Airbag System

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Abstract - The design of airbag systems in vehicles incorporates adaptive conditions to ensure optimal deployment and enhance occupant safety during crashes. These conditions are meticulously calibrated to respond to diverse factors, reflecting advancements in sensor technology and a commitment to strict safety standards. Crash severity is a primary determinant, with sensors gauging impact intensity. Airbags are programmed to deploy during moderate to severe collisions, surpassing predefined impact thresholds. Additionally, sensors discern the impact direction, allowing selective deployment based on whether the collision is frontal, side, or rear. Occupant safety is further addressed by considering position and weight. Advanced systems adjust deployment force based on occupant attributes, ensuring optimized protection. Seatbelt usage is also factored in, influencing deployment force depending on whether seatbelts are engaged. In scenarios involving multiple collisions, the system adapts by deciding not to deploy airbags in secondary impacts if already deployed in the initial collision. Vehicle speed at the time of impact is crucial, influencing airbag deployment for enhanced protection during high-speed collisions. Roll-over sensors add an extra layer of safety, detecting potential roll-over situations and triggering side curtain airbags.Furthermore, braking and acceleration patterns just before a collision are considered to fine-tune the airbag deployment strategy. This adaptive approach to airbag deployment varies between vehicle makes and models, highlighting the continuous evolution of safety measures. Rigorous testing and adherence to safety standards by manufacturers underscore the commitment to ensuring airbags deploy appropriately in diverse and challenging scenarios.

Key Words: Adaptive condition, Sensor technology, Crash severity, Occupant Attributes, Multiple collisions, Roll-over Sensors

1. INTRODUCTION

Airbag systems in vehicles are designed to deploy under specific conditions to maximize safety for occupants. These conditions are typically adaptive and take into account various factors to ensure the airbags deploy when needed. Here are some common adaptive conditions for airbag deployment:

1.1. Crash Severity

Airbags are designed to deploy during moderate to severe crashes. The system uses sensors to measure the intensity of the impact, and if it exceeds a predefined threshold, the airbags are deployed.

1.2 .Impact Direction

Sensors in the vehicle can determine the direction of impact. Airbags may deploy selectively based on whether the collision is frontal, side, or rear, deploying only those airbags that are most relevant to the impact.

1.3. Occupant Position and Weigh

Advanced systems take into account the weight and position of the occupants. They may adjust the deployment force or decide not to deploy certain airbags if the sensors detect that the seat is unoccupied or a child is in the seat.

1.4. Seatbelt Usage

Some airbag systems consider whether occupants are wearing seatbelts. In certain situations, the deployment force may be adjusted based on whether the seatbelt is being used to optimize protection.

1.5. Multiple Collisions

If a vehicle is involved in multiple collisions, the airbag system may adapt its response. It may choose not to deploy the airbags in a secondary collision if they have already deployed in the initial impact.

1.6. Vehicle Speed

The speed of the vehicle at the time of impact is considered. Higher speeds may trigger airbag deployment to provide additional protection during more severe collisions.

1.7. Roll-Over Sensors

Some vehicles are equipped with sensors that can detect a potential roll-over. In such cases, side curtain airbags may be deployed to protect occupants in the event of a roll-over.

1.8. Braking and Acceleration

Some systems take into account information about the braking and acceleration patterns just before a collision to determine the appropriate airbag deployment strategy.

It's important to note that the specific adaptive conditions for airbag deployment can vary between different vehicle makes and models, and advancements in sensor technology continue to enhance the precision of airbag deployment systems for increased safety. Manufacturers follow strict safety standards and conduct extensive testing to ensure that airbags deploy appropriately in various scenarios.

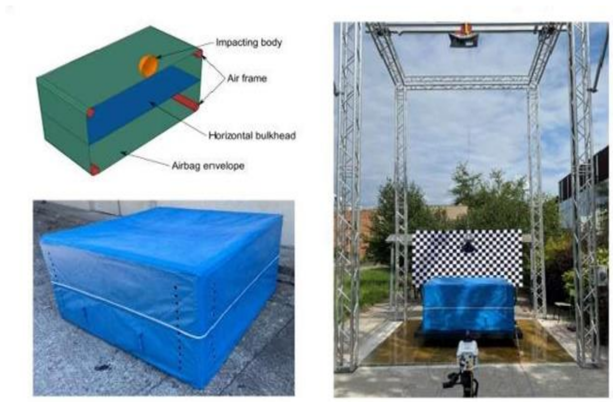

Figure 1:-Adaptive conditions testing airbagdeployment

The primary goal of a rescue air cushion is to minimize the negative effects of the impact resulting from an evacuated person landing on it. A number of quality indices is used in the automotive industry, including the classical head injury criterion (HIC). Similarly, the German norm DIN-14151 which is devoted particularly to rescue cushions specifies the maximum acceptable values of accelerations acting on head, chest and pelvis during the impact. These values cannot be exceeded for longer than Δt = 3ms. Within this study we consider one quality index for which the total force F, acting on the amortized object, is taken into account. Due to mechanical properties of the impacting object utilized in the experimental study, the minimization of total force may be considered as an equivalent to minimization of decelerations. The aim ofthe optimization procedure is to find the venting area Av which will ensure that the highest level of the total force F, exceeded for no longer than a time period Δt, is minimal.

It's important to note that the specific adaptive conditions for airbag deployment can vary between different vehicle makes and models, and advancementsin sensor technology continue to enhance the precision of airbag deployment systems for increased safety. Manufacturers follow strict safety standards and conduct extensive testing to ensure that airbags deployappropriately in various scenarios. The primary thing of a deliverance air bumper is to minimize the negative goods of the impact performing from an vacated person wharf on it. A number of quality indicators is used in the automotive assiduity, including the classical head injury criterion (HIC). Also, the German norm noise- 14151 which is devoted particularly to deliver cocoons specifies the maximum respectable values of accelerations acting on head, casket and pelvis during the impact. These values cannot be exceeded for longer than Δt = 3ms. Within this study we consider one quality indicator for which the total force F, acting on the amortized object, is taken into account. Due to mechanical parcels of the impacting object employed in the experimental study, the minimization of total force may be considered as an original to minimization of retardations. The end of the optimization procedure is to find the venting area Av which will insure that the loftiest position of the total force F, exceeded for no longer than a time period Δt, is minimum Comparison of numerical and experimental results in two named cases:-

- Case (a) m = 5.7 kg, v0 = 2.53 m/ s(h = 0.33 m)
- Case(b) m = 10.7 kg, v0 = 6.96 m/ s(h = 2.47 m) The study indicates a significant problem, which is veritably important from the practical point of view and should be addressed by the experimenters working in the field of engineering structures, in particular adaptive impact immersion. The donation consists of formulating a new problem and presenting a general frame, which is applied by the authors to break the problem and make evacuation operations safer. Numerical models of the airbag system, which haven't been published by any experimenters to date, were developed by the authors and outlined at the morning of the composition. Novelty of the presented exploration can be set up also in the proposed adaption system, which includes consideration of the delicacy of the impact parameters' estimation.

2. CURTAIN AIRBAG DESIGN

Since its invention in the early 1990s, the side curtain airbags have become an important part of vehicle restraint systems and they are widely used to prevent serious injuries by increasing head protection for both front and rear seat occupants. For the US market, one measurement is the safety criteria that include measuring the amount that a human head can go out of the widows (in millimeters) and is called, Ejection Mitigation. One of the principal requirements for inflatable curtains is to shield the occupants from intruding objects. The design process for curtain airbags in automobiles is a complex and iterative one, involving communication between car manufacturers (OEMs) and airbag suppliers. The coverage area, which includes considerations for various occupants and the positioning of car pillars, roof rails, door glass, seats, dashboard, and steering wheel, is a critical factor communicated to airbag manufacturers as a requirement. The design of the curtain airbag involves front-loading simulations from early conceptual phases to meet specific requirements such as volume and Energy-to-Mass ratio (EjM). The design process is simulation-driven and iterative, where finite element simulations are employed with separate models for each requirement. The coverage requirement is addressed first in a Computer-Aided Design (CAD) environment, and then volume and EjM are calculated using finite element simulation models. The number of islands and the size of chambers in the airbag design depend on the size of the designed bag, which, in turn, is influenced by the size of the vehicle. For larger vehicles like SUVs, additional chambers may be added, requiring a higher capacity of inflators. The iterative nature of the design process involves adjusting the design parameters, such as the number of chambers and inflator capacity, until all safety and design requirements are met The design process involves multiple loops between coverage, volume, and EjM requirements, with engineers going through as many as 50–60 iterations. This iterative looping continues until all three requirements are satisfied. The process is time-consuming, involving pre- processing, processing, and post-processing steps. The importance of an automated prediction model in the early phases of the design process is emphasized to streamline and expedite the overall process.

This investigates the impact of design parameters on airbag volume, focusing on a generic prototype inspired by the front chamber of an actual curtain airbag. The prototype incorporates essential features for comprehensive analysis. 14 carefully selected parameters are studied, guided by design

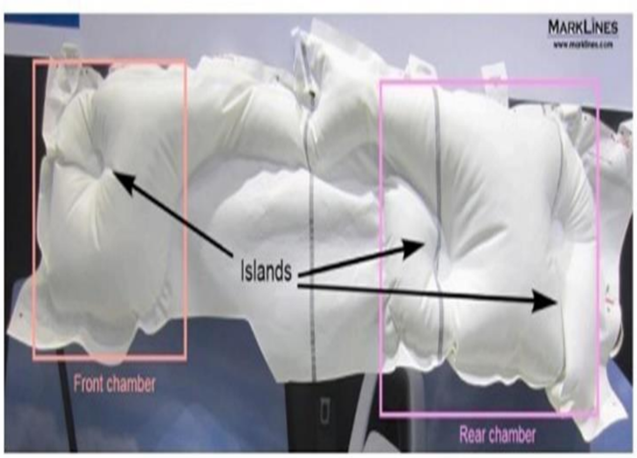

Figure.3:- Curtain Airbags Design

parameterization principles, including the Independence and Information axioms. The Independence axiom ensures the autonomy of design intent, with parameters confined to intervals allowing for variation. The Information axiom minimizes the information content by selecting parameters to cover diverse design cases with a minimal set. The study aims to identify the most influential parameters affecting airbag volume, with Table presenting parameter names and associated bounds.

Parameter Name	Min (mm)	Max (mm)
Offset1	50	100
Offset2	50	100
Radius1	40	135
Offset12	40	135
Radius2	40	60
Offset22	35	70
Radius3	40	100
Radius4	60	100
IslandOffset	100	250
IslandR1	10	50
IslandR2	10	50
IslandAngle	40°	130°
IslandLength	150	220
IslandBottom	40	180

This study investigates the impact of 14 geometry parameters on airbag volume using a One Factor at a Time approach, altering each parameter in five steps. The results, presented in, reveal the sensitivity of volume to parameter changes, with length-like parameters showing linear correlation and radiuslike parameters exhibiting quadratic correlation. Parameters 'IslandOffset' and 'IslandAngle' demonstrate a unique behavior, initially decreasing and then increasing the volume. The Pearson coefficient (R^2) is employed to evaluate correlations, indicating the linear relationship between parameters and volume. The study highlights the importance of considering parameter effects on volume change and the implications for machine learning precision. In a second study using a Latin Hypercube, 100 design samples are generated, illustrates the limited correlation (low R^2 values) between three parameters and volume. The lack of correlation among all CAD parameters and simulation output is attributed to varying impacts of parameters on volume change, affecting the accuracy of machine learning regression models. The study emphasizes the challenges of meaningful relation discovery in machine learning algorithms when using low- correlated features.

3. AIRBAG OPENING

Airbag in care safety devices that deploy in the event of collision to protect occupants. They do not operate on a frequency range like electronic signals or waves. Airbags in cars are designed to deploy in the event of a significant impact, such as a collision. The deployment of airbags is triggered by sensors within the vehicle that detect rapid deceleration or a collision. When these sensors detect a force that exceeds a predetermined threshold, they send a signal to the airbag control module. The airbag control module then activates an igniter or inflator within the airbag system. This igniter rapidly produces a gas, usually nitrogen or argon, which inflates the airbag. The inflated airbag acts as a cushion to help protect occupants from striking hard surfaces inside the vehicle during a crash. It's important to note that not all collisions will result in airbag deployment, as the sensors are programmed to consider various factors such as the severity and direction of the impact. Airbags are designed to deploy in moderate to severe frontal collisions, but not necessarily in low-speed impacts, side collisions, or rear-end collisions. After the airbags deploy, they generally deflate rapidly to allow the occupants to exit the vehicle safely. It's crucial for individuals involved in a crash to follow proper safety procedures, such as wearing seat belts, and to seek medical attention as needed. Additionally, once airbags deploy, they typically need to be replaced, and the vehicle's airbag system should be inspected by a qualified technician to ensure it functions properly for future use. Airbags deploy in response to significant impacts detected by sensors in the vehicle. The deployment process involves the activation of an igniter or inflator, rapidly producing gas to inflate the airbag. Not all collisions trigger airbag deployment, as various factors such as impact severity and direction are considered. After deployment, airbags deflate rapidly to allow occupants to exit safely.

4. TIME REQUIRED AIRBAG OPENING

The time it takes for airbags to deploy in a car varies, but it typically happens very quickly. In most cases, it takes just milliseconds (thousandths of a second) for the airbags to deploy once the sensors detect a collision or rapid deceleration that surpasses the predetermined threshold. The speed of deployment is crucial in ensuring that the airbags are fully inflated and able to provide protection to occupants before they come into contact with hard surfaces within the vehicle. Modern airbag systems are designed to react almost instantly to the forces associated with a collision. It's important to note that the exact deployment time may vary based on the make and model of the vehicle, as well as the specific design of the airbag system. Manufacturers conduct extensive testing to determine the optimal deployment time for their airbag systems to maximize safety in various crash scenarios.

5. PRESSURE

The pressure developed in airbags during deployment can vary, but it is typically within the range of 2,000 to 3,000 pounds per square inch (psi) or approximately 138 to 207 bar. The high-pressure gas generated by the inflator rapidly fills the airbag, causing it to inflate within milliseconds to provide a cushioning effect during a collision It's worth noting that the pressure in the airbag decreases quickly after deployment as the gas vents from the airbag. The primary purpose of the high pressure is to ensure rapid and effective inflation to provide protection to the vehicle occupants. The specific pressure levels can vary based on the design and specifications of the airbag system used by different vehicle manufacturers. These systems are carefully engineered and tested to meet safety standards and provide effective protection in various crash scenarios.

6. EFFECT OF IT

- **CASE 1-**

A 29- time-old manly subdued motorist of a 13- time-old compact hydrofoil was injured in a head- on collision. Paramedics set up him lying prone outside his auto, the airbag was noted to have stationed. He'd a Glasgow coma scale (GCS) of 15 and was noted to have a large rent on the right jaw. In sanitarium he was conscious and alert but due to the threat of a compromised airway, he was intubated alternatively. He'd no other egregious injuries. His head motorized topographic (CT) check-up flicks showed an oppressively milled fracture involving the right hemi- beak with disturbance of the right temporal and fibular joint. A2.2 ×2.1 ×2.1 cm hyper dense foreign body (FB) was seen in the vicinity of the fracture scrap at the position of the right ramus. Multiple fractures of the anterior and side walls of the right zygoma.

| Patient | Age/Sex | Crash Details | Vehicle Age
(Year of Manufacture) | Airbag Injuries |Other Injuries
| Outcome | Seatbelt | Foreign Body Dimensions |
| 1 | 29/M | Head-on collision, driver | 2008 | Right mandibular fracture | None | Alive, discharged on 14th post-injury day | Yes | 22 x 21 x 21 mm |
| 2 | 43/M | Single vehicle frontal collision,
driver, entrapped, extricated by EMS | 2009 | None | Expired on 128th post-injury day | Yes |
25 x 25 mm (Measured on CT Images) |

| 3 | 24/M | Head-on collision, driver, single vehicle collision | 2011 | None | Fracture of Cl vertebrae, basioccipital, etc. | Alive, discharged on 8th post-injury day | Yes | 20 x 15 mm maxillary sinus reaching the bottom of the right route were also noted. The case was taken to the operating room (OR) and passed disquisition with reclamation of a round metallic FB and open reduction and internal obsession (ORIF) of the beak.

| 4 | 37/F | T-bone or side impact on driver's side, driver, entrapped in vehicle, found in cardiac arrest | 2013 | Right sucking chest wound, lung laceration, etc. |Diffuse cerebral edema, Grade 2 spleen and liver injuries, etc. | Expired on 6th post-injury day | No | Not available |

| 5 | 28/M | Mechanic working on airbag, no damage to vehicle, Sedan vs. truck driver | 2009 | None

| Right mandible fracture, penetrating injury to right neck, etc. | Alive, discharged on 7th post-injury day | Yes | 25x25x2.1 cm |

| 6 | 21/M | Foreign body dimensions | 2008 | None
| The patient underwent ORIF right mandible | Alive, discharged on 4th post-injury day | Yes | None |

- **CASE 2-**

A 43- time-old manly intoxicated subdued motorist of a 3-time old hydrofoil was injured in an anterior collision with a fixed object. There was significant damage to the vehicle and the case was entangled. When the paramedics arrived he'd a GCS of 12, was tachycardia with a systolic blood pressure (SBP) of 90 and an oxygen achromatic below 80. He was also noted to have a stinking crack in the left upper casket with active bleeding.

The case was intubated at the scene, and a 3- sided dressing was applied to the crack, and a needle relaxation was performed. In the trauma bay, a left sided casket tube was fitted still his achromatic didn't significantly ameliorate. A casket x-ray (CXR) showed significant lung bruises with a rounded metallic FB noticed in his upper casket and verbose subcutaneous emphysema with mild pneumothorax was noted. Casket CT check-up showed a metallic FB lying between the left scapula and the skin. There was an substantiation of pre Being cystic bronchiectasis in both lung fields. Expansive surgical emphysema was also noted on the left side of the casket extending to the neck and abdominal wall with bilateral pneumothorax and multiple shattered caricatures on the left side and manubrium sternum.

The case passed a left thoracotomy. He was set up to have a rent in the apex of the left lung with a rounded metallic FB, bone, and cartilage fractions within the lung. Hemostasis was performed and the case was put on extracorporeal membrane oxygenation (ECMO) due to severe respiratory failure. He expired after 4 months in the sanitarium while still on extracorporeal membrane oxygenation (ECMO). This case series would help the trauma healthcare providers to more understand airbag-related injuries which could impact the operation of road business injury case that has an associated piercing trauma.

Also, it would bring attention to injury forestallment brigades as well as the state and artificial authorities to revaluate safety norms in vehicles. participating this information with original authorities who govern product safety norms and recalls is essential to insure that further conduct are taken to ameliorate the public safety in this regard.

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7. CONCLUSION

Real-life cases illustrate the impact of airbag deployment on individuals involved in accidents. The cases highlight injuries and the role of airbags in providing protection. The importance of proper medical attention, adherence to safety procedures, and the need for airbag system inspection and replacement after deployment are emphasized. In conclusion, the report provides a comprehensive overview of various aspects related to airbag systems, from design considerations to real-life impacts. It underscores the importance of continuous research, safety standards, and collaboration between automotive and safety authorities to enhance the effectiveness of airbag systems and reduce injuries in vehicular accidents.

8. REFERENCE

[1] Shivapirakasam S P[a], Balasubramanaian K R[a] and Surianarayanan M[b],Thermo-kinetic studies on azodicarbonamide/potassium periodate airbag gas generants (2020),[a]Industrial Safety lab, National Institute of Technology, Tiruchirappalli, Tamil Nadu, India, [b]Cell For Industrial Safety and Risk Analysis, Central Leather Research Institute, Chennai, Tamil Nadu, India.

[2] Faraj R, Poplawski B, Gabryel D, Kowalski T and Hinc K, Adaptive airbag system for increased evacuation safety (2022), Institute of Fundamental Technological Research Polish Academy of Sciences, Warsaw, Poland.

[3] Ahmad Z, The unassuming danger of car airbags: Injuries secondary to airbag deployment (2011), Department of Plastic Surgery and Burns, Salisbury District Hospital, Salisbury, Wiltshire SP2 8BJ, UK.

[4] Rada M A , Salomonssonb K , Cenanovica M , Balaguec H, Raudbergeta D and Stolta R, Correlation- based feature extraction from computer-aided design, case study on curtain airbags design (2022), Department of Product Development, School of Engineering, Jönköping University, Jönköping, Sweden.

[5] Khoschnau S, Ramzee A, El-Menyar A, Peralta R, Consunji R, Kloub A, Ajaj A, Abdelrahman H and Al- Thani H, Airbag-related penetrating injuries: A case series from a level 1 trauma center (2023), Department of Surgery, Trauma Surgery, Hamad Medical Corporation, Doha, Qatar.

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