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Considerations Regarding the Functioning of Marine 2-Stroke Engine with Supercharging Unit Faulty

Ion Serbanescu
Eng. PhD attendee Military Technical Academy, Bucharest,
Mangalia, Romania,
ionserbanescu@yahoo.com

ABSTRACT
The paper studied, some operation cases of naval propulsion whit internal combustion engines supercharged, that can be used when turbochargeraggregate is defective, or the situation when the engine is equipped with several turbocharger units, and at partial loads operation one turbocharger unit is removed from service.

Keywords:
marine engines supercharged, partial loads of marine engines, turbocharger

1. INTRODUCTION
In naval propulsion engine's pit intervene following situations of exploitation:

1.1 Faulty Supercharging Unit:

a).The four-stroke engines supercharged is going to run in naturally aspirated mode.

b) The four-stroke engines whit 2 or 3 supercharging unitsis going to run whit one supercharging unit less. (if was whit two units run with 1 unit, and so on)

c). The two-stroke engines are passing to running with the introduction of combustion air with electro blower or with scavenging pumps attached to the engine mechanism.

d) The two-stroke engines whit 2 or 3 supercharging units, is going to run whit one supercharging unit less. (if was with two units run whit 1 unit, and so on)

1.1.2 Deliberately Crossing To Partial Engine Load Operation:

a) The four-stroke engines whit 2 or 3 supercharging unitsis going to run with one supercharging unit less. (if was whit two units run with 1 unit, and so on)

b) The two-stroke engines whit 2 or 3 supercharging units, is going to run whit one supercharging unit less. (if was with two units run without 1 unit, and so on)

In this paper I will make a case study for situation I.a.3 "The two-stroke engines are passing to running with the introduction of combustion air with electro blower or with scavenging pumps attached to the engine mechanism.

2. MATCHING OPERATING PARAMETERS

2.1 Available Energy Flow Through The Combustion of Fuel

$$\dot{Q}_d = \frac{C_h \cdot Q_i}{3600} [kW] \quad (1)$$

2.2 Actual Engine Power:

$$P_e = \frac{C_h \cdot Q_i}{3600} \cdot \eta_e [kW] \quad (2)$$

Where:
$P_e\,[kW]$ - actual engine power; $C_h \left[\frac{kgcb}{h}\right]$ - hourly fuel consumption of the engine; $Q_i \left[\frac{kJ}{kgcb}\right]$ - inferior calorific power of the fuel; η_e - effective yield

Effective yield
$$\eta_e = \eta_i \cdot \eta_m \quad (3)$$
η_i - indicated yield
$$\eta_i = \frac{P_i}{\dot{Q}_d} \quad (4)$$
η_m - mechanical yield
$$\eta_m = \frac{P_e}{P_i} = \frac{p_{me}}{p_{mi}} = \frac{L_e}{L_i} = \frac{Ci}{Ce} \quad (5)$$
Where:
$P_i[kW]$ - indicated motor power
$$P_i = \sum P_{i_{cil}} \quad (6)$$
$P_{i_{cil}}[kW]$ - indicated cylinder power; $p_{m_i}\left[\frac{kN}{m^2}\right]$ - the mean indicated pressure; $P_{m_e}\left[\frac{kN}{m^2}\right]$ - mean effective pressure; $L_i[kNm]$ - indicated mechanical work; $L_e[kNm]$ - effective mechanical work; $C_i\left[\frac{kgcb}{kWh}\right]$ - indicated specific fuel consumption; $C_e\left[\frac{kgcb}{kWh}\right]$ - effective specific fuel consumption

2.3 Hourly Fuel Consumption:

$$C_h = C_i \cdot P_i = C_e \cdot P_e \left[\frac{kgcb}{h}\right] \quad (7)$$

2.4 Necessary air Flow for Gas Exchange:

$$C_{asg} = C_h \cdot m_{aer_t} \cdot \alpha_{sg} \left[\frac{kgair}{h}\right] \quad (8)$$

$m_{aer_t}\left[\frac{kgair}{kgcb}\right]$ - theoretical air mass necessary for complete burning of 1 kg of fuel

$\alpha_{sg} = 2.2 \div 4.6$ - excess air coefficient for gas exchange

From relation (8) we determine hourly fuel consumption:

$$C_h = \frac{C_{asg}}{m_{airt} \cdot \alpha_{sg}} \left[\frac{kgcb}{h}\right] \quad (9)$$

Entering relation (9) into relation (2), one gets the engine power according to the airflow necessary for gas exchange:

$$P_e = \frac{C_{asg}}{m_{airt} * \alpha_{sg}} \cdot \frac{Q_i}{3600} \cdot \eta_e \quad (10)$$

Running the engine with faulty supercharger unit:

a) The four-stroke engines are passing to running in naturally aspirated mode
b) The two-stroke engines are passing to running with the introduction of combustion air with electro blower or with scavenging pumps attached to the engine mechanism. If the blower is acted by an electric engine, the energy flow necessary for the air compress is determined by the relation:

2.5 Energy Flow Necessary for the Air Compress:

$$\dot{Q}_{as} = \frac{C_{asg}}{3600} \cdot C_a \cdot (T_{ref_S} - T_0)[kW] \quad (11)$$

Where:

$C_a = 1 \left[\frac{kj}{Kg.grd}\right]$ - specific heat of the air; $T_0[K]$ - air temperature at the blower suction;

$T_{ref_S}[K]$ - air temperature blown by the blower; $P_{ref}[bar]$ - air pressure blown by the blower;

$P_0\,[bar]$ - ambient air pressure; $n[-]$ compression exponent in the blower;

Table 1 – Characteristics of the air flow blown by the auxiliary blower (Aux.Bl)

$P_0\,[bar]$	$P_{ref}[bar]$	$T_0[K]$	$T_{ref_S}[K]$	$\Delta T_S[K]$
1	1.02	318	320	2
1	1.04	318	321.6	3.6
1	1.06	318	323	5
1	1.08	318	325	7
1	1.1	318	327	9
1	1.15	318	331	13
1	1.20	318	335	17
1	1.25	318	339	21
1	1.30	318	343	25

$n = 1.4\,[blower\ is\ not\ cooled]$;

2.6 Auxiliary Blower Power Drive:

$$P_{ant_S} = \frac{\dot{Q}_{as}}{\eta_S}[kW] \quad (12)$$

Driving with electric motor in three-phase AC:

$$\sqrt{3} \cdot U \cdot I \cdot \cos\varphi = \frac{\dot{Q}_{as}}{\eta_S}[kW] \quad (13)$$

Where:

U [kV] - voltage of electric current; I [A] – amperage; cos φ = 0.85 ÷ 0.87 – power factor;

$d_{asg} = 13.6 \cdot 3 \cdot 0.17 = 6.936 \left[\frac{kgair}{kWh}\right]$; $\eta_S = 0.7$;

From relation (12) results:

$$P_{ant_k} = \frac{P_e \cdot d_{asg}}{3600} \cdot Ca \cdot \Delta T_S \cdot \frac{1}{\eta_S} = \left(\frac{P_e \cdot d_{asg} \cdot Ca}{3600 \cdot \eta_S}\right) \cdot \Delta T_S = 2.75 \cdot \Delta T_S$$

$$I = \frac{P_{ant_k}}{\sqrt{3} \cdot U \cdot \cos\varphi};$$

Table 2. Electric motor for auxiliary blower (Aux.Bl)

$P_e\,[kW]$ engine	P_{ref} $[bar]$	ΔT_S [K]	$P_{ant_k}[kW]$ Aux.Bl	U $[kV]$	I $[A]$
1000	1.02	2.0	5.5	0.38	9.71
1000	1.04	3.6	9.9	0.38	17.49
1000	1.06	5	13.76	0.38	24.31
1000	1.08	7	19.27	0.38	34.04
1000	1.10	9	24.77	0.38	43.76
1000	1.05	13	35.78	0.38	63.21
1000	1.2	17	46.80	0.38	82.68
1000	1.25	21	57.80	0.38	102.12
1000	1.30	25	68.81	0.38	121.57

Table 3 Electric motor for auxiliary blower (Aux.Bl)

$P_e [kW]$ engine	P_{ant_k} $[kW]$ Aux.Bl	$P_e [kW]$ engine	P_{ant_k} $[kW]$ Aux.Bl	P_{ref} $[bar]$
10000	55	12000	66	1.02
10000	99	12000	118,8	1.04
10000	137,6	12000	185,24	1.06
10000	192,7	12000	231,24	1.08
10000	247,7	12000	297,24	1.10
10000	357,8	12000	429,36	1.05
10000	468	12000	561,6	1.2
10000	578	12000	693,6	1.25
10000	688,1	12000	825,72	1.30

Table 4 Electric motor for auxiliary blower (Aux.Bl)

$P_e [kW]$ engine	$Req. P_{ant_k}$ $[kW]$ Aux.Bl	$P_e [kW]$ engine	$Req. P_{ant_k}$ $[kW]$ Aux.Bl	P_{ref} $[bar]$
15000	82,5	20000	110	1.02
15000	148,5	20000	198	1.04
15000	206,4	20000	275,2	1.06
15000	289,05	20000	385,4	1.08
15000	371,55	20000	495	1.10
15000	536,7	20000	715,6	1.05
15000	702	20000	936	1.2
15000	867	20000	1156	1.25
15000	1032	20000	1376	1.30

Table 5 Electricmotor for auxiliary blower [1]

Number of cylinders	Engine Power kW	Numbers of auxiliary blowers	Required power/ blower kW	Installed power/ blower kW
5	11.900	2	45	52
6	14.280	2	54	65
7	16.660	2	63	65
8	19.040	2	73	85

3. PROCEDURES APPLICABLE ON BOARD OF SHIP

In the operating documentation ship propulsion motors are the predicted operating instructionsfor outstanding dependability conditions.The crew must respect and apply these instructions to ensure safe for the crew, ship and cargo carried, avoid losses or accidents and marine pollution.For safe operation of the engine with turbocharger faulty, must beensured a minimum pressure drop in scavenging air route and exhaust gas route, as we can see in Figure 1 (B1). In such cases operation of the propulsion engine , they can no longer be recovered energy flows from the exhaust gas, so that should be used donkey boiler with burner and diesel engines to drive electric generators as shown in Fig .2[2]

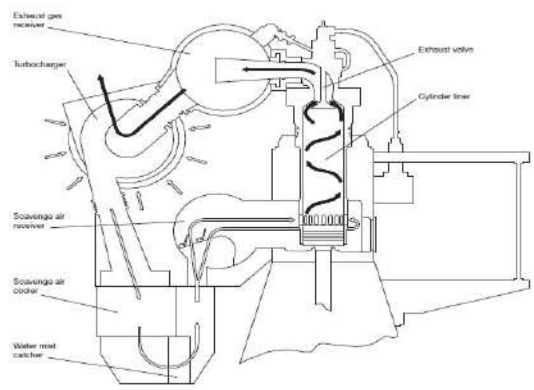

Fig. 1: Scavenge Air System [1]

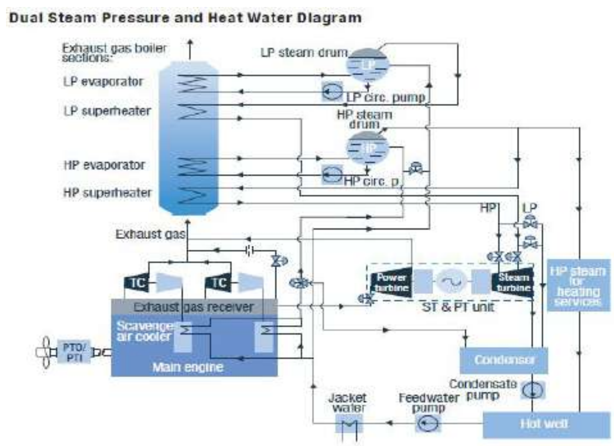

Fig. 2: Recovering energy flows [2]

4. CONCLUSIONS

a) 4-stroke marine diesel engines, which for the intake air in the cylinder motor has full stroke of the piston at TDC until BDC, natural intake may take the pressure difference $(p_0 - p_{cil})$.

b) 4-stroke marine diesel engines, supercharging unit if damaged, until repaired is done the engine may be switched to operation with natural intake.

c) 2-stroke marine diesel engines propelling, the gas exchange (gas evacuation and air inlet to the engine cylinder) is performed when the piston is in the BDC about position ; unable to achieve such depression in the cylinder motor, the introduction of air into the cylinder must be made with an blower (compressor) aggregate engine drive mechanism or with electric motor drive .

d) The electric drive of the auxiliary air supply unit, allowing the automation of its operation, according to air manifold pressure and the pressure set.

e) Comparing the values for electric power drive blowers, operating result as engine load is between 15 % -25 %.

f) Electric-blower discharge pressure is 1, 01-1.05 bar, and are the value for witch is sized the electric motor drive.

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