Developing the safety features and emission control features of a 2 Door Sports Coupe

ABSTRACT

The concept of our new sports coupe is developed for achieving high performance with full safety measures and luxurious comfort with a level of environment performance meeting the demands of the future. For this, a new 3L V6 twin turbocharged gasoline engine is developed. A 6 speed Manual transmission was developed and placed as below as possible to bring the CG down and increase the downforce meeting the high aerodynamic aspects. To meet the future emission norms, engine shut off technology is developed with a catalytic convertor to reduce the emissions. Also the engine is compatible with BS-6 fuel norms. The main aspect of this paper is to meet the safety requirements of the future generation entrepreneurs and CEO's.

INTRODUCTION

The new generations of entrepreneurs and CEO's have an increased interest in the luxurious drives. Their increasing demands for high performance coupled with luxury and comfort are to be met. With increased performance and luxury, it becomes extremely necessary to think about the environment and cope up with the future emission norms.

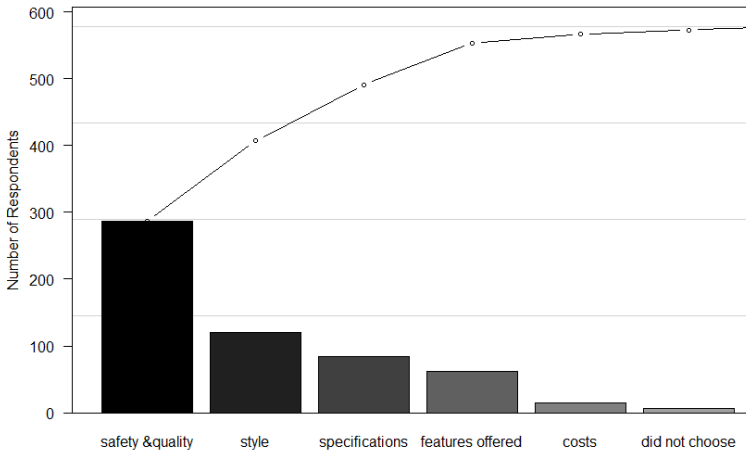
The following paper is focused on fulfilling the increasing demands of performance coupled with high end advanced safety features and meeting the future emission norms. Safety features are the main aspect of this paper and further the emission control techniques are discussed.

MAIN SECTION

Safety Measures:

Being a major public health problem worldwide, Road Traffic Injuries (RTIs) are projected to increase in upcoming years. Effective measures are needed to prevent RTCs and thus RTIs. These measures include Anti-lock Brake System (ABS) and Electronic Stability Control (ESC) system installation to prevent RTCs; seat belt, car seat and air bag to limit injury severity; and effective post-crash measures to minimize RTIs consequences [11].

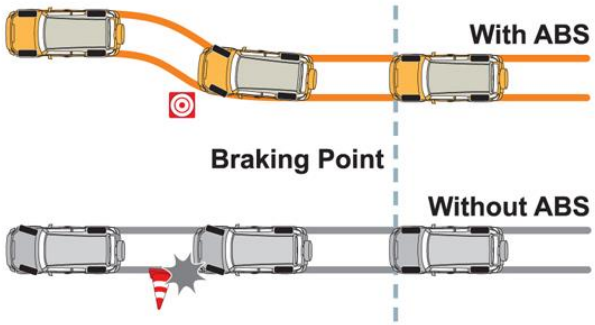
According to a survey, owners provided the reasons why they selected their current vehicles. In general, drivers showed greater emphasis on [A] safety and quality when selecting a car (n=287, 49.1%). The other top two reasons are: [B] I liked the styling and looks (n=120, 20.5%); and [C] I wanted the basic specifications (e.g., seating capacity) (n=84, 14.4%). Less participants chose their vehicle because the [D] features offered (n=62, 10.6%) and [E] the costs (n=14, 2.4%). Relatively few of the current vehicles reported were not the selections by the respondents [F] (n=6, 1.0%).

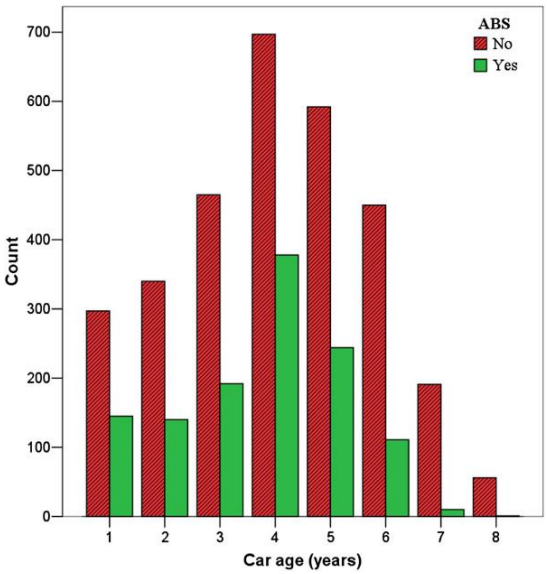


Anti-Lock braking system:

An anti-lock braking system or anti-skid braking system[1] (ABS) is an automobile safety system that allows the wheels on a motor vehicle to maintain tractive contact with the road surface according to driver inputs while braking, preventing the wheels from locking up (ceasing rotation) and avoiding uncontrolled skidding. It is an automated system that uses the principles of threshold braking and cadence braking which were practiced by skilful drivers with previous generation braking systems. It does this at a much faster rate and with better control than many drivers could manage.

ABS generally offers improved vehicle control and decreases stopping distances on dry and slippery surfaces; however, on loose gravel or snow-covered surfaces, ABS can significantly increase braking distance, although still improving vehicle steering control.





Bosch generation 9 ABS is used in the development of this vehicle. Generation 9 of the antilock braking system (ABS) is the consistent further development of the Bosch active driving safety system. The most important feature is the scalable product concept with modular software architecture. 30% reduced weight and size compared to the previous version only 1.1 kg weighs the most compact ABS. ABS generation 9 offers an optimized microprocessor design as well as a control unit based on printed-circuit technology. The modular software architecture CSMosar incorporates tried and proven features of the previous system. This leads to a significant reduction in the costs incurred by an automaker for testing and application work. Motors that use rare-earth magnets permit a significant improvement of the power-to-weight ratio. It has thus been possible to reduce weight and size of generation 9 by up to 30 percent compared to the previous version. The most compact ABS weighs only 1.1 kilograms.

PRODUCT BENEFITS:

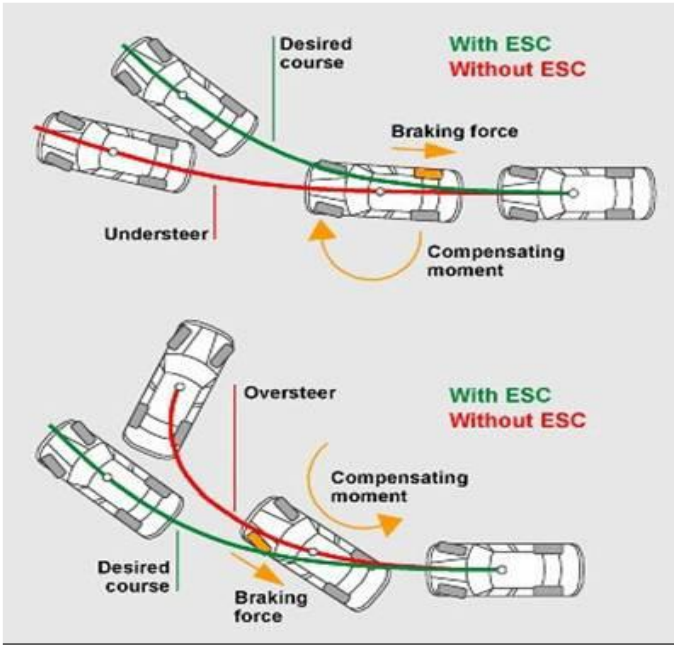
Scalable product concept for maximum flexibility
Small box volume and low weight
Extremely good noise behavior and pedal feel
Reduced application effort, in particular with optional ABS/ESP® installation

The only disadvantage people say about ABS is that they need time to brake efficiently if they are new to the system. Also the complexity of vehicle increases.

Electronic Stability Program:

Electronic Stability Control An electronic stability control (ESC) system selectively applies the vehicle's brakes and/or reduces the engine power to keep the vehicle moving in the desired direction and prevent loss of control. ESC attempts to compensate for inappropriate steering actions by the driver (oversteer), and reduced traction causing the vehicle to plow ahead rather than turning as the driver intends (understeer). The system assists the driver to maintain directional control and thus helps prevent the vehicle running of the road into the ditch, rolling over, or travelling across the roadway centerline into the path of oncoming vehicles. The intent is to avoid these and other similar undesirable situations that can potentially result in a collision and consequent occupant injury.

Recent analysis of real world accidents in the USA suggest that Electronic Stability Control (ESC) can be remarkably effective at preventing loss-of-control accidents

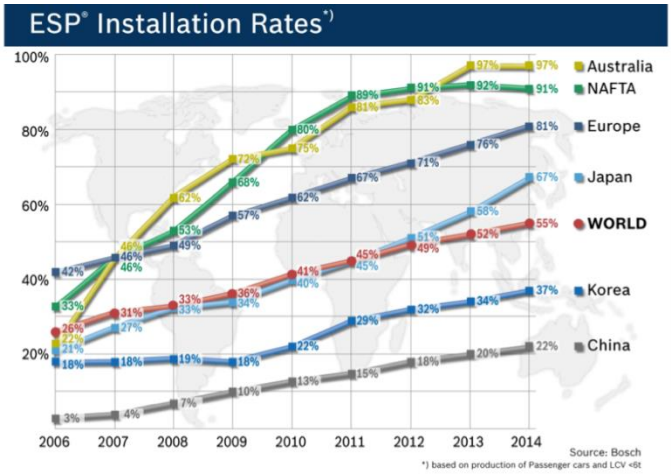


The ESP used in this vehicle is one from BOSCH and its technical specifications are as follows:

Components:

- ESP-Hydraulic unit with integrated Engine Control Unit (ECU)
- Wheel speed sensors
- Steering angle sensor
- Yaw-rate and lateral-acceleration sensor
- Communication with engine management ECU

Along with these the value added functions included are Hill hold control, tire pressure monitoring system and roll over mitigation.



Blind Spot Monitoring:

Blind spot monitoring systems (BSMs) use sensors to detect vehicles in adjacent lanes that may not be directly observed by the driver. The BSM alerts the driver that another vehicle may be present and to use caution if planning a lane change. BSMs use sensors to detect one or more vehicles in adjacent lanes that may not be directly observable by the driver. The system warns the driver of the approaching vehicle's presence to help facilitate safe lane changes.
Crash involvement rates in lane-change crashes of all severities and with injuries were 14% and 23% lower, respectively, among vehicles with blind spot monitoring than those without.

Manufacturer	BSM	All severity crashes	Injury crashes
Acura	Yes	27	3
	No	227	26
Fiat Chrysler	Yes	82	10
	No	641	86
GM	Yes	386	44
	No	380	44
Mazda	Yes	674	89
	No	1412	174
Mercedes Benz	Yes	20	4
	No	227	28
Volvo	Yes	121	10
	No	423	50
Overall	Yes	1310	160
	No	3310	408

Also known as side view assist by BOSCH. It consists of ultrasonic sensors. Following are the system details which are installed:
The 6th generation of the ultrasonic sensor enables extremely comfortable parking in very small parking spaces, maneuvering in narrow situations and automatic/remote parking. The system supports emergency braking functions at low speeds through presence detection of very close objects and faster reaction to various suddenly appearing obstacles (e. g. pedestrians).

Optimum support Ultrasonic sensors are the basis for parking and maneuvering systems as well as connected and automated parking.
Most sensitive ultrasonic system on the market for highly precise parking and maneuvering
Detection range: max. 2.5 m, min. 15 cm; object presence 6 cm
Product Benefits:
Very fast and robust object detection Safety level up to ASIL B for highly automated parking functions.
Scalable platform concept offers maximum flexibility – systems solutions can be precisely tailored to individual vehicles.
Highly integrated control unit ASIC enables functions to be easily integrated into a central control unit, or into a stand-alone control unit.
Small installation volume and variable connector design facilitate the installation in the bumpers.

Adaptive Cruise Control:

Driving in heavy traffic or keeping a safe distance to the preceding vehicle calls for a high level of concentration. ACC, adaptive cruise control from Bosch can reduce stress for the driver by automatically controlling vehicle speed and maintaining a predefined minimum distance to the preceding vehicle. This isn't just convenient for the driver – he/she is also able to better concentrate on the traffic situation.
ACC can automatically adjust speed in order to maintain a set distance between vehicles in the same lane. A long range radar sensor is used to detect a target vehicle up to 200 m ahead and automatically adjusts the vehicle speed and headway accordingly.
Forward-looking radar, installed behind the grill of a vehicle, sends information to a digital signal processor, which translates the speed and distance information for a longitudinal controller. If the lead vehicle slows down, the system sends a signal to the engine or braking system to decelerate. Subsequently, when this road ahead is clear, the system will accelerate the vehicle back to the set speed while maintaining the proper headway. The driver can override the system at any time.
Not only the car accidents are reduces, but also the fuel consumption decreases by 10%.

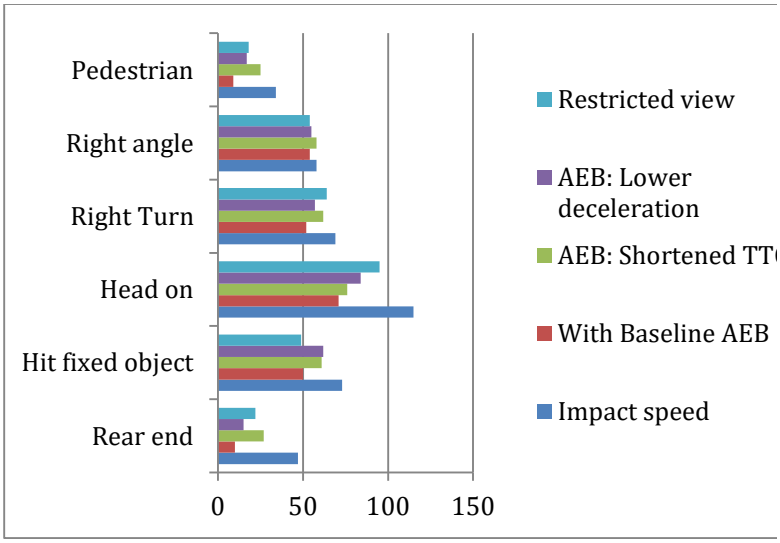
The ACC used is also of BOSCH and the 2 important components are as below:
Mid Range Radar Sensor (MRR): The MRR is a bi-static multimodal radar with four independent receive channels and digital beam forming (DBF). These technologies allow the MRR to be configured with independent antennae for different directions, which improves the angular measurement accuracy and means that the radar's field of view can be adjusted depending on the situation. tailor-made solution The Bosch mid-range radar sensor is a customized, cost-effective solution for the implementation of driver assistance functions. compact design Significantly smaller and lighter than a 250-gram pack of butter,

the radar sensor fits into even the smallest cars. Specs: 76 - 77 GHz frequency; range: 0.36 - 160m detection range; 32 max number of detected objects; ~190 g weight.
PRODUCT BENEFITS FOR AUTOMOBILE MANUFACTURERS Digital beam forming (DBF) for flexible antenna use and high accuracy throughout the angular range Independent mode for height measurement using an elevation antenna, enabling the system to reliably classify objects and brake safely, even when the object is stationary Cost-effective design means that the system can be installed as standard across all vehicle segments Self-calibration function reduces fitting costs

Automatic emergency Braking:

Substantial parts of all traffic accidents involving passenger cars are rear-end collisions and most of them occur at low speed. Auto Brake is a feature that has been launched in several passenger car models during the last few years.

Estimates of the effect of the speed reductions in each crash were made



Results of the crash test with different AEB's are as below:

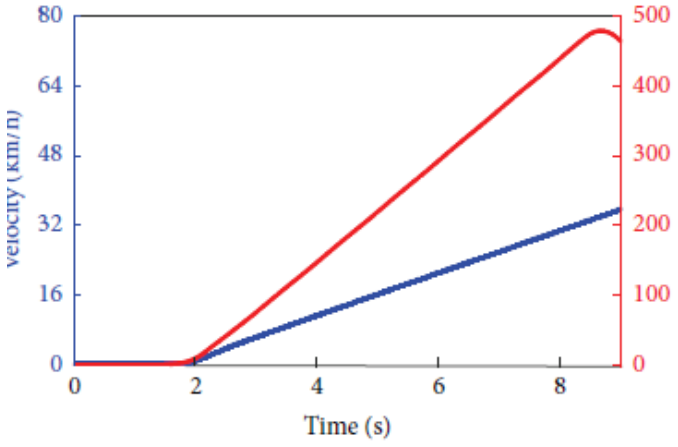
System	Percentage reduction	
	Fatal crash	Injury
Baseline System	27	37
Shorter TTC	16	27
Lower Deceleration	20	34
Restricted view	23	34

Engine Immobilizers:

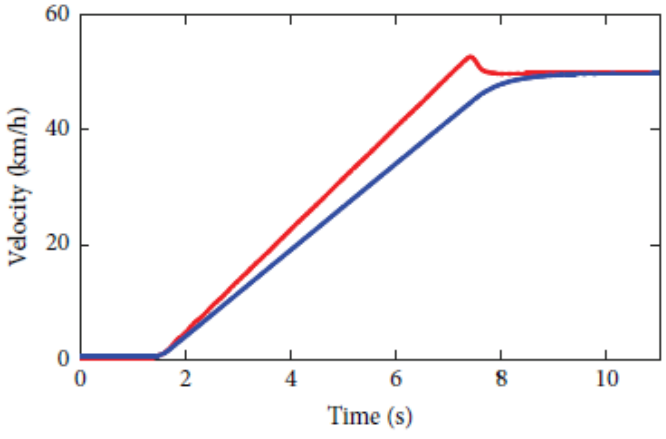
The engine immobilizer is a state-of-the-art anti-theft system. When you insert your key into the ignition switch or bring a Smart Key fob into the vehicle, the key transmits an electronic code to the vehicle. The engine will only start if the code in the transponder chip inside the key or Smart Key fob matches the code in the vehicle's immobilizer. The electronic engine immobilizer is an unobtrusive device that does not require anything else than taking the key out of the ignition. It does not pose additional effort on motorists. The additional manufacturing costs related to installing an electronic engine immobilizer have been estimated by the Netherlands Institute for Certification of Vehicle Security Systems (SCM) to be no more than Rs 1000 per car.
A 2016 study in the Economic Journal finds that the immobilizer lowered the overall rate of car theft by about 40% between 1995 and 2008.[1] The benefits in terms of prevented thefts are at least three times higher than the costs of installing the device.

Traction Control:

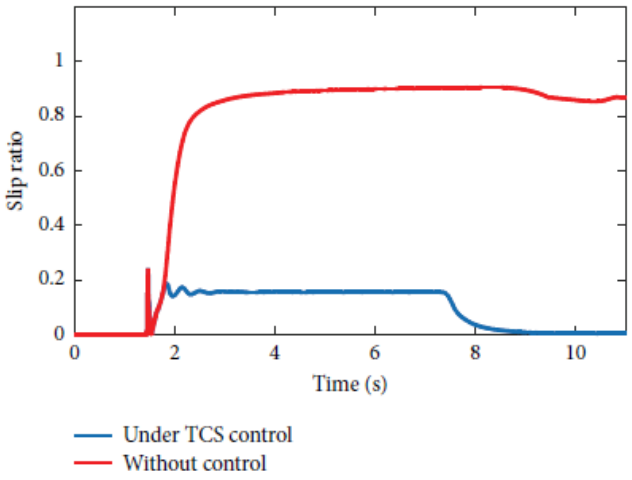
Vehicle traction control system plays an important role in electronic stability control (ESC) system.



(a) Velocity versus time in Case 1 with no control



(b) Velocity versus time in Case 1 under control



(c) Comparison of slip ratio between the one under control and the noncontrolled one

FIGURE 5: Simulation result of Case 1.

Figure shows the simulation result of the vehicle driving under a low μ slippery road surface condition. The friction coefficient of road surface is 0.2. From Figures 5(a) and 5(b), from the comparison between the non controlled one and the controlled one, we can find that the speed of uncontrolled vehicle is 50 km/h at 11 s, but that of the controlled one is 50 km/h at 7s. We can also find that there is about 45% improvement in the performance of longitudinal acceleration. From Figure 5(c), the one under control keeps the slip ratio within the range of optimal slip ratio (about 0.16). However, the driving wheels of the uncontrolled one slipped excessively.

The characteristics of the TCS can be described as follows:

(1) A method for real-time calculation of optimal slip ratio is realized by Variable Forgetting Factors Recursive Least Square (VFFRLS) algorithm. And then the optimal slip ratio is considered as the desired value of slip control.

(2) The cascade control method with fuzzy control algorithm and sliding mode control algorithm can be effectively adapted to the complicated road surface conditions.

(3) The algorithm takes 2ms to run a time and runs once every 20ms, so that the TCS controller can discover and correct the vehicle wheel slipping phenomenon in time.

(4) Simulation, which is based on Matlab software, and typical road tests were carried out. The results indicate that the control scheme is fit for complicated working circumstances.

Airbags:

An airbag is a type of vehicle safety device and is an occupant restraint system. The airbag module is designed to inflate extremely rapidly then quickly deflate during a collision or impact with a surface or a rapid sudden deceleration. It consists of the airbag cushion, a flexible fabric bag, and inflation module and impact sensor. The purpose of the airbag is to provide the occupants a soft cushioning and restraint during a crash event to prevent any impact or impact-caused injuries between the flailing occupant and the interior of the vehicle.

Technology	Relevant crash types	Proportion of deaths accounted for by relevant crash types	Reduction in fatality risk in relevant crashes (per cent)	Overall reduction in fatality risk for equipped vehicles (per cent)	Proportion of light vehicle fleet with technology in 2014 (per cent)	Estimated fatality reduction in 2014 (per cent)
Driver airbags	Front impact	60[a]	25[a]	15	79	12
Passenger airbags	Front impact with passenger	12[a]	20[a]	2	55	1
Side airbags	Side impact	20[b]	51[c]	10	36	4

The airbag control unit AB plus is flexible and scalable with respect to the number of firing loops and sensor interfaces for peripheral crash sensors. The airbag control units can trigger up to 32 firing loops and control 12 PSI5 sensor interfaces. There is also the option to expand the control units to trigger up to 48 firing loops and control up to 18 sensor interfaces.

Better protected: The occupant protection system based on the airbag control unit keeps the accelerations and forces acting on occupants in the event of an accident as low as possible.

Reduced severity of injury: The appropriate activation of restraint mechanisms in the vehicle by the airbag control unit offers the best possible protection for vehicle occupants.

PRODUCT BENEFITS FOR MANUFACTURER:

- Configurable for all markets, vehicle segments and platforms
- Flexibility in the use of connector systems
- Integration of inertial sensors possible
- Modular integration of both established and new algorithms
- Safety concept compliant with ISO 26262

Seat Belt Pretensioners:

Pyrotechnic seat belt pretensioners help develop proper seat belt fitment and manage occupant energy in a crash by removing seat belt slack. Pretensioners can be integrated into the buckle or retractor and take up as much as 15 cm of torso or lap belt slack. Activation of the pretensioner either pulls down on the buckle side of the seatbelt mechanism, or tightens up the spool side of the mechanism, thus reeling in some length of the seatbelt webbing. Keeping a front seat occupant from moving forward relative to the vehicle interior is crucial to minimizing injury when the air bag deploys. [11] Seatbelt pretensioners typically use the same sensor system as the vehicle's airbag to detect a rapid deceleration caused by a collision. A

means of mechanically locking the webbing to maintain belt tightness is usually also employed. It takes approximately 10 to 20 milliseconds for a pretensioner to activate once a deployment event is determined. If deployment is commanded relatively late in the crash sequence, such that the belt is already under significant occupant load prior to pretensioning, there is a chance of injury. Some high end vehicles may also have a motorized reversible pretensioning feature in addition to the pyrotechnic pretensioner. The motor on the reversible pretensioner activates when critical situations such as panic braking are recognized.

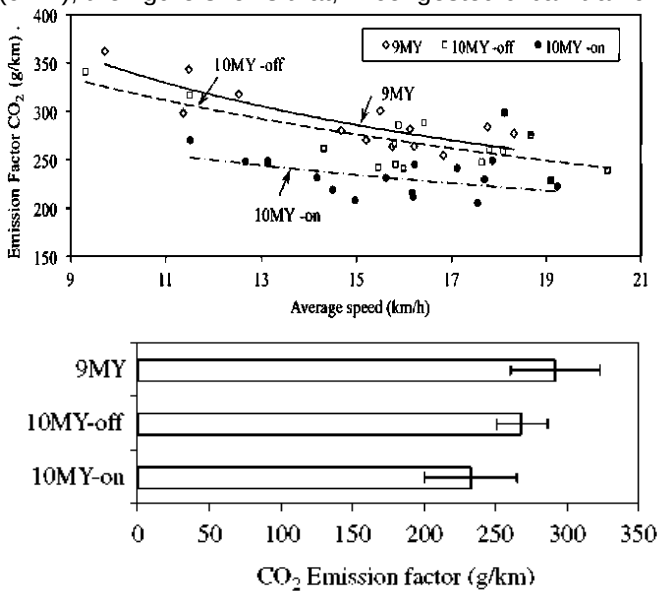
The most common retractor pretensioner is the ball-in-tube version as seen in the image below. An electrical pulse from the Crash electronics (ECU) ignites a pyrotechnical squib. The burning generant generates a great deal of outward pressure. The pressure pushes the ball in the tube forward over a cogwheel. The cogwheel is connected to the spindle in the retractor and when turning it will retract webbing, up to 120mm.

Emission Control:

Engine start stop:

In automobiles, a start-stop system or stop-start system automatically shuts down and restarts the internal combustion engine to reduce the amount of time the engine spends idling, thereby reducing fuel consumption and emissions. This is most advantageous for vehicles which spend significant amounts of time waiting at traffic lights or frequently come to a stop in traffic jams. Start-stop technology may become more common with more stringent government fuel economy and emissions regulations.[1] This feature is present in hybrid electric vehicles, but has also appeared in vehicles which lack a hybrid electric power train. For non-electric vehicles fuel economy gains from this technology are typically in the range of 3-10 percent, potentially as high as 12 percent.

Fig shows the average and standard deviation values of C02 emission factors for each vehicle for all tests of both urban circuits. Compared with the conventional car (9MY), the figure shows that, in congested urban traffic



the C02 emission is reduced by more than 20% when using the car equipped with the S/S system (lOMY-on). From these results, it can be estimated that a 12.2% fuel consumption reduction (lOMY-off versus lOMY-on) can be attributed to idle consumption and 8% (9MY versus lOMY-off) to engine calibration and optimisation of the version 10MY with the S/S system.

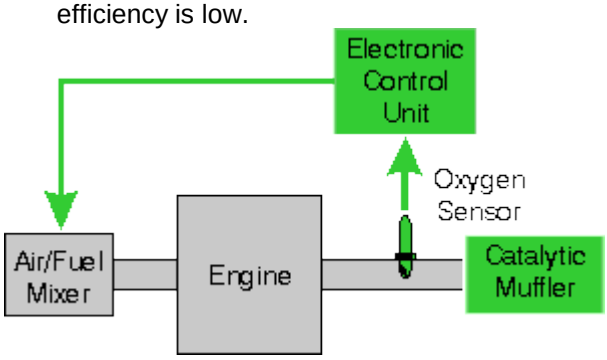
Catalytic converters:

The catalytic converter in an automobile is an expanded section of exhaust pipe occurring upstream of the muffler in which pollutants generated in the engine are converted to normal atmospheric gases. It is an essential element in the emissions control system of modern automobiles. This technology was introduced in the United States in the late 1970s and became legally required by the early 1980s because of more stringent exhaust emission control standards.

Catalytic converters have proven to be reliable and effective in reducing noxious tailpipe emissions. However, they also have some shortcomings in use, and also adverse environmental impacts in production.

THREE-WAY CATALYTIC CONVERTER
Three-Way catalytic mufflers are the most effective way of controlling Carbon Monoxide, Hydrocarbons, and Nitrogen Oxides emissions from LPG, CNG, and gasoline engines. CO and NO_x emissions can be simultaneously reduced by 90-99%. A three-way catalytic converter has three simultaneous tasks: Reduction of nitrogen oxides to nitrogen and oxygen: 2NOx → xO2 + N2 Oxidation of carbon monoxide to carbon dioxide: 2CO + O2 →2CO2 Oxidation of unburnt hydrocarbons (HC) to carbon dioxide and water: CxH(2x+2)+ 2xO2 → xCO2 +

2xH2O These three reactions occur most efficiently when the catalytic converter receives exhaust from an engine running slightly above the stoichiometric point. This is between 14.6 and 14.8 parts air to 1 part fuel by weight for gasoline. Generally engines fitted with 3-way catalytic converters are equipped with a computerized closed - loop feedback fuel injection system employing one or more oxygen sensors, though early in the deployment of 3-way converters, carburetors equipped for feedback mixture control were used. While a 3-way catalyst can be used in an open-loop system, NOx reduction efficiency is low.



We used a NETT Technologies T series 3 way closed loop catalytic converter in our vehicle. The complete system (shown in green) includes a catalytic muffler with built-in Three-Way catalyst, a zirconium oxygen sensor, and an electronic control unit (ECU). The ECU receives a feedback signal from the O_2 sensor and maintains the engine air/fuel ratio at the stoichiometric point, which yields optimal catalyst performance. This system provides the best conversion of both Carbon Monoxide and Nitrogen Oxides and can improve the fuel economy of the car.

CONCLUSION

The technology was developed keeping in mind the ever increasing safety demands of the young generation embedded with high sports car performance and limiting the cost to as low as possible. Hence as a solution to the problem, following are the main safety features adapted:

- Antilock Braking System
- Advanced Air Bag assembly
- Traction Control
- Electronic stability program
- Blind Spot Monitoring
- Automatic Emergency Braking System
- Adaptive Cruise Control
- Engine Immobilizers and keyless ignition

Other safety features adapted are Lane change assistance, ride by wire, 360 degree camera, Beam bending LED Headlights, hill hold assist and seatbelt pretensioners.

As far as emission control is concerned, a 3 way catalytic converter and engine start stop systems are used along with the BS-6 compatible gasoline engine.

ACKNOWLEDGMENTS

This paper was written for development of a 2 door sports coupe as a project given by Expertshub for Automotive Industry Simulation Internship. Thanks to guides and experts at expertshub to help us out throughout the project.

REFERENCES

1. POTENTIAL BENEFITS OF AUTONOMOUS EMERGENCY BRAKING BASED ON IN-DEPTH CRASH RECONSTRUCTION AND SIMULATION; By Robert Anderson, Samuel Doecke, James Mackenzie, Giulio Ponte, Centre for Automotive Safety Research, The University of Adelaide, AUSTRALIA
2. The Engine Immobilizer: A Non-Starter for Car Thieves; By Jan C. van Ours, Ben Vollaard, CESIFO WORKING PAPER NO. 4092
3. Gang Liu and LiQiang Jin, “A Study of Coordinated Vehicle Traction Control System Based on Optimal Slip Ratio Algorithm,” Mathematical Problems in Engineering, vol. 2016, Article ID 3413624, 10 pages, 2016. doi:10.1155/2016/3413624
4. Kevin McClafferty and Alan German, “high-tech motor vehicle safety systems”
5. NataliaFonseca, JesúsCasanova and ManuelValdés, “Influence of the stop/start system on CO2 emissions of a diesel vehicle in urban traffic”
6. Hutchinson EJ, Pearson PJG. An evaluation of the environmental and health effects of vehicle exhausts catalysts in the UK. *Environmental Health Perspectives*. 2004; 112(2):132-141.
7. Michael Paine, “ELECTRONIC STABILITY CONTROL: REVIEW OF RESEARCH AND REGULATIONS” ROADS AND TRAFFIC AUTHORITY OF NSW June 2005
8. Sahil Jitesh, “Antilock Braking System”
9. Cheng Lin and Xingqun Cheng, “A Traction Control Strategy with an Efficiency Model in a Distributed Driving Electric Vehicle,” The Scientific World Journal, vol. 2014, Article ID 261085, 12 pages, 2014. doi:10.1155/2014/261085
10. Julie M Pardiwala, Femina Patel, Sanjay Patel “Review paper on Catalytic Converter for Automotive Exhaust Emission” institute of technology, Nirma University, ahmedabad
11. Forkenbrock, G., Hoover, R. L., Gerdus, E., Van Bushkirk, T. R. and Heinz, M. 2014. Blind Spot Monitoring in Light Vehicles – System Performance.DOT HS 812 045.N.H.T.S.A., Washington D.C., July.

ADDITIONAL SOURCES

1. https://en.wikipedia.org/wiki/Main_Page
2. http://www.team-bhp.com/
3. http://www.team-bhp.com/
4. https://www.hindawi.com/
5. www.ncbi.nlm.nih.gov
6. https://www.hondarandd.jp/
7. http://www.sciencedirect.com/
8. https://www.springeropen.com/journals