8-24-2014

Discussion on EEOI reduction measures based on modern management

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Discussion on EEOI Reduction Measures Based on modern management

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A research thesis submitted to the World Maritime University in partial
Fulfilment of the requirements for the award of the degree of

MASTER OF SCIENCE

(MARITIME SAFETY AND ENVIRONMENTAL MANAGEMENT)

2014

Declaration

I certify that all the materials in this research paper that are not my own work have been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this research paper reflect my own personal views, and are not necessarily endorsed by the University.

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Acknowledgement

This dissertation was developed as part of my studies to apply for the master degree of Maritime Safety and Environmental Management at WMU and DMU. This dissertation would not have been completed successfully without the generous support of a number of people and organizations to which I would express sincere thanks and ultimate gratitude.

First, I would like to give thanks to Dalian MSA, providing me such a long period of time to expand the horizons of maritime knowledge.

Second, I would like to give my sincere thanks to my research thesis supervisor Prof. XXX. He provided me a lot of valuable and constructive advices in the writing process.

Third, I would like to give my sincere thanks to DMU and WMU which give me much supports and care during my maternity leave.

Last but not least, my son encouraged me to achieve the accomplishment including this thesis. This thesis will be a gift to my family.

Title of Research thesis: **Discussion on EEOI Reduction Measures**

Based on modern management

Degree: **MSc**

Abstract

This thesis introduces various methods of reducing ship GHG emissions by controlling the Energy Efficiency Operational Indicator (EEOI) and focuses on the management measures.

EEOI is promoted by the IMO to measure the energy of ships in MARPOL Annex VI Prevention of Air Pollution from Ships. The annex entered into force on 19 May 2005. It sets limits on sulphur oxide and nitrogen oxide emissions from ship exhausts and prohibits deliberate emissions of ozone depleting substances; designates emission control areas, and sets more stringent standards for SO_x, NO_x and particulate matter(www.imo.org).

This thesis starts from MARPOL Convention, then introduces some measures of the CO_2 emission controlling on operational ships from three aspects. The author mainly focuses on the SEEMP, which was put forward by IMO as the management measures that control the EEOI, and expounds two management theories combined with the SEEMP system practice.

PDCA (plan–do–check–act or plan–do–check–adjust) is an iterative four-step management method used in business for the control and continuous improvement of processes and products. If the operational ship adopts the theory in SEEMP, variables can be controlled continuously. The using of this theory must be reflected in the whole management procedure in shipping companies. This thesis gives some introduction to

PDCA in chapter 3 and analyzes the way ship companies practice it in SEEMP. The decision-making level should have the thinking mode of PDCA management and the idea should be embodied in company regime systems.

People-oriented management promotes the people to get their enthusiasm. This thesis discusses the practice of it in SEEMP. The evaluation of ship crew may lead to the expected result of EEOI controlling.

KEYWORDS: Emissions Reduction; EEOI; SEEMP; PDCA; Humanistic Management.

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List of abbreviations

IMO	International Maritime Organization
UNFCCC	United Nations Framework Convention on Climate Change
SEEMP	Ship Energy Efficiency Management Plan
EEDI	Energy Efficiency Design Index
EEOI	Energy Efficiency Operational Index
MEPC	Maritime Environment Protection Committee
MARPOL	Maritime Agreement Regarding Oil Pollution
GHG	Greenhouse Gases
METS	Marine Emission Trade System
ICF	International Oil Pollution Compensation Fund
ET	Emissions Trading
JI	Joint Implementation
CDM	Clean Development Mechanism
IEEC	International Energy Efficiency Certificate

1. Introduction

1.1 Research background

Global warming has become the hot topic in the international community and its results of high mountains ice melting, sea levels rising, climate anomalies has evolved into a very serious environmental problem. A global temperature increase of 2 °C above pre-industrial levels is expected to lead to severe consequences and endanger the survival of many species. A global temperature increase of 6°C will end life on the earth in a few years. According to the research results, the emission of greenhouse gases (GHG) is the main cause of global warming. Greenhouse gases include carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), etc. Human live and produce on the earth and burn fossil fuels for energy; at the same time, a large amount of greenhouse gases accumulate in the atmosphere as a direct result, making the global temperature rise gradually. The only way to overcome this problem is to reduce GHG emissions.

The Intergovernmental Panel on Climate Change (IPCC) predicted that global temperatures are expected to increase about 1.4 to 5.8 ℃ from 2000 to 2100 if no action were taken to reduce emissions according to the climate models. Based on the forecast, global temperatures will undergo huge changes that never happened in the past ten thousand years and thus potentially impact on the global environment.

Therefore, the international community has been paying more and more attention to the problem of greenhouse gas emissions in recent years. IPCC was set up, and it established the United Nations Framework Convention on Climate Change (UNFCCC) , which entered into force formally in March 1994. So far, the convention has 189 parties. Since March 1995 when the first conference of the parties held in Berlin, the parties hold a meeting every year. The 15th session of the party conference lowered the curtain in Copenhagen, Denmark in 2009.

In each annual meeting, leaders of many countries often discuss the issue of greenhouse gas emissions and have made a number of consensuses. The IPCC concluded that the amount of global GHG emissions needs to be cut by 50%–85% than current levels in 2050 to reach this target (Zheng, 2008).

Kyoto protocol was set in December 1997 in Kyoto as the supplement of the UNFCCC. The ultimate objective of the UNFCCC is the

"stabilization of greenhouse gas concentrations in the atmosphere at a level that would stop dangerous anthropogenic interference with the climate system."(Kyoto Protocol, 1997). The treaty went into force in February 2005 and there are 183 countries join in it so far. It should be said that through the joint efforts, the international community has made certain achievements in terms of greenhouse gas emissions, but it is not enough. It needs the joint efforts between countries and industries to control the global warming.

Shipping industry can produce a large amount of greenhouse gases such as CO_2 due to the fuel consumption of sailing ships. But it has not been covered in the adjustment range of Kyoto protocol due to the uncertainty discharge area.

In recent years, with the increasing amount of international trade, the demand of energy, mineral and commodity goods transport have risen steadily. Shipping companies put on extra and encryption voyage route. Ship emissions of greenhouse gases inevitably increase substantially, therefore the international shipping industry is facing greater pressure to reduce GHG emissions.

The International Maritime Organization (IMO) began to pay more attention to cut ship emissions. The Marine Environment Protection Committee (MEPC) as a subsidiary of IMO works on researching and making suggestions for ship emissions of greenhouse gases in addition to studying on the gas emission and standards. In 2003, the IMO convention passed a resolution on marine policy and implementation

of the greenhouse gas emission reduction called resolution A.963 (23), which became the programmatic document to solve the ship emissions of GHG in IMO. The resolution clearly pointed out that CO_2 should be the main greenhouse gas when making emission index method system. However, the responsibility and specific methods of emissions reduction have not been substantially progressing, and IMO is faced with queries from some countries and regional organizations such as the European Commission and Swedish Secretariat of Acid Rain. Facing the pressure, IMO made great progress on the issue of greenhouse gas emissions of the ship finally in 2008 through various efforts.

So far, IMO has largely determined the regulatory framework of shipping GHG reduction emissions and set the main measures and work process. The premise of these regulations and measures is to develop an index system to measure CO_2 emission. IMO made significant progress in this area in 2009. EEOI was put forward as well as other three techniques in the 59th MEPC meeting. EEOI is applicable to all operating ships and provides important reference basis for monitoring ship emissions of greenhouse gases and evaluating ship energy efficiency. Before the formal launch, EEOI has experienced several years of trial and got wide recognition. So the index is expected to become another international standard. The study of EEOI, therefore, as the entry point of CO_2 emissions condition and effective reduction measures has practical significance(Su, 2005).

1.2 Significance of the research

In December 1997， The Kyoto protocol passed by the third parties convention of UNFCCC. It provides responsibilities of 6 kinds of greenhouse gas emissions for developed countries. The Kyoto protocol does not require the data contained in the national report because the particularity of international shipping. IMO was requested to implement the emissions reduction by relevant countries. In the same year, MARPOL parties convention passed the resolution of shipping carbon emission and

the convention asked IMO to study the shipping emissions of GHG so as to determine the amount of GHG emissions from ships, as well as the percentage of the total global emissions. Meanwhile, the Maritime Environment Protection Committee (MEPC) was requested to deliberate over the strategy of GHG emissions. In July 2009, the MEPC passed and approved four guidelines including Energy Efficiency Design Index (EEDI) calculation method, EEDI voluntary validation, ship energy efficiency management plan (SEEMP) formulation and energy efficiency operational Index (EEOI) voluntary using guide. EEOI is the index which measures the ship energy efficiency through the ratio of CO_2 emissions (come from the ship fuel consumption) and freight turnover (t/TEU/p-nm). EEOI emphasizes the improving of fuel efficiency in order to reduce the unit CO_2 emissions of transportation operations. Although EEOI is a monitoring tool aiming at the existing ship energy efficiency level, the essence is that IMO hopes to establish the relevant management system with EEOI to gradually achieve the optimization of existing ships with operation, equipment and management related to energy efficiency, and if possible, to improve technological transformation and upgrading of existing ships for the purpose of raising the energy efficiency of existing ships.

Through the study of EEOI we can get a better understanding of MARPOL annex VI. The research conclusion will play an important role in the implementation of the convention. This thesis will discuss the control mechanism of EEOI from the aspect of management. It is a new exploration of the existing EEOI control management mechanism and could help to achieve the emission reduction target by EEOI controlling in the management level.

1.3 Main research contents

Beginning with the EEOI controlling this thesis mainly expounds technology, market and management mechanism kinds of measures for operational ship emission reduction. The author puts the emphasis on one of the management measures called

SEEMP and uses the management theory to practice the SEEMP and touch the target of emission reduction.

In chapter 2, the thesis will introduce relevant international conventions in depth, and then expounds the significance of CO_2 emission reduction of operating ships and some measures.

Chapter 3 contains the key points and innovation of the thesis so it is the key chapter. This chapter analyzes EEOI based on modern management theory and discusses how to combine the concept of PDCA Circle and humanistic management with SEEMP process. Green management initiates changing the root of people. People should take the concept of environmental protection and emission reduction into consideration and implantation into decision-making level.

Humanistic management applies to SEEMP management through arousing the enthusiasm of people because the main part that implements the emission reduction rules is the relevant personnel. People will largely determine the effect of emission reduction. The theory adopted in the personnel assessment system may lead to the expected goal.

Chapter 4 is the application practice in shipping companies. The author will elaborate on how to establish the SEEMP to control EEOI based on chapter 3. The reference function will come into being after this part.

Chapter5 is the conclusion.

2. MARPOL Convention and carbon emission reduction

2.1 Instruction of MARPOL Convention

Sea area account for 71% of the earth, At present, more and more serious marine pollution has directly impacted the earth ecology and human life. According to statistics, 10% of the pollution comes from ships mainly including ship garbage and petroleum products. In order to protect the marine environment, the IMO put forward the slogan “make the ocean cleaner”. Meanwhile the International Convention for the Prevention of Pollution from Ships (MARPOL) was put forward. It is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. The MARPOL Convention was adopted on 2 November 1973 at IMO. The Protocol of 1978 was adopted in response to a spate of tanker accidents in 1976-1977. As the 1973 MARPOL Convention had not yet entered into force, the 1978 MARPOL Protocol absorbed the parent Convention. The combined instrument entered into force on 2 October 1983. In 1997, a protocol was adopted to amend the Convention and a new Annex VI was added which entered into force on 19 May 2005. MARPOL has been updated by amendments through the years (HTTP://WWW.IMO.ORG).

2.2 Annex VI of MARPOL

Ship diesel engine exhaust emission is one of the primary sources of air pollution. MARPOL annex VI which stipulates the controlling of this harmful emission from ship diesel engine was also put forward under the circumstances and put into practice on January 1, 2000.

In recent years, with the growing of negotiations on climate change and the rapid growth of the emissions of shipping, the voice of greenhouse gas emissions control in international shipping is strengthened. Meanwhile, some developed countries are trying to raise money from the international aviation and marine industry. The

reduction of GHG emissions in international shipping industry has become one of the focuses of the climate change negotiations. In 1997, the IMO formulated the Protocol of 1997 to amend MARPOL 73/78 Resolutions adopted at 1997 Conference of Contracting Governments to MARPOL 73/78 (hereinafter referred to as the "MARPOL 73/78") according to the principle of article 15 in "Rio Declaration on Environment and Development" and added the "MARPOL 73/78 annex VI" which is the rule of prevention of air pollution in the form of new attachment. The effective conditions are for no less than 15 countries and its total merchant gross tonnage is no less than 50% of the world's total merchant tonnage. It will enter in force after being signed for 12 months. On May 18, 2004, Samoa Islands approved to join the convention so the rules achieved the effective situation, and it entered into force on May 19, 2005. The Chinese government approved to join the rule on March 25, 2006 and it got effective formally on August 23. After 14 years of hard negotiations, the 62nd meeting of the Marine Environment Protection Committee (MEPC 62) of IMO passed the MARPOL 73/78 annex VI amendment about the ship's energy efficiency rules (hereinafter referred to as "amendment") on July 15, 2011, determined two energy efficiency indicators of the ship, EEDI and SEEMP. According to the default effect program, the amendment was expected to enter into force on January 1, 2013 and practiced in 2015. This is not only the IMO formulated and passed on mandatory technical indicators of ship energy efficiency for the first time but also the first specialized legal documents in human history for international ocean shipping to reduce GHG emissions(Tang,2013).

2.3 Significance of operational ship carbon reduction and measures

2.3.1 Significance of operational ship carbon reduction

According to survey reports and related data of IMO in recent years, ships that sail on the sea influence the atmosphere and marine environment greatly. Ships cost 3% of the world's total energy consumption and the pollution caused by them has accounted for 7% of global pollution. And the pollution has a strong mobility, large diffusivity

and long duration. It is obvious that it has caused a lot of damages such as the environmental degradation of ocean and atmosphere, the pollution of inshore and inland waters as well as the emergence of the Antarctic ozone hole. The harbour is the sufferer which has been influenced most directly and seriously. Ships discharge a large amount of waste gas when they sail and dock intensively in the port. It damages the port environment and causes great harm. According to the scientific research institution of Japan, thousands of sailing ships shuttle from Hamming Shi Strait to Osaka Bay in Setouchi caused serious pollution. SO2 released into the atmosphere will form the acid rain. NO with sunlight will trigger the photochemical reaction which can produce harmful substances that cause human hemodynamic disorders. Because the NO is colorless and tasteless, the crew and other personnel are very easy to be poisoned by inhalation. The inland would be suffered by the sea pollution in places where condition of land-sea breeze is bad such as the famous industry zone Hanshin (Li & Sun).

According to "the second greenhouse gas research report 2009" of IMO, in 2007, the emissions of CO_2 from the whole shipping industry reached 1.054 billion tons, which is 1.87 times higher than 1990. The international shipping emissions of CO_2 reached 870 million tons which is 1.54 times higher than 1990. If we do not take any effective measures to control GHG emissions, the amount of emissions will be 50% more than in 2007 by 2050.

Table 1-Exhaust emissions (million tonnes) from international shipping, 1990-2007

year	NO_X	SO_X	PM	CO	NMVOC	CO_2	CH_4	N_2O
1990	12	6.5	0.8	1.1	0.4	468	0.05	0.01
1991	12	6.8	0.8	1.2	0.4	488	0.05	0.01
1992	12	7	0.9	1.2	0.4	498	0.05	0.01
1993	13	7.4	0.9	1.2	0.4	519	0.05	0.01
1994	13	7.5	0.9	1.3	0.4	535	0.05	0.01
1995	14	7.7	1	1.3	0.4	551	0.05	0.01
1996	14	7.9	1	1.3	0.4	565	0.05	0.01

1997	15	8	1	1.4	0.5	596	0.06	0.02
1998	15	8	1	1.4	0.5	590	0.06	0.02
1999	15	8	1	1.4	0.5	601	0.06	0.02
2000	16	9	1.1	1.5	0.5	647	0.06	0.02
2001	16	9	1.1	1.5	0.5	652	0.06	0.02
2002	16	9	1.1	1.6	0.5	660	0.06	0.02
2003	17	10	1.2	1.7	0.5	706	0.07	0.02
2004	18	11	1.3	1.8	0.6	755	0.07	0.02
2005	19	11	1.4	1.9	0.6	795	0.08	0.02
2006	20	12	1.4	2	0.6	838	0.08	0.02
2007	20	12	1.5	2	0.7	870	0.08	0.02

Source: Cai,M.C. (2011, June). Operating ship low carbon emission evaluation researeh. Unpublished master's thesis, Dalian Maritime University. Dalian, China.

Table 2-Exhaust emissions (million tonnes) from total shipping, 1990-2007

year	**NO_X**	**SO_X**	**PM**	**CO**	**NMVOC**	**CO_2**	**CH_4**	**N_2O**
1990	14	7.9	1	1.3	0.4	562	0.05	0.01
1991	15	8.2	1	1.4	0.4	587	0.06	0.02
1992	15	8.4	1	1.4	0.5	598	0.06	0.02
1993	16	8.7	1.1	1.5	0.5	624	0.06	0.02
1994	16	9	1.1	1.5	0.5	644	0.06	0.02
1995	16	9.3	1.1	1.6	0.5	663	0.06	0.02
1996	17	9.5	1.2	1.6	0.5	679	0.07	0.02
1997	18	10	1.2	1.7	0.5	717	0.07	0.02
1998	18	10	1.2	1.7	0.5	709	0.07	0.02
1999	18	10	1.2	1.7	0.6	722	0.07	0.02
2000	19	11	1.3	1.8	0.6	778	0.07	0.02
2001	19	11	1.4	1.8	0.6	784	0.08	0.02
2002	19	11	1.4	1.9	0.6	794	0.08	0.02
2003	21	12	1.5	2	0.6	849	0.08	0.02
2004	22	13	1.6	2.1	0.7	907	0.09	0.02
2005	23	13	1.6	2.3	0.7	955	0.09	0.02
2006	24	14	1.7	2.4	0.8	1008	0.1	0.03
2007	25	15	1.8	2.5	0.8	1050	0.1	0.03

Source: Cai,M.C. (2011, June). Operating ship low carbon emission evaluation researeh. Unpublished master's thesis, Dalian Maritime University. Dalian, China.

Ports countries attach great importance to the ship's GHG emissions and formulated the strict control standards to achieve the goal of sea and atmospheric environment protection. Since 1988, IMO has committed to research of preventing, reducing and controlling the air pollution caused by ship. IMO stepped up to formulate the relevant laws and regulations and eventually revised and approved the MARPOL73/78 convention annex VI in party conference of MARPOL73/78 held in London in 1997 and has made some progresses.

IMO passed a new annex-MARPOL annex VI, the prevention of air pollution caused by ships in 1997, aiming to reduce air pollutant emissions of ship (including sulfur oxides, nitrogen oxides, ozone-depleting substances, volatile organic compounds, etc) and reduce their influence on the regional and global air pollution and environmental problems. The annex is considered the basis of the GHG emission reduction mechanism of global shipping industry from IMO. It is easy to include the ship GHG emission controlling into the framework of the IMO international convention just through the corresponding revision of the supplementary provisions. At the same meeting of the MARPOL parties, a resolution about ship carbon emissions was also passed. The resolution invited and entrusted IMO Marine Environment Protection Committee (MEPC) to research and consider some practicable strategies of ship carbon reduction. MEPC carried out extensive work on multiple policy instruments and means (as shown in table 2). Meanwhile, it has conducted research and comparative analysis particularly so as to determine three main working directions – technological measures (aimed at improving the efficiency of the ship design policy choice), operational measures (aimed at improving the efficiency of ship operation policy choices) and market-based measures. IMO analyzed and found that the emission reduction policy tools as shown in table 2 almost had their own advantages and disadvantages. For new ships, for example, implementation of mandatory provisions on the EEDI is easy but it can only affect the design of a new ship and the overall effect on the shipping industry is very limited. Another example of mandatory provisions on the EEOI, despite the cost of reduction by optimizing operation is

relatively low, but it is hard to establish and update shipping operation efficiency of the baseline and set a goal because of technical difficulties. Market-based measure is one of the policy tools that IMO prefers. MEPC thinks that the market-based tools can provide certainty about total emission reduction or carbon price. It can also help developing countries ease and adapt to the funding and capacity building activities, and effectively promote technical progress of shipping and operation optimization. It also provides the opportunity to use the credit of other departments to offset the shipping industry. But it takes a long time to research and consult the discussion and design of market-based measures. So IMO made a breakthrough in the technologic and operational measures at the beginning. In July 2011, MEPC passed an amendment of MARPOL annex VI on the 62nd meeting. The amendment proposed added the fourth chapter “about the rules of the ship's energy efficiency” in annex VI to enforce the new ship to implement the mandatory regulation about EEDI, and enforce all operational ships to implement the SEEMP. This new rule is applicable for all ships whose load is more than 400 tons regardless of the flag state or owner. According to IMO default accept the application, the amendment shall come into force on January 1, 2013. This is the first global GHG emissions rule in the system of the shipping industry.

Table 3- The Alternative Policy Tools of Shipping Industry from IMO

	Market-based tools	**Mandatory tools**	**Voluntary tools**
GHG emission on the sea	1.Emission trading. e.g. METS 2.Emission tax. e.g. ICF		
The operational efficiency	1.EEOI tax 2.EEOI tax/ benefit plan	1.restrict EEOI forcibly 2.report EEOI forcibly 3.implement SEEMP forcibly	1. voluntary agreement of EEOI improving 2. voluntary agreement of SEEMP implementation

The design efficiency	1.EEDI tax 2.EEDI tax/ benefit plan	1.implement EEDI forcibly to the new ship	1. voluntary agreement of EEDI improving 2. meet the voluntary standard
Lifecycle carbon emission	1. differentiation tax collection of fuel	1.Lifecycle carbon emission standard 2.Biological fuel standard	

Source: Shao, S.Y & Li, Z.Y. (2012). Analysis on greenhouse gases emission reduction policy of global shipping industry. *Environmental Economy*,2012(9):14-17.

2.3.2 Technical measures

1) Technical reform to the existing equipment of the ship

This is a fast and economical way which needs less investment.

The main engine as the main fuel consumption device on ship is the key of the technical reform. Without affecting the working situation, plug and manage the supercharger to increase the scavenging pressure, improve the working condition and improve the economic returns through reducing speed. To transform the slide valve type oil head of the main engine can improve the timing of fuel injection and quality of atomization; meanwhile, it optimizes operation condition of low load, and reduce the effect on the flue.

a. Adjust the fuel injection/engineered to keep fuel injection finished in a shorter period of time. This measure can realize the oil-saving about 2-4 g/kw·h, oil-saving rate about 1% -2%. The cost involved in such adjustment/modification is moderate.

b. Adopt the new type of turbocharger turbine supercharger to replace the original one will cost much money because of the big change of the major technology. This measure can realize the oil-saving about 2-4 g/kw·h, oil-saving rate about 1% -2%.

c. Rated efficiency optimization of the diesel engine requires that the material has high mechanical strength to withstand higher pressure. At the same time, we must pay attention to the fact that the measures may be affected by the NO_x emission limits.

2) Technical innovation of shipbuilding

More and more ship owners and shipping companies distract their attentions to the shipbuilding technology innovation. There are many new technical breakthroughs in the field of improvement of propeller, recycling of ship waste and drag reduction of hull, etc. The innovation of propeller is most remarkable. For example, the using of double propellers can not only save the fuel consumption, but also reduce the noise and vibration. One propeller will be set in the feathering state when the ship needs to slow down to save fuel consumption of the main engine. Improving the hub can make the water gleam along the flow, distort the rudder with rudder ball, then the efficiency of propulsion can be improved.

a. hull and propeller design

This part focuses on the existing water power science and technology in order to realize the energy saving, so as to realize the GHG emissions reduction.

MARINTEK researched the traction ship and found that the small improvement of the bow and (or) the boats hull could achieve the power reducing of 20%. So it is presumable to save energy greatly by an optimal design of hull. For the quantitative description of the potential capacity of energy saving by hull optimization design, MARINTEK chose different types of ships to conduct the experiment research, and drew a speed-power relation curve that reflected different types of ships according to the obtained data. This study concluded that there was about 30% more energy saving space of the ship which achieved the optimal speed through the optimization of relationship between speed and power than the other selected ships.

The traditional propeller efficiency is mainly based on the design of the propeller. The design of the propeller is mainly related to the cavitation performance, noise and the pressure pulsation. The main constraints of propeller design are the size, the cavitation performance and load performance. Therefore, propeller type selection is the main problem for the propeller design to reduce power consumption.

According to some studies, slow-revolution propeller can reduce power consumption by 9% to 13%. Coaxial reverse propeller can reduce power consumption by 15% to 20%. Additional free rotating impeller propeller can reduce power consumption by 9%. The guiding device installed in front of the propeller or just in the propeller can reduce the power consumption by 5% 10% and 12%.

b. The new ship machinery and equipment

New ship can use a series of comprehensive measures to improve the efficiency of the power plant including increasing compression ratio, improving the fuel injector, etc. The improvements of fuel injection include using higher injection pressure and higher pressure valve. Through using the latest technology, a new type of medium speed diesel engine can realize energy saving of 10% -12%. Two-stroke diesel engine can achieve a 2%-5% fuel saving. It must be noted that the implementation of fuel saving may be likely to conflict with the NO_x, which emission has been strictly limited.

3) Using electronically controlled diesel engine

Electronically controlled fuel injection diesel engine is the new type of diesel engine which adopts electronic equipments and softwares. By controlling the fuel injection timing, injection volume, injection rate, pressure, inlet and exhaust valve timing, the diesel engine can effectively realize performance optimization under all kinds of workloads, and improve combustion efficiency as well as the quality of combustion, thereby reduce emissions and improve its efficiency.

4) Using marine diesel oil instead of marine fuel oil

Because the marine diesel fuel oil has a lower hydrocarbon ratio, so, carbon content in the same calorific value of fuel will be reduced by 4% -5%. However, this measure is obviously subject to the conditions of resources and oil refining technology (by the author).

2.3.3 Market-based measures

Theoretically speaking，ships can use a lot of technical and operational GHG emission reduction measures that have been extensively researched and studied on. However, most research data is obtained on the basis of data calculated from a mathematical model so the effect will be very difficult to determine without actual application practice of the conclusion. Therefore we will not be able to formulate a unified mandatory standard. The management goal of the ship owner or ship manager is profit. If ships of different emission standards are attached to different economic factors, the owners or managers of the ship will consciously pursue the maximum benefits, actively introduce new technology to meet with the smallest input to achieve the emission reduction requirements. Based on the principle of market economy, the market-based reduction measures will be effective. Here are several international emission reduction measures based on the market.

1) Environmental index method

The guiding ideology of environmental index is establishing the environment index system in accordance with the theory that environment reflects the efficiency of the Marine. According to the index system, each ship will be given a different environment index which will become the pursuant of all kinds of taxes on the ship, port charges, insurance rate, etc. Environmental index system has been adopted in a limited scope and some of them focus on some specific pollutants. For example, Swiss environmental index was limited to NO_x and SO_x. The key of environmental

index system adoption is how to determine the index system and how to inspire the ship owners correctly. In addition, it is important to note that this kind of system to perform complex degree increases with the enlargement of the area. While one of the most important characteristics of GHG emissions is that it needs to adopt a worldwide implementation, the implementation of this method requires a wide range of international coordination.

2) Voluntary agreement

Voluntary agreement is also known as consultation agreement. Many countries adopted it as energy efficiency and climate change policy since the Kyoto protocol was passed. There are many kinds of voluntary agreements, it can be a statement of a company or an industry, or binding contracts of an industry including the violation. Strictly speaking, what is not voluntary agreement, because if the enterprises or industries are not willing to participate in the negotiation and reach an agreement, sanctions will be imposed in other forms of rules and if they join in the agreement and not meet the target, they will also be affected by the rule, such as emissions fee or other taxes and fees. Some developed countries have adopted this approach as a part of the national plan to address climate change within the framework of the UNFCCC. Germany and the Netherlands are the two precursors in this field.

3) Carbon tax

In many cases, the cost of fuel occupies a large proportion in the shipping business, and the specific proportion is related to ship type, age and the price of fuel. Study shows that in the 1990s when the oil price was lower, the cost of fuel accounted for 20%-25% of overall shipping cost. By contrast, in the past two years rapidly increasing oil price made the oil cost account for 40%-50% of the overall cost. As the growth of the age the proportion of fuel costs is also gradually increasing. Carbon tax will increase the fuel cost and inspire the enthusiasm of the ship owner to save fuel and reduce emissions as the emissions of GHG are closely related to fuel consumption.

Historically, the demand for fuel oil was closely related to the oil price. The fuel demand is fell rapidly when oil prices rose in 1973 and 1979. However carbon tax may produce adverse effects if implemented improperly such as reducing the maritime traffic and making the transportation requirements move to other forms of transportation that have a lower efficiency.

4) Setting emissions standards

IMO has successfully set up some international standards about the ship navigation safety and they have been effectively implemented. For example, port states conduct the PSC supervision and inspection, and report the defects to flag states and they can strand the ship until the hidden safety trouble is eliminated form the ship. This conduct is mainly aim at the security in the past, but there were also standards regarding the environment such as the requirement of equipments which prevent oil pollution, NO_x technology, etc. The GHG emission of ship is not only related to equipment technical indicators but also the actual operation, therefore the ship's standards on GHG emissions have two directions to choose as follows. One is setting the technical standards for power plant. This standard is relatively easy to implement because once the devices are installed on the ship and under the condition of correct maintenance it will meet the emission requirements. However, to some extent this method may restrict the development of new technology because the standards setting must base on the existing mature application technology. The other is setting efficiency standards. Because the ultimate goal of standards is to achieve the reduction of emissions, the formulation and implementation of efficiency standards will make ship owners commit to improving the overall efficiency and take all feasible measures to reduce emissions.

5) Emissions trading

This measure determines and assigns to each emission subject a certain emission amount according to certain methods. Once the emissions are beyond the limitation,

the subject should pay some fees to purchase additional permits. On the other hand, emission subjects who make effort to achieve emission reduction can sell its remaining permits to recover some of its costs. This kind of market-based mechanism can urge the ship operators to take various measures to reduce emissions. The emissions trading method comes from the flexible mechanisms of the Kyoto Protocol. Kyoto Protocol admits that some flexible mechanisms are effective to reduce GHG emissions such as emissions trading between countries (annex I), joint implementation and the clean development mechanism.

2.3.4 Management measures

1) Monitoring the speed

The decisive factor to greenhouse gas emissions and the fuel consumption for a ship to complete a task is the speed. The amount of fuel consumption of a ship that sails unit distance is in direct proportion to the square of the speed at least. So speed reducing can achieve substantial emission reduction. According to the function relationship between ship resistance and speed, when the speed is reduced by 10%, the fuel consumption is reduced by more than 20%.

2) Meteorological navigation

Meteorological navigation is the whole system of technical ways that can help the ship select the optimization route across the ocean in practice according to the weather and sea condition forecasting, ship performance and technical conditions and shipping task. This measure can reduce fuel consumption by reasonable use of wind and ocean current.

3) Optimizing the operation parameters

a. The best draft

Adopting the optimum draft balance can save 0.1% -1% of the fuel consumption while maintaining the speed under the condition of established mean draft.

b. A minimum of ballast

To minimize the ballast water and carry the extra fuel could save 0.1% -1% more of the fuel consumption than the traditional approach.

c. The best pitch

The best pitch can be determined by determining draft, rotational speed and weather conditions, and adjustment of pitch can be done by man or the automation system. When variable pitch propeller ship adopts the best pitch, it can save 0.1% -2% more of the fuel consumption than traditional practices.

d. Optimizing the steering

The change of rudder angle will increase effective power loss of propeller. Using the multivariable automatic navigation system based on computer control instead of the old navigation system can make the ship steer by steering the stability of the smallest angle. This way can reduce the hydraulic loss, and thus maintain fuel consumption at the lowest level. This way of steering can save about 0.1 -0.3% of fuel consumption.

e. Ballast time and capacity utilization

Ballast voyage will increase the fuel consumption of complete effective transportation needs, thereby increasing emissions of greenhouse gases. So if ship owner can avoid the ballast voyage as much as possible and improve capacity utilization, the total amount of fuel consumption can be reduced.

f. Improving the fleet management

The improvement of the fleet management can develop ship capacity and the fleet

capacity can usually be effectively implemented to maximize the saving of fuel consumption, so as to realize the emissions reduction of greenhouse gases.

g. Freight affiliated

If ship owners initiatively unite to form more efficient logistics system and improve capacity utilization by freight affiliated, it can reduce greenhouse gas emissions to a considerable degree.

h. Operation of cargo

Saving time for navigation by improving the efficiency of cargo operation can save 1 %- 5% fuel consumption potentially (by the author, 2014).

4) Implement ation of the SEEMP

This method was put forward by IMO. IMO released the MEPC. 1 / Circ. 683 circular (guidelines for the formulation of SEEMP) and required the shipping companies to carry out the SEEMP for their ships to reduce the EEOI. This is the focus which the author emphasizes on in the next chapter.

3. The analysis of EEOI control based on management theory

3.1 Introduction to EEOI

In order to promote the ship energy saving and reduce GHG emissions, IMO put forward three key control measures, namely EEDI, EEOI and the mechanism of the carbon emission market. The EEOI mainly aims at the operational ships and forces them to establish, implement and maintain the SEEMP. IMO released the MEPC. 1 / Circ. 683 circular (guidelines for the formulation of SEEMP) and required the shipping company that they must make and carry out the SEEMP for their ships to reduce the EEOI (Sun, 2013). In this part of thesis, the author will analyze how to implement the SEEMP based on management theory.

3.1.1 Definition of EEOI

EEOI can be expressed as

$$\frac{\sum_{j} F_{Cj} \times C_{Fj}}{m_{c\arg o} \times D}$$

The numerator of the formula describes the total CO_2 emissions of a certain voyage. F_C describes the fuel consumption quantity for the ship sailing. C_F, also called CO_2 emission factors, describes CO_2 emissions quality of unit fuel combustion. The summation of the product describes the CO_2 emissions quantity of some kind of fuel. We should consider the CO_2 emissions from all equipments such as host, auxiliary machinery, boiler because not all sorts of equipments consume the same fuel. It is necessary to sum the product. The j indicates different kinds of fuel. The denominator is the total volume of the ship, described as the product of cargo capacity ($M^{c\arg o}$) and

navigation mileage (D). The unit of the cargo may be ton (t), TEU or person (for passenger ships). EEOI is actually CO_2 emissions of transporting one ton goods per sea mile (Gao, 2010). The definition of the EEOI shows that the smaller the value is, the higher the ship's energy efficiency. We can control the value by reducing the ship loading capacity or using fuel with lowered CO_2 emission factor. EEOI is usually calculated from data statistics based on a voyage or a number of voyages. It needs all of the fuel oil consumption statistics from the ship's main engine, auxiliary engine, boiler when the ship is on the voyage and in port. So, we must establish an effective management system of energy efficiency of the ship. With the rapid development of information technology, the shipping company can realize the real-time monitoring and management of ships with the aid of maritime satellite, computer network for the navigation of ships, ship's cargo capacity, ship fuel consumption per day and information of fuel saving (Ni, 2010).

3.1.2 Application of EEOI

EEOI can be applied in all cargo transport ships- dry bulk ships, oil tankers, liquid natural gas ships, container ships, ro-ro ships, cargo ships, passenger ships, ro-ro passenger ships and so on. Because of carrying varieties goods the unit of measurement is different as follows (Sun, 2013).

1) The ship type classification

Dry bulk ships- the ore-ships, coal-ships, other bulk carriers;

Tankers- oil tankers, oil product carrier;

Container ships- ordinary container ships, refrigerated container ships;

Ro-ro ships- car carriers, ro-ro passenger ships;

Passenger ships- ordinary passenger ships, passenger-cargo ro-ro ships;

Special ships- liquid natural gas ships (LNG), liquid petroleum gas ships (LPG), engineering ships;

2) The cargo type classification

Bulk cargo- liquid and solid bulk goods;

General cargo- twenty-foot equivalent unit, heavy liquid, freeze cargo, wood products, freight car goods, cars and cargo vehicles on ro-ro ship, etc;

Passenger- the quantity of passengers;

3) The measure unit type of cargo classification

Bulk carriers, oil tankers, general cargo ships- ton;

Passenger ships- number of passengers;

Car ro-ro ships- number of cars or the length of channel cars taking up;

Container ships- ton, quantity of TEU;

Train ferry- number of carriages or the length of channel carriages taking up

It should be noted that, if the ship carries many kinds of cargoes, we shall adopt the ton as the measurement unit. The unknown weight container in the bulk ship can be calculated as this: the heavy container-10 tons, the empty container- 2 tons.

3.2 Introduction of SEEMP

The SEEMP refers to ship energy efficiency management plan. On July 15, 2011, the 62nd session of MEPC passed the amendment of MARPOL convention annex VI, added the fourth chapter called energy efficiency rules for new ships. It required the new ship and major conversion ships should satisfy the supplementary provisions

concerning the requirements of EEDI and SEEMP. The existing ships should meet the requirements of the supplementary provisions about SEEMP. It entered into force since January 1, 2013 and requested that after the inspection in accordance with requirements, ships of 400 gross tonnes and above which leave for the jurisdiction of other parties to port or offshore loading and unloading station shall be issued the international energy efficiency certificate (IEEC) by the competent authority or any organization authorized by the official before sailing.

3.3 Summary of the relative management theories

3.3.1 PDCA Circulating

PDCA (plan–do–check–act or plan–do–check–adjust) is an iterative four-step management method used in business for the control and continuous improvement of processes and products. It is also known as the Deming circle/cycle/ wheel, Shewhart cycle, control circle/cycle, or plan–do–study–act (PDSA) (Wikipedia.2010). It was put forward by the American statistician Dr Deming to reflect the law of quality management activities. PDCA Circulating is a working procedure which can make any work effective and logical. The four letters represent four steps as follows.

Table 4- Meaning of each letter of the PDCA Circulating

P(Plan)	Establish the objectives and processes necessary to deliver results in accordance with the expected output (the targets or goals). By establishing output expectations, the completeness and accuracy of the spec is also a part of the targeted improvement. When possible start on a small scale to test possible effects.
D(Do)	Implement the plan, execute the process, make the product. Collect data

	for charting and analysis in the following “Check” and “Act” steps.
C(Check)	Study the actual results (measured and collected in “Do” above) and compare against the expected results (targets or goals from the "Plan") to ascertain any differences. Look for deviation in implementation from the plan and also look for the appropriateness and completeness of the plan to enable the execution, i.e., “Do”. Charting data can make this much easier to see trends over several PDCA cycles and in order to convert the collected data into information. Information is what you need for the next step “Act”.
A(Act)	Request corrective actions on significant differences between actual and planned results. Analyze the differences to determine their root causes. Determine where to apply changes that will include improvement of the process or product. When a pass through these four steps does not result in the need to improve, the scope to which PDCA is applied may be refined to plan and improve with more detail in the next iteration of the cycle, or attention needs to be placed in a different stage of the process.

Source: http://en.wikipedia.org/wiki/PDCA#cite_note-1

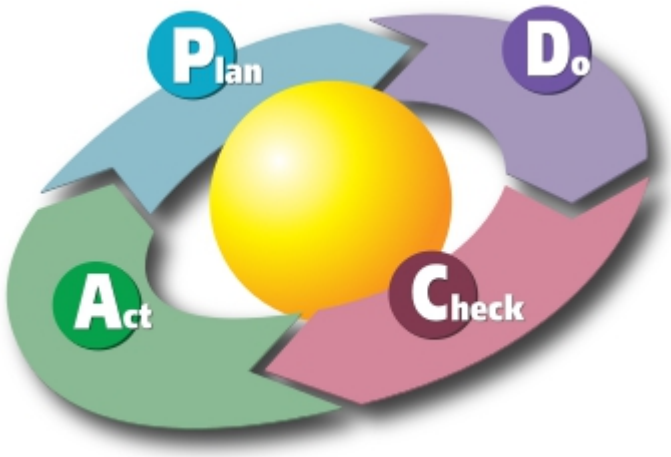

Figure 1- The PDCA Circle

Source: Wikipedia. Taking the First Step with PDCA. February 2009. Retrieved 17th, March 2011. Web site: http://en.wikipedia.org/wiki/PDCA#cite_note-2

3.3.2 Humanistic Management

Humanism refers to the “people-oriented”, approach which regards nature and status of the person as the center. Humanistic management refers to establishing the core status of “people-oriented” in the process of management. The management theory shows that the organization’s goal is to meet the people’s various needs and respect the personality, create the survived and development environment suitable for people, stress peoples active involvement in the management and the effective self-management to arouse people's enthusiasm and creativity, and realize the overall development of people through competition and cooperation. “People-oriented” is not only a kind of management concept and method, but also the ultimate goal of management. The significance of the humanistic management has two aspects:

First, establish the core status of the people in the management process and highlight the essence of people. Go back to the essential aspects of human being from the "tool". Management practice shows that the first step of the management is to fundamentally identify and determine the nature of man, then to determine the management program and method.

Second, the ultimate meaning of humanistic management is to satisfy the all-round demands of people through the human-centered management and the production and business operation activities, make the person realize the comprehensive development beyond the physical requirements and obtain spiritual and material needs.

Humanistic management not only emphasizes the value of people, but also arises the enthusiasm of people by respecting, caring, understanding people. It stresses to establish a good interpersonal relationship and develop human resources at the same time. The management which only arouses the enthusiasm of people to help the enterprise to achieve its profit purpose is not the real humanistic management.

3.4 Establish the SEEMP system based on management theory to control EEOI

3.4.1 Establish the SEEMP system based on PDCA

The SEEMP system can improve the EEOI through the continuous four steps of PDCA according to the IMO.MEPC.1/Circ.683.

Plan- This step is to identify and confirm the energy efficiency factors of shipping company or ship; identify the relevant international conventions, laws, regulations, standards and other requirements of EEOI; identify and adopt suitable techniques and best practices of energy saving; determine the energy efficiency management benchmark by analysis and determine benchmarking when it is practicable; establish energy efficiency policy, objectives and indicators, formulate SEEMP to achieve the desired goals of company's energy efficiency policy.

Do- This step is to implement the process include providing the required resources, clarifying the responsibility and authority; determining the requirements of ability and consciousness to train; establishing information communication mechanism; set up the required documents and records; implement the operation control; implement the SEEMP and carry out related activities.

Check- this step is to supervise and measure and evaluate the energy efficiency indicators according to the requirements of guidelines, objectives, conventions and regulations, and report the results of identification; check and dispose inconformity; carry out internal audit and review.

Act- this step is to adopt measures to improve ship energy efficiency, save energy consumption, reduce emissions. After this step, a new EEOI control plan may be put forward to realize the continuous improvement.

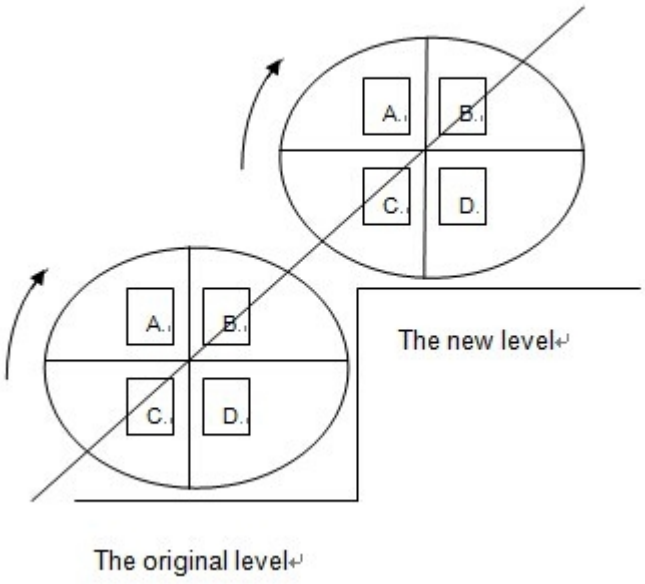

Figure 2- Continuous improvement by PDCA circle

Source: Guo, X.H.(2012). The construction of ship energy efficiency management system based on P-D-C-A. Journal of Qingdao Ocean Shipping Mariners College.

3.4.2 Apply the Humanistic management to the SEEMP

The crew's awareness of energy efficiency plays an important role in energy efficiency management so the development of human resources should be given full consideration in the first phase of SEEMP. In the implementation process of SEEMP, we must have the corresponding training program to train the shore-based and

onboard personnel related to energy efficiency management in order to improve their awareness of energy efficiency and abilities of energy efficiency measures' executing. In every link of the SEEMP implement the enthusiasm of people is very important. We should give full play not only to the operational level but also to the management level in order to improve people's consciousness and achieve the goal of energy conservation and emissions reduction.

4. Application examples of the SEEMP system

4.1 SEEMP system based on PDCA and Humanistic Management

These factors as follows should be taken into account when the shipping company establishes the SEEMP system:

The top of the company should make commitment to the establishment, implement, maintenance and continuous improvement of ship energy efficiency management system; pass and execute the applicable international conventions, laws, regulations, standards and other requirements and further implement them in the company.

Policies and goals of energy efficiency shall be formulated and implemented and as a part of the company's strategic target and development direction. Review them regularly and ensure the appropriate resources equipped to the management system so as to provide objective evidence.

It is important to note that the top of company should ensure that the SEEMP is suitable to the characteristics of the shipping company/operation services when they establish the company's energy policy, and the SEEMP system should be coordinated with the company's existing policy (such as the ISM, ISO14000, etc). Companies' SEEMP system should contain the commitment of energy consumption saving/ energy efficiency improvement/ CO_2 emissions reduction and continuous improvement as well as comply with applicable international conventions/laws/regulations/standards and other requirements of ship energy efficiency management. Besides the top of the company, all staff participation is very important too. People are the main part of the energy efficiency management and energy conservation and emissions reduction (Zhang, 2013).

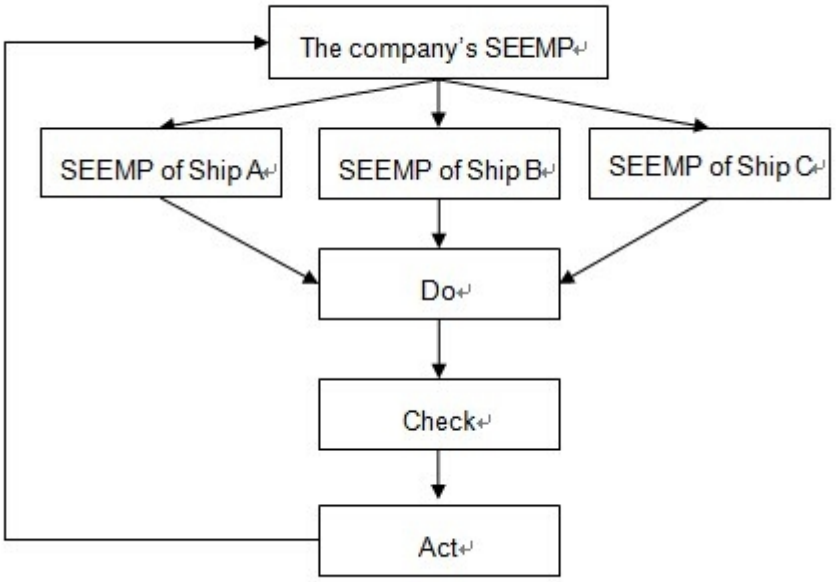

Figure 3- The framework of SEEMP system in the shipping company/ships

Source: compiled by the author.

4.2 Plan the SEEMP-P

The shipping company should first identify the factors which affect the energy consumption efficiency and CO_2 emissions in shipping/operation service when planning the SEEMP. Then, evaluate the factors of energy efficiency to determine the priority control factors of energy efficiency according to the international conventions/laws/regulations/standards and other requirements, as well as the characteristics of the shipping company/operation services, etc.

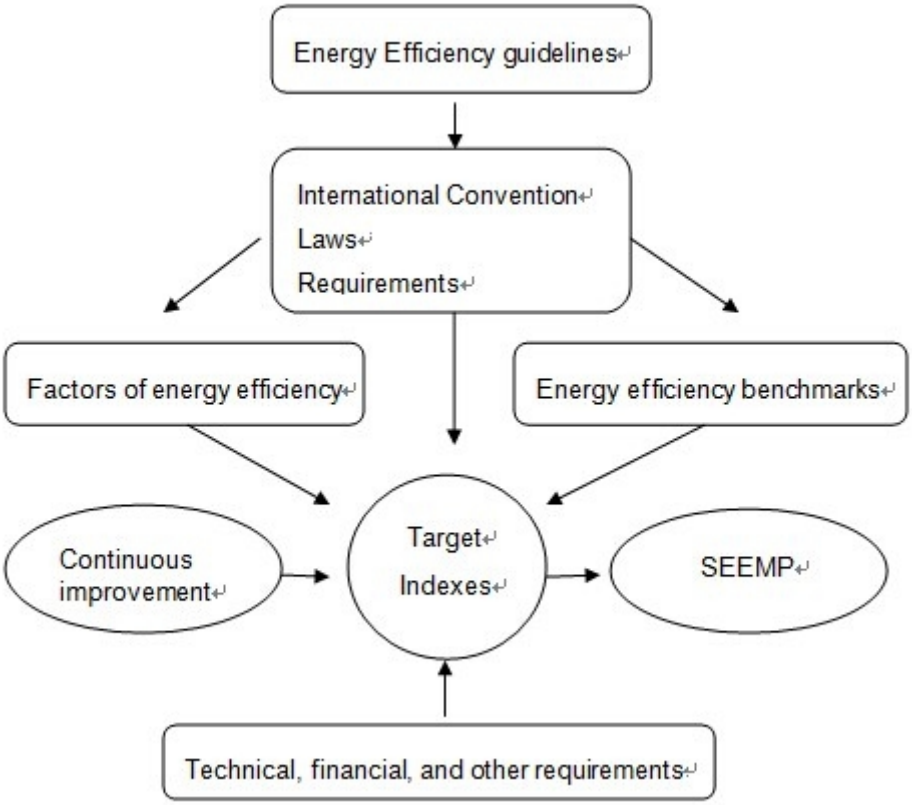

Figure 4- Factors that should be considered when setting the goals of SEEMP

Source: compiled by the author.

The company shall establish the benchmark of energy efficiency management as the main basis of evaluating the performance of energy efficiency and the goals or indicators of energy efficiency when it is appropriate. The company's energy efficiency goals and indicators should contain the EEOI from IMO. At the same time the company should pay special attention to the energy efficiency goals/indexes developed by the competent authority. Of course, the company's goals and indexes of energy efficiency are not invariable; they should be updated or adjusted. The company should aim at the goal/index of energy efficiency to formulate and implement the SEEMP. There are many possibilities to improve the EEOI of existing ships. Although there are many choices, it usually depends on the area and trade. It may require cooperation and support from many different stakeholders. The company and ship should consider the compatibility of energy saving measures to take the best solution according to the ship features/ navigation area/trade and other related requirements.

Energy efficiency management plan should reference to the MEPC.1/Circ.683 of IMO as far as possible or other industry/organization's guide of he guide. SEEMP should contain the contents such as responsibility and authority of relevant functions and levels, energy efficiency measures and requirements, timetable, requirements of supervising/measure, requirements of evaluation and the date of next evaluation, etc. In the process of the formulation and implementation of SEEMP, the company should try to minimize the administrative burden on board. From the view of Humanistic management, in this phase, all staff of the shipping company should participate in the SEEMP implement. The company should strengthen the propaganda and form the identity of energy efficiency management.

4.3 Operate and implement the SEEMP system-D

The implementation of SEEMP includes eight aspects, namely resources, ability/training and awareness, information exchange, documents, document control, record control, operation control, emergency preparedness and response. The company should be equipped with shore base personnel and crew who have the relevant professional ability, and fully recognize and develop their best energy saving management practices and experiences as well as the effective energy saving technologies and methods. At the same time, train the personnel related to the management of energy efficiency with the SEEMP system, provide all kinds of resources and take measures to make all staff have the consciousness of the importance of the SEEMP and the requirements of energy efficiency, reducing energy consumption, improving energy efficiency and the company's benefit brought by CO_2 emissions reduction, and the improvement of energy efficiency performance brought by individual's work, etc.

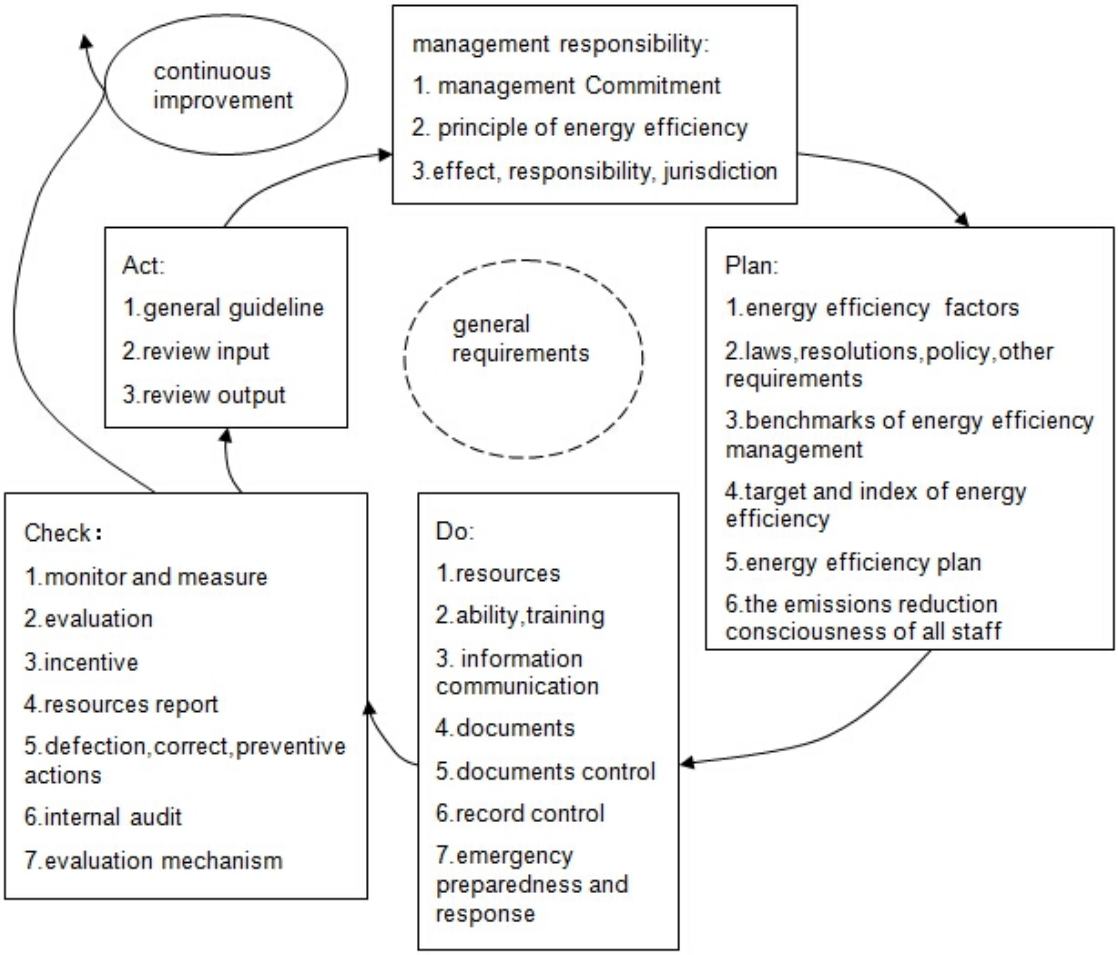

Figure 5- Contents of SEEMP

Source：compiled by the author.

Operational control is an important part of the effective implementation of the SEEMP. It generally contains that: ship design/construction/renovation and purchase, maintenance and repair of the ship equipment, energy management and fuel procurement, management and operation of shipping/operation process, cooperation with related parties/stakeholders. The control of the operational ship is mainly the management and operation of shipping/working which includes but not limited to:

1) Optimization of the ship voyage plan, such as choosing the best route

2) Weather route drawing: select weather route

3) Optimization of the ship speed: choose the best speed

4) Optimization of the ship maneuvering: choose the best trim and ballast

5) Optimization of the cargo plan: full communication between ships and ports, seek the best cargo plan

6) Optimization of the diesel engine: adopt new technology (electric control/common rail, etc)

7) The improvement of diesel engine fuel injection and combustion efficiency

8) Use the new fuel additives: diesel catalytic/gasification, makes the diesel full combustion in the cylinder, reduce the black smoke, improve fuel efficiency

In this step, human resources development is particularly important. All staff related to the SEEMP should be equipped with the ability and knowledge which are qualified for the work.

4.4 Check and rectify the SEEMP- C

The company shall establish, implement and maintain one or more programs to monitor and measure the key features which have significant impact on the ship energy consumption/energy efficiency/ CO_2 emissions, and conduct routine analysis. EEOI and its measurement/calculation methods formulated by IMO are internationally recognized as the numerical monitoring method for operational ships and/or fleet efficiency. The company and ships can choose EEOI and these methods as their main monitoring method. If they use the EEOI, they should collect fuel type and quantity/sailing distance and cargo type and quantity and some other related information in accordance with requirements of the IMO documents and calculate them. They can calculate EEOI values of rolling average index to monitor the ship's energy efficiency if appropriate. At the same time, the company can also use the

monitoring method recommended by the competent authority of flag state. In dealing with actual or potential deficiencies, we should pay attention to identify and correct the deficiencies and take steps to reduce the impact. Investigate and analyze deficiencies, determine the causes and take corrective measures to avoid repetition. For potential deficiencies we should evaluate the demand of taking preventive measures, if necessary, develop and implement preventive measures in order to avoid the happening of deficiency.

Human factors in this step embody in the operation procedure standardizing and evaluation mechanism establishing. The energy conservation and emissions reduction index will be added into the crew's assessment system.

4.5 Continuous improvement of the SEEMP-A

The SEEMP system based on PDCA circle can make the continuous improvement of energy efficiency by continual circulation. The system monitor/evaluate the result mainly through three processes and looking for opportunities to improve: first is the monitoring and measuring of process and energy efficiency index; second is internal audit; third is the management review. The company should make regular internal audit to judge whether the SEEMP system match the company's needs and documentation requirements, whether have been effectively implemented and maintained. Then, report the audit results to the managers. Based on the review of the audit results, the management should be able to determine the effectiveness of the SEEMP and meet the goals. Confirm its completion status through comparing with the efficiency guidelines, objectives, indicators and requirements of management system. If there are unfinished or unqualified goals, we should analyze the reasons and formulate corrective actions. If the goal/indicator has been completed, we should establish the new energy efficiency target/index and system improvement plan according to the requirements of internal and external and with the consideration of technology, management and economic factors. Management review is one of the important means of continuous improvement and effective management of SEEMP

system. It is the active behavior of the top of the company to understand, promote and improve the SEEMP operation. The top managers should conduct a comprehensive inspection and evaluation of the guidelines/target/index and the suitability/effectiveness/sufficiency of the SEEMP in accordance with the time interval of the plan, find out where need to improve then formulate the feasible corrective actions.

5. Conclusion

In this thesis the author formulates how to implement the SEEMP to control EEOI emissions in order to achieve the CO_2 reduction goals from the view of management theory. SEEMP was proposed by the IMO as the management mechanism of CO_2 emission reduction, it will be asked to compulsory execution in the shipping industry.

As a kind of management measure, SEEMP put some quantitative requirements to the ship's CO_2 monitor of shipping company and help the company to manage ships efficiency during the operating. The ship owner/operator and other related parties should establish targeted planning for the ship such as PDCA mode and establish a set of management mechanism to enhance the energy efficiency of the ship.

In order to better implement the SEEMP, we can apply PDCA cycle theory and humanistic management in practice. PDCA is the management theory which ensures that the continuous improvement in the management procedure. Humanistic management theory can achieve the self-consciousness management through change people's awareness and motivation fundamentally.

The author believes that in today's environments of energy conservation and emissions reduction the SEEMP operation mode integrating the two theories is very meaningful.

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