EURO TECH MARITIME ACADEMY , KOCHI

TOPIC:
HYBRID RENEWABLE POWER GENERATION AND THEIR APPLICATION IN SHIPPING INDUSTRY

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ABSTRACT

Shipping is vital to the world economy. It is a critical part of international import and export markets and supports the global distribution of goods. Our paper briefly discusses the scope for Waste Heat Recovery systems (WHRS) which is already notching up important milestones in recovering appreciable amount of the energy from main engine’s exhaust gases and thus improve a vessel’s energy efficiency design index (EEDI). As our present concern about climate change, require the reduction of greenhouse gas emissions from the shipping sector which calls for low sulphur fuels, this entails higher fuel prices. Rapid depletion of fossil fuels has necessitated an urgent need for alternative sources of energy to cater the continuously increasing energy demand. Although waste heat recovery systems are commonly used in industrial power generation, the highly transient operation of engines introduce significant technical challenges to heat exchanger durability, caused by the resultant high thermo-mechanical stresses and shipboard space constraints may limit the applicability of commercially available systems. This paper seeks to explore innovative, affordable, advanced concepts and technologies to develop compact, durable waste heat recovery systems for application on ships are looked upon to take a giant leap into the future.

KEYWORDS : PRINCIPLE, REASONS FOR WHRS , CASE STUDY, WHRS IN SERVICE, INSTALLATION ASPECTS ,WASTE HEAT RECOVERY PLANT COMPONENTS.

INDRODUCTION:

Conventional gas turbine engines are not so appreciably efficient at its full power, and significantly less at partial power. Even though diesel engine efficiency is more uniform across its operating power range, thermal efficiency typically does not exceed the expectations. The engine exhaust stream is the primary pathway of engine waste heat. Recovering useful energy, in the form of electrical power, alternative heating and cooling, from engine exhaust waste heat would directly reduce system fuel consumption, increase available electric power and improve overall system efficiency by augmenting the power produced by the prime mover and enabling it to operate at a lower net power with lower net fuel consumption. Industrial gas turbines have achieved efficiencies—up to 60%—when waste heat from the gas turbine is recovered by a heat recovery system in a combined cycle configuration. Identification and development of a viable shipboard waste heat recovery system in this effort will provide reduced ship service electric power fuel consumption.

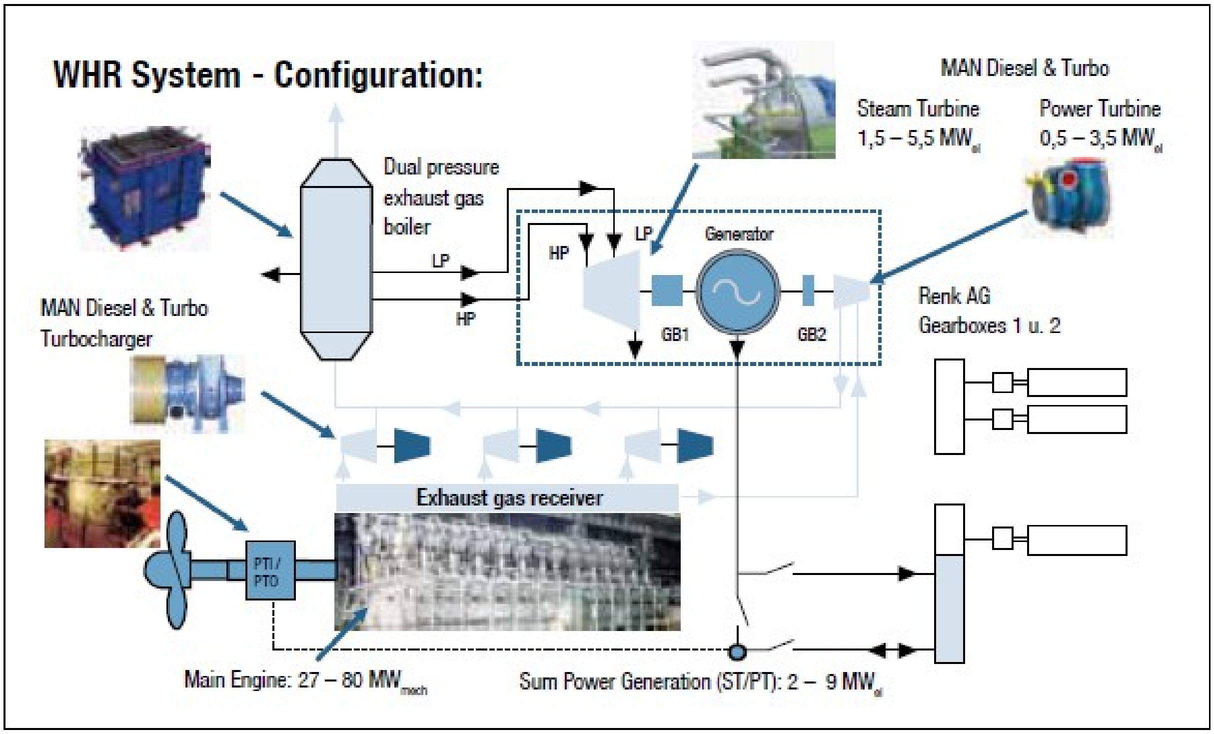
The principle of Waste Heat Recovery Systems

The principle of the WHRS is that part of the exhaust gas flow is bypassed the main engine turbocharger(s) through an exhaust gas bypass. As a result, the total amount of intake air and exhaust gas is reduced. The reduction of the intake air amount and the exhaust gas amount results in an increased exhaust gas temperature after the main engine turbocharger(s) and exhaust gas bypass. This means an increase in the maximum obtainable steam production power for the exhaust gas fired boiler – steam, which can be used in a steam turbine for electricity production. Also, the revised pressure drop in the exhaust gas bypass, which is part of the WHRS, can be utilised to produce electricity by applying a power turbine.

Choosing a system for a project depends on the power demand onboard the ship (electrical load at sea), the ship's running profile (hours at different main engine loads at sea), the acceptable payback time for the proposed WHRS solution based on the running profile and the space available on the ship, among others. A very important part of selecting the best WHRS for a ship project is choosing the best suited propulsion power and rpm for the ship – biggest possible propeller – so as to ensure the lowest possible fuel consumption for the basic performance of the ship.

In many cases, WHRS will be able to supply the total electricity need of the ship as a standalone power source, but it can also run in parallel with a shaft generator, shaft motor and auxiliary diesel generating sets. This type of advanced power system requires an advanced power management system (PMS), with which the MAN Diesel & Turbo engine control system is designed to communicate.

Particularly for container ship designs, WHRS has found its place where it contemplates a technological step forward in lowering fuel consumption and emissions of the ship, but the interest for WHRS solutions is spreading to other ship types with the aim of reducing total fuel costs, ship EEDI and emissions.



Main engine and WHRS system Control

The main engine control and the WHRS control must be able to function as an integrated part of the total control system of the ship, which means that integration between the systems must be in place. The development of the WHRS and main engine controls is based on the ship owner's demand for full control and optimum fuel consumption in all operational modes. Focus is very much on fuel economy because of the continuously increasing fuel oil prices

REASONS FOR WHRS:

- Reducing emissions and reducing engine operating costs
- To increase exhaust gas energy and employing both steam and exhaust gas turbines in a Total Heat Recover Plant
- In low-speed marine engines there is only little potential for achieving significant reductions in emissions. WHRS Controls the generation of the emissions inside engine cylinders, removing the emissions by after treatment of the exhaust gases, or in the case of SOX emissions restricting the fuel specification.

CASE STUDY

The economic benefits of the high-efficiency WHR system can be illustrated by the case of a container ship powered by a 12-cylinder Wärtsilä RT-flex96C engine. In the case, the engine would operate at an average of 85% load for about 6500 hours a year on bunkers costing US$ 250/tonne, with an average total electrical load of 5350kW, including reefer containers. The annual operating costs for the main and auxiliary engines, including fuel the main and auxiliary engines, including fuel US$ 19.54 million without a WHR plant and US$ 17.29 million with a high-efficiency WHR plant. There would thus be annual savings of US$ 2.25 million. If the bunker price increased from US$ 250 to US$ 400/tonne, then the annual savings would increase to about US$ 3.48 million. The complete high-efficiency WHR plant and its installation would call for an investment cost of about US$ 9.5 million. This would thus have an expected payback time of less than five years.

HIGH-EFFICIENCY WHR IN SERVICE

The first installation of this new high-efficiency WHR plant entered service in the 7500TEU container ship Gudrun Maersk of the A.P. Moller-Maersk Group in June 2005. It successfully confirmed the benefits of the new WHR plant concept. During sea trials and in operation, the performance of the WHR plant exceeded expectations. Similar WHR plants are also now in normal operation in the complete class of six 7500 TEU sister ships. The WHR plant for these vessels was developed in a joint effort headed and integrated by Odense Steel Shipyard Ltd in cooperation with Wärtsilä, Siemens AG, Peter Brotherhood Ltd and Aalborg Industries Ltd. The ships are each propelled by a Wärtsilä12RT-flex96C low-speed common-rail engine with a maximum continuous power output of 68,640 kW at 102 rpm. Exhaust gases pass through a dual-pressure exhaust gas economiser from Aalborg Industries to generate superheated steam which is utilised in a 6 MWe turbogenerator set from Peter Brotherhood. The turbogenerator sets incorporate both a multi-stage dual-pressure steam turbine and an exhaust-gas power turbine. The generated electricity is supplied to the ship’s main switchboard and employed both in a Siemens shaft motor/generator to assist in ship propulsion, and in shipboard services.
A portion of the steam from the exhaust economiser is utilised in shipboard heating services. The calculated output of the turbogenerator set is based upon ISO standard reference conditions which include an ambient temperature of 25°C. During the sea trials of the first ship, this performance was exceeded as such output was already achieved at the ambient temperature of 14°C. The vessels are also each equipped with three eight-cylinder Wärtsilä 32 diesel generating sets having a combined electrical output of 11.2 MWe. The high-efficiency WHR plant enables each ship to be fitted with one fewer diesel generating sets than it would otherwise have.The high-efficiency WHR concept has been taken a step further in the new 11,000 TEU container ships of the A.P. Moller-Maersk Group. The first of this class, the Emma Maersk, was delivered in September 2006 from Odense Steel Shipyard. She has since been joined by a number of sister ships. The ships are each powered by a 14-cylinder Wärtsilä RT-flex96C common-rail engine.

These are the world’s first 14-cylinder in-line engines and also the world’s most powerful electronically-controlled engines –with an MCR power of 80,080 kW each at 102 rpm. This propulsion power is augmented by two shaft motors in each vessel. The main engines are each associated with a high-efficiency WHR plant incorporating a turbogenerator set having a nominal output of 8.5 MWe. This operates in conjunction with each ship's five diesel generating sets that have a combined output of 20.7 MWe.

The high-efficiency waste heat recovery plant concept is attracting much attention from ship owners interested in saving fuel costs and reducing emissions. It must be remembered that modern large, low-speed engines are very highly developed and there is little potential for achieving significant savings. A central part of this is the ship's power management system, which controls the different power sources onboard, so that minimum fuel consumption can be pursued for the different sailing conditions. It is therefore very important to understand the complexity of the power systems and their interfacing when planning the control functions and interfaces for the main engine and WHRS control. The engine control and the WHRS control have to be strongly integrated because the WHRS steam turbine and power turbine use the energy in the exhaust gas to recover energy. The dynamics of the main engine will influence the behaviour of the steam turbine and power turbine.

Installation aspects

The decisive aspects when choosing a WHRS installation for a new ship project are the size of the system and the complexity of the piping and cabling, and other preparations to be considered by the shipyard. All WHRS generator systems are prepared on a common bedplate, where the different components already are installed and assembled. The main concerns of the shipyard are therefore to find space in the machinery room onboard near the main engine installation for foundation, piping and cabling between these main components.

Waste Heat Recovery Plant components:

- **Exhaust gas economizer**
  High-pressure part with HP evaporator and superheating section and a low-pressure part with LP evaporator and superheating section
  Economizer outlet temperature is not less than 160°C to avoid sulphur corrosion

- **Feed water heating**
  The feed water is heated from the engine's jacket cooling water to a temperature of 85°C
  Feed water for the high-pressure section is further heated in the engines scavenge air cooler to about 150°C to 170°C

- **Turbo generator**
  The high-pressure side works at about 8.5–9.5 bar (g) inlet pressure

This requires three stages at a condenser pressure of 0.065 bar
Economizer outlet temperature of 160°C, a low-pressure steam pressure at the turbine inlet of 3.0–3.5 bar (g) pressure

- **Power Turbine:-**
  Uses a part of the exhaust gas stream (about 10%) from the diesel engine. The torque of the power turbine is fed to the steam turbine rotor through a reduction gear and an overrunning clutch .The power turbine operates between 55% and 100% engine load less than 55% load is not sufficiently high and therefore does not allow exhaust gas to be branched off to drive a power turbine Waste gate.

<u>Conclusion</u>

Waste Heat a recovery system has a wide scope in saving fuel costs and reducing emissions from ships to a great extent. In modern large, low-speed engines are very highly developed and there is little potential for achieving significant savings in fuel consumption, and thereby reducing emissions by engine developments alone. Benefits from an improved competitively in the freight market and to bring out environmentally-friendly solutions.

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-THANK YOU.