employing a porous surface medium can lead to large reductions in drag (reported on the order of 40%), but would require reducing the amount of cargo/cabin space in the vehicle by 10%. With over 60% of the pressure drag on the model due to the after-body separation, control is often implemented on the after body in order to directly modify the wake to yield an aerodynamic benefit.

The researcher experimented on different angels of grill flaps on the front end of the car and found out the best angels for flaps to open at certain speed which can be different for different speed and effectively improve efficiency and stability.

The researchers experimented on an active diffuser and only at high speeds (above 70 km/h) does the rear diffuser device become active and control the rear flow of the automobile to reduce the aerodynamic drag.

The researchers experimented on a flat back body of a vehicle specifically trucks and buses and achieved an active flow control at the back of the vehicle by developing active back body which will get a conical shape at the back and effectively reduced drag and increase fuel efficiency for heavy vehicles.

Effect of Front End and Front Grill of Automobiles

The car manufacturing organizations have committed many different efforts to improve fuel economy due to the fact many countries have established the emission norms for reduction of air pollution due to harmful exhaust gases, and the depletion of fossil fuel is also coped by Ministry of Environment, 2014. Attempt to enhance the fuel performance starts the new era of designing conceptual car [13-14,29].

Front End Air Flow (FEAF) impacts the drag aerodynamics in addition to cooling of engine loads. Therefore, one way to improve cooling and reduce aerodynamic drag is to manipulate the FEAF, which flows and passes to engine room through condenser, radiator, and fan module (CRFM). The grill shape influences FEAF lots in order that the examiner of grill form should be finished to enhance FEAF [29].

The advantages of restricting huge amount of cooling air flow getting into the below-hood area are not best confined to lowering the aerodynamic drag. Cooling drag is a part of the total aerodynamic drag, which arises attributable to air flowing via the grill, cooling module, and the irregular underneath-hood area [30].

The trend is to continuously increase cooling necessities, each as a result of accelerated engine energy, and for the Air Conditioning (AC) machine, exhaust after treatment and auxiliary systems to work nicely. The cooling drag issue may
be up to 8% of the overall drag, which is a substantial amount. At the equal time because the cooling demand is growing, there are also discussions regarding how to shut some cooling flows off, for instance at toll road speeds, whilst the entire cooling capacity is not wanted. In such situations, gasoline intake can be decreased as the cooling airflow is cut off [31-32].

Active Grill Shutter is around and emerging as a new system. It controls the grill beginning according to the cycles of the car. Due to this it could trade the flow of cooling air into the engine room, decreasing the resistance to aerodynamics and controlling temperature of the engine [33-34].

MATERIALS FOR AUTOMOBILE EXTERIOR PANELS

The automobile industry uses a high-quality number of substances to construct automobiles, which include aluminum, metal, glass, iron, steel, rubber, petroleum products, copper, and others. Automobile substances have advanced substantially in the past years, developing to extra sophisticated, better constructed, and more secure. It has changed as new manufacturing technology have emerged in automotive sector over time and are utilized in more and more progressive ways [35].

Automotive is one among the biggest purchasers of construction substances within the international. Increasing the sturdiness and trustworthiness of the work of the elements of motors is an applicable and crucial trouble of material technology. The development and increase in the requirements for the quality and protection for used materials calls for the application and creation of new methods [35-37].

Alongside the cost elements like fuel consumption, weight, safety, comfort, and emission of pollutants will increasingly affect the market of a new automobile inside the coming years. The purchase selection is going to be critical at the gas intake and luxury. In order to understand a lower fuel intake, both, the development of engines with an excessive performance and the lightweight layout must be taken into consideration as well [38].

One way to get low emissions is via reduction of load in the automobile consequently reducing the pollutants and fuel cost. Reduction of weight by 100 kg which leads to a gasoline savings up to 0.35 liters per 100 km and 8.4 grams CO₂ per km with petrol engines considering the adjustment of tools without any exchange with acceleration and in elasticity. Even with the growing use of new construction materials in the automobile sector, steel consumption continues to show a leading role in the steel production. Most weight on modern cars come from steel. The average car was produced with 1090 kg of steel, and an average SUV or pickup truck used nearly 1360 kg in 2007 [35,39].

Smart materials can also be considered to lower the weight of the vehicle and achieve low emissions. Smart materials can respond to a clever in a beneficial and reproducible way. The materials aren’t “smart” by themselves; they react passively to an input rather than adapting themselves and making their own decisions [40-42].

Current Materials and Reconfigurability

Steel or various metallic alloys are used to make all accountable parts of the automobile. Steel has high reliability and strength, but it is vulnerable to rust, and the elements fabricated from it, range a large mass. Improved stiffness collectively with reduction in weight results in the improvement and software of various grades of excessive steels strengths. Many phosphorous-alloy and micro-alloy steels each with and without bake-hardening are used often. Increase in the use of twin phase steels, TRIP-steels and interstitial-free (IF) steels even ultra-low and superb extremely low carbon steels are also determined [35,43].

Excessive strength and their rigidity in an advanced composite help to preserve identical or better degree of safety as given by way of materials used conventionally to manufacture aerospace and road shipping vehicles. The first attempts had been made to facilitate the design of the automobile by the usage of components made from synthetic fibers. Insufficiently worked out technologies did not allow to acquire high strength material, consequently, from synthetic fibers at the start, produced cosmetic panels of the car. Using the modern advances in science, polymer compounds prove a lot more strength and hardness than traditional steel. Due to the interweaving of artificial fibers, a robust reinforcing body is shaped due to which the load is uniformly distributed over the whole floor of the structure. The primary benefits of the use of polymer composite in car is the reduction in weight because the composites are 60%
more lighter than steel and 35% more lighter than aluminum and the usage of composites in car could lead to an ordinary automobile loss of weight up to 10% [35,44].

Composite materials currently used are thermoset based in addition to thermoplastics consist of SMC (sheet molding compounds) or GMT’s (glass fiber mat thermoplastics), BMC (bulk molding compounds), and LFRT (lengthy fiber reinforced thermoplastic composites), in which glass fiber is used. Different class of light weighting materials being used in automobile for the “greening” are natural fiber reinforced composites used in automotive sector. Natural fibers if replaced by glass fibers which allows lighter additives as the density of natural fibers at 1.5 g/cc is less in comparison to glass fibers at 2.5 g/cc at the same time as concurrently growing the share of renewable useful resource content material within the car. Lately, for the reinforcement of plastic matrices, carbon fibers are being used, as those composites have maximum reduction of weight capacity, with featuring high stiffness in comparison to glass parts, industry grade carbon fibers give a modulus of 230 GPa, that's 3 instances higher in comparison to E-glass fibers (70 GPa) having particular gravity simplest of 70% E-glass fibers. But the high value appears as an obstacle to exploitation of large scale of this material. Developments in production of low-cost carbon fiber and recycling has spread out new grounds for light-weight automobile production [45].

Smart Materials Used in Automotive Structures

“Intrinsically adaptive materials” and “Active materials” are also the names given to smart materials. Adaptive materials are substances which lay open to adjustments in their microscopic or molecular structure because of a specific external stimulus (typically specified with a small percentage of electricity concerning the deforming strength of the fabric), results in mechanical residences changes. The SMP (shape memory polymers) and SMA are samples of intrinsically or naturally adaptive materials. Active materials act as transducers, changing some kinds of electricity (normally magnetic, thermal, and electrical) into mechanical power. Piezoelectric ceramics, electroactive polymers and magnetostrictive (Terfenol-D) are few examples relating to active materials. Active materials having excessive electromechanical coupling also can be utilized in an “intrinsically adaptive mode”; in this example, they need low electricity delivered, but they show extra restrained performance. [40,42]

The best concepts and materials to be adopted depend upon specified purpose of morphing. As the aim is to deliver flight control with the change in shape of wings, the morphing system is required, faster dynamics; ability to operate for a wide range conditions; ability of repetitive actuations; high reliability; sturdiness against disturbances and uncertainties; lower power intake; Insensitivities to environment variation [35,38,40].

The polymer-based composites in automobile sector are glass fiber-reinforced thermoset polymers used in non-structural parts of the automobile especially for low- and mid-volume cars and trucks [46].

Self-Healing Materials and Coatings

Self-healing materials have attracted lots interest because that they possess the potential to increase the lifetime of substances and reduce the total value of systems for the duration of the manner of long-time period use; incorporation of practical materials enlarges their uses. Self-recovery materials are synthetic materials which can self-heal after being broken. Self-recovery materials have attracted a whole lot attention due to lifetime of the materials, reduction in maintenance cost, and improve public safety [47-48]. Graphene, as a promising additive, has obtained extremely good interest due to its huge specific floor vicinity, ultra-high conductivity, sturdy antioxidant traits, thermal stability, high thermal conductivity, and properly mechanical properties [47].

STP (silanol-terminated polydimethylsiloxane) is a restoration agent with DD (dibutyltin dilaurate) compound is used to self-heal in low temperatures. The response of STP inside the existence of DD progressed at low temperatures (20o C) to create a viscoelastic material, which exhibits viscoelasticity at 20o C. STP and DD had been one at a time microencapsulated the use of urea formaldehyde polyurethane and resin as shell materials. When the self-healing layers having microcapsules get damaged, DD and STP releases from the broken microcapsules and fills the broken area at lower temperatures (20o C), which turns into showed through release tests. STP/DD-based microcapsule-type self-recuperation system has suitable self-healing at low-temperature potential [47-48].
CONCLUSIONS

1. In automobile industry aerodynamic performance is very important factor. Therefore, the aerodynamic enhancements stated involves the improvement of drag reduction, aerodynamics, vehicle efficiency, fuel efficiency, emission control, weight control of the automobile exterior panels, stability of the vehicle.

2. Use of active aerodynamic enhancements help in adapting to different speeds and adjust the aerodynamics accordingly giving the advantage to reduce drag and lift experienced by vehicle.

3. Materials used in the automobile industry has had a variety of changes regarding materials used, weight of material, various reinforcements, re-configurability.

4. Material re-configurability using smart materials and polymer composites leading to light weight structure enhancing the performance of the automobile by strengthening the structure and use of lightweight materials lead to higher emission control.

5. Material advancements and use of this advanced material can help in various aspects like having multifunctionality for different parts which would save weight.

6. Advanced polymers and coating which have self-healing properties can help in vehicle protection and lower maintenance of the vehicle.

REFERENCES


