IFERP connecting engineers... developing research

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 2, Issue 3, March 2017

Comparison of Performance and Emission characteristics of biodiesel as a alternative fuel with Ceramic Coated Piston on 4-Stroke D.I diesel Engine

[1] S. Rajasekhar [2] R. Bhaskar reddy [3] Dr. B.Jayachandraiah [4]Dr. S. Sunilkumar Reddy
[1] U.G Student, Department of Mechanical Engineering, SKIT, Srikalahasti, Chittoor(dt), A.P, INDIA
[2] Lecturer, Department of Mechanical Engineering, SKIT, Srikalahasti, Chittoor(dt), A.P, INDIA
[3] Professor, Department of Mechanical Engineering, SKIT, Srikalahasti, Chittoor(dt), A.P, INDIA
[4] Professor, Department of Mechanical Engineering, SIETK, Puttur, Chittoor(dt), A.P, INDIA.

Abstract:— **Diesel engines are being used extensively for fuel economy but due to gradual depletion of Petroleum resources and increase in exhaust emissions, there is an urgent need for suitable alternative fuels for the diesel engines. As our country is an agricultural country, if the alternate fuels are produced by our farmers it will be beneficial for the country and the farmers also. In recent studies, researchers studied various vegetable oils like canola oil, aloveera oil, soya been oil, flaxseed oil and hone oil etc. Out of all flaxseed oil and hone oil play an important role as an alternative fuel. But the properties of flaxseed oil and hone oil are not suitable for the usage in the existing diesel engines without blending with diesel fuel. The performance of the engine depends on the combustion phenomenon and it further depends on the amount of heat retained in the combustion chamber. Hence the present work is planned accordingly to develop an insulated engine by coating the piston with TIO2 material. So that more amount of heat will be retained in the combustion chamber which aids the combustion. Further the performance of flaxseed and hone oil blends by equal proportions with diesel namely B10(5%of flaxseed oil+5%of hone oil), B20(10%of flaxseed oil+10%of hone oil), B30(15%of flaxseed oil+15%of hone oil) and B40(20%of flaxseed oil+20%of hone oil) are tested and the results are mentioned accordingly.**

Keywords:-- **Blended oil, Exhaust emissions, Flaxseed oil, Hone oil, Piston Crown, Performance parameters, TiO2 Coating.**

NOMENCLATURE

CP	Coated Piston
NP	Normal Piston
TiO_2	Titanium Oxide
Al_2O_3	Aluminum Oxide
NOx	Nitrogen Oxide
CO_2	Carbon di-oxide
HC	Hydro-carbon
CO	Carbon monoxide

I. INTRODUCTION

The consumption of petroleum fuels has been increased tremendously in both industries and transport sector, which leads for emissions. The alternate fuels should be renewable, easily available, produce low emissions and high performance. An intensive search is being carried in developing an alternate for diesel. Among all, biodiesels are renewable and can be produced easily in rural areas. Since they have properties comparable to diesel fuel, these can be used in diesel engines without much modification in the existing diesel engine. Based on the literature these are clean burning fuels without much harmful emissions. But with the higher temperatures in the combustion chambers the combustion will be complete. In general, the much amount of heat produced is transferred through the piston. Hence in the present work for the retaining of heat in the combustion chamber the piston is coated with an insulated material TiO2.

II. LITERATURE REVIEW

Considerable amount of work has been done on biodiesel and is represented below. Helmisyah A.J et al.,[2] has studied the performance of engine with PSZ coated piston by compressed natural gas and compared the same with uncoated piston. They concluded that high thermal stresses were induced in the piston and piston crown fails to operate effectively with insufficient heat transfer. Detailed analyses of microstructure, hardness, surface roughness, and interface bonding on the deposited coating were conducted to ensure its quality. The PSZ coated piston demonstrated lesser thermal stresses than the uncoated piston crowns despite a rough surface. Aydin Huseyinet al.,[1] experimentally investigated the combined effects of thermal barrier coating with zirconium oxide (ZrO_2) and blending with diesel fuel on usability of vegetable oils in diesel engines. With the engine coating the heat will be retained in the combustion chamber and increases the thermal efficiency and performance of the engine. Further the work was extended with cottonseed oil and sunflower oil blended with diesel fuel and concluded that exhaust emission parameters such as CO, HC and smoke opacity were decreased. Also, sunflower oil blends presented better performance and emission parameters than cottonseed oil blends. H. Hazaret al., [8] studied the effect of Al_2O_3-TiO_2 coating in a diesel engine on the performance and emission of corn oil methyl ester and compared the same with uncoated engines. A decrease in engine power and specific fuel consumption, as well as significant improvements in exhaust gas emissions (except NOx), were observed for all test fuels used in the coated engine compared with that of the uncoated engine. Investigations were carried out by Altinet et al. *[6]* to study the effects of vegetable oil fuels and their methyl esters with Al-Ti coated piston on a DI, four stroke and single cylinder diesel engine. They concluded that raw vegetable oils can be used as fuel in diesel engines with some modifications and when compared to diesel fuel, a little amount of loss in power was observed and the particulate emissions were higher than that of diesel fuel. Vegetable oil and methyl esters exhibited the performance and emission characteristics closer to the diesel fuel when compared to uncoated piston engine. Giannakos et al. [7] The physical, chemical and fuel related properties of tobacco seed oil were investigated and suggested that this non edible oil may be an appropriate substitute for diesel fuel. In the view of the potential properties large number of investigations has been carried out internationally in the area of vegetable oils as alternative fuel. Some of the vegetable oilsfrom the form and the forest origin have been identified. The most predominantly Sunflower, Soyabean, Jatropa, Cotton seed, Canola, Champaka, and Peanut oils have been reported as an appropriate substitute of petroleum based fuels. Govindasamy et al. [8] investigated the

Performance and emission of a 2-stroke S.I engine fitted with a fuel injection system. The use of strong magnetic charge from the magnet put into fuel line gave a complete and clean burn so that power was increased with reducing operating expenses. The magnetic flux on the fuel line dramatically reduced harmful exhaust emissions while

Increasing mileage thereby saving money and improving engine performance. It increased combustion efficiency and provided higher-octane performance. The experimental results show that the magnetic flux on fuel reduces the carbon monoxide emission up to 13% for base engine, 23% in copper coated (inside the cylinder head) engine and 29% in zirconia coated (inside the cylinder head) engine. Non supercharged SI engine using LPG with mixture formed by evaporated LPG has lower power output by about 8% as compared to original petrol engine.

III. FLAXSEED OIL

Flaxseed oil scientific name is Linum usitatissimum, (or) Linaceae. The yellowish drying oil is derived from dried ripe seeds of flax plant through pressing and extraction. Fresh, refrigerated and unprocessed, flaxseed oil is used as nutritional supplement.

Fig.1 Flaxseed Plant and seeds

HONE OIL:

It is a one type of alternative fuel. It's scientific name is "Calophyllum inophyllum". It is made from the fully matured fruits, in that fruits seeds can be collected and then crush the seeds then crude calophyllum oil is extracted. After pre-Treatment the hone oil employed.It's chemical name is C3H8O3. It is used for soap making, burning, painting works, lubricants, substitute for castor oil etc., Refined oil is injected intramuscularly to relieve pains in Leprosy.

Figure-2: Fresh fruit with shell

Distributed in India:

Commonly in coastal regions, Orissa, Maharashtra, Karnataka, Tamilnaadu, Kerala, Lakshadweep, Andaman & Nicobar Islands. It is available in Asian countries. The procedure for the production of flaxseed oil and Hone oil from the plant is shown in the following layout.

IFERP
connecting engineers... developing research
ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 3, March 2017

Chemical formula	$Ti\text{-}O_2$
Density	4.23 g/cm^3
Melting point	1843°C
Boiling point	2972°C
Thermal Conductivity(25°C)	11.7 WmK^{-1}
Thermal expansion (RT-1000°C)	9 x 10^{-6} /°C
Hardness	10290 MPa
Modulus of Elasticity	230 GPa
Shear Modulus	680 MPa
Tensile Strength	367 MPa
Compressive Strength	680 MPa
Endurance limit	330.7 MPa

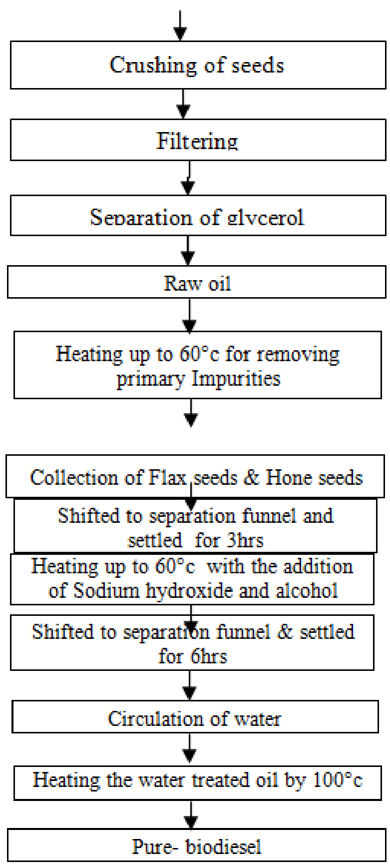


Fig.2.Production process of bio-diesel

IV. PROPERTIES OF TITANIUM OXIDE:

Thermal and physical properties of titanium oxide materials are found with standard equipment's and are mentioned below.

Table 1: Properties of Ti-O2

S.No.	Particulars	Specifications
1	Make of the Engine	Kirloskar
2	Cylinders arrangement	Vertical
3	No. of cylinders	One
4	Lubricants	SAE 20/SAE 40
5	Bore	85mm
6	Stroke length	110mm
7	Rated speed	1500 rpm
8	Rated power	5 HP
9	Type of cooling	Water cooling

Coating Procedure:

The following procedure was adopted during TiO_2 coating process:

- The substrates were cleaned and roughened using emery paper (p220) and grit-blasted using sand blast system with pressure 4-6 bar by sand blast device.
- The grit-blasted substrates were cleaned using a hydrous ethanol alcohol and dried at 200°C by a furnace for 30 min.
- The TiO2 powder with particle size ranging from 50-90 µm was used for piston coating.
- The substrate is fixed on the flange normal to the flame and powder flow.
- The cooling system (air compressor) is switched on to cool the substrates and protect it from melting during spraying process.
- The bond powder required for the first layer is loaded into the holder.
- The substrate is heated to a suitable temperature around (300°C) by the flame.
- The coating process is started by moving a lever on the hopper to allow all the powder (TiO_2) to flow through the holder with the flame. A distance of about (20 cm) between the flame and the specimen is maintained until 350-400 µm thickness for piston is obtained.
- For adhesion process, it is to be preheated to about 1500°C directly after completing the spray process.
- The flame is then withdrawn gradually away from the valve to minimize thermal shock.

- After the thermal coating process is completed, the excess parts of coating material are removed by grinding process to avoid crankshaft breakdown.

Fig.3. Pistons before and after coating with TiO2 powder

V. EXPERIMENTAL WORK:

In order to analyze the performance and emission characteristics of diesel engine, an experimental set-up was developed. In the present work, titanium oxide (TiO_2) was coated on piston crown and flax seed oil was used as biodiesel on volume basis. The experiment was carried out on a single cylinder water cooled direct injection diesel engine. Eddy current dynamometer is used for loading i.e. electrical loading. The experimental set up is as shown in the following figure-4.

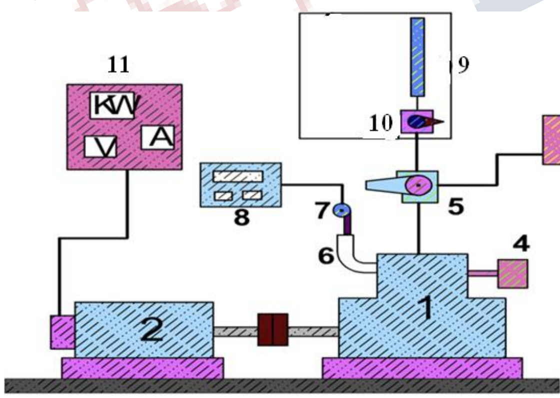


Fig.4. Experimental setup of 4-Stroke Diesel Engine

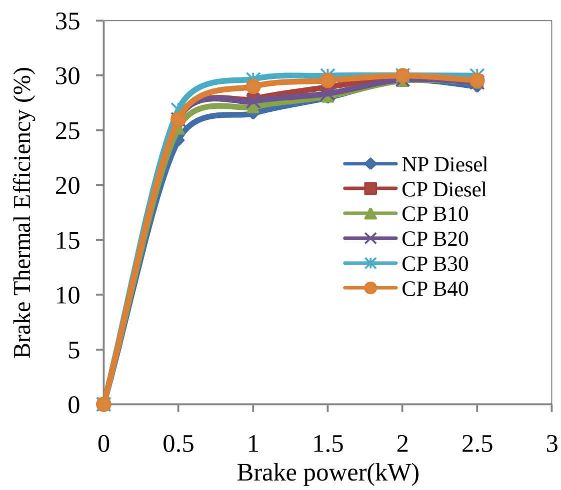
1. Engine,
2. Alternator,
3.Diesel tank,
4.Air-Filter,
5. Three-way valve,
6. Exhaust Pipe
7. Probe
8. Exhaust Gas Analyzer
9. Burette,
10. Three-way valve
11. Panel Board

VI. SPECIFICATIONS OF ENGINE:

Table 2 Engine specifications

S.No.	Particulars	Specifications
1	Make of the Engine	Kirloskar
2	Cylinders arrangement	Vertical
3	No. of cylinders	One
4	Lubricants	SAE 20/SAE 40
5	Bore	85mm
6	Stroke length	110mm
7	Rated speed	1500 rpm
8	Rated power	5 HP
9	Type of cooling	Water cooling

VII. RESULTS AND DISCUSSIONS:



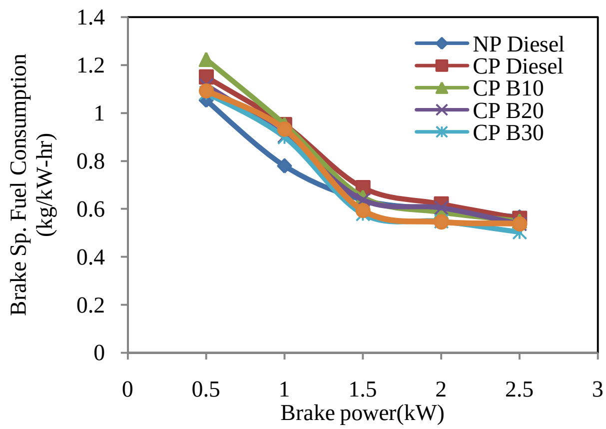
Brake thermal efficiency

Graph-1 Variations of Brake thermal efficiency with B.P

The graph-1 shows the variation of brake thermal efficiency at rated load. As the properties of biodiesel (flaxseed and Hone oil) and diesel are nearer, there is much variation in the thermal efficiency at any load. Among all it is clearly observed that the coated piston engine of B30 blend gives higher brake thermal efficiency compared to normal piston engine. The efficiency of B30 and B40 blends with coated piston are 1.449% and 1.334% higher than the normal piston engine respectively. The performance of the remaining blends is in between B30 and B40 blends performance.

ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 3, March 2017

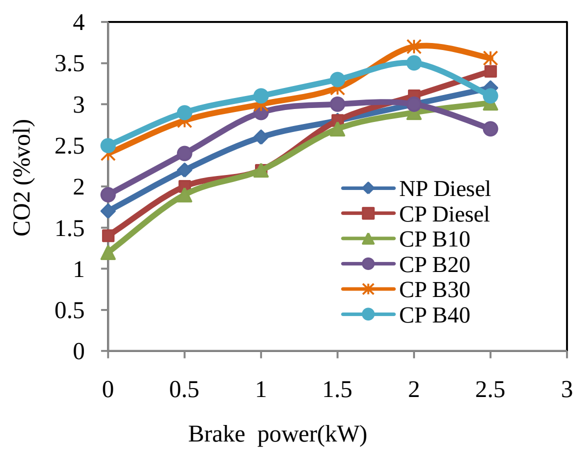
Brake specific fuel consumption



Graph-2 Variations of B.S.F.C with Brake power

The variation of B.S.F.C with brake power is shown in the graph-2. With the complete combustion in the chamber, amount of power generation increases and BSFC decreases. It is clearly observed that the coated engine piston of B30 blend oil gives lower B.S.F.C compared to normal piston engine. This was because of TiO2 material which acted as thermal insulator and aided for complete combustion. F or coated piston engine B30 and B40 blended oil was reduced by 10.17% and 6.50% respectively compared to normal piston engine.

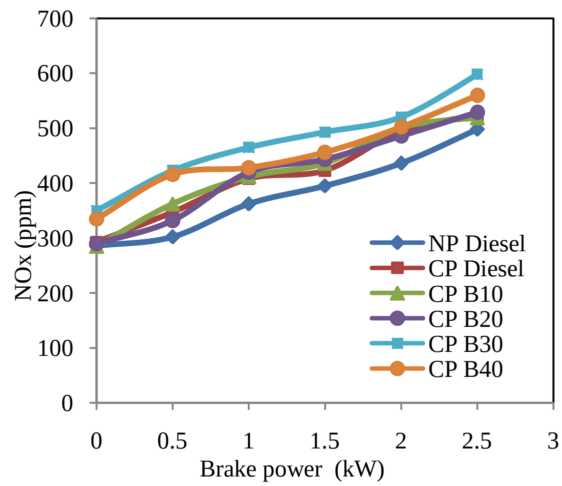
Carbon di-oxide Emission



Graph-3.Variations of CO2 emissions with Brake power

With the complete combustion of the fuel in the combustion chamber, CO will react with the inherent oxygen in the biodiesel and converts into CO2. Hence as the load on the engine increases CO2 content also increases. This is illustrated from the graph-3. It is evident that the coated piston engine of B30 blend oil gives higher CO2 emission and lowest with B40 blended oil compared to normal piston engine. The emissions of remaining blends are in between these two. For coated piston engine with B30 and B40 blended oil, the CO2 emission increased by 13.51% and 8.10% than normal piston engine.

NO**x** Emission**:**



Graph -4.Variations of NO_X Emissions with Brake Power

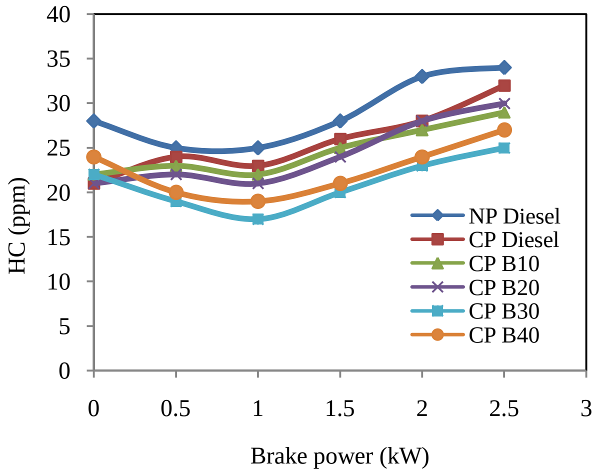
Nitrogen acts as an inert gas at lower temperature and will be active at higher temperatures. The formation of NOx emissions depends on the combustion phenomenon and the amount of oxygen content available in the engine. If the combustion is complete the amount heat generation inside the combustion chamber is also more. The graph-4 illustrates the variation of NO_X emissions with load. It is clearly observed that the coated piston engine with B30 blend oil gives higher NO_X emissions, because of its inherent oxygen content and combustion to that of normal piston. For B30 and B40 blended oil on coated piston engine, the NO_X emissions increased by 16.72% and 6.35% to normal piston engine respectively. For all the other blends it is in between the two blends.

H C Emission

The formation of HC emissions in the engine depends on the wall quenching, incomplete combustion and improper mixing of air and fuel. The coated piston acts as an insulator for the heat transfer through the piston and retain the heat inside the chamber. With the good amount of heat complete combustion of the fuel takes place and results high heat production. The variation of HC emissions with brake power is illustrated in the graph-5. It is observed that the coated piston engine of B30 blend oil gives less HC Emission when compared to normal piston engine. As the load increases the fuel also increases and the oxygen content available also increases which enhances the formation of HC

ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering
(IJERMCE)
Vol 2, Issue 3, March 2017

emissions. For the coated piston engine with B30 and B40 blended oil, the HC Emissions reduced by 19.04% and 10.52% to normal piston engine respectively.



Graph-5.Variation of HC Emissions with Brake Power

CONCLUSION

In the present work, the performance of the diesel engine is studied with ceramic coating (TiO_2) on the piston with various blended oils of flaxseed and Hone oil blend with diesel. The obtained results for flaxseed and Hone oil and their blends with diesel were compared with the diesel. Based on the performance and emission characteristics, B30 blended oil on coated piston engine gives the better performance and emissions than the normal piston engine.

The folowing results are obtained by experimental work.

- Brake specific fuel consumption for the flax seed and Hone oil blend with diesel (B30) is 0.503kg/kw-hr. It is lower than the normal piston engine
- The brake thermal efficiency of the engine enhances with good combustion in the chamber. For B30 blend with coated piston gives high efficiency compared to other blends. Brake thermal efficiency of B30 blend of coated piston engine is 29.3% and increased with1.449% and 1. 334% at rated load for coated piston of diesel and B40 oil.
- With inherent oxygen in biodiesel and high temperature due to coating on the piston, CO2 emission is high for coated piston with B30 and is 3.2%vol and then increased slightly for normal piston diesel engine and coated piston engine blend (B40) is 13.51% and 5.40 respectively.
- NOx emissions are higher with higher temperatures in the combustion chamber. For B30 of coated piston engine, the NOx emission is 598 ppm and is in creased by 16.72% and 12.54% at rated load to normal piston and coated piston engine respectively.
- HC emission of flax seed and honne oil with diesel fuel of B30 blend gives less emission and is 17ppm. It is reduced as the temperature inside chamber increases.

From the above analysis the main conclusion is that flax seed and Hone oil blends with diesel are suitable substitute for diesel as they produce lesser emissions on the ceramic coated piston engine than diesel and the ceramic coated piston engines enable the use of low cetane fuels with its high operating temperatures have satisfactory performance and emission characteristics.

REFERENCES

[1] Beg, R.A., Bose, P.K., Ghosh, B.B., Banerjee, T.Kr. Aydin Huseyin examined the "Combined effects of thermal barrier coating and blending with diesel fuel on usability of vegetable oils in diesel engines"Applied Thermal Engineering 51(2013) 623e629.

[2]. Helmisyah A.J., Ghazali M.J "Characterization of Thermal barrier coating on piston crown for compressed natural gas direct injection (CNGDI) engines" AIJSTPME (2012) 5(4):73-77.

[3]. T. Karthikeya Sharma "Performance and emission characteristics of the thermal barrier coated SI engine by adding argon inert gas to intake mixture "Journal of Advanced Research (2014).

[4] Kimura, S., Matsui, Y. &Ltoh, T. (1992), Effects of Combustion chamber insulation on the heat rejection and thermal efficiency of diesel engines, International & Congress and Exposition, Detroit, Michigan February pp, 24-28, USA.

[5] MdNurunNabi, SM Najmul Hoque, "Biodiesel Production from linseed oil and performance study of a diesel engine with diesel bio-diesel", Journal of Mechanical Engineering, 2008, 39(1), pp: 40-44g

[6] Altin R. Cetinkaya S. and Yucesu H.S., 2001. The Potential of using vegetable oil fuels as fuel for diesel engines, Energy Conversion and Management, Vol. 42, pp. 529 – 538.

[7] Giannakos P.N., Zannikos F., Stournas S., Lois E., Anastopoulos G., 2002, Tobacco seed oil as an alternative diesel fuel: physical and chemical properties, Industrial Crop s and Products, 16, pp.1– 9.

ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 3, March 2017

[8] P. Govindasamy and S. Dhandapani. “Experimental investigation of cyclic variation of combustion parameter in catalytically activated and magnetically energized 2 stroke SI engines”, Journal of Energy &Environment, Vol. 6, pp. 45-59, 2007

[9] Hazar H., 2010. Cotton methyl ester usage in a diesel Engine equipped with insulated combustion chamber, Applied Energy, 87, pp. 134–40.

[10] Jeffrey SG and Nancy AM, 2009. The impacts of Combustion emissions on air quality and climate – From coal to biofuels and beyond, Atm. Environment, 43, pp. 23–36.