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Considerations on engine room ventilation

Levent Ali[1], Beazit Ali[2], Daniel Marasescu[3],

[1]Assistant lecturer. PhD eng, Naval Academy “Mircea cel Bătrân”, Constanța, RO
[3]Professor PhD eng, Naval Academy “Mircea cel Bătrân”, Constanța, RO
[4]Lecturer, PhD eng., Naval Academy “Mircea cel Bătrân”, Constanța, RO

E-mail: Levent.ali@anmb.ro

Abstract. Part of the energy resulted from combustion is lost in environment in form of radiant heat. The heat generated by surfaces of the propulsion engine and exhaust piping is equivalent to the radiated heat of the engine.The high temperature in engine room compartment can advserely affect the maintenance, equipment and performances of engines.
Keywords: engine room, ventilation, blowers

I. Flow of intake fans

The choice of air inlet fans is decided by the calculation of the total air flow and the pressure drop Δp (t). When determining the pressure drops of the extraction fan on the intake and discharge side, special attention should be paid to fixed shutters and silencers, but also to air resistance due to stiffening elements of the hull, deck penetrations or spontaneous variations in air flow. In case of axial fans, the difference between the air inlet to the engine room compartment and outlet air in the entire section will be taken into account. One solution should be to equip the fans with ducted stabilization tubing on the intake and discharge fans equal in length with 5 times the diameter of the rotor.

II. Air supply ducts

The air supply ducts must be arranged in such a way that:

- Efficient ventilation of the engine room is ensured
- An adequate amount of air is supplied to the closed compartments for temperature regulations
- Air consumers such as diesel engines are supplied with sufficient air necessary for combustion

The air supply connections must be designed to ensure the flow of air such as the air ducts can be joined in main ducts, in which case the air will be guided in the branch duct. In closed compartments, the speed of the air coming from the supply pipe will be between the values of 1 to 3 m/s. Higher speeds are also accepted if the blades are installed in the cross sections of the exhaust openings.

III Methodology of testing

Special openings for the elimination of used air must be designed in the engine room and these openings are not doors or other openings serving different purposes. The size of openings for the elimination of used air will be calculated according to the exhaust air flow at a maximum speed of 6 m/s using the formula below:

q(ab) = q - (q(dp) + q(dg)), where:

q(dg) is applied to an auxiliary diesel engine and is equivalent to 0, when the diesel generators are shaft generators. Exhaust fans will be installed if exhaust air cannot be satisfactory exhausted through the openings already installed with this purpose. If the exhaust openings contain internal elements such as fixed shutters, the area calculated from the air flow and velocity will be multiplied with 1.6 as per class registry construction rules.

IV Ventilation of closed compartments

The supply air and exhaust openings must be arranged in such a way to ensure optimum ventilation of the space in question. In order to optimize the ventilation of the open compartment of engine room, the supply air ducts must be positioned as far as possible from the exhaust air openings.
In open compartments in the engine room, the supply air openings should be located as far as possible, in the upper half of the opposite bulkhead, ensuring diagonal ventilation in the longitudinal direction of the compartment.

V Direct ventilation

Air ducts shall be arranged orizontally and equipped with at least three exhaust openings facing upwards to ensure improved air distribution and the end section of these ducts must be closed. They will be positioned at height of 1.5 m and if this is not possible for structural reasons, the ducts may be placed at higher heights, provided that the supplied air is directed at an anghe of 45 ° downwards.

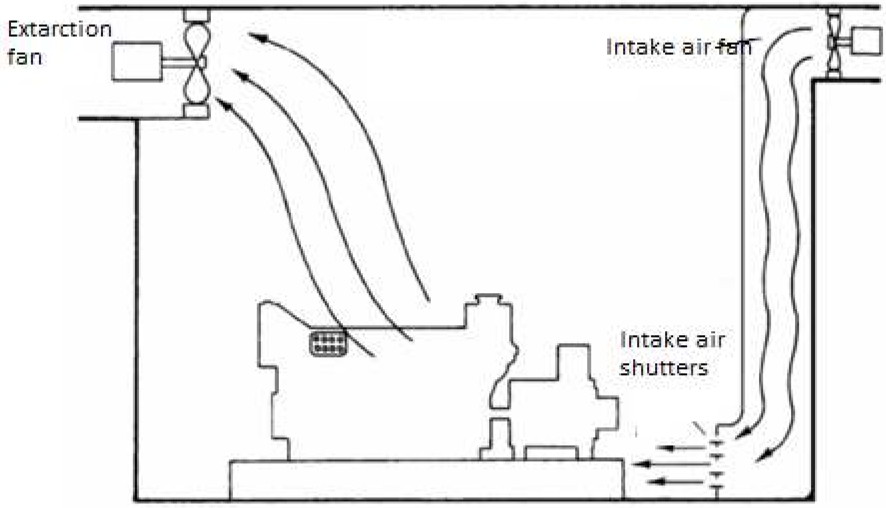

Figure 1 – Typical arrangement of a ventilation system

VI Admitted temperatures in engine room compartment

Location in engine room	Maximum temperature of air	Temperature difference when environment temperature is over 28˚C
Workshop	33˚C	Δt=5˚C
- Main engine cylinders - Main engine fuel oil pumps - Auxiliary engines - Fuel filtration compartment - Boilers platform	35˚C	Δt=7˚C
Engine room control room	35˚C	Δt=7˚C

The condition requiring a temperature difference of 7°C is normally satisfied if the total air supplied to main and auxiliary engines corresponds to the sum of combustion air flow V(LVH) and the amount of heat removed by the engine room ventilation. For areas including fuel separators the difference of 7˚C is satisfied by air ducts located in these compartments.
The design of the air inlet fans will be made so that the direction of rotation is reversed. Also the cooling air expelled from the auxiliary engines cannot be removed in the immediate vicinity of the engines, therefore the supply and exhaust air in the engine room compartment must be designed so that the pressure of 50 Pa is not exceeded.

VII Physical composition of air

By volume it contains: 78% Nitrogen; 21% Oxygen; 0,9% Argon; 0,03% Carbon Dioxide
To these are added traces of: Neon, Helium, Krypton, Sulphur dioxide, Methane and Hydrogen. The amount of water vapours changes depending on the geographical areas and weather. The density of liquid air obrained at 140,7˚C şi 38,4 at is 960 $kg/m^{3.}$
Gases contained in air are divided in several categories:

- Permanent gases represented by noble gases: NE, Ar, Kr, Xe
- Qusi-permanent gases with a lifespan of thousands of years: N_2, O_2, He;
- Slowly varying gases with a lifespan of years: CO_2, CO, H_2, CH_4
- Gases with rapid variation whose lifetime is order of days: SO_2, H_2S, NO, NO_2

Water is present in the air in all forms of aggregation and its distribution is very variable, the concentration depending on the geographical position, having the maximum in Ecuador and decreasing slightly to the poles, where its concentration is very low.

VIII Air for supercharging thermal engines

The power of an engine is greater with variation of mechanical work done and with engine cycle which was performed in a short interval. But the mechanical work done in a cycle is obtained by burning a certain amount of fuel that requires a certain amount of air, so the power of an engine is directly proportional to the increase in the amount of fuel burnt. Increasing the air mass by increasing the density in order to increase the amount of fuel burned is called supercharging.
Increasing the power of an internal combustion engine can be done by increasing the size of cylinder and their number. Thus most efficient process of increasing the power is to increase the mass of air in the engine cylinders in which a large amount of fuel can burn,
The supercharging of an internal combustion engine can be classified according ot air pressure and the mode of operations.
The design of a standard 2-stroke engine is based on the requirements of ISO 3046-1:2002 and ISO 15550:2002 where the environmental conditions are:

- Barometric pressure: 1,000 mbar
- Turbo blower inlet temperature: 25°C
- Air coolant temperature: 25°C
- Relative humidity: 30%

Under these conditions, the engine can work unrestricted at 100% rate of turn in both winter and summer conditions.

IX Calculation of air flow needed for supercharging

In order to calculate the air flow needed for supercharging, considering that it is known the oxygen quantity needed for combustion:

$$m_{O_{2(\min)}} = 32\left[\frac{c}{12}+\frac{h}{4}+\frac{s}{32}-\frac{o}{32}\right]\left[\frac{kgO_2}{kg\ comb}\right]$$

$$\upsilon_{O_{2(\min)}} = \frac{c}{12}+\frac{h}{4}+\frac{s}{32}-\frac{o}{32}\left[\frac{kmolO_2}{kg\ comb}\right]$$

$$m_{aermin} = \frac{m_{O_{2(\min)}}}{0,23}\left[\frac{kgaer}{kg\ comb}\right]$$

$$\upsilon_{aermin} = \frac{\upsilon_{O_{2(\min)}}}{0,21}\left[\frac{kmol\ aer}{kg\ comb}\right]$$

$L_c\left[\frac{kJ}{kg}\right]$ – Specific mechanical work for compressing the air in turbocharger.

$$L_c = \frac{K}{K-1} R_{aer} T_0 \left[\left(\frac{p_s}{p_0}^{\frac{n_s-1}{n_s}}-1\right)\right]\left[\frac{kJ\ aer}{kg\ aer}\right]$$

k=1,4 (Compression exponent in the adiabatic process)

R_{aer}= 0,287 $\left[\frac{kJ}{kg\ K}\right]$ (c)

n_s = 1,35 Compressor polytropic exponent in turbocharger

$$Lc_1 = \frac{K}{K-1} R_{aer} T_0 \left[\left(\frac{p_{s1}}{p_0}^{\frac{n_s-1}{n_s}}-1\right)\right]\left[\frac{kJ\ aer}{kg\ aer}\right] = 120,79\left[\frac{kJ\ aer}{kg\ aer}\right]$$

$$Lc_2 = \frac{K}{K-1} R_{aer} T_0 \left[\left(\frac{p_{s2}}{p_0}^{\frac{n_s-1}{n_s}}-1\right)\right]\left[\frac{kJ\ aer}{kg\ aer}\right] = 142,37\left[\frac{kJ\ aer}{kg\ aer}\right]$$

p_{s1} = 3,45 [bar]

p_{s2} = 4,15 [bar]

p_0 = 1 [bar]

Considering that we have the below mentioned vessels:

Name	Super Lady	Western
Engine type	Sulzer 6RTA58T	Hyundai-MAN 6S46MC-C
Nominal power [kW]	12 000	7700
Fuel consumption [kg/h]	2113	1437
Excess air coefficient (α)	2	2
Theoretical molar amount of air (L_{min}) [kmol/kg]	$\frac{14}{28,96}$=0,4894	0,4894
The air flow required for superchargինh (m_{aer})[kg/s]	16,43	11,17
Turbocharger rpm	15000	19171
Compressor mechanical work: $L_c = \frac{K}{K-1} R_{aer} T_0 [(\frac{p_s}{p_0}^{\frac{n_s-1}{n_s}} -1)]$ $[\frac{kJ\ aer}{kg\ aer}]$	120,79	142,37
Compressor drive power [kW]	2481	1988

CONCLUSIONS

Engine room for marine vessels is equipped with ventilation system of great importance which provides fresh air for oil burning in combustion engines. In addition to keep the temperature within minim parameters is necessary for ensuring satisfactory working conditions for crew. Since warm air does not contain as much as oxygen, engines ends up with less power, less efficiency and burning more fuel in order to achieve same power. In the view of current legislation on ship energy efficiency and reducing pollutant emissions, more studies are necessary in order to optimize engine room ventilation systems from design but also operational point of view.

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