REDUCTION OF EXHAUST GAS EMISSION FROM SHIPS

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Abstract

The paper deals with impact of exhaust gases on the Environment, methods for its reduction (especially usage of biodiesel) and existing legislative. Emissions from shipping contribute significantly to the concentrations of harmful air pollutants in Europe. Protocols for reducing emissions under the Convention on Long-Range Transboundary Air Pollution (LRTAP) do not cover those from international shipping. Moreover, the emissions of greenhouse gases from international shipping are not covered by the Framework Convention on Climate Change or its Kyoto protocol. As shipping is an international business, an attempt has been made in the Marine Environment Protection Committee of the UN International Maritime Organization (IMO) to bring global agreement for control of harmful air pollutants emissions. After years of negotiation, agreement was reached in 1997 on an air-pollution annex to the MARPOL 73/78 Convention. Annex VI establishes a global sulphur cap of 4.5 per cent for bunker fuel, and it designates sulphur emission control areas, where fuel used by ships must be below 1.5 per cent. It also prescribes emission standards for NOx for diesel engines with a power output greater than 130 kilowatts, but these standards are so weak that virtually all new engines are already in compliance. There are technical means by which these pollutants could be cut by as much as 80-90 per cent, and very cost-effectively compared with what would have to be done to achieve similar results by taking further measures on land-based sources. Such reductions are needed for protecting health and the environment, and for shipping to develop into a more sustainable mode of transport.

Introduction

Ships carry over more than 90% of international trade of goods which has been doubled during the last 25 years. Ships produce between 600 and 800 millions of tons of carbon dioxide that makes 5% of global CO_2 emission. Exhaust gas emission from ships is between 20 and 30% of total emission of exhaust gases in coastal areas. Until 2010, 40% of global air pollution on Earth will came from ships (Harrabin, 2003). Panetta (2003) states that 14% of global emissions of nitrogen gases and 16% of sulphur gases origins from ships. According to British Petrol air pollution from ships will raise for 75% next 15 to 25 years.

Thesis

Reduction of greenhouse gases emission from the ships is crucial factor that will comprise to the compositeness of maritime transport market. Ships energy-generating products have high concentration of matters that pollute marine environment but implementation of new strict

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legislative of marine environment protection will restrict use of heavy residual diesel oils. Boundedness and high prices of oil forces engine producers to construct high efficient motors with low consumption of fuel. In accordance with requests for diesel engines to have more power and low exhaust gas emission, some shipping companies choose as propulsion systems combination of gas and stem turbines (Tirelli, 2005). The development of new generation of gas turbines (SMGT - Super Marine Gas Turbine), appliance of electromotor propulsion and alternative drives, are some of possible solutions. One of these solutions can also be usage of biodiesel. Biodiesel is almost completely biodegradable and non-toxic so it is suitable for usage in confined and sensitive waters as harbours and waterways. It can be used in classic diesel engines, increase power, spinning moment and duration of the engine and also represents renewable source of energy together with constant reduction in price. All the fore mentioned comprises to the great perspective of biodiesel.

Sources of information

<u>Legislative</u>

The United Nations Framework Convention on Climate Change (UNFCCC ili FCCC, Rio de Janeiro, 1992) and Kyoto Protocol, as also Convention on Long-Range Transboundary Air Pollution (LRTAP) and its Protocols, they do not apply to the international maritime transport. In 1997, Marine Environment Protection Committee (MEPC) of UN International Maritime Organization (IMO) adopted Protocol 1997, which represents addition to the MARPOL 73/78 Convention. Limits of NO_x emission are defined for marine diesel engines with power over 130 kW by MARPOL Annex VI The limits are applied to the engines in new ships which are built after 1st of January 2000, and to the engines in old ships which go under serious modifications. The average NO_x emission from new ships should be 30% less than emission from the ships in 1990. Annex VI limits sulphur content in fuel on 4,5% by mass. Areas of special interests are introduced in order to protect those areas. In areas of special interest, fuel with less than 1,5% of sulphur should be used or exhaust gases should be treated to reduce sulphur oxide emission less than 6 gram per kWh.

<u>Methodes of exhaust gases reduction</u>

Contemporary marine diesel engines about 1,7 m^3 of exhaust gases per MWs, no matter on type, construction, working regime and used fuel (Lenac, 2005). Specific fuel consumption of those engines is reduced 15 to 25% in last decade. But great number of marine diesel engines use low quality fuels what brings to high NO_x and SO_x emission, and to the some extent to the increased hydrocarbons (HC) and particular matters (PM) emission. NO_x emission is increased 30 to 40%, because contemporary marine diesel engines work on peak combustion temperatures and pressures that result in NO_x increase and CO, HC and PM reduction. In last few years, new generation of engines appeared with reduced NO_x emission, but higher fuel consumption and, consequently, higher emissions of CO_2, CO, HC and PM. Marine gas turbines produce: 40 to 220 ppm of NO_x (40 ppm for methane combustion, 220 ppm for heavy fuel oil), respectively 3 to 5 ppm after injection of water in exhaust gases and Selective Catalytic Reduction (SCR) method of exhaust gases purification; max 10 ppm of CO; max 10 ppm of HC. Diesel engine exhaust gases contain about 1500 ppm of NO_x, 600 ppm of SO_x, 60 ppm of CO, 180 ppm of HC and 120 mg/Nm^3 of PM (Tirelli, 2006). It is obvious that gas turbines are future alternative to the diesel engines.

Findings and discussion

<u>Biodiesel</u>

Biodiesel refers to a non-petroleum-based diesel fuel consisting of short chain alkyl (methyl or ethyl) esters, typically made by trans-esterification of vegetable oils or animal fats, which can be used (alone, or blended with conventional petrodiesel) in unmodified diesel-engine vehicles. Biodiesel is a renewable sustainable fuel. Blends of biodiesel and conventional hydrocarbon based diesel are products most commonly distributed for use in the retail diesel fuel marketplace. Blends of 20 percent biodiesel with 80 percent petroleum diesel (B20) can generally be used in unmodified diesel engines. Biodiesel can also be used in its pure form (B100), but may require certain engine modifications to avoid maintenance and performance problems. B5 and B20 are transitional solution to B100, because B100 production is not still sufficient and its price is still higher than fossil diesel. Usage of B20 on passenger ships provides secure transition to the B100 and leaves enough time to the companies to train their crews in managing, usage, transport and storage of pure biodiesel.

Biodiesel is safe, biodegradable and reduces air pollutants. Due to the higher oxygen content (11%), biodiesel burns better and has lower emissions of all exhaust gases except nitrogen oxides. If burned without additives, Biodiesel (B100) is estimated to produce about 10% more nitrogen oxide NO_x tailpipe-emissions than petrodiesel (Bio-Mer, 2005). During the manufacture of biodiesel, to comply with low SO_2 engine emission limits set in modern standards, severe hydro-treatment is included. As biodiesel has low sulfur content, NO_x emissions can be reduced through the use of catalytic converters to less than the NO_x emissions from conventional diesel engines. Moreover, as a transportation fuel, biodiesel is in its infancy in terms of additives which are capable of improving energy density, resistance to gelling, and NO_x emissions. Further research is needed. Recent advances in the use of cerium oxide help eliminate NOx emissions from both petrodiesel and biodiesel, and diesel fuel additives based on cerium oxide can improve fuel consumption by 11% in unmodified diesel engines (Wikipedia, 2008).

Usage of B100 results in significant reduction of total particular matter (TPM) (82%). The fact that TPM reduction is proportional to the content of pure biodiesel in the biodiesel blends confirms the statement that pure biodiesel burns better than petrol biodiesel. B100 has about 75% lower emission of fine particulate matter (PM2,5) than petrodiesel (B20 about 42% and B5 about 21%). Total hydrocarbons THC emission is more than 37% reduced for B100, while B20 has 4% increase in THC emission. Even blend B5 reduces polycyclic aromatic hydrocarbons (PAHs) 45%, while B100 reduces PAHs 86% compared to fossile diesel. Nitrogen oxides NO_x emissions are 10,5% higher for B100, 4,7% for B20 and 2,3% for B5 compared to normal diesel. By increase in engine working regime NO_x emission reduces for B100 while for B5 and B20 increases. Biodiesel B100 has 95%, B20 16% and B5 9,6% less sulphur dioxide emission compared to fossil petrol. Reduction in carbon monoxide emission is not proportional to biodiesel content in the blends; i. e. reduction is not linear and depends on working regimes of engine. B100 reduces CO emission for 35%, B20 for 17% compared to regular diesel. B100 has about 1,0%, B20 about 1,7% and B5 about 2,0% lower emission of carbon dioxide than regular diesel. It has been found out that usage of 117 000 l of biodiesel reduces CO_2 emission for 356 metric tons (mt). Reduction in CO_2 emission amounts to 1,830 mt, if the consumption of fuel is increased to 600 000 l (≈514 mt). (Bio-Mer, 2005)

Biodiesel is a liquid which is immiscible with water, has a high boiling point and low vapor pressure. Biodiesel blends have great termal stability and they do not alter on temperatures even higher than 70°C. Typical methyl ester biodiesel has a flash point of ~ 150 °C (300 °F). Biodiesel has a viscosity similar to petrodiesel, the current industry term for diesel produced from petroleum. Biodiesel has high lubricity and virtually no sulfur content, and it is often used as an additive to Ultra-Low Sulfur Diesel (ULSD) fuel. Biodiesel addition reduces wear (signs of wear is 50% less with B5 compared to regular diesel) increasing the life of the fuel injection equipment that relies on the fuel for its lubrication, such as high pressure injection pumps, pump injectors and fuel injectors. Biodiesel gives better lubricity and more complete combustion thus increasing the engine energy output and partially compensating for the higher energy density of petrodiesel. Biodiesel has higher cetane number (52) compared to regular diesel (about 42) that results in better combustion and shorter delay in spontaneous combustion of fuel. As biodiesel burns better than regular diesel, it eliminates dark colouration on the ships hull; it smells better and is non-toxic and completely biodegradable. All of these make it suitable for usage on yachts and cruising boats. It is also less hazardous as potential pollutant in the case of spillage especially in harbours and coastal areas.

Only one problem connected with biodiesel usage is often demand for filters change of fuel filters (every 4–6 weeks) especially for B100 which is great solvent.

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