Analysis of CO$_2$, CO and HC emission reduction in automobiles

K N Balan$^{1*}$, T N Valarmathi$^2$, Mannem Soma Harish Reddy$^3$, Gireddy Aravinda Reddy$^4$, Jammalamadaka K M K Sai Srinivas$^5$, Vasan$^6$

$^1$ Assistant Professor, Faculty of Mechanical Engineering, Sathyabama University, Chennai, India
$^2$ Assistant Professor, Faculty of Mechanical & Production Engineering, Sathyabama University, Chennai, India
$^3, 4, 5$ UG Students of Mechanical Engineering, Sathyabama University, Chennai, India
$^6$ UG Students of Mechanical & Production Engineering, Sathyabama University, Chennai, India

Email id: knb5463@gmail.com

Abstract. In the present scenario, the emission from automobiles is becoming a serious problem to the environment. Automobiles, thermal power stations and Industries majorly constitute to the emission of CO$_2$, CO and HC. Though the CO$_2$ available in the atmosphere will be captured by oceans, grasslands; they are not enough to control CO$_2$ present in the atmosphere completely. Also advances in engine and vehicle technology continuously to reduce the emission from engine exhaust are not sufficient to reduce the HC and CO emission. This work concentrates on design, fabrication and analysis to reduce CO$_2$, CO and HC emission from exhaust of automobiles by using molecular sieve 5A of 1.5mm. In this paper, the details of the fabrication, results and discussion about the process are discussed.

1. Introduction

Pollution is becoming a challenging problem in our environment. It is not an exaggeration to say that the advancement in science and technology had caused an uncontrollable change in the environment along with an alarming increase in the pollution. Among all the pollutions, air pollution is considered as a major constituent which is causing diseases, damaging food crops and causing ecological imbalance. Air pollution can be caused by both anthropogenic and natural sources. Air pollution is causing stratospheric ozone depletion which is recognized as a threat to human health as well as to the Earth’s ecosystem. Air pollution is defined as emission of harmful gases like CO$_2$, CO, HC, SO$_2$ and NOx from the industrial chimneys, automobiles and aircrafts. Worldwide air pollution is caused due to the emission of hydrocarbons, nitrogen oxides, carbon monoxide and carbon dioxide. Emission of these gases takes place mainly due to the incomplete combustion of fuel and air mixture.
Fuel + Air $\rightarrow$ Unburned Hydrocarbons + Nitrogen oxides + Carbon dioxide + Carbon monoxide + water

1.1 CO$_2$ sequestration process

It is a process involving the carbon dioxide capture and long term storage of CO$_2$. It has been proposed as a way to slow the atmospheric and marine accumulation of greenhouse gases, which are released by burning fossil fuels. There are two major types of CO$_2$ sequestration: Terrestrial and geological.

- Terrestrial sequestration
- Geological sequestration

2. Literature review

Shuichi Yamamoto [1] conducted experiments on CO$_2$ sequestration and found that sequestration in deep aquifers is one of the options for reducing the emission of greenhouse gases. An axisymmetric horizontal aquifer-caprock system is modeled, to study various factors such as injection rate, permeability, stiffness, and stability of the cap rock and aquifer. Koji Kadono [2] in collaboration with Kansai electric power and Mitsubishi heavy industries limited developed an economical process to reduce the CO$_2$ emissions by carbon capture. MEA is chosen as the solvent. It will capture approximately 150000 tons of CO$_2$ annually at a CO$_2$ capture rate of over 90%. Nikolett Sipocz [3] conducted experiments on low temperature CO$_2$ capture using MEA 30% Wt solvent. In the desorbed the absorbed CO$_2$ is heated up and stripped from the solution. Eventually the purified CO$_2$ is sent for compression while the regenerated solvent is sent back to absorber.

Jillian Dickinson [4] determined that sequestration process is a two stage process which consists of absorption and desorption columns. The process relies on the reversible reaction between the CO$_2$ and MEA, at lower temperature CO$_2$ is absorbed and at higher temperatures CO$_2$ is released. Xu [5] studied sequestration process on by injecting CO$_2$ into high permeability sand stone and found that there is sharp decrease in Ph value with an increase in HCO$_3$.$^-$. The CO$_2$ solubility will increase enhancing the solubility trapping with a decrease in density of aqueous phase. Anggit Raksajati [6] studied sequestration using phase change solvent by considering few samples of L-CLASS solvent and S-CLASS solvent which will form carbonate ions and bicarbonate ions on reacting with CO$_2$. Takashi Nakamoto [7] conducted experiments on aqueous solutions of amine in high pressure conditions to study CO$_2$ absorption among three samples RH-X, MDEA aqueous solution and DEPG solutions, he found that RH-X has the highest CO$_2$ absorption performance.

3. Experimental work

Literature suggests that CO$_2$ sequestration process is one of the methods to reduce CO$_2$ emission rate from thermal power station and industries. However, limited information is available in contribution of CO$_2$ sequestration process. The present study has chosen to investigate the interactions of various gas reductions from automobile exhaust. The various gases include CO$_2$, CO and HC.

3.1. Experimental setup

The assembled exhaust unit consists of stainless steel cylinder, fan, SS mesh. Inside the cylinder a stainless steel mesh is provided at the middle height from the base, in which the mesh is to support the chemical and it doesn't allow falling down. Base of the cylinder is fitted with a fan in which it circulates air equally in all direction inside the cylinder. At the base of the cylinder is tapered to reduce the pressure. Assembled exhaust unit
3.2. Plan of experiment
NETEL auto exhaust/multi gas analyzer offers the greatest benefit of having the need to conduct the experiment and to study the measurement of CO, CO$_2$, HC gases. Hence it is used to measure the relative volumes of certain gaseous constituents in the exhaust of automobile vehicles. The gases are Carbon monoxide (CO), Carbon dioxide (CO$_2$), Hydrocarbons (HC). In this study, experiment has conducted on three control parameters (CO, CO$_2$, and HC) at seven levels.

3.2.1 Molecular sieve 5A of 1.5mm
The aim of the present study is to propose a chemical to reduce the emission rate from auto mobile exhaust and compare its effectiveness against the normal exhaust silencer is taken into under consideration. The chemical used in this study is molecular sieve 5A of 1.5mm.
Upon including the chemical of molecular sieve 5A of 1.5mm, a series of experiment was conducted by inserting the chemical in the assembled exhaust unit, in which the experiment was carried out for the consideration of molecular sieve 5A of 1.5 mm and compared with normal engine exhaust.

4. Results and discussion
By using the NETEL auto gas analyzer, two experiments were carried out for the two wheeler, four stroke petrol engine without using molecular sieve exhaust unit and by using molecular sieve 5A of 1.5mm and their results are recorded at relative volume at a speed range of 1000 rpm to 7000 rpm shown in table:

Table 1. Emissions at different speeds with and without using Molecular sieve 5A of 1.5mm.

| S.no | Speed in rpm | Without using Molecular sieve 5A of 1.5mm | Using Molecular sieve 5A of 1.5mm |
|------|--------------|------------------------------------------|----------------------------------|
|      |              | HC in ppm vol | CO in % vol | CO₂ in %vol | HC in ppm vol | CO in % vol | CO₂ in %vol |
| 1    | 1000         | 240            | 1.3          | 1.1         | 110            | 1.20          | 1.6         |
| 2    | 2000         | 260            | 1.5          | 1.4         | 130            | 1.38          | 2.1         |
| 3    | 3000         | 280            | 1.7          | 1.8         | 160            | 1.69          | 2.3         |
| 4    | 4000         | 341            | 3.7          | 3.9         | 179            | 2.0          | 2.5         |
| 5    | 5000         | 478            | 7.9          | 8.2         | 190            | 3.0          | 2.9         |
| 6    | 6000         | 639            | 8.9          | 8.9         | 250            | 4.1          | 3.2         |
| 7    | 7000         | 752            | 9.8          | 9.5         | 271            | 4.4          | 3.3         |

4.1 Comparison of CO emission rate
The comparison of the CO emission rate for both experimental values obtained using molecular sieve and without using molecular sieve for a speed range of 1000 to 7000 rpm shown in Table 1.
4.2 Comparison of CO\textsubscript{2} emission rate
The comparison of the CO\textsubscript{2} emission rate for both experimental values obtained using molecular sieve and without using molecular sieve for a speed range of 1000 to 7000 rpm shown in above Table 1.

4.3 Comparison of HC emission rate
The comparison of the HC emission rate for both experimental values obtained using molecular sieve and without using molecular sieve for a speed range of 1000 to 7000 rpm shown in above Table 1.
Figure 7. Comparison of HC emission rate

From the above graphs it is concluded that the emission of CO\(_2\), CO and HC was optimized successfully.

5. Conclusions

In this work it has been presented a dynamic effort to reduce HC, CO and CO\(_2\) emissions through Carbon capture and storage mechanisms. Adsorption technique is followed to control the Carbon emissions from the exhaust gas. The solid adsorbent used in this work is molecular sieve 5A of 1.5mm, in which it locks and holds the carbon molecules from the exhaust. The carbon capture storage is successively applied for automotive emission control. It is the action taken for the automobile sector for controlling HC, CO, CO\(_2\) emission rate from the automobile exhaust. Finally it is concluded that the emission of HC, CO, CO\(_2\) gases for four stroke petrol engine was reduced successfully by using molecular sieve 5A.

References

[1] Shuichi Yamamoto, Satoru Miyoshi, Shin Sato, Kenichiro Suzuki 2013 Energy Procedia p 3989.
[2] Koji Kadono, Asao Suzuki, Masaki Iijima, Tsuyoshi Ohishi, Hiroshi Tanaka, Takuya Hirata, Masami Kondo 2013 Energy Procedia p 1785.
[3] Nikolett Sipocz, Alvaro Hernandez-Nogales, Miguel A.Gonzalez-Salazar, Roger Shisler, Vitali Lissianski 2013 Energy Procedia p 1228.
[4] Jillian Dickinson, Graeme Puxty Andrew Percy, T.vincent Verheyen 2015 IFAC-Papers Online p 216.
[5] Xu,T and Li,J 2013 Procedia Earth and Planetary Science p 912.
[6] Anggit Raksa jati, Minh T.Ho, Diane E.Wiley 2014 Energy Procedia, Pages 2280–2288.
[7] Takashi Nakamoto, Toshinori Muraoka, Shin Yamamoto and Takayuki Higashii 2014 Energy Procedia p 1940.