JAROSŁAW MARCINIAK, M.Sc.,M.E.
RYSZARD MICHALSKI, D.Sc., M.E.
Technical University of Szczecin
Faculty of Maritime Technology

Ability assessment of electric energy production by the ship waste-heat turbogenerators, based on a real object analysis

SUMMARY

Two variants of waste heat recovery from the exhaust gas emitted by the ship main engines are compared. Input data to calculations of the systems were obtained from sea trials of two containerships.

INTRODUCTION

Interest to the waste heat recovery problems on the ocean objects is directly proportional to fuel prices on the world market. A new research trend in the area has been initiated along with introduction of the high efficiency turbochargers onto the market. It appeared that the gas energy in the exhaust gas collector exceeded that demanded by the turbocharger. Almost immediately the surplus was proposed to be used for driving the so-called exhaust gas efficiency booster. The energy produced by the turbine can be applied to supporting the main propulsion or driving an electric generator.

In [1] J.B.Woodward compared ways of the waste heat recovery in the steam turbine system, realized in Rankine cycle with that in the system with the exhaust gas efficiency booster. Finally, he formulated several general conclusions on possible applications of those particular variants. The authors of this paper do not intend to argue with these conclusions, but they would like only to comment that the possible utilization of the waste heat, recovered from the exhaust gas, to produce steam in a waste-heat boiler has not been taken into account when considering the system with the efficiency booster.

This paper is aimed at development of the above mentioned analysis by making comparison of the waste-heat recovery systems closer to real objects with application of the data acquired from real ship sea trials and exploitation stage.

The computer software UTIL 1 [2] based on the algorithms published in [3] and [4] was applied to calculate the steam turbine system.

INPUT DATA TO CALCULATIONS OF THE SELECTED WASTE-HEAT RECOVERY SYSTEMS

To perform the analysis some data were collected upon two containerships : of 2500 TEU and 1700 TEU.

Data on 2500 TEU containership

The containership was built by Hyundai Shipyard in 1988. Recently she has operated on the route between West Europe and South America. From September to December 1998 one of the authors served as III engineer onboard the ship to record some power plant operation parameters (loading of the main engine and electric power plant - see Fig.1, temperatures of exhaust gas, sea water and air in the engine room etc) by means of the ample measuring equipment installed on the ship. The data formed the basis for calculations of the waste-heat recovery systems of the ship in question.

The ship is propelled by 7RTA84 Hyundai Sulzer low-speed diesel engine of the contract maximum continuous engine rating CMCR = 21 252 kW at 90 rpm speed. Determination of the mean service load of the engine met some difficulties due to a.o. too small statistical sample of the service data. On the basis of [7] a load frequency histogram for the main engine was made, as shown in Fig.2. The mean load value of 14 545 kW resulting from it is contained within a load interval of low frequency of occurrence and therefore cannot be assumed a representative value. Hence the middle values of the intervals of the highest occurrence frequency, i.e. of 13 180 and 15 580 kW, respectively, were taken for further computations. To check rightness of the design prediction calculations of the waste-heat recovery systems were also performed for the continuous service rating CSR, i.e. the mean service load value assumed at design stage of the ship power plant.

As an assumed value of the steam demand was unknown the value of 2100 kg/h estimated on the basis of the fuel consumption of

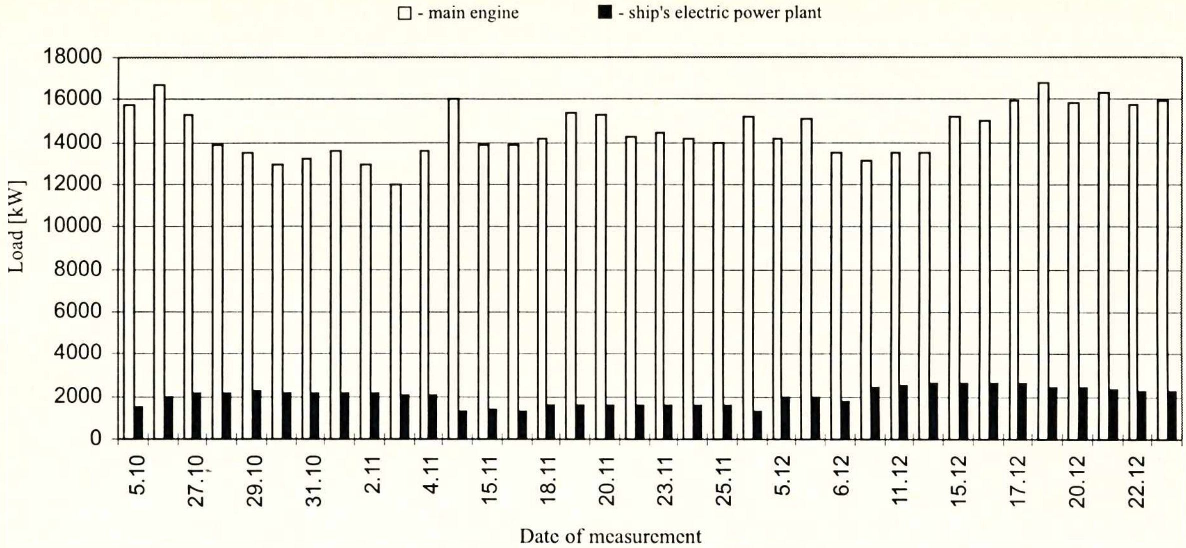

Fig. 1. Loading of the main engine and electric power plant of 2500 TEU containership at sea

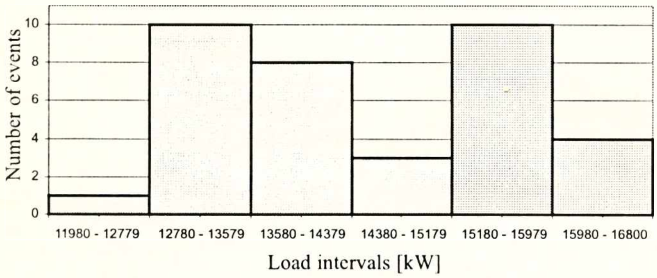

Fig. 2. Load frequency histogram of the main engine of 2500 TEU containership

the boilers during ship lying in the port in winter was taken into account. It can be justified because the steam produced by the waste-heat boiler satisfied the steam demand in all climatic zones (the output of the boiler was 2500 kg/h at the main engine load of 85% CMCR, according to the manufacturer).

The exhaust gas mass flow rate was determined with the use of the engine manufacturer guidelines [6] as well as technical information obtained from the shipyard. Values of the temperature in front of and behind the turbochargers were determined on the basis of the measurements carried out during the ship's operation. The temperatures were reduced to the same ambient conditions (i.e. to the temperature of 27°C in the engine room). The obtained results were approximated by a cubic curve. Values of the exhaust gas pressure in front of and behind the turbochargers were evaluated on the basis of the report from the engine tests on the test bed.

The main engine in question was fitted with two VTR 714-32 turbochargers. The engine manufacturer provided for installation of the efficiency booster system (EBS/PTO) of NTC-214 type (of 550 kW) or NTC-254 type (of 800 kW) although the turbochargers did not belong to a group of the modern and highly efficient devices. Therefore the calculations concerning the efficiency booster system were carried out in a similar way as in the case of the more modern unit.

The ship is intended for carrying the reefer containers which can be fitted with individual refrigerating units or connected to the ship refrigerating system (so called CON-AIR system). The assumed large number of the reefer containers of both types to be carried and 1500 kW bow thruster installed onboard made it necessary to provide an electric power plant of a high power output. The total power of the electric power plant of the ship in question was 6700 kW. It consisted of four electric generating sets driven by Wärtsilä medium-speed diesel engines : 2 x 6R32 of 2000 kW and 2 x 4R32 of 1350 kW.

The mean load of the electric power plant during sea voyage was 2004 kW at simultaneous power surplus of 1341 kW. The relative power surplus, defined as the ratio of the power surplus to the sum of the load and surplus, was 40% on the average. This high surplus value can be explained in the following way. The ship in question has an unattended engine room. The chief engineer decides on a number of generating sets to operate in such a way as to lower risk from unforeseen situations (e.g. black-outs). Therfore safety at sea and good seamanship becomes superior to economic demands in this case.

In Fig.3 the load frequency distribution of the electric power plant is illustrated. The arithmetic mean load of 2004 kW is located within the interval of the highest frequency of occurrence. Hence it can be accepted as the representative value.

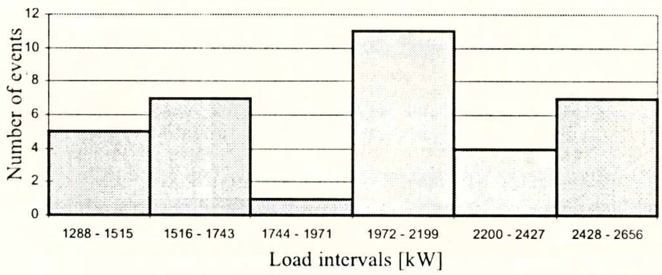

Fig. 3. Load frequency histogram of the electric power plant of 2500 TEU containership

No correlation between loading of the main engine and electric power plant was found, as shown in Fig.4.

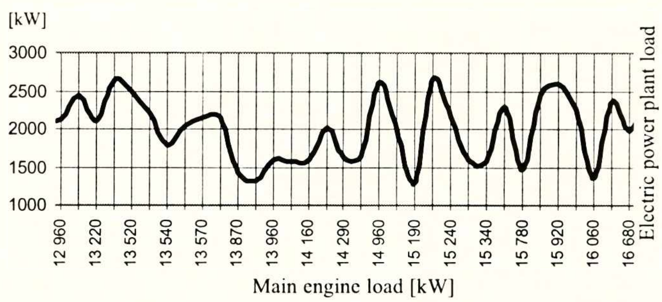

Fig. 4. Load changes of the electric power plant versus the main engine load

Data on 1700 TEU containership

The containership of B-170 type was built by Szczecin Shipyard in 1998. She was fitted with 6RTA62U Sulzer low-speed diesel engine of the nominal continuous engine rating CMCR = MCR = 13 320 kW at 113 rpm. The assumed continuous service rating CSR = 11 988 kW (90% CMCR) at 109.1 rpm. The heating steam demand in winter was assumed equal to 1844 kg/h. The electric power plant consisted of three generating sets, driven by 9S20H Cegielski Sulzer diesel engines, with the total electric power of 3700 kW. The electric power plant mean service loading of 1990 kW was assumed.

The main engine load equal to the design CSR value was assumed for calculations of the waste-heat recovery systems because service performance data of the ship was not available.

The exhaust gas mass flow rate was determined on the basis of the engine manufacturer guidelines [5]. Values of the temperature in front of and behind the turbocharger were recorded during sea trials of the ship. The pressure in the exhaust gas collector was analytically determined in function a.o. of the exhaust gas temperature in front of and behind the turbocharger and of the pressure behind it.

The main particulars of both ships in question are collected in Tab.1.

***Tab.1.** Main particulars of both considered ships*

Systems			
Systems	Ship type :	2500 TEU containership	1700 TEU containership
	Year of completing the ship :	1988	1998
Main Engine	Engine loading state	Main engine type	
		7 RTA 84	6 RTA 62U
	MCR	23170 kW at 90 rpm	13320 kW at 113 rpm
	CMCR	21252 kW at 90 rpm (92% MCR)	13320 kW at 113 rpm (100% MCR)
	CSR	18383 kW at 85.7 rpm (86.5% CMCR)	11988 kW at 109.1 rpm (90% CMCR)
	Service load	13180 kW and 15580 kW (62% and 73% CMCR resp.)	CSR (expected)
Electric power plant	Total rating	6700 kW	3700 kW
	Service load	2004 kW	1990 kW (expected)
Steam system	Heating steam demand at sea in winter	2100 kg/h	1844 kg/h
	Steam pressure	0.7 MPa	

Scope, input data and conditions of the calculations

The calculations were carried out in compliance with ISO conditions, namely :

- air temperature in the engine room : 27°C
- cooling water temperature in the low-temperature system : 27°C.

Two design solutions were analyzed :

* the waste-heat recovery system with the steam turbogenerator (TPU)
* the waste-heat recovery system with the efficiency booster and steam turbogenerator (EBS/PTO +TPU).

The calculations were performed at the following service loadings :

- ME loading of 2500 TEU containership :
  - 13 180 kW
  - 15 580 kW
  - CSR
- ME loading of 1700 TEU containership :
  - CSR

***Tab.2.** The input data to calculations of the waste-heat recovery systems (common for both ships)*

Parameter	Symbol	Value	Unit
Exhaust gas temperature behind KU (waste-heat boiler)	tsp2	160	°C
Exhaust gas temperature drop behind ME	dt1	5	°C
Difference of exhaust gas and steam temperature in steam superheater	dt2	75	°C
Waste-heat boiler (KU) efficiency	eKU	0.98	-
Steam turbogenerator (TPU) efficiency	eTPU	0.675	-
EBS/PTO system efficiency	eEBS/PTO	0.7	-
Steam consumption rate of TPU	epw	0.07	-
Heating steam drip temperature	tspg	98	°C
Supply water temperature	twol	60	°C
Steam pressure drop in front of TPU	dp1	0.015	MPa
Steam temperature drop in front of TPU	dt4	2	°C
Steam pressure in condenser	pk	0.005	MPa
Specific thermal capacity of exhaust gas	cpsp	1.069	kJ/kgK
Specific steam enthalpy	-	2712	kJ/kg
Steam dryness level	x	0.98	-
Superheated steam pressure	pn	0.7	MPa

Waste-heat recovery system with the steam turbogenerator (TPU)

The system in question is presented in Fig.5.

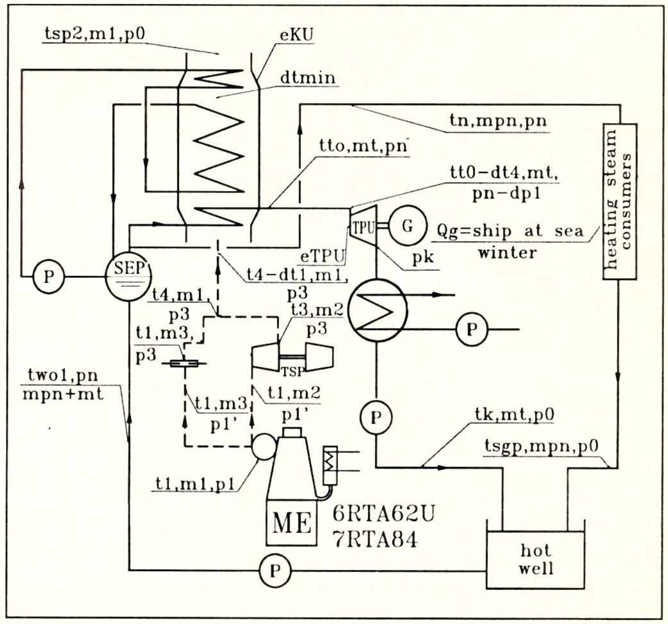

***Fig.5.** Scheme of the waste-heat recovery system with the steam turbogenerator (TPU)*

A gas surplus from the exhaust gas collector directly flows into the main funnel piping passing by the turbocharger. The exhaust gas is choked to the pressure in the main piping. The waste-heat boiler consists of a steam superheater, evaporator and exhaust-gas heater of supply water. Possible waste heat recovery in the charging air cooler is not provided. The turbine is supplied with superheated steam. The input data to calculations of the TPU systems in question are given in Tab.2,3 and 4.

***Tab.3.** Input data to TPU system calculations of 1700 TEU containership (Main Engine load : CSR)*

Parameter	Symbol	Value	Unit
Exhaust gas flow rate from ME	m1	28.105	kg/s
Exhaust gas flow rate by passing turbocharger (11% m1)	m3	3.091	kg/s
Exhaust gas temperature in front of turbocharger (TSP)	t1	405	°C
Exhaust gas temperature behind ME	t4	289	°C

***Tab.4.** Input data to TPU system calculations of 2500 TEU containership*

Parameter ME load :	13 180 kW	15 580 kW	CSR
Exhaust gas flow rate from ME m1 [kg/s]	28.667	33.917	40.028
Exhaust gas flow rate by passing turbocharger (11% m1)	3.152	3.731	4.403
Exhaust gas temperature in front of turbocharger t1 [°C]	398	397	432
Exhaust gas temperature behind ME t4 [°C]	321	306	308

Waste-heat recovery system with the efficiency booster and steam turbogenerator (EBS/PTO + TPU)

A scheme of the system is presented in Fig.6.

A part of the gas from the exhaust gas collector (about 11% of the entire flow rate, acc. to [8]) supplies the efficiency booster. After expansion in the booster and turbocharger, respectively, both fluxes (of m1 and m2 rate) join together and enter the waste-heat boiler. If the amount of steam possible to be produced is greater than that demanded for heating purposes of the ship it will be possible to investigate adding the steam turbogenerator to the system. In this case a waste-heat boiler should be similarly provided as in the above considered solution.

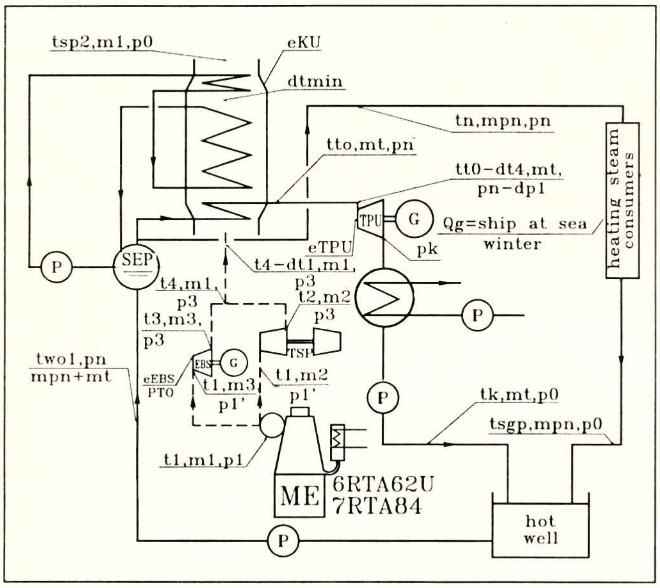

Fig.6. Scheme of the waste-heat recovery system with the efficiency booster and steam turbogenerator (EBS/PTO + TPU)

The input data to calculations of the (EBS/PTO +TPU) system in question are given in Tab.2,5 and 6.

Tab.5. Input data to calculations of (EBS/PTO +TPU) system of 1700 TEU containership. (Main Engine load : CSR)

Parameter	Symbol	Value	Unit
Exhaust gas flow rate from main engine (ME)	m1	28.105	kg/s
Exhaust gas flow rate feeding the booster (EBS/PTO) (11% m1)	m3	3.091	kg/s
Exhaust gas pressure in ME collector	p1	0.2566	MPa
Exhaust gas pressure in funnel piping	p3	0.1031	MPa
Exhaust gas pressure in front of booster (EBS/PTO) and turbocharger (TSP)	p1*	0.2564	MPa
Exhaust gas temperature in front of turbocharger (TSP)	t1	405	°C
Exhaust gas temperature behind ME	t4	278	°C

Tab.6. Input data to (EBS/PTO +TPU) system calculations of 2500 TEU containership.

Parameter ME load :	13 180 kW	15 580 kW	CSR
Exhaust gas flow rate from ME m1 [kg/s]	28.667	33.917	40.028
Exhaust gas flow rate feeding the booster (EBS/PTO) m3 [kg/s]	3.152	3.731	4.403
Exhaust gas pressure in funnel piping p3 [MPa]	0.103	0.1035	0.1037
Exhaust gas pressure in front of booster (EBS/PTO) and turbocharger (TSP) p1* [MPa]	0.1715	0.1952	0.2233
Exhaust gas temperature in front of turbocharger (TSP) t1 [°C]	398	397	432
Exhaust gas temperature behind main engine (ME) t4 [°C]	315	298	197

CALCULATION RESULTS

Results of the calculations of the waste-heat recovery systems are presented in Tab.7.

Tab.7. Calculation results of the waste-heat recovery systems

System version	Ship type :	2500 TEU containership			1700 TEU containership
	ME load :	13 180 kW	15 580 kW	CSR	CSR
EBS/PTO + TPU (1+2)	N2 [kW]	539	576	727	360
	N1 [kW]	204	296	435	341
	N1+N2 [kW]	743	872	1162	701
	dtmin	21.6	18.8	18.8	15.5
	mpn [kg/h]	2113.6			1845.5
	gmt [kg/kWh]	7.45	7.57	7.55	7.75
TPU (2)	N2 [kW]	572	628	804	418
	dtmin	22.6	20.1	20.4	17.3
	gmt [kg/kWh]	7.77	7.50	7.63	7.56

Output values of the steam turbogenerator TPU calculated at the assumed dtmin = 5°C are presented in Tab.8. In this case the heat exchange area of the waste-heat boiler would be greater, as well as the steam pressure and other parameters would be changed.

Tab.8. Output values of the steam turbogenerator TPU calculated at the assumed dtmin = 5°C

System version :		EBS/PTO + TPU		TPU	
Ship type	ME loading	N2 [kW]	pn [MPa]	N2 [kW]	pn [MPa]
2500 TEU containership	13 180 kW	577	1.1798	615	1.2216
	15 580 kW	611	1.0689	670	1.1182
	CSR	791	1.0794	862	1.1289
1700 TEU containership	CSR	374	0.9572	439	1.017

In Tab.9 the electric output values available by means of the steam turbogenerator only, estimated on the basis of [5] and [6], are given for comparisons.

In [6] the assumptions can be found which the nomograms for estimating the TPU output are based on, namely :

- no exhaust gas temperature drop between the turbocharger outlet and waste-heat boiler inlet
- the exhaust gas temperature behind the waste-heat boiler equal to 160 °C
- the condensate temperature is lower than that of cooling water by 10 °C
- the specific steam consumption by TPU equal to 7 kg/kWh
- the steam pressure equal to 0.7 MPa
- exhaust gas from the main engine is only used as the heat source.

Tab.9. The electric output values available by means of the steam turbogenerator only, estimated on the basis of [5] and [6]

Ship type	ME loading	N2 [kW]
2500 TEU containership	13 180 kW	672
	15 580 kW	763
	CSR	882
1700 TEU containership	CSR	480

FINAL REMARKS AND CONCLUSIONS

After analysis of the presented results the following conclusions could be formulated :

As far as 2500 TEU containership is concerned

- The electric power obtained from the waste-heat recovery sources does not satisfy the mean power demand. In spite of that, the idea of the exhaust-gas heat deep utilization still seems attractive for the following reasons :

  - Saved amounts of fuel oil and lubricants are measurable. According to Ssangyong Heavy Industries, the generating set producer, the specific fuel oil consumption (at the applied fuel oil calorific value of 42 700 kJ/kg) is equal to :

    ⇒ for 6R32D engine - 191 g/kWh ± 5 %
    ⇒ for 4R32D engine - 194 g/kWh ± 5 %.

    The determined mean load of the electric power plant is of 2004 kW. To obtain this output at least two generating sets : 2 x 4R32D or 4R32D + 6R32D are to operate. Usually the second variant is chosen for safety reasons (40% power surplus). The sets operated with 800 and 1200 kW output, respectively. Had the system (EBS/PTO + TPU) been installed, the smaller generating set would have been switched-off (under the condition of maintaining 60% CMCR main engine output). In this case 3757 kg of fuel consumption per day, i.e. 4.6% of the entire daily consumption could be saved.
  - When only one diesel engine generating set operates then it is possible to devote more time to maintain and overhaul the rest of the sets. Maintenance period of each of the sets becomes longer. However as far as the ship in question is concerned, it is not sure whether application of the system (EBS/PTO + TPU) would make it possible to lower ratings of the installed generating sets. The power distribution system of the ship was so designed that the bow thruster cannot be started if all four generating sets are switched onto the electric network.
  - Noise and vibrations in the engine room can be lower.

- The measurements on the ship were carried out by means of the engine room measuring instruments. Most of them was of the indicator type and not those for strictly measurement purposes.
- The ME service load , CSR, assumed at the design stage is much higher than the real one.

As far as 1700 TEU containership is concerned

- The output of the system (EBS/PTO + TPU) is high, but does not satisfy the assumed power demand.
- Real service loading values of the main engine and electric power plant of the ship were not available. Only one measurement result performed on the new ship was used.

General conclusions

- The energy of the exhaust gas passing by the turbocharger (TSP) can be used to drive the efficiency booster (EBS) or to increase output of the steam turbogenerator (TPU). The results given in Tab.7 indicate that the application of EBS/PTO system only (without TPU) provides small power amounts especially at low ME loads. However application of the system consisting of an exhaust-gas-driven efficiency booster and steam turbogenerator can substantially increase output of the waste-heat recovery turbines. Therefore if maintenance considerations are not accounted for , the concept of the combine system (EBS/PTO + TPU) can be assumed rational.
- The TPU power outputs estimated on the basis of [5] and [6] are higher than those calculated in this elaboration. This could be caused by different assumptions made for the calculations presented in the paper. It is not possible to accurately compare the two methods of TPU output determination given in [1] and [5, 6] because of an insufficient scope of information contained in the publications of the main engine producer.
- In the TPU systems rather high values of dtmin were obtained at the assumed steam pressure. Hence the waste-heat boilers of a moderate size and price could be sufficient. The engine rooms of the ships in question are, in opinion of the authors , spacious enough to additionally contain a TPU installation together with condenser.
- For the containerships it is not possible to determine the electric power plant output in function of the ME output only (see Fig. 4), as many factors, a.o. number of the shipped reefer containers, type of the cargo contained in them, ship operation zone, influence loading of the electric power plant.
- The calculated output of the waste-heat turbogenerators [in both TPU and (EBS/PTO +TPU) systems] is high. It means that satisfying the entire electric power demand could be possible on the ships of a lower electric energy consumption. Especially the bulk carriers seem to be in a promising situation. Most of the ships are not fitted with cargo handling equipment and bow thrusters which substantially lowers electric power demand. Installation of the (EBS/PTO + TPU) system could be connected with resigning from one of the three diesel-engine-driven electric generating sets. However attention should be paid to the following fact : 7RTA84 diesel engine mentioned in the paper can be appropriate for propelling a bulk carrier of about 150 000 dwt (for propulsion of a 30 000 dwt bulk carrier a 7500 kW engine would be sufficient). Nowadays few such large bulk carriers are built. Therefore one cannot count on wide market supply of the waste-heat deep recovery systems.
- The large drop of dtmin value shown in Tab.8 and thus the increased heat exchange area of the waste-heat boiler makes the TPU power output greater to a small extent only.

NOMENCLATURE

CMCR	-	Contract Maximum Continuous Rating
CSR	-	Continuous Service Rating
EBS/PTO	-	exhaust gas efficiency booster
G	-	electric generator
KU	-	waste-heat boiler
MCR	-	Maximum Continuous Rating
ME	-	main engine
P	-	pump
SEP	-	separator
TPU	-	waste-heat recovery steam turbogenerator
TSP	-	turbocharger
cpsp	-	specific exhaust gas heat capacity [kJ/kgK]
dp1	-	steam pressure drop in front of TPU [MPa]
dtmin	-	minimum temperature difference in KU [°C]
dt1	-	exhaust gas temperature drop behind ME [°C]
dt2	-	difference between exhaust gas and steam temperature in steam superheater [°C]
dt4	-	steam temperature drop in front of TPU [°C]
eKU	-	efficiency of KU
epw	-	steam consumption factor of TPU
eEBS/PTO	-	efficiency of EBS/PTO system
eTPU	-	efficiency of TPU
gmt	-	specific steam consumption of TPU [kg/kWh]
mpn	-	saturated steam flow rate for heating purposes [kg/s]
mt	-	superheated steam flow rate [kg/s]
m1	-	exhaust gas flow rate from ME [kg/s]
m2	-	exhaust gas flow rate passing through TSP [kg/s]
m3	-	exhaust gas flow rate by passing TSP [kg/s] or that feeding the booster (see Tab.4 and 5, respectively)
N1	-	power output of EBS/PTO system [kW]
N2	-	power output of TPU system [kW]
Qg	-	heat amount for heating purposes [kW]
pk	-	steam pressure in condenser [MPa]
pn	-	pressure of produced steam [MPa]
p0	-	ambient pressure [Pa]
p1	-	exhaust gas pressure in ME gas collector [MPa]
p_1*	-	exhaust gas pressure in front of EBS/PTO system and TSP [MPa]
p3	-	exhaust gas pressure behind TSP [MPa]
tk	-	condensate temperature behind condenser [°C]
tn	-	steam saturation temperature [°C]
tsgp	-	heating steam condensate temperature [°C]
tsp2	-	exhaust gas temperature behind KU [°C]
tt0	-	superheated steam temperature behind KU [°C]
two1	-	supply water temperature [°C]
t1	-	exhaust gas temperature in front of turbines [°C]
t3	-	exhaust gas temperature behind TSP [°C]
t4	-	exhaust gas temperature behind ME [°C]
x	-	steam dryness level [-]

Appraised by Romuald Cwilewicz, Assoc.Prof.,D.Sc.

BIBLIOGRAPHY

1. Woodward J.B.: „Evaluation of Brayton and Rankine alternatives for Diesel waste heat exploitation." Journal of Engineering for Gas Turbine and Power, vol. 116, January 1994
1. Osmólski P.: „Wielowariantowe obliczenia cieplne i analiza termodynamiczna układów utylizacyjnych w siłowniach motorowych". Politechnika Szczecińska, Wydział Techniki Morskiej. Szczecin, 1997
3. Michalski R., Zeńczak W.: „Ocena egzergetyczna procesów zachodzących w elementach układów utylizacji ciepła odpadowego". XII Międzynarodowe Sympozjum Siłowni Okrętowych. WSM Szczecin, 1990
4. Czubliński A., Michalski R., Zeńczak W.: „Modernizacja systemu utylizacji strat cieplnych na masowcach serii B 545 wyposażonych w silniki typu 6RTA 58". Politechnika Szczecińska, Instytut Okrętowy. Szczecin, 1986
5. NEW SULZER DIESELS : „Engine Selection and Project Manual of RTA52U, RTA62U and RTA72U Diesel Engines". November 1994
6. SULZER : „General Technical Data for RTA38, RTA48, RTA58, RTA68, RTA76 and RTA84 marine diesel engines". 1986 issue
7. Bobrowski D.: „Probabilistyka w zastosowaniach technicznych". WNT. Warszawa, 1980.
8. Demmerle R., Eicher E.: „The Sulzer Efficiency - Booster. Summary of Test Results". Sulzer, February 1985.

Conference

Drives and Control Systems '99

Form 24 to 26 February 1999 the Fair of Manufacturers, Subcontractors and Sellers of Power Units and Control Systems was held, already for the fifth time, in Gdańsk. On this occasion a seminar was organized by the Technical University of Gdańsk during which experts from technical universities and manufacturing companies presented papers dealing with problems of mechanical, hydraulic, pneumatic and electric drives as well as automation and electronic control of different applications.

The seminar consisted of three sessions :

I - Hydraulic and pneumatic drives (10 papers)
II - Drives and control of machines (10 papers)
III - Electric drive automation - electronic control (9 papers)

6 papers prepared by authors from the Technical University of Gdańsk and Navipres firm directly dealt with shipbuilding :

- „Influence of ship power system type on marine environment pollution" (by Z. Domachowski, M.Dzida)
- „Laboratory tests of integrated power system with SW-680 high-speed diesel engine" (by J.Krępa)
- „Auxiliary power systems as means to increase redundancy of ship propulsion" (by J.Jamroż)
- „Synchronous electric motors applied to driving a remotely operated underwater vehicle" (by L.Rowiński)
- „Monitoring the underwater objects with the use of Kalman's filtering" (by P.Urski, Z.Kowalczuk)
- „Hydraulic drive of running rigging on the ROYAL CLIPPER sail ship" (by B.Rogalski, W.Niesłuchowski)

The seminar was a very good occasion for producers and operators to be acquainted with scientific achievements in question, and for research workers to confront their ideas with specialist experience gained from practice.

Conference

Congress of underwater archeology

Central Maritime Museum (CMM) in Gdańsk, under the management of Prof. A. Zbierski and Dr Jerzy Litwin, plays an important role not only in the field of museum activities but also greatly contributes to achievements of underwater archeology. Recently, CMM, one of the leading European research centres in this area, took part in organization of the International Congress of Underwater Archeology in Sassnitz.

Apart from Polish and German teams, scientists of underwater archeology research centres from Greece, Netherlands, Sweden and Great Britain participated in the congress. As usual, infomation about results of current research was exchanged, moreover, an important problem was discussed of legal protection of material culture heritage to which wrecks of foundered ships have belonged too. Unfortunately, they are more and more often looted by underwater seekers of valuable things. During such actions many objects of historical importance are damaged.

During presentation of the latest achievements of underwater archeology and preservation of historical objects CMM representatives demonstrated results of exploration of wrecks of the medieval boats sunk in Puck Bay as well as preservation methods used by CMM to the objects brought out from the sea bottom, and results of such works.