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Pollution Control-Contribution of Mechanical Engineering towards Environment

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***Abstract*—Today's world runs on technology. It is all about being smarter, making things easier, more efficient and more accessible to everybody. We cannot imagine our life without technology. But are we concerned about our Environment? Which being affected and is, in turn, disturbing our cycle of life. From the evolutionary process of early man to humans, carriages pulled by animals or men to Automobiles. This has made our life easy but affected our Mother Nature as well. In this paper, I have described the negative effects of technology and development that can be overcome by following a few necessary steps to control the release of dangerous emissions into the atmosphere and use of non-conventional methods and machines in our Automobiles and Industries. The study aimed to research the contributions of mechanical engineering towards the environment.**

Keywords — Global Warming, Pollution, Emissions (Greenhouse gases), Natural resource (Fossil fuels), Environment, Automobiles, Electric Vehicles, Coronavirus, Innovation and Technologies, Fuel Economy, Catalytic converters, Digital manufacturing, On-demand production, Connected supply chain, Waste management.

I. INTRODUCTION

Our planet earth is the most beautiful place to live in. We are destroying our mother nature by our activities affecting our environment. Global Warming was first claimed in 1896 by Svante Arrhenius. Global warming or anthropogenic climate changes have become a part of our lexicon since the last century. Global warming is the increase in the average temperature of the earth's surface due to the depletion of the ozone layer because of radiation due to the release of emissions and greenhouse gases or use of Non-renewable resources.

The environment is suffering as the amount of greenhouse gas emissions is reaching new heights every year. It has become very difficult to live and has reduced the life span from 150 years to 60 years. Engineering which worked in streamwise today has become inter-discipline collaborating with almost all streams of engineering contributing towards the growth of technology. Automobiles have a drawback that they use fuel as its prime source of energy that forms the main source of air pollution. NASA study declared that the largest net contributor to climate change were automobiles officially.

As per our current scenario, we will be using fuel as the primary source of Automobiles for another two decades. Then the conventional vehicle market will transform into an electric one. Electric vehicles have prominence as a possible solution to many modern environmental and economic issues. Since 1830s electric motors have been an interest of many inventors, but fully electric vehicles were not prevalent until 2008 when Tesla Motors released the Roadster. The electric vehicles are confronted with a couple of barriers for market penetration:

- Limited range
- The lack of charging infrastructure.
- Adaptability to the change

As we are in the early stage of technological development, investments are still rather limited due to high investment risks. The emissions released during the manufacturing of the electric vehicles are much higher compared to that of a conventional Automobile manufacturing. But is vice-versa when coming to the emissions released while driving the vehicles.

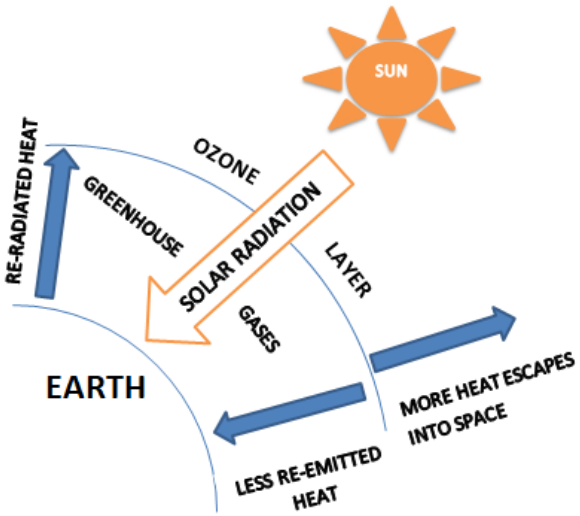

Fig. 1. Natural Greenhouse Effect

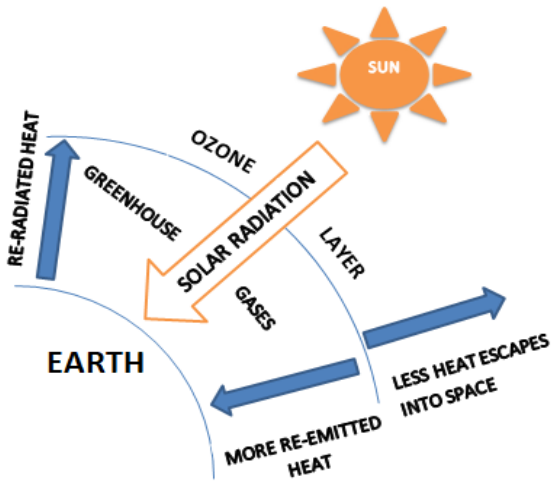

Fig. 2. Human-Induced Greenhouse Effect

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The major reason is the Human activities. Global Warming or Climate change is a cyclic process which was caused by humans and is affecting humans now.

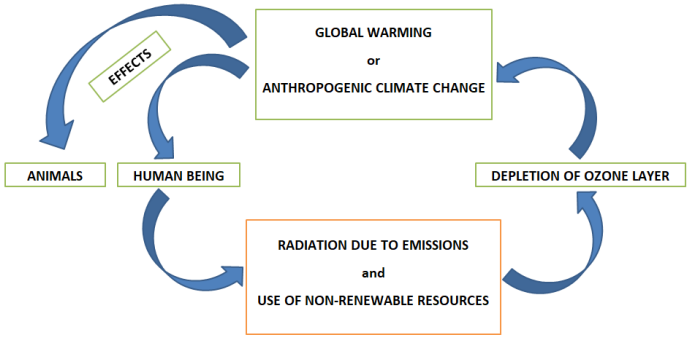

Fig. 3. Cyclic Process of cause and effect of Global warming

Coronavirus: The whole world is shut down due to the pandemic situation occurring due to Coronavirus. The outbreak of Coronavirus pandemic has global lockdowns, quarantines and restrictions resulting to solve one of our major global concern, the ozone layer depletion which has now started healing itself as the emissions from Automobiles and Industries have reduced drastically worldwide as the result of the decrease in carbon footprints.

Due to the global lockdown, the Global warming causing major greenhouse gases like ground-level ozone, particle pollution (or particulate matter), carbon monoxide, sulphur dioxide, and nitrogen dioxide have been reduced comparatively.

This time period has given the wildlife its natural habitat and freedom to live which we have destroyed for our needs and luxurious lifestyles

From the Fig. 4 & Fig. 5 it is evident that there is a significant amount of drop in the NO_2 emissions cross the highest populated countries in the world i.e. China and India, respectively.

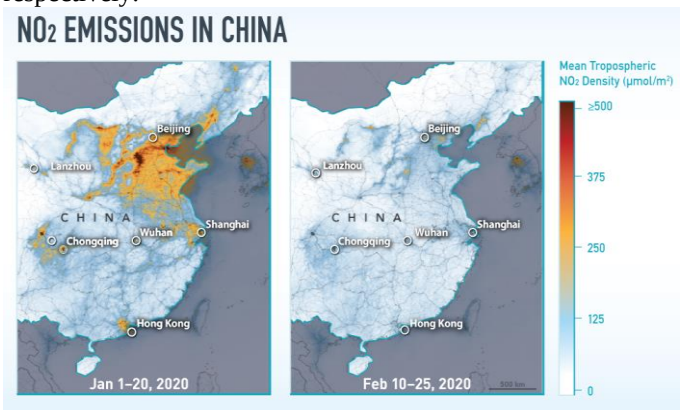

Fig. 4. Decrease of NO_2 emissions in China during the Global lockdown

Data source: Tropospheric Monitoring Instrument (TROPOMI) on ESA's Sentinel-5 satellite
Image credit: Josh Stevens , NASA Earth Observatory

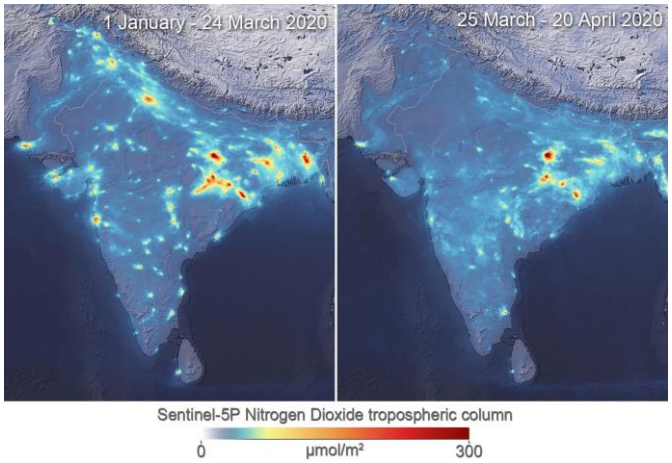

Fig. 5. Decrease of NO_2 emissions in India during the Global lockdown

Data source: These images, using data from the Copernicus Sentinel-5P satellite, show the average nitrogen dioxide concentrations.
Image credit: ESA

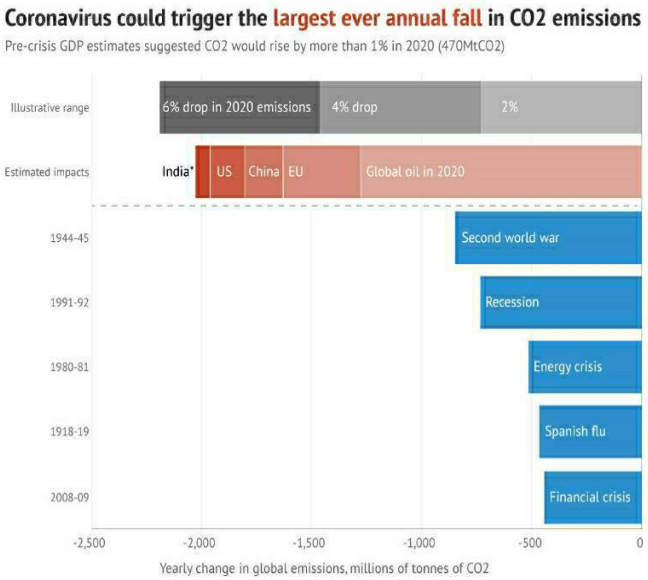

Fig. 6. Decrease of CO_2 emissions Globally during the Global crisis

Chart source: Carbon Brief.
Data Source: Simon Evans, Carbon Brief analysis of emissions data from the Carbon Dioxide Information Analysis Centre (CDIAC) and the Global Carbon Project; analysis of assessments from ICIS and the US Energy Information Administration; analysis of daily data from India's Power System Operation Corporation (POSOCO).

The five largest falls in annual global CO_2 emissions ever recorded are shown in blue bars, in millions of tonnes of CO_2. The grey bars illustrate how far emissions would fall in 2020 under a 2%, 4% or 6% reduction compared to 2019 levels. The red bars show estimated emissions impacts of the coronavirus crisis in 2020 on the global oil sector, the EU carbon market, China, the US and India, with the latter only accounting for changes in the power sector. Where possible, estimates are shown relative to pre-crisis forecasts. Geographical estimates exclude oil.

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We must follow a few necessary steps to control this release of dangerous emissions into the atmosphere so that the world would be a better place for us as well as the future generations to live.

II. EFFECTIVE CHANGES IN THE CURRENT AUTOMOBILES TO REDUCE THE EMISSIONS

A. Use of Eco-friendly Public Transportation Systems

Increase the use of Electric Bikes, Cars, Buses and Trains. There is a close relationship between transport and the environment. Transport has a huge impact on the environment due to its toxic emissions. As our fuels are limited and the usage of fossil fuels leads to more CO2 emissions. After 2020, the conventional engine efficiency improvements will be limited and relatively expensive. Biofuels will also be limited. Therefore, when searching for ways to lower the ecological impact, we see the necessity of a change in our transport system. Electric vehicles are comparatively silent and have zero emissions while driving. Hence, use of Electric vehicles with primary energy sources (gas, coal, oil, biomass, wind, solar and nuclear). They can significantly improve the local air quality when taken over the conventional car market.

B. Cleaner Fuel

Natural gas burns cleaner producing less air pollution than coal. Clean fuel cuts down pollution, reducing health risks, and giving consumers more choices. The cost of Fuel is dropping significantly. There is an uncontrollable environmental and economic case to break oil's ownership of the transportation sector. Emissions (primarily from gasoline and diesel) account for nearly half of the greenhouse gases which have massive health impacts on affected communities. Not only that, but money also flows out of our states each year to pay for the fuels and that money could circulate in our local economy rather, if we reduce our consumption of petroleum. Not just biofuels, clean fuel standards promote a full range of alternatives to petroleum. Electric vehicles, renewable fossil gas, hydrogen, sustainable biofuels, and lower carbon fossil alternatives, such as propane and fossil gas are a full range of alternatives choices required to be included in our transportation. By measuring the life-cycle carbon emissions of each fuel source and ensuring that energy sources with the lowest carbon footprints receive the greatest support.

C. Use of Fuel-efficient vehicles

Several technologies aimed at improving the fuel economy in Gasoline and Diesel Vehicles.

1) These general technologies include:

• Electrically driven oil and water pumps in the vehicle.
• Efficient alternators, air conditioners and heat pumps that consume minimum fuel.
• Fast engine warm-up technologies.
• Idle-off systems.
• Reducing the tractive force by reducing vehicle weight, drag and rolling resistance.
• For every drive cycle increasing the average efficiency of the engine.
• Reducing internal friction losses.
• Reducing power consumption by accessories.
• Limiting engine speeds (by using automatic gear system and changing transmission ratios).

2) Engine Technologies

Specific output has increased greatly due to:
• Higher compression ratios.
• Improved intake and exhaust manifolds.
• Improved and innovative design of cylinder head and valve port.
• Use of minimum two intake and exhaust valves.
• Reduced internal friction.
• Use of electronic injection and engine management systems application.
• Variable valve timing (VVT)
• Variable valve lift and timing (VVLT)
• Cylinder cut-out
• Fuel injection
• Computer-controlled electronic spark timing
• Lean burn gasoline direct injection

3) Low Ambient Temperatures

Diesel engines require much less advancement during cold starts. It consumes excess fuel at a 0°C cold start and its about 35 to 40% of the excess fuel used in a gasoline engine. Resulting a minor effect on actual in-use diesel fuel economy in many of the "fast warm-up" technologies and electrically driven water pumps.

4) Hybrid Technologies

Engine combined with electric motor results in maximizing engine efficiency. This provides opportunities for both the test cycle and on-road operating conditions. The efficiency of hybrid power trains can improve by the following means:
• Engine shutoff during idle/braking.
• Launch assist.
• Regenerative braking.
• Electric traction at low speeds.
• Transmission optimization.

5) Tyre Technologies

The impact of tyres on fuel economy is not a priority or attention by most drivers. Higher performance four-wheel-drive cars are equipped with wider and larger tyres and are associated with higher drag and inertia losses. The design of the tyre contributes to vehicle fuel economy in the following ways:
• The aerodynamic drag force is created by a finite area on the tyre.
• Mass of the tyre leads to inertia loss.
• Tyre-road friction and hysteresis are caused due to the rolling resistance. Hysteresis plays a major part of a tyre's

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rolling resistance. Due to the visco-elastic nature of rubber heat is dissipated in the various components of the tyre when the tyre deforms.

6) Daytime Running Lights

DRL power consumption depends on the implementation. Present DRL systems consume about 5 watts (LED system) to over 200 watts (headlamps and all parking, tail, and marker lights on). Engine provides the power required to run the DRLs. This requires burning of additional fuel. Therefore high-power DRL systems increase CO_2 emissions.

This affects the country's compliance with the Kyoto protocol on greenhouse gas emissions. In europe, at the beginning of 2011, after DRLs became mandatory the low-power solutions are being encouraged and headlamp-based systems are not allowed.

Effective DRL without a significant increase in fuel consumption or emissions have reduced fuel consumption up to 0.5 mpg which may be found when comparing a 55 W DRL system to a 200 W DRL system.

7) Aids to improve driving habits

Driver behaviour is complex and is characterized by numerous independent parameters and plays an important role in fuel economy driving styles. Among the most influential behavioural factors affecting fuel economy are:

• Selection of gear accordingly and maintaining RPM (engine speed – revolutions per minute).
• Acceleration and deceleration patterns.
• High-speed driving.
• Prolonged idling.

8) Fuel-saving Driver Support Devices

There are a number of technologies that provide feedback to the driver or directly control the vehicle and thus give fuel economy benefits. To encourage less aggressive driving and driving in a manner to maximize fuel economy the systems have been designed to provide visual or audible aids.

These include:

• Engine speed for good fuel economy is marked to show regions on RPM gauges.
• Average or as a real-time instantaneous calculation the display of fuel economy in miles per gallon or km/litre as computed by the vehicle electronic control unit.
• Shift indicator light (SIL), indicating the optimum point to shift gears, usually based on engine RPM, or dashboard lights to indicate fuel-efficient driving modes.
• Engine load (vacuum) indicators (econometers)
• (Adaptive) cruise control.

9) Effects of Other Technologies

Technologies that reduce engine loads in terms of percentage will have similar effects on diesel or gasoline vehicle fuel economy. Including technologies like vehicle weight and drag reduction, tyre rolling resistance reduction and accessory load reduction (with use of efficient alternator, electric power steering, and improved water and oil pumps). However, diesel engines have higher internal engine friction than gasoline engines effecting improved engine oils.

At the same time, improved oils have their most significant benefits during cold starts, where the diesel fuel consumption penalty is not as large as that for a gasoline engine. Hence, the net fuel economy benefit of improved oils may be almost similar to that for gasoline engines.

D. Catalytic convertors

The catalytic converter is the most important component of the exhaust system. In automobiles, it converts harmful compounds to harmless compounds in the exhaust. Its shape appears similar to the muffler

In a typical passenger car is between the engine and the muffler. In a typical passenger car is between the engine and the muffler.

There are two types of catalytic converters:

1) Two-way: A two-way (oxidation) catalytic converter has two simultaneous assignments.

• By the general process of oxidation of carbon monoxide (CO) to carbon dioxide (CO_2):

$$2CO + O_2 \rightarrow 2CO_2$$

• Oxidation of hydrocarbons (un-burnt and partially burnt fuel – incomplete combustion) to carbon dioxide and water (a combustion reaction)

$$C_xH_{2+x} + [(3x+1)/2]\ O_2 \rightarrow xCO_2 + (x+1)\ H_2O$$

In diesel engines these are widely used to reduce hydrocarbon and carbon monoxide emissions.

2) Three-way: A Three-way(oxidation-reduction) catalytic converter has three simultaneous assignments.

• Reduction of nitrogen oxides (NO) to nitrogen (N_2) and oxygen (O_2):

$$2NOx \rightarrow xO_2 + N_2$$

• By the general process of oxidation of carbon monoxide (CO) to carbon dioxide (CO_2):

$$2CO + O_2 \rightarrow 2CO_2$$

• Oxidation of hydrocarbons (un-burnt and partially burnt fuel – incomplete combustion) to carbon dioxide and water (a combustion reaction)

$$C_xH_{2+x} + [(3x+1)/2]\ O_2 \rightarrow xCO_2 + (x+1)\ H_2O$$

E. Use of the new innovative Mobility systems like MaaS

Usage of this new Mobility as a Service aims to reduce the total private car ownership in the world. By converting mobility into a service, the number of people who own the

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cars will reduce and increase the rental or sharing service. Soon many new mobility modes like micro-mobility or air mobility will be coming into action, which would eventually reduce the private car ownership as we have made our earth occupied and very suffocating to live.

III. EFFECTIVE CHANGES IN THE CURRENT INDUSTRIES TO REDUCE THE EMISSIONS

A. *On-demand production in factories (to reduce the excess production)*

All Industries follow the On-Demand Production.

1) Production = Demand + Supply

Marginal Revenue is generated. When the product is available in excess quantity in the market, the demand for the product decreases.

2) Demand = Production - 1

When the demand is high, supply and production should be low so that it results in high demand for the product and leads to profit in business.

B. *Use of Connected Supply chain*

Connected Supply Chain is drafted to withstand future challenges in logistics due to the complication in the supplier and production network as well as the unstable condition of the markets by enhanced digitalization and innovative Industry.

1) Digital transformation in connected supply chain

Today's world has transformed into a massive digital network, and it is an on-going struggle for many organizations to stay connected and in communication with their trading partner networks. Technologies and requirements change without notice as our global business is complex. And when companies think they have found a tool that will work for them, a new requirement emerges.

C. *Digital Manufacturing*

Digital manufacturing can determine as an integrated procedure for manufacturing that is focused on a computer system. A machine can read a CAD (computer-aided design) file to deliver within a few hours. This process provides prototype, produce and fabricates moulds to aid production.

As consumer's habits and expectations are changing, it is necessary that we find a new production model. Digital manufacturing appears as an answer to this changing world. To meet consumer's demand it allows an iterative production. Productivity has enhanced as the prototypes are produced quicker with high-quality. The real-time inventory monitoring allows companies to master their whole production line and interfere when it is necessary to adapt the product to the changing market.

D. *Innovative methods of Waste Management to reduce pollution*

1) Monitor Waste
2) Streamline Trash Pickups with innovative companies providing eco-friendly waste technology for various sectors.
3) Improved Recycling Rates
4) Automated Waste Collection
5) Route Optimization
6) Landfill Modernization
7) Enhanced Safety
8) Quick Turnaround Times

E. *Measuring carbon footprint*

By evaluating how much pollution an organization's operations generate. It can be measured by the greenhouse gas emissions assessment. After the size of the carbon footprint is determined. Design a strategy to reduce it through technological developments, product management, carbon capture, and others. We can change minor policies and can see an overall significantly reduce.

F. *Carbon Capping*

Emissions trading, also known as cap-and-trade policies. It restricts the limit on carbon dioxide emissions. The government has set a "cap" on the emissions that can be produced and companies are given carbon allowances. Therefore allowances can be used or traded to other companies.

G. *Reducing energy use*

Energy efficiency certifications have been made mandatory by the building industry. These standards help set significant and attainable goals, reducing the amount of energy used by the building. Ensuring new buildings have the energy-efficient certifications by earning any of these ratings the energy usage can be reduced.

H. *Rewarding green commuters*

Transportation of industrial products can be done with equal intervals and reducing the number of travel cycles. Motivate employees to use public transportation, carpooling, biking, telecommuting, and other environmentally friendly commutes resulting in reduce traffic jams and minimize the environmental impacts due to drive-alone commuting.

I. *Reducing fossil fuel dependence*

Burning coal produces energy resulting in carbon dioxide emissions, in turn, contributing to irreversible climate change. Deliberate efforts to take up sustainable energy sources, such as wind or solar power can help to reduce their daily CO_2 emissions.

J. *Voluntary offsets*

If a company can't afford to, there are alternatives such as undertaking new energy-efficient building initiatives for balancing your carbon footprints through alternative projects, such as solar (solar panels on buildings) or wind energy or reforestation, is known as carbon offsetting.

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IV. CONCLUSION

Mechanical Engineering has invented, and developed systems based on the principles of force, energy, and motion for the world. These contributions of Mechanical Engineering help to eliminates excessive usage of resources by optimizing and improving efficiency making the world a better place to live. The goal to control pollution is the process of designing new innovative technologies and manufacturing processes towards the promotion of a green environment.

As engineers, every stream has an important and crucial role in the successful transformation of Earth to a pollution-free place.

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