Vehicle Safety Technology

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ABSTRACT

Vehicle safety has been developed to ensure the safety and security of automobiles and passengers. Of all systems used on daily basis, road transport is by far the most complex and dangerous, claiming lives estimated at almost 1.2 million. Thus it has become a prime target in order to achieve safer road traffic system and curb minor and fatal injuries to occupants. This has caused innovation of various devices, projects and new technology. These technologies addresses need to help avoid a crash or reduce injuries during crash termed as crash avoidance and crash protection. In this advanced era, technology has grown in leaps. There are many technologies or devices to choose from. This paper analyzes various vehicle safety features and technologies available today, there working and there importance in the vehicle.

Keywords: *Vehicle safety, Road accidents, crash severity and prevention, Active and Passive safety features.*

1. INTRODUCTION

Due to introduction of new technologies, craze for high speed and increasing vehicular population, occurrence of vehicle accidents is increasing day by day. Thus taking more human lives same as or even at times more than any natural calamity.

In order to curb the accident rates a comprehensive action plan has to be drawn. This plan has to take into consideration the interaction between users, vehicles as well as the road environment. Safety precautions are taken in vehicles to avoid human errors that may lead to a crash or protect passengers in the vehicle. Advance safety measures included in vehicles help to reduce the intensity of or severity of a crash.

The development of cars fulfilling upcoming safety requirements is getting more and more complex. One of the reasons of this is the continuous establishment of new safety assessments for vehicles by governments or customer demands/organizations. Beyond these assessments, automobile manufacturers seek to realize Vision Zero, which aims for avoiding seriously injured or killed people on the road. These demands for safe cars drive the development of new and advanced safety systems.

2. Road Crash Causes

As mentioned above, due new technologies and increasing vehicular population, occurrence of vehicle accidents is increasing, thus taking more human lives, at times even more than any natural calamity.

Road accidents are the ninth leading cause of death globally with over 12 lakh people dying on the roads each year across the globe, according to the World Health Organization. India too has a fair share in this figure, losing 1.46 lakh people in 2015 alone. Top 10 Cities with the highest number of Road Crash Deaths (Rank –Wise): Delhi (City), Chennai, Jaipur, Bengaluru, Mumbai, Kanpur, Lucknow, Agra, Hyderabad, Pune [5].

According to statistics, over 1, 37, 000 people were killed in road accidents in 2013 alone, that is more than the number of people killed in all our wars put together.

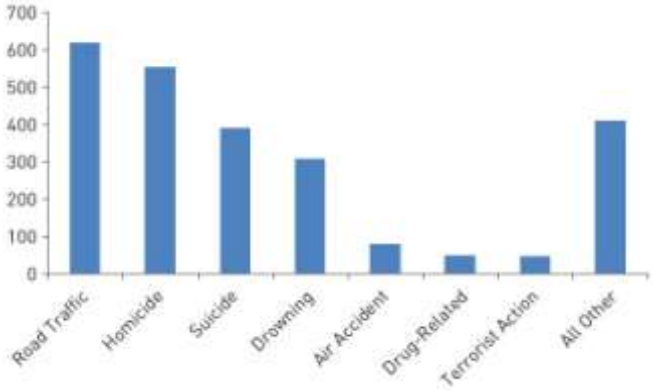

Fig. 1: Leading causes of injury death for US citizens in foreign countries

The road accident crash causes are classified as follows:

Human related
Vehicle related
Road related
Environment related

Statistics show that out of the above causes, 90% of the crashes are as a result of human limitations (human related causes), in short it is very rare that accidents occur due to some technical malfunctions in the vehicle. The statistics is as shown in the following fig.2.

Fig. 2: Injury crash cause

3. Safety features and technologies

Though road crash causes are mostly human related, as mentioned earlier, it is a problem that requires changes, modifications or advancements in human behavior as well as vehicle technology.

The safety features or technologies in vehicles have reached new heights from simple features like wearing helmets or seatbelts (which can drastically reduce severity of injury) to driving safely through traffic without human input, e.g. autonomous car.

3.1. Active and Passive Safety Features

Passive safety features are those which assist after a crash has taken place [1]. These include airbags, seatbelts, helmets, also the structure of the vehicle that deforms in collision, it absorbs the energy of the impact thus protecting the passengers.

Active safety features are those which prevent crashing altogether [1]. These include Anti-Lock Braking System (ABS technology), Electronic Stability Controller (ESC), etc. Some active safety technologies are as follows:

3.1.1. Anti-Lock Braking System (ABS):

ABS includes a central electronic control unit (ECU), four wheel speed sensors, and at least two hydraulic valves within the brake hydraulics.

The ECU constantly monitors the rotational speed of each wheel. If it detects a wheel rotating slower than the others, it actuates the valves to reduce hydraulic pressure to the brake at the affected wheel, thus reducing the braking force on that wheel; the wheel then turns faster. Similarly, if the ECU detects a wheel turning faster than the others, brake hydraulic pressure to the wheel is increased so the braking force is reapplied, slowing down the wheel. The stopping distance of vehicle with ABS system is less after application of brakes, as compared to those without ABS system. This helps in preventing skidding or crashing of the vehicle moving with high speed [1][2].

ISSN: 2321-8169
876 – 881

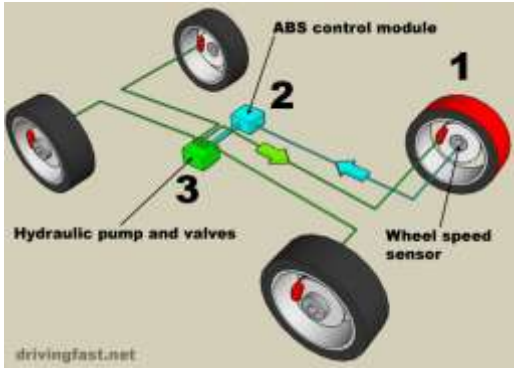

Fig. 3: Components of the ABS system

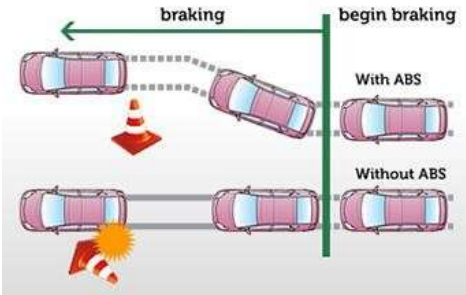

Fig. 4: Comparison between vehicle with ABS and vehicle without ABS

3.1.2. Electronic Stability Control (ESC):

25% accidents resulting in severe injuries are resulted because of skidding. Sudden braking causes wheels to lock and skidding of vehicle takes place.

ESC has speed sensors that keep track of the position of vehicle and determines when the vehicle is going off-road or off-lane. It then uses ABS to brake the required wheel in order to get the vehicle back on road. Also helps in maintaining the lane during sharp turns. ESC helps in counteracting skidding action and helps in preventing the potential risk of road crash. It provides support to drivers in critically dangerous situations.

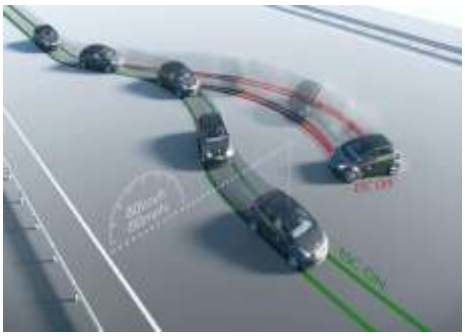

Fig. 5: Comparison between vehicles with and without ESC system

Fig. 6: Comparison between vehicles with and without ESC system while taking a sharp turn.

3.1.3. Collision warning with automatic braking:

In this system, the sensors that are present on the front of the car, senses the traffic whether it is slowing or stopped. It alerts the driver with audible warning or with a red signal which will flash on to the windshield and an alarm will go off. All the while the car pre-charges the brakes, so even the smallest amount of brake application helps to stop the car faster or immediately.

Fig. 7: Row of red signal flashing on windshield to alert the driver

Fig. 8: Basic principle of Collision warning

Some passive safety technologies are:

Passive safety features are those that help to protect vehicle occupants from further injury once a crash has already occurred. The main function of passive safety features is to keep the driver and passengers protected within a certain area which is referred to as a life space [6]. The life space is a protected area around vehicle occupants within which the chances of escaping a crash with minimal injuries are more likely [6]. Passive safety features work to ensure that vehicle occupants remain in this space throughout the crash. Crumple zones help to absorb and distribute crash forces before they reach the passenger and driver's seats. For this seatbelts**,** airbags and headrests help keep the occupants stationary within the life space of the vehicle. Safety features like these reduce the risk of serious injury to occupants of vehicle.

Despite the classification of these features as "passive", they are extremely important when it comes to reducing the severity of crash injuries.

3.1.4. Seatbelts:

When the belt is worn correctly, it will apply most of the stopping force to the sturdy parts i.e. rib cage and pelvis. Since the belts extend across a wide section of your body, the force isn't concentrated in a small area, so it can't do as much damage. Also, the seatbelt is of flexible material. It stretches to avoid abrupt stop. The central operating element in this mechanism is a weighted pendulum. When the car comes to a sudden stop, the inertia causes the pendulum to swing forward. The pawl on the other end of the pendulum catches hold of a toothed ratchet gear attached to the spool. With the pawl gripping one of its teeth, the gear can't rotate counter-clockwise, and neither can the connected spool. When the webbing loosens again after the crash, the gear rotates clockwise and the pawl disengages [8].

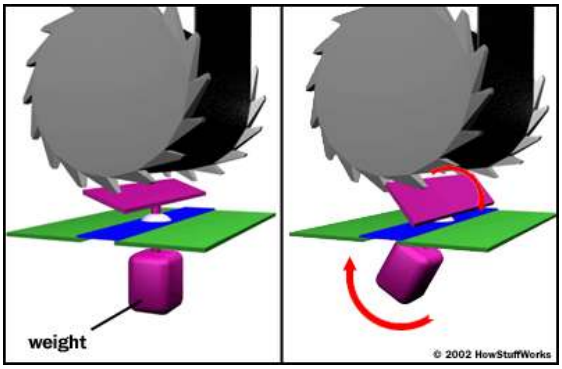

Fig 9: Locking mechanism of retractor of seatbelt

3.1.5. Airbags:

These are large fabric sacs designed to inflate immediately after a crash. The purpose of airbags is to protect occupants from hitting the hard interior of the vehicle. Airbags previously were only installed in steering column or the dashboard. Nowadays, many vehicles come with airbags installed also in the side-panels and around the knees. The inflation of an airbag happens very quickly, in fewer than 40 milliseconds. There are three parts to an airbag that help to accomplish this [9]:

The bag is of a thin, nylon fabric, which is folded into the steering wheel, dashboard, the seat or door.

The sensor is the device that tells the bag to inflate. Inflation happens when there is a collision force equal to running into a brick wall at 10 to 15 miles per hour (16 to 24 km per hour). A mechanical switch is flipped when there is a mass shift that closes an electrical contact, telling the sensors that a crash has occurred. The sensors receive information from an accelerometer built into a microchip.

The airbag's inflation system reacts sodium azide (NaN3) with potassium nitrate (KNO3) to produce nitrogen gas. Hot blasts of the nitrogen inflate the airbag.

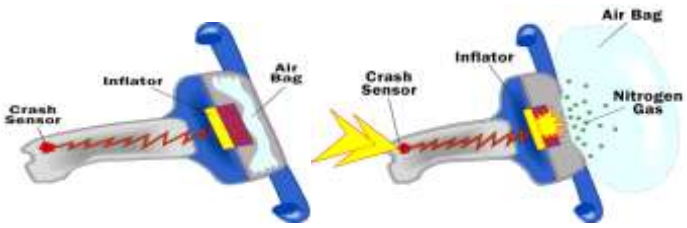

Fig. 10: Working of Airbag

3.1.6 Crumple zones:

Crumple zone or crush zone are areas of a vehicle that are designed to deform and crumple in a collision. This absorbs some of the energy of the impact, preventing it from being transmitted to the occupants. Engineers have to consider many factors in designing safer cars, including vehicle size and weight, frame stiffness and the stresses the car is likely to be subjected to in a crash. For example, race cars experience far more severe impacts than street cars, and SUVs often crash with more force than small cars.

Crumple zones accomplish two safety goals. They reduce the initial force of the crash, and they redistribute the force before it reaches the vehicle's occupants. But car frame has to hold together so the occupants aren't thrown out, thus, an entire car can’t be made crumple zone because you don't want the people inside it to crumple also. That's why cars are designed with a rigid, strong frame enclosing the occupants, with crumple zones in the front and rear.

In small cars, the driver and passenger are enclosed in a safety cell of steel framework with excellent rigidity for its size. The geometry is designed to distribute impacts across the entire frame. At the front and rear of the car are crash boxes. These are small steel frameworks that collapse and crumple to absorb impacts. Because the crash boxes are so small, other impact-absorbing features have been used to supplement them.

In case of race cars, great advancements have been achieved in engineering the structural frame of the race cars to avoid deaths of racers. Prior, the frame of race car was so made that the entire car was a crumple zone. Thus all the force is absorbed by the frame and spent on the destruction of the car. However nowadays, the use of less rigid chassis construction, soft wall technology and head, neck and body restraint systems have greatly reduced crash impact forces on drivers. Though, auto racing will always be a dangerous sport.

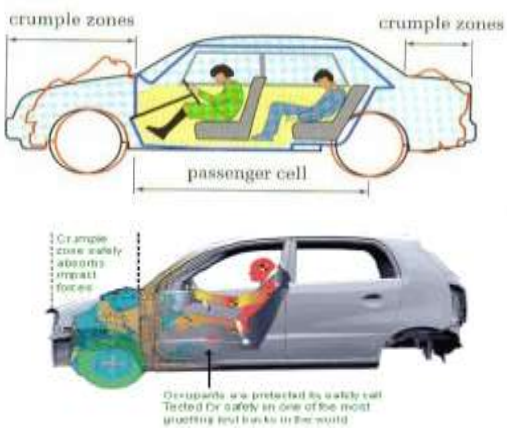

Fig. 11: Crumple zones in car

4. CONCLUSION

Vehicle safety design requires safe interaction between users, vehicles and environment. It has to take into account behaviour and vehicle technology. Also help prevent crash, risk of crash and crash fatality.

If more advancements and new technologies are introduced then surely, the accident rates would drastically decrease. Indians have a long way to go to achieve the kind of safety measures and features that are available in foreign countries.

Drivers have to be aware of their capabilities, learn from these technologies and from experiences, as well as know the limitations of the vehicle technology.

ACKNOWLEDGEMENT

I want to express my gratitude to Prof. Anilkumar Sathe for giving me the opportunity to do the project work titled "Vehicle Safety Technology".

It was his support and guidance because of which I could complete the project on time. I am grateful for having his support and guidance in spite of his busy schedule.

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