

GREEN TECHNOLOGY

R.L.INSTITUTE OF NAUTICAL SCIENCES,MADURAI.

AUTHOR

**Cdt.BALAMURUGAN.N
F-34 mcl colony
R.R-nagar post-626204
Virudhunagar district
Tamilnadu**

**Email id:bala711290@rediffmail.com
Mobile no:09597284748**

CO -AUTHOR

**Cdt.AATHITHAN.R
T.S.NO-4372,
SOUTH SECOND STREET,
PUDUKKOTTAI.
TAMILNADU.**

EMAIL ID:AATHITHAN92@GMAIL.COM

MOBILE NO:09659345250

Cdt.KEERTHITHARAN.T

**3,BHARATHIYAR NAGAR,
KAIKATTIVALASU,
VILLRASAMPATTI POST-638107
ERODE,
TAMILNADU.**

**EMAIL ID:keerthitharan@rediffmail.com
MOBILE NO:08883108438**

ABSTRACT

In the last few years, both international and national legal requirements regarding the exhaust emissions of large-bore diesel engines have become much stricter. For shipping industry, these requirements focus primarily on the reduction of nitric oxides (NO_x) and sulphur oxides (SO_x). Exhaust emissions from ships are considered to be a significant source of air pollution. The **environmental impact of shipping** includes greenhouse gas emissions. Carbon dioxide emissions from shipping is currently estimated at 4 to 5 percent of the global total, and estimated by the International Maritime Organisation (IMO) to rise by up to 72 percent by 2020 if no action is taken. The third stage of the IMO emissions regulations, “IMO Tier III” is planned for 2016 and will be so strict that completely new measures and technical solutions will be required. In this paper we are focusing what are the new technologies in marine industry to protect environment. Because Shipping is also responsible for induction of ozone depleting substances and green house gases such as CFC’s, SO_x, NO_x, and various volatile hydrocarbons in the atmosphere. So there is an extreme urge to make shipping more eco-friendly. On concentrating external modification in diesel engine we come across **EXHAUST GAS RE-CIRCULATION** which reduces nitrogen oxide emissions effectively. **SEA WATER SCRUBBING** technology utilizes the natural alkalinity of seawater to reduce the SO_x emission from the exhaust stream. Both combined **EGR WITH SCRUBBER** is more efficient in the reduction of NO_x emission. **SELECTIVE CATALYTIC REDUCTION** is an after treatment technology that can be used to effectively reduce the exhaust gas emission. **HUMID AIR MOTOR** technology utilizes the heat generated by the engine to produce the temperatures needed to vaporize the seawater. By moisture scavenge air we can achieve emission control and variable turbine area technology.

KEYWORDS-Marine pollution, International maritime organization, peak cylinder temperature, NH₃, Humidification, Slow steaming, Hydrocarbon, Particulate matter, scrubbing liquid, Sulphur emission control area.

TABLE OF CONTENTS:

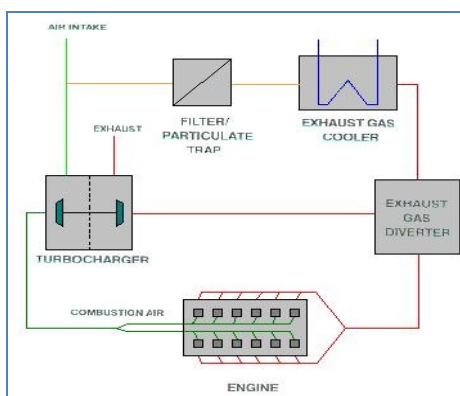
- | | |
|--|---|
| <input type="checkbox"/> INTRODUCTION | <input type="checkbox"/> HUMID AIR MOTOR |
| <input type="checkbox"/> EXHAUST GAS RE-CIRCULATION | <input type="checkbox"/> SCAVENGE AIR MOISTURIZER |
| <input type="checkbox"/> WET SCRUBBER | <input type="checkbox"/> PLASMA REDUCTION |
| <input type="checkbox"/> EGR WITH SCRUBBER | <input type="checkbox"/> VARIABLE TURBINE AREA TECHNOLOGY |
| <input type="checkbox"/> SELECTIVE CATALYTIC REDUCTION | <input type="checkbox"/> CONCLUSION |

INTRODUCTION:

Although fuel prices have tripled over the last six years the booming freight rates have been able to absorb this. Fuel cost has, however, very different impacts on the ship owners. According to one estimate international shipping consumes about 5% of the total world oil consumption for transporting 90% of the world trade. The pressure on the shipping industry to reduce fuel consumption continues unabated. The alternatives such as Biofuels, hydrogen fuel cells, wind energy, solar photo voltaic energy or a combination of these alternatives. The need for reducing fuel consumption today is not only for cutting cost but also for the conservation of the fast depleting oil resources and production of environment.

Diesel particulate matter exhaust from diesel engine during the combustion process cause a various human health and environment impact. In recent years, global and local regulation covering exhaust gas emissions from heavy duty medium speed diesel engine have become progressively more stringent. They cover all application i.e. Power generation and propulsion systems on land and at sea. In particular, emissions, of oxides of nitrogen (NO_x) have become a major issue. In general today, modern marine diesel engines are capable of meeting the requirements of the first and second stages of the MARPOL 73/78 ANNEX VI regulations commonly called IMO TIER I and 2 using only on-engine and in-cylinder modification TIER III which is to enter into force on 1 January 2016 so that additional devices needed. In response to these regulation ship owners have an incentive to adopt NO_x reduction systems on their fleet.

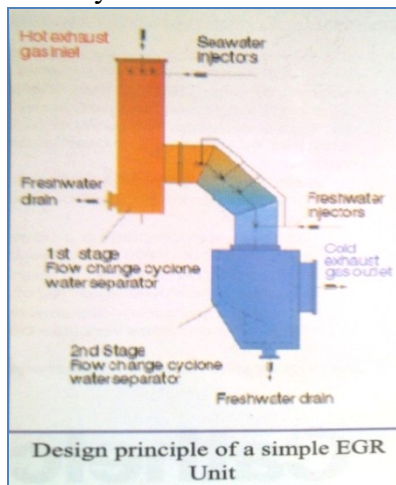
EXHAUST GAS RECIRCULATION:



Exhaust gas recirculation has proven to be successful at reducing NO_x levels due to higher specific heat capacities of the principal exhaust components (CO₂ and H₂O) in comparison with air. Exhaust gas re-circulation (EGR) works on the PRINCIPLE of reintroducing the portion of the exhaust gas into the engine combustion chamber to reduce peak cylinder temperatures. Inserting a particle trap in the exhaust gas recirculation path can reduce smoke and particulates.

Simple setup of the EGR system had two water injection stages, with a simple water separator unit after both. The first water injection stage involves humidification with salt water in order to ensure that there is no fresh water consumption in the second fresh water injection stage. The outlet temperature of the first stage is approximately 100 degree Celsius. This stage has a single multi-nozzle injector. This system gives considerable reduction of NO_x emission.

The reduction in nitrogen oxides (max. combustion temperature) by EGR is mainly due to the effects of:

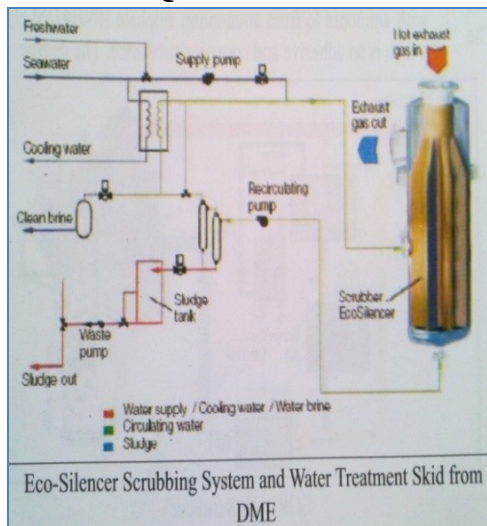


- 1) The heat capacity of CO₂ contained in the re-circulated exhaust gas is about 25% higher than that of N₂ and O₂ which absorbs more energy during the combustion. Therefore results in a lower combustion temperature rise.
- 2) The lower partial pressure of O₂ in the combustion air resulting from the recirculation of lower oxygen concentrated exhaust gas leads to lower combustion temperature.
- 3) Both above decrease the combustion velocity which in turn results in an additional temperature decrease.

WET SCRUBBER:

Wet scrubbers are capable of removing SO_x, NO_x, hydrocarbon and particulate matter emissions. Which emissions are reduced and how efficiently they are removed is strongly dependent on the configuration of the scrubber and the scrubbing liquid used. Usually water is used as a scrubbing liquid.

TECHNIQUE:



Sea water scrubbing technology utilizes the natural alkalinity of seawater to reduce the SO_x emission from the exhaust stream. After mixing the seawater with the exhaust gas i.e., when SO_x comes in contact with seawater, there is a fast and efficient reaction between the SO_x and calcium carbonate (CaCO₃) in the seawater, to form calcium sulphate (gypsum) and CO₂. The reaction neutralises the acidity of SO_x, and consumes some of the buffering capacity of the seawater. The reaction is complete in a very short time, so the equipment to bring the exhaust gas with SO_x and the seawater into contact can be compact and still achieve high reduction efficiencies (~95%). However, it must be clear that this reaction depends on the CaCO₃ content of the available water and therefore the performance will be difficult in brackish and freshwater. Moreover one source of emissions is transformed into another type that will have to be treated on board. The humidity of the exhaust gas leaving the scrubber will be laden with sulphuric acid not converted into the scrubber. This scrubbing

technology provides an alternate to fuel switching for vessel operators travelling in SECA areas.

By allowing the vessel operator to burn high sulphur fuels, the system will lower fuels cost and reduce the sensitivity to the low-sulphur fuels market. However, there are discussions of the quality of the used water and how it should be treated. Due to formation of sulphuric acid in the in scrubber, corrosion problems may arise.

EGR WITH SCRUBBER:

EGR without scrubber, it is doubtful whether the re-circulated exhaust gas can be cleaned sufficiently before entering the air cooler and the scavenge air system. So, EGR with and water treatment has been introduced. This resulted in a reduction of up to 70%, with a relative small penalty and, thereby, increases in fuel oil consumption.

Very promising operating conditions have been obtained by the system. The relative changes in the emission parameters were measured as a function of the recirculation amount. At increased recirculation amounts, the HC and PM emissions are reduced correspondingly to the reduction of the exhaust gas flow from the engine. This indicates that each engine cycle has the same production of HC and PM independent of the recirculation amount, and that the HC and PM in the recirculation gas is eliminated during the normal combustion process.

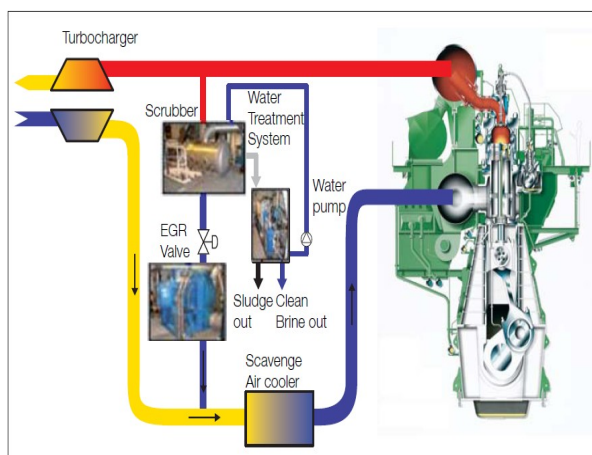


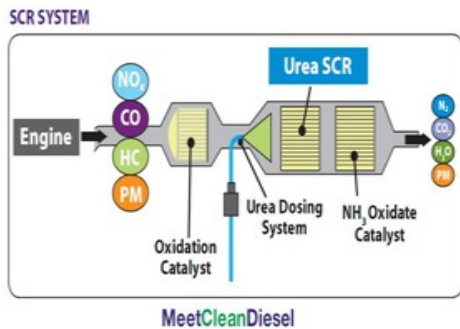
Fig. 14: CGR system

A small increase in CO emissions with increased recirculation amount result in larger local regions in the combustion chamber with lack of oxygen. Furthermore, the expected significant reduction of the NO_x level has been confirmed.

The results indicate that scrubbing reduces PM emissions to 20-25% (highest at low loads and lowest at high loads), and that HC and CO pass the scrubber nearly unaffected.

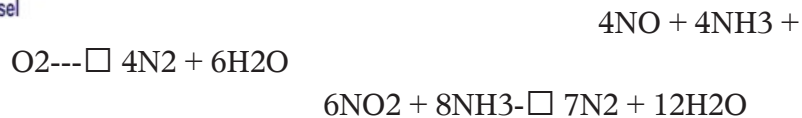
The NO₂ fraction of the NO_x is dissolved in the water, and the NO fraction of the NO_x passes the scrubber nearly unaffected.

SELECTIVE CATALYTIC REDUCTION (SCR):



Working principle:

With the SCR technique, the exhaust gas is mixed with ammonia NH₃ or urea (as NH₃ carrier) before passing through a layer of a special catalyst at a temperature between 300 and 400°C, whereby NO_x is reduced to N₂ and H₂O. The reactions are, in principle, the following:

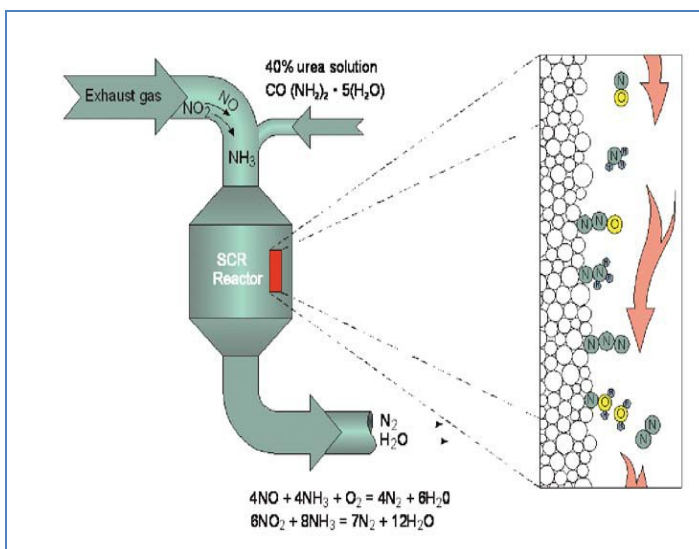


NO_x reduction by means of SCR can only be carried out in this specific temperature window:

If the temperature is too high, NH₃ will burn rather than react with the NO/NO₂. If the temperature is too low, the reaction rate will also be too low, and condensation of ammonium sulphates will destroy the catalyst. If the temperature limits are violated, the channel diameter is optimised according to the dust content, the composition of the exhaust gas and the permissible pressure drops across the SCR reactor, and the catalyst will block.

LOCATION:

To keep the temperature within the limits, the SCR catalyst must be located between the exhaust gas receiver and the turbocharger, so that the SCR catalyst can sustain the pressure at the turbocharger inlet (i.e. no pressure drop). Due to a high pressure at the inlet the SCR can be reduced in size compared to catalysts on some medium and high speed engines, where the SCR unit is located in the exhaust gas funnel.



When engine exhaust gas is released from the exhaust gas receiver, urea or ammonia is supplied to the pipeline via double-wall piping into a mixer. The engine exhaust gas is mixed with the agent and led into the turbocharger in the turbine side. To compensate

for the pressure loss across the SCR system, high-efficiency turbochargers and high performing auxiliary blowers are mandatory. Due to the ammonia/urea heat release in the SCR

process, the exhaust gas temperature from the turbocharger is slightly higher than the exhaust gas temperature in engines without SCR.

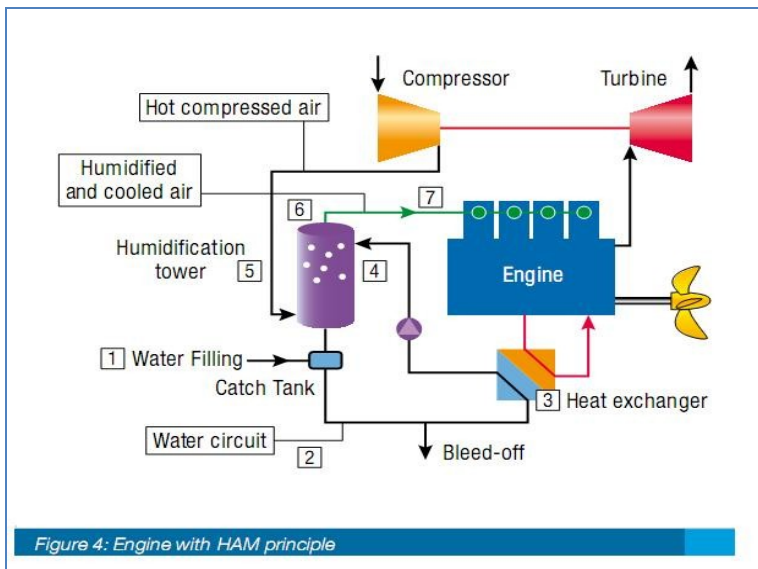
The SCR process is feasible on two stroke diesel engines with only minor impact on the engine performance, but with restrictions on the engine load, sulphur content, cylinder lube oil, and excess of ammonia (or urea).

HAM:

A second, widely acclaimed technology for reducing NOx pollution from diesel engines is the “Humid Air Motor” (HAM). This technology is able to reduce NOx formation by up to 65%. In the HAM system the turbocharged combustion air is saturated with water vapour produced aboard the ship using sea water and engine heat. This lowers the temperature peaks in the combustion chamber, which are normally the main reason for NOx formation. HAM is characterised by extremely low operating costs due to sea water usage, decreased lube oil consumption, very low maintenance costs and a very high availability factor.

H2O against NOx It is well known that the cooling effect of water can prevent NOx formation during the combustion process. Well proven methods employing water to reduce NOx are fuel-water emulsification and humidification of inlet air (HAM principle).

HAM Principle



Over 90% of NOx formation results from combustion temperature peaks. The principle of HAM is to humidify the inlet air in order to lower these temperature peaks. The HAM system humidifier produces saturated air. The ability of water to decrease the formation of NOx is exploited in the same way as with fuel water emulsification, but the quantity of water added is much higher and the heat

for water vaporisation is taken from the compressed air after the turbocharger or other engine-related heat sources. When the water vapour is mixed with the compressed charge air, two mechanisms can be identified: Increase of the specific heat capacity of the mixture, Dilution of the charge air: water vapour replaces air. The quantity of water

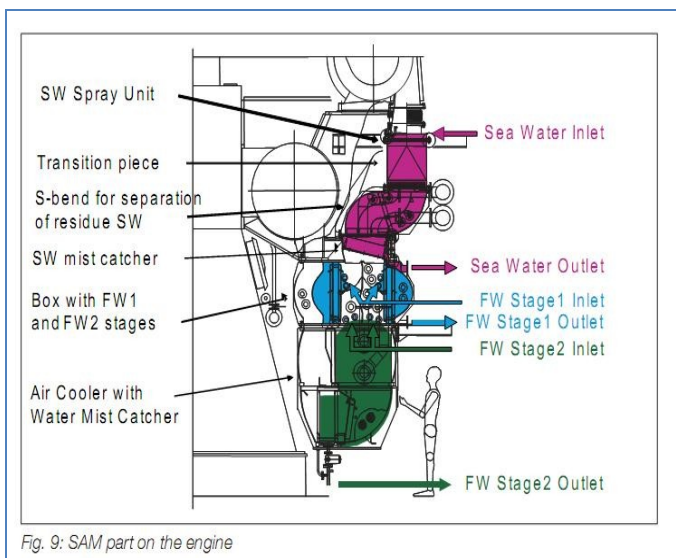
(in g/kg dry air) which can be injected into the inlet air depends on the temperature and the pressure of the mixture.

WORKING OF HAM:

The functional principle of HAM is quite simple. figure illustrates the HAM Process:

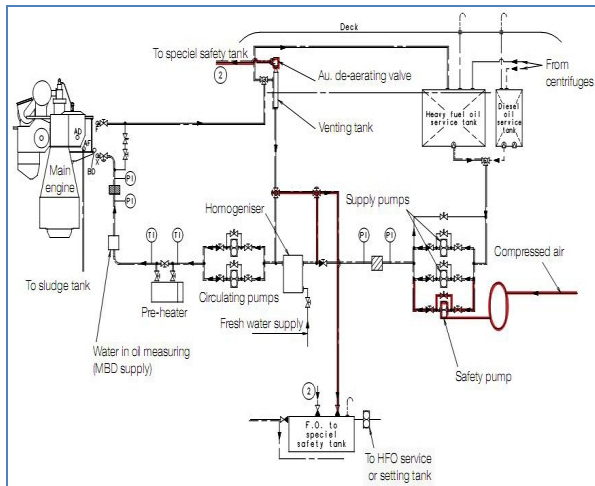
1. Filtered saltwater is pumped to the catch tank to replace evaporated and purged loop water.
2. The HAM system itself cycles water in a loop between the catch tank and the Humidification tower (“HAM vessel”)
3. A heat exchanger between the catch tank and the HAM vessel heats the saltwater using an on-engine heat source.
4. Three injection stages spray the heated saltwater into the charge air.
5. At the same time the compressed charge air from the exhaust turbocharger bypasses the charge air cooler and is piped into the HAM vessel air inlet. Flowing through the HAM vessel, the charge air absorbs the water. Due to the high loop capacity of the water all particles (incl. salt) fall back into the catch tank and, over a certain salinity level, are purged. Thus no salt from the saltwater can enter the engine.
6. To avoid tiny droplets reaching the combustion chamber, the humidified charge air passes through a high-performance mist catcher at the end of the humidification tower.
7. This humidification leads to saturated charge air which is fed into the engine.

SAM system on the engine:



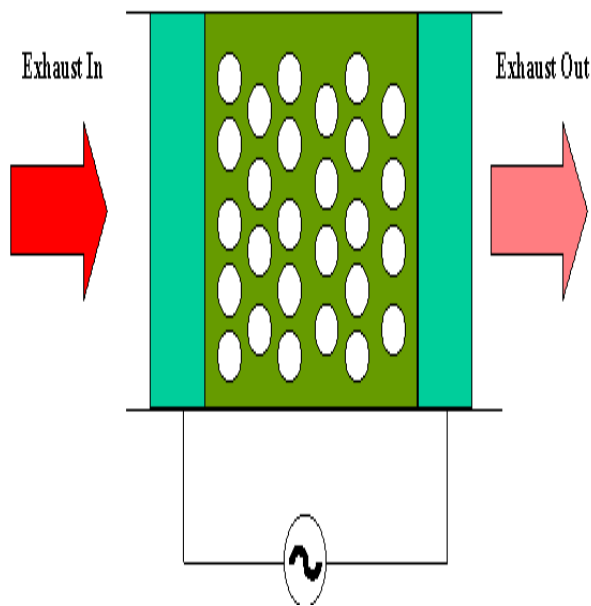
The SAM system has a sea water injection stage, where a surplus of sea water is injected for saturation and cooling of the hot air from the compressor. The sea water stage will provide a near 100% humidification of the scavenge air and supply all of the water for humidification. The freshwater stages 1 and 2 will be near temperature neutral to the scavenge air and create a small freshwater production depending on the operation parameters chosen. The freshwater stages only act as

cleaning stages for removal of any salt which may pass with the air from the sea water stage. A continuous accumulation of salt in the freshwater stages would eventually cause the salt content to reach an



unacceptably high level. This is counteracted by cooling the saturated air with the air cooler and generating some extra freshwater for stage 2. The extra freshwater is then sent upstream on the tank side of the SAM system, as illustrated in Fig. Thereby the content of salt in the freshwater stages can be controlled.

Plasma Reduction Systems:



Plasma is a partially ionised gas comprised of a charge of neutral mixture of atoms, molecules, free radicals, ions and electrons. Electrical power is covered into electron energy and the electrons create free radicals, which destruct pollutants in exhaust emissions. The plasma is reactively hot but thermally cool which means that after treatment, little heating, if any, of the exhaust gas results.

VARIABLE TURBINE AREA TECHNOLOGY (VTA):

The nozzle rings of VTA turbochargers are equipped with adjustable vanes whose pitch is varied to regulate the pressure of the exhaust gas on the turbine.

VTA allows the quantity of charged air to be precisely match to the engine load. This benefits fuel consumption, emissions and dynamic behaviour. Like common rail fuels injection, VTA provides new operating possibilities for marine diesel engines at a time when flexibility of air and fuel management is increasingly important in meeting not only tightening emission limits. But new demands from operators on engine flexibility and fuel consumption notably 'slow steaming'.

CONCLUSION:

Now-a-days most of the diesel engine manufacturing company is focussing of reducing exhaust emissions and fuel consumption have long been the major driving forces of large engine development. Some of the companies progressively introduced engines with optimised exhaust emissions and offers a complete range of both two and four stroke IMO TIER II complaint diesel engines for marine propulsion and on board power generation. Few of the vessels are enrolled in environmental friendly fuel program instead of bunker fuel known as Intermediate fuel oil 380 switching to low sulphur fuels reduces emission of fine particles as well as carbon di oxide., nitrous oxides and contributes to the improvement of the environment.

Today engine designer have a range of technology solution to cater for future emission control needs of low speed 2-stroke diesel engine. A full effort is put onto maintain a balance between fuel economy and emission reduction. On the basis of studies, we have concluded that technologies such as HAM and SCR will be able to receive major reduction in NOx emission.

There are no modifications that could be made to diesel engine or boilers to reduce emission of sulphur di oxide, so the only way to reduce SOx emission is to burn fuel with low sulphur content or treat the engine exhaust gases.

ACKNOWLEDGEMENT:

We have taken efforts in this paper presentation. However, it would not have been possible without the kind support and help of many individuals and organizations. We would like to extend our sincere thanks to all of them.

We are highly indebted to (RL Institute of Nautical Sciences) for their guidance and constant supervision as well as for providing necessary information regarding the paper presentation & also for their support in completing the paper presentation.

We would like to express our gratitude towards our parents & member of Organization for their kind co-operation and encouragement which help us in completion of this paper presentation.

We would like to express our special gratitude and thanks to industry persons for giving me such attention and time.

Our thanks and appreciations also go to our colleague in developing the paper presentation and people who have willingly helped us out with their abilities.

REFERENCES:

- 1) Exhaust gas emission control today and tomorrow application on **MAN B&W TWO STROKE MARINE DIESEL ENGINES** published by **MAN DIESEL ENGINE**.

- 2) Selective catalytic reduction system published by **DIESEL TECHNOLOGY** form.
- 3) **HUMID AIR MOTOR TECHNOLOGY** for greep profits published by **MAN DIESEL**.