DIMINISHING PORT EMISSIONS FROM FISHING VESSELS

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Abstract. Marine engine emission has a global, regional and local impact. On board the ships exist two types of engines: main engines and auxiliary engines. In ports, ships use their auxiliary engines to produce electricity for cruising, manoeuvring and hotteling.

Port emissions are fled by the port surrounding community in a very negative way, especially if ports located inside the cities, as it happens in Turkey.

The Turkish fleet has a number of 176 fishing vessels. Having in view the long Turkey's coastline, fishing has the potential to become an important contributor to the economy.

This paper assesses port emissions from fishing vessels. In order to reduce the environmental problems, consequent to the port activities, in this work is proposed an energy supply for the fishing vessels utilities from the national grid. Such a scenario allows a NOx diminishing at berth of about 97%.

Keywords: engine, port, emissions, electricity

1. Introduction

Diesel engines begun to be used in seagoing vessels in the late 1920's and their application has been improving continuously since 1930.

The development of the combustion engines is determined mainly by the minimisation of the fuel consumption and the optimisation of exhaust gases.

During the last decades, the pollutant emission control reached an important status in internal combustion engine research and development activity.

An extensive worldwide investigation and development effort is ongoing in order to make the performance of advanced reciprocal internal combustion engines meet emissions requirements for plants to come.

During the last decade, is registered a growing concern on the effects of emissions from ships. Ship emissions are significantly increasing globally due to the fact that growth in the world economy and international merchandise has fuelled demand for maritime transport services. Like any anthropic activity, maritime transport carries an environmental impact, emissions from ships having a significant impact on air quality on sea and land.

The most important pollutants emitted from ships are seen in Figure 1 where is depicted the material and energy balance of an internal combustion engine. The inputs of diesel engines that are used as the main propulsion plants of ships are air, fuel and lubricating oil and the outputs are work, waste heat and exhaust gases.

The greenhouse effect is a natural process by which a part of the infrared radiant heat emitted by the Earth and by the lower atmosphere is absorbed and remitted by certain gases, known as greenhouse gases. Results a warmer Earth surface than would be the case without the presence of these gases. The greenhouse effect allows the regulation of temperature on Earth at levels appropriate to life.

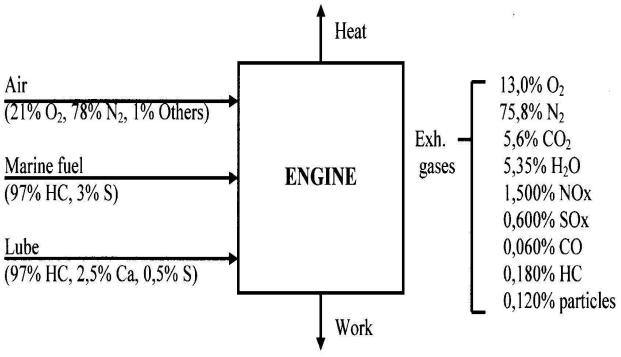

Figure 1. Typical emissions from a low speed marine diesel

Nowadays, the atmospheric composition is being changed by anthropogenic emissions, leading to the alteration of the greenhouse effect giving the climate change that we are facing.

The atmospheric gases that are classified as greenhouse gases are those able to absorb the infrared radiation. Natural greenhouse gases are: water vapor, carbon dioxide, methane, nitrous oxide, ozone.

Carbon dioxide emissions from ships do not come under Kyoto agreement or any proposed European legislation. Annual carbon dioxide emissions from world shipping reached 1.12 billion tones in 2007, about 3.5 % of total global carbon dioxide emissions.

Up to now, work on reducing CO_2 emissions from ships has been carried out within the framework of the International Maritime Organization (IMO), but it has focused mainly on establishing methods to calculate emissions, rather than concrete measures to reduce them. CO_2 emissions can be reduced by actions taken on existing vessels and for new buildings. This desideratum can be reached by technological and operational improvements, by optimization of energy consumption and by close cooperation between charterers and owners.

2. Consideration on fishing industry

Nowadays, fishing industry becomes more competitive with each catch, even if distances grow and quality demands are at higher levels. Professionals in this industry intent not only to survive, but to obtain important profits in the frame of the sustainable fishing [1].

Having in view the long Turkey's coastline, fishing might become a more important contributor to the economy. In the present, the fishing industry is concentrated on the coasts of the Black Sea and the Sea of Marmara, where output has been cut by pollution and over-fishing. In the last years, Turkey's fish catch totalled about 600,000 tons, a substantial decrease from the annual totals of the 1990 s.

The fishing season starts on 1st September each year and ends on 1st of May. Statistics show that in Turkey fish consumption per person is about 6 kg/year.

The Turkish fleet consists of 1566 ships, fishing vessels representing 11% of this total [2]. Its total gross tonnage is of 49379, this being an important factor related to the fuel consumption, meaning to the emitted pollutants.

The annual average main engine running hours for fishing vessels being:

main engine running hours	-	6500
% two stroke	-	3
% four stroke	-	69
average engine load	-	70

3. Assessment of port emissions from fishing vessels

In diesel engines, the liquid fuel is generally injected at high velocity through one or more small orifices inside the cylinder. Processes of atomization, vaporization, air-fuel mixing and combustion continue till is burned the entire fuel quantity. The fast variation of temperature, pressure, density and composition of the cylinder gases and also the injection timing and injector type contribute effectively to the combustion and pollutants formation processes for a specific fuel.

On board the ships are two kinds of engines: main engines and auxiliary engines. The main engine might be a slow-speed or a medium-speed diesel engine [3]. The main engine serves to the ship propulsion at sea, while auxiliary engines supply power for other purposes than propulsion. A ship has one main engine and several auxiliary engines which are usually coupled with generators in order to produce electrical power.

Pollution from maritime transportation activities is referred as "Marine Pollution From Vessels". Pollution from vessels was observed in 1950's and turned into an important problem to be solved at international level. For this purpose, some studies were made first by International Marine Organisation, which is a part of United Nations and has made a sequence of international conventions, protocols, regulations and similar rearrangements. Additionally, some private or voluntary organisations have also contributed to combat marine pollution by arranging special agreements. The most important international agreement effective all over the world is "International Convention for the Prevention of Pollution from Ships, 1973", known as MARPOL 73/78. Except MARPOL 73/78 and other international agreements for prevention of pollution from vessels, some penalties work in the job of deterring ship pollution. These penalties represent important amounts of money. Thus, seas became common property from the point of view of marine pollution. Therefore, marine pollution reduction became an important aspect of the modern marine transportation.

Emission assessment depends on the following parameters:

- ship type
- number of the ships splitted in three categories: small, medium, large
- engine powers
- running hours of engine, (t)
- engine load factors

- emission factors of pollutants, (EF)
- fuel type.

Emission factors of pollutants are related to the operating mode: cruising, manoeuvring and hotteling. In ports, ships use only their auxiliary engines to produce electricity for hotteling, unloading and loading activities. Having in view that manoeuvring duration is short compared to hotteling, hotteling emissions at berth are given by:

$$E = t(h) \cdot AE(kW) \cdot Load\ Factor(\%) \cdot EF(at\ berth).$$

Auxiliary engines will run several hours at berth, meaning a significant contribution to the port emissions, fled by the port surrounding community. In many cases, Turkish ports are inside the cities, making the port emissions more undesirable.

Having data on engine powers, engine powers, engine load fractions and running hours, is possible to determine fishing vessel energy demand for hotteling.

Comparing values of emission factors from fishing vessels occurred in ports are given in Table 1.

Are seen the most important pollutants emitted from these ships: sulphur dioxide (SO_2), nitrogen oxide (NOx), carbon dioxide (CO_2), hydrocarbons (HC), particle matter (PM) and also specific fuel consumptions (SFC).

Table 1. Emission factors at berth, from fishing vessels

Year	NOx	SO_2	CO_2	HC	PM	SFC
2007	13.3	12.2	723.0	0.40	0.90	227.0
2008	14.84	13.63	802.53	0.44	1	251.97

Taking a look to values belonging to consecutive years, results the impact of port emissions from fishing vessels on the environment.

Total emissions of fishing vessels during hotelling are given in Table 2.

Shipping escaped from being included in the Kyoto global emissions reduction target for CO_2 and other GHG, but results clearly that the time for non regulation is fast approaching its end.

Table 2. Total fishing vessels emissions for hotelling, ($kt \cdot y^{-1}$)

NOx	SO_2	CO_2	HC	PM
0.857	0.715	31.94	0.018	0.037

4. Shore-side electricity supply

Above made assessment indicates the importance of the reduction of emissions from ships docked.

A measure of emissions diminishing at berth is to supply energy to ship utilities from the national grid and not from the auxiliary engines on board.

Typical technical requirements related to the shore-side electricity are given in Figure 2.

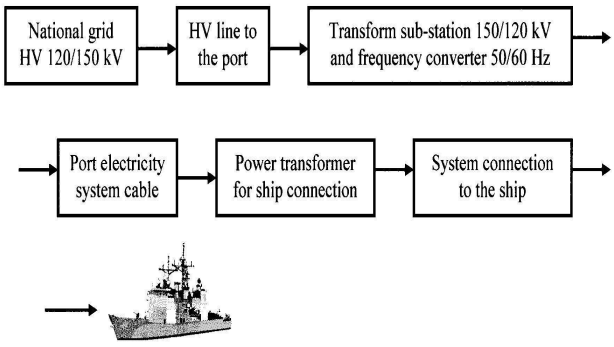

Figure 2. Scheme of typical technical requirements

It is seen that is needed a connection to the national grid carrying 120/150 kV electricity from a local sub-station, where is transformed to 20 kV. It is possible to be asked a frequency conversion from the grid standard of 50 Hz to 60 Hz, depending on ship's technical requirements. Electricity is distributed to the terminal throughout the port electricity system cable. In order to satisfy ship's energy voltage is possible a voltage transformation. An other technical element is the system connection to the ship. On board the ship exists a stocked asked by the connecting cable. From this point the electricity is supplied to the ship and the auxiliary engines are switched off.

In order to make possible the connection between the sub-station and the utility transformers, is installed a plug on the shore. The system called "shore-box" permits the connection between the ship and the shore, as seen in figure 3 [4].

To realise the connection, some ship adjustments are required:

- point of entry into ship hull,
- watertight door and specific compartment,
- safety interlocks,
- internal power cable routing to high voltage switchboards,
- shipboard shore power circuit breaker,
- power management system,
- shipboard control panel,
- auxiliary voltage transformer.

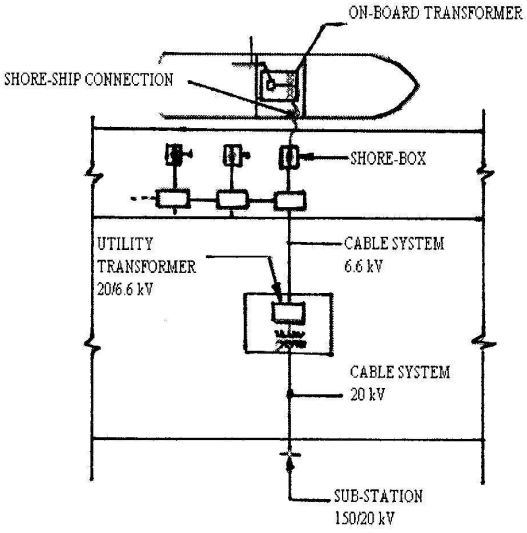

Figure 3. Scheme of ship and shore connection

NOx and SOx create acid rains in the atmosphere. As a result, both water and land pollution can occur. The acid rains derived from NOx and SOx cause not only corrosion in some materials, but also some respiratory and dermatological disorders. Atmospheric NOx also causes an increase in tropospheric concentration of ozone, which are a poison and an effective green house gas [5]. The International Maritime Organization target for the year 2012 is a 40% cut in NOx emission for the marine engines. This is why concerns are directed towards NOx control methods. Table 3 presents rules proposed by marine authorities.

Table 3. Proposed NOx emission rules

Concentration, max	
New ships	Old Ships
600 ppm, 15% O_2	750 ppm, 15% O_2

In order to reduce emissions of fishing vessels at berth, the energy utilities are supplied by the shore-side electricity. This practice permits the NOx emissions reduction of about 97%.

5. Conclusions

Port emissions generated by fishing vessels during hotteling are increasing due the high demand for maritime transport services. Total Turkish fishing vessels emissions during hotteling are found as:

NOx = 0.857 kt/y; SO_2 = 0.715 kt/y;
CO_2 = 31.94 kt/y; He = 0.018 kt/y;
PM = 0.037 kt/y.

By the scenario offered by shore-side electricity supply, is obtained a mitigation of environmental impacts. For NOx emission from auxiliary engines on board the ships, might be reached 97% reduction.

The port-cities might benefit of reduced shipping emissions avoiding bad effects on health and environment.

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Received in February 2010