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Innovative Technologies for Sustainable Development of Automobile Industry

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***Abstract*— Automobile industry is an important pillar of National industries in India. According to recent studies India is the sixth largest producer of Automobiles in the world. The industry is a growth driver and also employment provider, but is a robust sector that drives technology, innovation and R&D globally. The industry which is as important for economic profitability is also an important arm of mobility, as road transport contributes largely to mobility of goods and services. Our Industry growth is promising and prospective also but needs a sustainable development.**

Sustainable development is one which satisfies the needs of the present without compromising the ability of future generations to satisfy theirs. The Sustainable Development implies the fulfillment of several conditions: preserving the overall balance, preserving the environment, and preservation of natural resources. Competition in the automotive industry is characterized by overcapacity, high market saturation, high labour and fixed costs, and the need for constant product development and innovation. From the environmental point of view, the crucial issue is a relatively long life span of the industry's products. Thus, about 80% of environmental impacts stem from the usage phase of the Vehicle. This offers room for improvement, in innovative technologies, especially in the design phase; using lightweight materials, improving fuel efficiency, inventing new energy sources.

I. INTRODUCTION

Our Automobile industry most prominent in the development of the country. The industry growth is promising and prospective the demand for passenger and goods is expected to grow between 8 and 12 % yearly and number of vehicles on road expected to double by 2020. There are sustainability issues prevailing in the industry. Sustainable development of Automobiles has assumed greater significance in the past decade mainly owing to depleting fossil fuel reserves and increasing carbon emissions. International agencies, reported that the global energy consumption is likely to rise by 53% between 2006 and 2030, and about three-quarters of the projected increase in oil demand is likely to come from the transportation sector. The transportation based on fossil-fuels constitutes the second largest source of carbon dioxide emissions globally. It is reported from extracts that CO2 emissions from road transportation is expected to increase by 80 to 100 million tons. The rising cost of fuel is pushing OEMs to design and develop vehicles with alternate fuel, enhance engine efficiency, match environmental compliances etc.

Due to various factors of fuels, cost of fuel, emission norms etc., world over, automobile manufacturers invest heavily in developing vehicles based on alternative propulsion systems including hybrid and electric drives. Hence, the industry may witness some degree of alternative fuel transportation in the near future. The push towards alternative and fuel-efficient technologies will pose new challenges for the manufacturers in terms of revamping their core processes in preparation for mass-produced, non-internal combustion engine vehicles.

The automotive industry contributes to various modes of pollutions, both at user level and at source of manufacturing. Greenhouse Gas (GHG) emissions from auto and auto ancillary sectors are major contributors to climate change. About 90% of GHG emissions in the life cycle of the vehicle happen at the stage of usage and the rest 10% GHG emissions are estimated to be from the manufacturing side, though small on the overall scale the end impact it has on the climate and environment are huge. With growing concern about the climate change auto manufacturers have already started mitigation measures through various approaches.

In all the cases technology plays a predominant role in addressing the major issues discussed above. Green manufacturing, a modern manufacturing mode considers both the environmental impact and the resource consumption during the whole product life cycle from design, fabrication, packaging, transportation, usage, recycling, to waste disposal.

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Green technologies imply application of advanced systems and services to a wide variety of operations in order to improve sustainability. Application of green technologies, systems and practices need not be especially high tech in nature. Even better design and engineering for a wide range of products that is lighter in weight, more recyclable, less reliant on petrochemicals and cutting down on the energy used will impact by reducing the carbon footprint.

Green technologies for the automotive sector embraces technology solutions and systems, both at user and manufacturing end. Studies estimate that a wide range of green vehicle technologies together could improve in fuel economy by 30 to 55% in the next decade. Whatever the future holds, automakers will need to be flexible in their core manufacturing processes to accommodate a range of transportation technologies, including alternative fuel vehicles, to stay on the path toward high performance.

Technologies at the manufacturing end play a stronger role to wisely utilize the resources and adopting efficient processes to exploit resources and environment safely and sustainably, which is also an act of sustenance. In product development arena, Green aspect plays a key role in the product design for innovating better environment- friendly products offering high energy efficiency and a long useful life, Green Manufacturing with least environment impact, Green Procurement ensuring green supply chain, EOL management for proper waste disposal & RRR (Reuse, recover & recycle) and Life cycle Assessment covering carbon footprint prediction during the life of the product.

OEMs in pursuit of reducing the pollution and enhances the core competitiveness of automotive manufacturing industry are obliged to focus on the value chain in developing and managing a Green supply chain management. Increasing political and social demand for a more sustainable society, coupled with emerging global legislation is affecting the way products need to be designed, manufactured, used and also disposed off. This calls for Sustainability creation as an end-to-end continuous improvement program driven top-down across the entire enterprise panning supply chain and reverse supply chain spanning across, product, process and end-of-life.

Therefore automotive companies are increasingly adopting green practices in an attempt to benefit through long–term cost savings, brand enhancement with customers, better regulatory traction, greater ability to attract talent and higher investor interest. However, these benefits require a long term commitment and making tradeoffs against short term objectives, as the economics of green manufacturing is still evolving and not well understood as yet. Although considerable technologies and models of green energy related developments exist, better cost and operational justifications are still required to increase the pace of implementation.

Auto Industry Trends

The following are the some of the important trends in Automobiles for the sustainable development

- Reduction in fuel consumption and greenhouse gas emissions
- Reduced vehicle weight through smart design and material selection
- Downsized and boosted DI gasoline engines
- Alternative fuels
- Alternative propulsion systems
- Reduced vehicle energy consumption
- Vehicle connectivity
- Renewable/sustainable materials
- Recyclable materials

(A) Reduction in fuel consumption and greenhouse gas emissions by:

1. Advanced Combustion Modes

Engineers are working to increase the efficiency of internal combustion engines by developing several advanced combustion modes. One of these modes is called (homogeneous charge compression ignition) HCCI. In the HCCI combustion, a highly homogenized mixture of air, fuel, and combustion products from the previous cycle is auto-ignited by compression. "This combustion mode aims at combining the advantages of modern diesel and gasoline combustion processes, namely low emissions and high efficiency."

Another research trend targets ways to recover the energy that is normally dissipated through the coolant and the exhaust gas systems of automotive powertrains using innovative waste heat recovery devices. These systems can convert thermal energy into mechanical or electrical energy, thus increasing the overall efficiency of the vehicle. Organic Rankine cycle, thermoelectric systems, turbo compounding, and recuperative thermal management systems all have potential for significantly increase engine efficiencies.

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A smaller but still significant aspect of fuel-efficiency research is called "intelligent energy management." "This ability to more intelligently control the accessory loads in a vehicle—such as the alternator or power steering, etc., will also contribute to better gas mileage. "With smarter control of these loads and the addition of stop-start technology there can be significant increases in fuel economy, with small or no increase in total vehicle cost."

2. Reduction in emissions by the use of New and Innovative Technologies

(1) Crank case emission

Crank case emissions can be minimized by providing positive crank case ventilation (Positive Ventilation system). Emission from the exhaust can be controlled by a combination of methods like,

1) Exhaust gas re-circulation for control of the oxide of Nitrogen,

2) Catalytic or non-catalytic conversion of hydrocarbons

3) Oxidation of carbon monoxide and unburnt hydrocarbons in the exhaust system by low pressure air injection in to the exhaust port.

4) Engine modification to reduce the volume of contaminants released from the cylinders.

(2) Evaporative emission

Emission of fuel vapor from carburetor and fuel tank may be reduced by installing fuel vapor recovery systems. For example, an Evaporative Loss Control Device (ELCD) has been developed by ESSO, can be used.

The vapor-return line connects the fuel pump to the fuel tank. It allows the vapor formed in the fuel pump to return to the fuel tank. At the same time, it permits excess fuel being pumped by the fuel pump to return to the fuel tank.

In some cars, a vapor separator is connected between the fuel pump and the carburetor. The vapor formed in the fuel pump enters the vapor separator, as bubbles, along with the fuel. The vapor rises to the top of the vapor separator, from where it is forced, by the fuel pump pressure, to pass through the vapor returning line to the fuel tank.

(3) Exhaust Emissions

(i) Control of Oxides of Nitrogen from SI (Spark Ignition) Engine Exhaust.

There are several methods of controlling the oxides of nitrogen (NO2) present in the IC engine exhaust. Basically there are two ways,

1) By controlling the formation of NOx itself by changing the operating or design parameters or by some device to reduce the peak combustion temperature mainly responsible for the formation of NOx in the combustion chamber and

2) By using a catalyst in the exhaust system to reduce NOx to nitrogen and oxygen after its formation.

3) The other possible methods of controlling NOx emissions at the sources are

- Recirculation of the part of the exhaust gas
- Water injection in the inlet manifold.
- Charge dilution with some gas like carbon-dioxide, helium, argon, etc.

(ii)Exhaust Gas Recycling (EGR)

1) It is proved from the experiments that EGR is a promising method of controlling NOx emission. EGR controlled 81-88% of NOx at 30% recycling.

2) With 30% recycling, there is a fuel penalty of 23.1% to 28% considering to minimum bsfc value increased from 3.85% to 28% when the percentage recycling increased from 10% to 30%.

3) With 30% recycling, as the speed increased from 1200 rpm to 1800 rpm the loss is maximum power output increased from 9% to 13.5% and from 1.88% to 13.5% in the recycling range of 10% to 30%. Even with 20% recycling, the loss is maximum power was high as 31.8% with running at 2400 rpm.

4) The rate of reduction of NOx emission is much faster at higher speeds with increase in percent recycling

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5) The peak exhaust temperature increases with increase in percent recycling as well as speed.

6) Exhaust gas recycling helps in the reduction of carbon monoxide emission also.

(iii) Diesel Smoke

(1) Black Smoke: It is a suspension of spot particles in the exhaust gases and results from incomplete combustion of fuel

(2)Blue Smoke: The blue smoke is usually due to excessive lubricating oil consumption and its emission indicates a very poor condition of the engine, such as worn out piston rings or valve guides, etc.

The factors affecting Diesel smoke are Fuel Factors, Engine Design Effect of engine life and maintenance.

(iv) Fuel factors are Cetane Number, Volatility, Viscosity and Chemical Composition.
Considerable success has been achieved in recent years on diesel smoke problems by fuel additives; certain additives containing barium effectively reduce the exhaust smoke density

(v) Engine Design: The type of combustion system is the most important engine design features which affects exhaust smoke density. An indirect injection engine gives less smoke than a direct injection engine for large part of the operating range of loads, due to high rate of air swirl resulting in better air utilization.

(vi) Effect of Engine life and maintenance: From the engine maintenance point of view, the condition of the fuel injection system has the greatest influence on exhaust smoke density. To perform the functions of engine satisfactorily throughout the engine service life, all the components of the fuel system must be in good mechanical condition and must be correctly assembled and tuned. As the wear of these components with increasing use is inevitable, and as deposit build up takes place on some of the critical components, periodic maintenance is essential to keep the smoke level low.

(B) Reduced vehicle weight through smart design and material selection

(1)Auto manufacturers are currently researching and testing body panels that can store energy and charge faster than conventional batteries of today.

Exxon Mobil predicts that by 2040, half of all new cars coming off the production line will be hybrids [source: Kahn]. That's great news for the environment, but one of the problems with hybrids is that the batteries stakes up a lot of space and is very heavy. Even with advances in lithium-ion batteries, hybrids have a significant amount of weight from their batteries. That's where energy-storing body panels come in.

In Europe, a group of nine auto manufacturers are currently researching and testing body panels that can store energy and charge faster than conventional batteries of today. The body panels being tested are made of polymer fiber and carbon resin that are strong enough to be used in vehicles and pliable enough to be molded into panels. These panels could reduce a car's weight by up to 15 percent [source: Volvo].
The panels would capture energy produced by technologies like regenerative braking or when the car is plugged in overnight and then feed that energy back to the car when it's needed [source: Volvo]. Not only would this help reduce the size of hybrid batteries, but the extra savings in weight would eliminate wasted energy used to move the weight from the batteries.
Toyota is also looking into lightweight energy storing panels, but they're taking it one step further and researching body panels that would actually capture solar energy and store it in a lightweight panel. Whether

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future body panels collect energy or just store it, automotive companies are looking into new ways to make our cars more energy efficient and lightweight.
For more information about future car technologies and other related topics, follow the links on the next page.

(C) Downsizing and Turbocharging

The two main benefits in downsizing an internal combustion engine are thermodynamic and mechanical. "From a thermodynamic point of view, the engine operation will move towards higher loads, at which the engine efficiency is higher." From the mechanical point of view, the positive aspect lies in the reduction of the friction in the piston units, together with the reduction of the number of cylinders."
Downsized engines are lighter than conventional engines, thereby reducing vehicle mass and the improving vehicle fuel consumption. Turbocharging recovers the energy of the exhaust gasses to increase the inducted charge, therefore increasing the power-to-displacement ratio. "A downsized and turbocharged engine has the potential to have the same or better performance as a non-downsized, normally aspirated engine, with the advantage of a significant increase of fuel efficiency,"

(D)Mitigation measures by the use of Alternative fuels

1) LPG: Liquefied Petroleum Gas is mixture of gases, chiefly propane and butane, produced commercially from petroleum and stored under pressure to keep it in a liquid state. The LPG is an attractive fuel for internal combustion engines; because it burns with little air pollution and little solid residue, it does not dilute lubricants, and it has a high octane rating.
The international research experience in this area indicates that there is 90% reduction in toxic emissions as compared to reformulated gasoline. It also reduces the CO2 22-24% as compared to gasoline. (Source: Book-Gupta R, "Automobile Engineering" Satya Prakashan, New Delhi, 2009, page No.979,)

2) CNG: Compressed Natural Gas is composed of Methane, Ethane, Propane, Butane and other contaminants. The main constituent of CNG is Methane which will be up to minimum of 90%. Due to its low energy density, it is compressed to a pressure of 200-250 kg/cm2 and the name is Compressed Natural Gas.

Table 4: Comparative Emissions from Diesel and CNG for Buses

Fuel	Pollution Parameter		
	CO	NOx	PM
Diesel	2.4 g/km	21 g/km	0.38 g/km
CNG	0.4 g/km	8.9 g/km	0.012 g/km
% Reduction	84	58	97

Source: Frailey et al. (2000) as referred in World Bank (2001b: 2).
It reduces CO to 97%, HC to 20 to 25% as compared to gasoline fuel.

3) Bio-Diesel Blends: To cut foreign exchequer and contribute towards protection of earth from the threat of environmental degradation, bio-fuels can be good alternative for diesel for most of developing countries. Vegetable oils have considerable potential to be considered as appropriate alternative as they possess fuel properties similar to that of diesel. There are more than 300 different species of trees in India which produce oil bearings.

The following table shows the reduction in various pollutants by the use of Bio-Diesel blends.

Table 5: Average Bio-diesel emissions compared to Conventional Diesel

Emission Type	**B100**	**B20**
Total Unburned Hydrocarbons	-67%	-20%
Carbon Monoxide	-48%	-12%
Particulate Matter	-47%	-12%
NOx	+10%	+2% t0 -2%

(Source www.epa.gov/otaq/models/analysis/biodiese/p02001.pdf)

If we use B100 i.e.100% blend of Bio-Diesel then we will reduce the Unburnt Hydrocarbons to 67%, Carbon Monoxide to 48%, Particulate Matter to 47% and Nitrogen Oxide may be minimized by two percent or it may increase.
If we use B20 i.e.20% blend of Bio-Diesel then we will

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reduce the Unburnt Hydrocarbons to 20%, Carbon Monoxide to 12%, Particulate Matter to 12% and Nitrogen Oxide may increase by 10%. But here the Nitrogen oxide problem may be minimized by using the catalytic convertors.

4) Battery Operated Vehicles: The vehicles use the battery power to move the vehicle. The batteries are recharged by conventional trickle charging method or we may use alternators to charge the same, where as yet inventions are in progress to charge the battery fully on alternators. Now in India REVA car is popular for battery operated vehicle, the Vidyut and some other motors have launched two wheelers. As of now these vehicles run with 40 to 80km/hour. By these battery power operated vehicles exhaust emissions will zero, as no fuel is burned to produce energy.

5) Hydrogen fueled vehicles: Hydrogen is high in energy content as it contains 120.7 MJ/kg, which is the highest for any known fuel. However, its energy content compared to volume is rather low. This poses challenges with regard to its storage for civilian applications, when compared to storage of liquid fossil fuels. When burnt, hydrogen produces water as a by-product and is, therefore, environmentally benign. Although no CO2, etc. are produced if hydrogen is burnt in air, yet NOx will be formed at high temperatures. One of the advantages of hydrogen as a fuel is that it can be used directly in the existing internal combustion engines and turbines. It can also be used as a fuel in fuel cells for electricity generation. Hydrogen applications, besides industrial application, cover power generation, transport applications and heat. However, when compared to other alternatives, use of hydrogen in transport sector appears to be more beneficial as it is possible to store hydrogen on-board.

6) Solar Operated Vehicles: Solar Photo Voltaic method is used with solar panels placed on the vehicles and designed as per the Aerodynamic necessities of vehicles. By using solar we can recharge the batteries and with the battery power we can run the vehicles where no tail pipe emissions will appear. Yet we have to make various innovative efforts to attract the people towards solar operated vehicles.

CONCLUSION

Automobile Engineering focuses on advanced electric propulsion and energy storage systems, engines and alternative fuels, intelligent transportation and vehicular communication systems, autonomous vehicles, vehicle chassis systems, and vehicle safety.

One of the biggest trends right now in automotive engineering is improving engine efficiency and fuel economy, this includes downsizing, down-speeding, direct fuel injection, and boosting.

Other engineering trends focus on improving transmissions (adding speeds), accessory load reduction through the intelligent energy management of other vehicle components, vehicle electrification, hybridization, improved battery management systems, new battery chemistries, and power electronics.

Weight reduction in vehicle subsystems is also being tested by using lightweight structures made from alternative materials such as aluminum, magnesium, composites, plastics, and multi-material construction.

Therefore, if we use aforesaid innovative technologies of automobiles the Sustainable Development will take place. In this way both Automobile Industry and Environment will be safeguarded.

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