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STUDY OF ENVIRONMENTAL INFLUENCES ON THE FUNCTIONAL PARAMETERS OF THE COOLING SYSTEMS

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Abstract: *Advances in Computational fluid dynamics and actual simulation possibilities are the best way to present the thermal and fluid dynamics inside the cooling systems. Onboard all ships, coolers are available and are the common way to cool engines, pumps and all systems. The numerical investigation based on Ansys software will present data for different environmental parameters inside cooling systems. Also heat from the cooling systems is asource of free energy and shipbuilders are strongly ask for inexpensive energy solutions.*

Keywords*: cooling systems; thermal; environmental parameters, Ansys.*

INTRODUCTION

The heat transfer is the process of heat irreversible propagation heat exchange area, and is performed between the two bodies (two parts of the same body, the two streams etc.), as a result of the temperature difference between them.

Therefore, heat transfer can be defined as the transfer of energy between physicochemical systems or between different parts of a system in which the transformation is not performed work.

The parameter by which to assess the quality of heat is the temperature, defined as the overall size of the processes that determine the intensity level of a body internal energy (thermal agitation of the molecules in liquids and gases movement or vibration of atoms and free electrons in metals).

Said heat exchange:

- I principle of thermodynamics, which expresses the energy conservation law;
- II principle of thermodynamics, which sets the natural sense of propagation of heat, always the source of higher temperature to lower temperature source.

Heat transfer is done in three different ways: conduction; radiation; convection.

According to the former definition, conduction and radiation is only proper processes of heat exchange, this being achieved solely temperature difference. Convection is a more complex process that necessarily involves a transfer table.

Mass transfer is defined as a spontaneous process irreversible exchange of substance between two regions with different concentrations. The meaning is always the mass transfer from the region with higher concentration to lower concentration region.

Mass transfer is done and it in two different ways: through molecular diffusion; by turbulent diffusion (mass transfer by convection).

In practical applications, processes of heat transfer and mass transfer can take place separately or together.

HEAT TRANSFER PROCESSES

Thermal conductivity λ is the coefficient of proportionality of Fourier law and is a physical property of materials. Materials with high thermal conductivity are called pipe, while the materials with low thermal conductivity are known insulators.

Considering a flat wall thickness δ, lateral surface and constant thermal conductivity λ, with constant temperatures T1 and T2 of the two side surfaces, relationship

$$grad t = \frac{t_1 - t_2}{\delta}$$

It is the simplest case of unidirectional heat conduction in steady state. For the case of t1> t2, the integration of the relationship, with separation of variables follows:

$$\frac{Q}{S} \cdot \int_0^{\delta} dx = - \int_{t_1}^{t_2} \lambda \cdot dt$$

$$\dot{q}_s = \frac{Q}{S} = \frac{\lambda}{\delta} \cdot (t_1 - t_2) = \frac{\Delta t}{\frac{\delta}{\lambda}}$$

where$\Delta t = t_1 - t_2$is the difference in temperature between the two side surfaces of the wall.

The wall plan has taken into consideration thermal conduction resistance:

$$R_{cond} = \frac{\delta}{\lambda}[m^2 \cdot {}^{\circ}C/kW]$$

Table 1Presents some typical value of thermal conductivity for various heat transfer medium.

Tab.1The common values of thermal conductivity

Material	Thermal conductivity λ [kW/m·°C]
Gas	(0,006...0,270) x10^{-3}
Insulation materials	(0,02...0,20) x10^{-3}
Liquids	(0,04...0,55) x10^{-3}
Construction materials	(0,03...0,30) x10^{-3}
Liquid metals	(8...140) x10^{-3}
Alloys	(14...300) x10^{-3}
Pure metals	(7...500) x10^{-3}

Heat transfer processes that occur in nature are complex processes that occur simultaneously in two or three fundamental modes of heat exchange.

The transfer of heat from the flue gases to the water-steam takes place in three successive stages:

- Heat is transferred by convection and radiation initially from flue gases at the outer wall of the pipe;
- Conduction heat flows through the metal wall of the pipe;
- Heat is transferred by convection from the inner wall of the pipe heated fluid: water or steam inside the piping.

In the first stage, the amount of heat taken from the flue gas duct is

$$\dot{Q}_1 = \dot{Q}_{conv1} + \dot{Q}_{rad} = \alpha_{conv1} \cdot S \cdot (t_g - t_{p1}) + \alpha_{rad} \cdot S \cdot (t_g - t_{p1}) = (\alpha_{conv1} + \alpha_{rad}) \cdot S \cdot (t_g - t_{p1}) = \frac{S}{R_1} \cdot (t_g - t_{p1})[kW]$$

where:

$$R_1 = \frac{1}{\alpha_{conv1} + \alpha_{rad}}[m^2 \cdot {}^{\circ}C/kW]$$

It is effective thermal resistance (combined) of the first stage. Within the framework of the second stage, the heat flow is

$$\dot{Q}_2 = \dot{Q}_{conv2} = \frac{\lambda}{\delta} \cdot S \cdot (t_{p1} - t_{p2}) = \frac{S}{R_2} \cdot (t_{p1} - t_{p2})[kW]$$

where:

$$R_2 = \frac{\delta}{\lambda}[m^2 \cdot {}^{\circ}C/kW]$$

is the thermal resistance from conducting metal wall. Finally, the de- third stage (which was neglected thermal radiation), heat will flow from the convection thermal resistance:

$$\dot{Q}_3 = \dot{Q}_{conv2} = \alpha_{conv2} \cdot S \cdot (t_{p2} - t_a) = \frac{S}{R_3} \cdot (t_{p2} - t_a)[kW]$$

where the convection thermal resistance

$$R_3 = \frac{1}{\alpha_{conv2}}[m^2 \cdot {}^{\circ}C/kW]$$

In practice, known only flue gas temperatures (Tg) and fluid piping (ta). By explaining the differences in temperature can be eliminated TP1 and TP2 pipe wall temperatures:

$$\dot{Q}_{total} = \frac{S \cdot (t_g - t_a)}{\frac{1}{\alpha_{conv1} + \alpha_{rad}} + \frac{\delta}{\lambda} + \frac{1}{\alpha_{conv2}}} = \frac{S \cdot \Delta t_{total}}{R_1 + R_2 + R_3}[kW]$$

In practical calculations (calculation of a heat exchanger, for example), it is conveniently simplified writing relations and:

$$\dot{Q}_{total} = K_s \cdot S \cdot \Delta t_{mln} \text{ [kW]}$$

$$\dot{q}_s = \frac{\dot{Q}_{total}}{S} = K_s \cdot \Delta t_{mln}$$

In the two expressions, K_S parameter is the global heat exchange coefficient

$$K_s = \frac{1}{R_{total}} = \frac{1}{R_1 + R_2 + R_3}[kW/m^2 \cdot {}^{\circ}C]$$

its usual values are given in Table 2.

Tab.2. The common values of the global heat exchange coefficient

Material		Global heat exchange coefficient[kW/m²·°C]
cald	rece	
Gaz	Gaz	(10...300) x 10^{-3}
Gaz	Water	(10...350) x 10^{-3}
Water	Water	(1000...6000) x 10^{-3}
Steam	Steam	(30...350) x 10^{-3}
Steam	Water	(1000...10000) x 10^{-3}
Oil	Water	(100...900) x 10^{-3}
Oil	Oil	(50...450) x 10^{-3}

Ks corresponding coefficient has physical significance inverse total resistance to heat transfer Rtotal. Increasing global heat exchange coefficient Ks, which is followed in all the heat exchange process involves reducing the thermal resistance of the global heat transfer components.

The calculation of the surface heat exchanger are based on two main equations:

heat balance equation: $Q_1 = Q_2 + Q_P = \frac{Q_2}{\eta_r}$;

the heat transfer equation: $Q = k_S \cdot S \cdot \Delta t_{med} = k_l \cdot L \cdot \Delta t_{med}$.

In the two equations, we have used the following parameters:

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$$\begin{cases} Q_1 = G_1 c_{p1} \cdot \left(t_1^{'} - t_1^{''}\right) = G_1 \cdot \left(i_1^{'} - i_1^{''}\right) = W_1 \cdot \left(t_1^{'} - t_1^{''}\right) = W_1 \cdot \delta t_1; \\ Q_2 = G_2 c_{p2} \cdot \left(t_2^{''} - t_2^{'}\right) = G_2 \cdot \left(i_2^{''} - i_2^{'}\right) = W_2 \cdot \left(t_2^{''} - t_2^{'}\right) = W_2 \cdot \delta t_2; \\ W_1 = G_1 \cdot c_{p1}; \\ W_2 = G_2 \cdot c_{p2}; \\ \delta t_1 = t_1^{'} - t_1^{''}; \\ \delta t_2 = t_2^{''} - t_2^{'}. \end{cases}$$

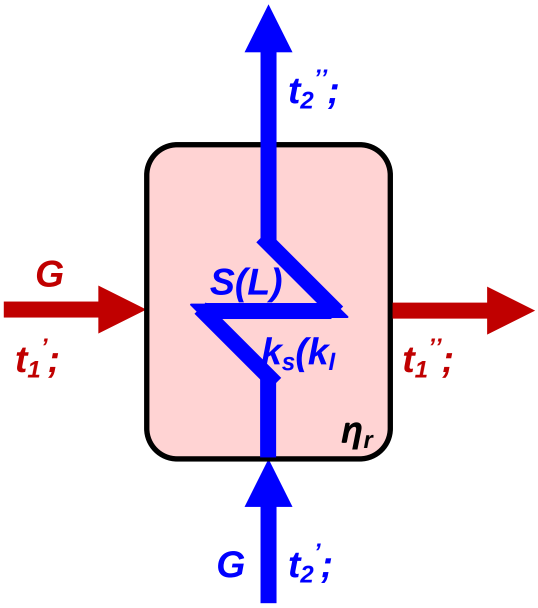

Fig. 1.Flows of fluids in the heat exchanger

THE DNS INVESTIGATION FOR FLUID FLOW IN HEAT EXCHANGERS

Direct numerical simulation (direct numerical simulation - DNS) calculates all fluctuations in the full range of stairs turbulence, without any empirical hypothesis. This eliminates the influence of patterns, but it is extremely resource intensive computing. The modeled need a wider range of length and time scales, the computational effort increases. The calculated is proportional to the third power of the Reynolds number (Re), leading to the possibility of approaching the Re flows only small, simple to flow in areas with simple geometries. Further difficulties arise because the terms are nonlinear convection and pressure. These nonlinear equations must be solved numerically with initial and boundary conditions imposed.

THE STUDY FUNCTIONAL PARAMETERS OF PLATE HEAT EXCHANGER

Hypotheses for first case DNS calculation

- **The inlet temperature of cooling water in heat exchanger 36ºC**
- **Oil inlet temperature of 47.2ºC heat exchanger**

DNS results obtained:

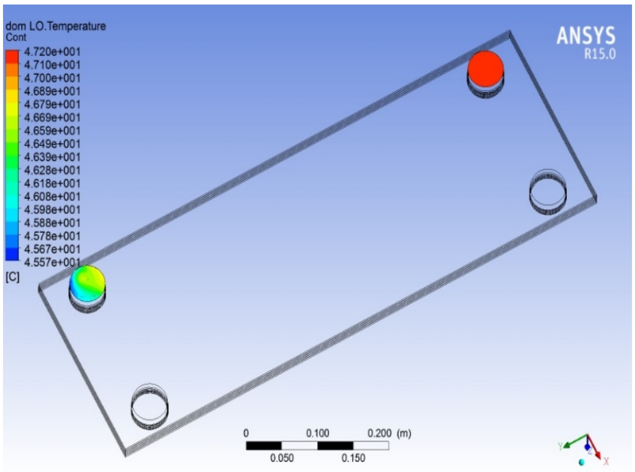

Fig. 2.Inlet and outlet temperature of lubricating oil

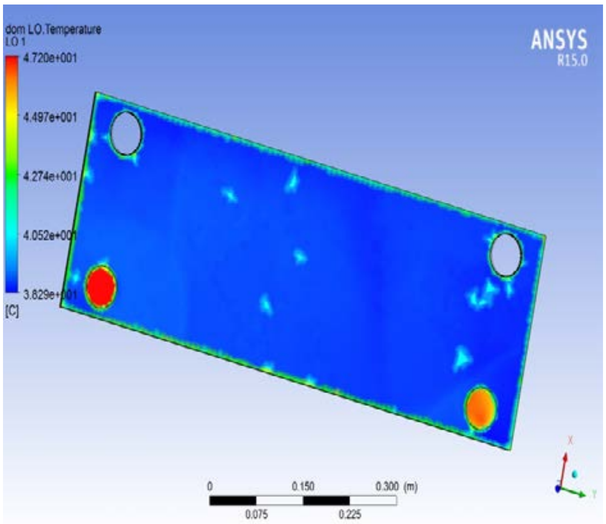

Fig. 3.Lubricating oil temperature variation in the first channel

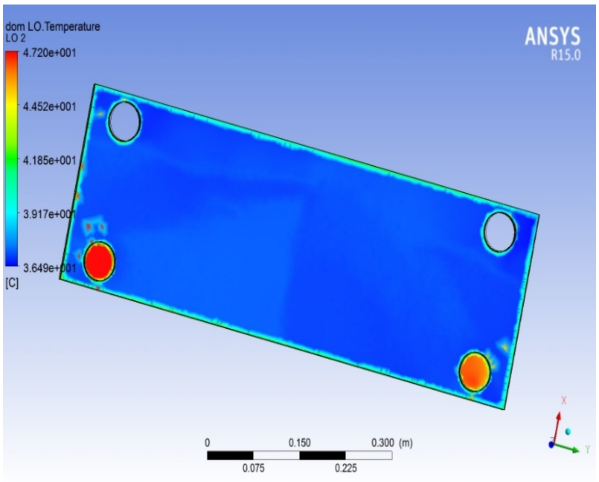

Fig. 4. Lubricating oil temperature variation channel No. 2

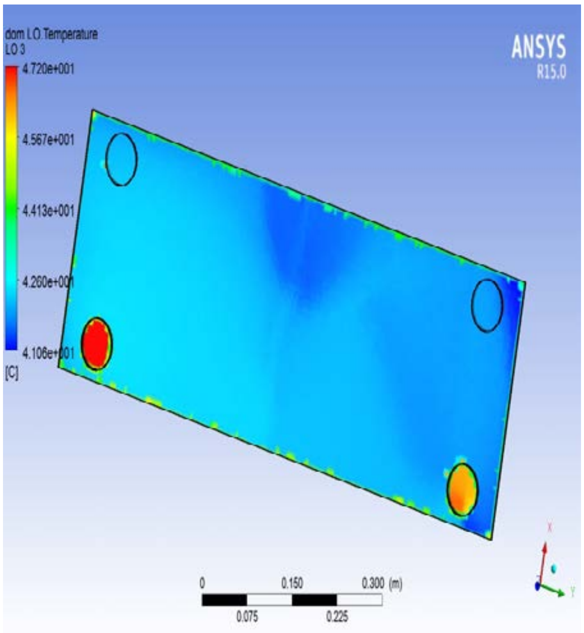

Fig. 5. Lubricating oil temperature variation in channel 3

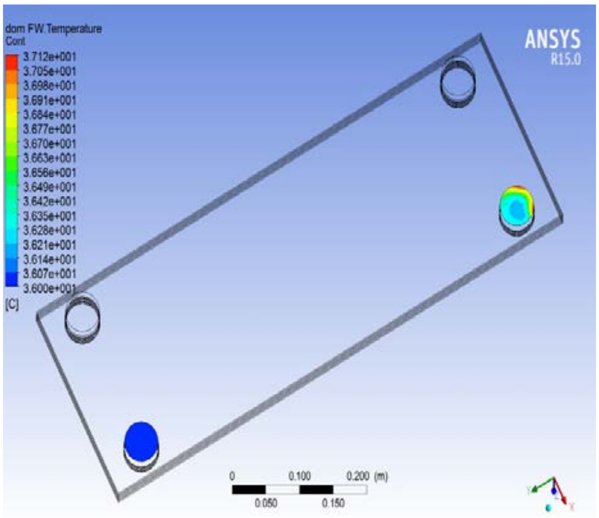

Fig. 6. The temperature of the cooling water inlet and outlet

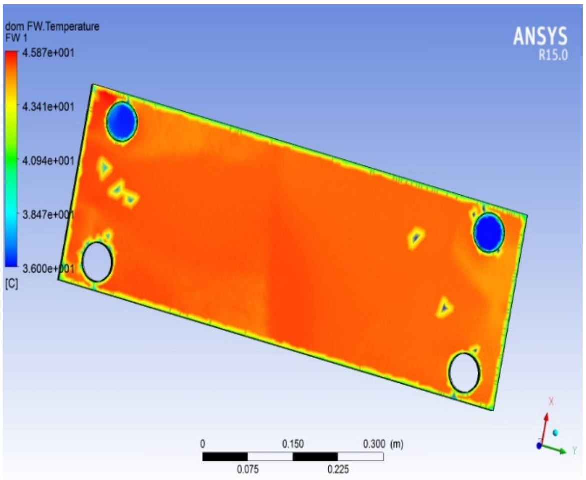

Fig. 7. The variation of the temperature of the cooling water in the first channel

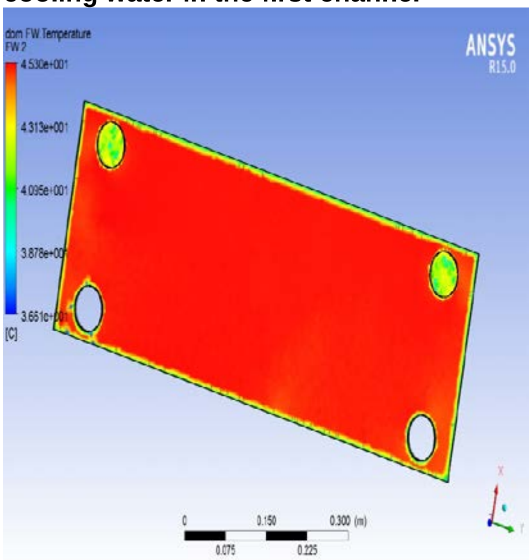

Fig. 8. Cooling water temperature variation in the channel No. 2

Hypotheses for second case DNS calculation

- **The inlet temperature of cooling water in heat exchanger 34ºC**
- **Oil inlet temperature of 47.2ºC heat exchanger**

Obtained results:

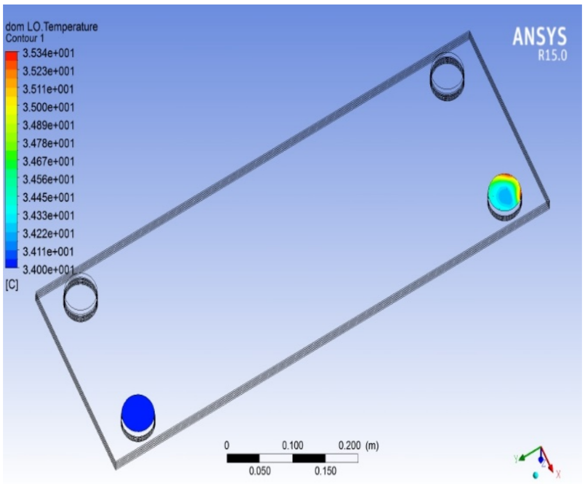

Fig. 9. Inlet and outlet temperature of lubricating oil

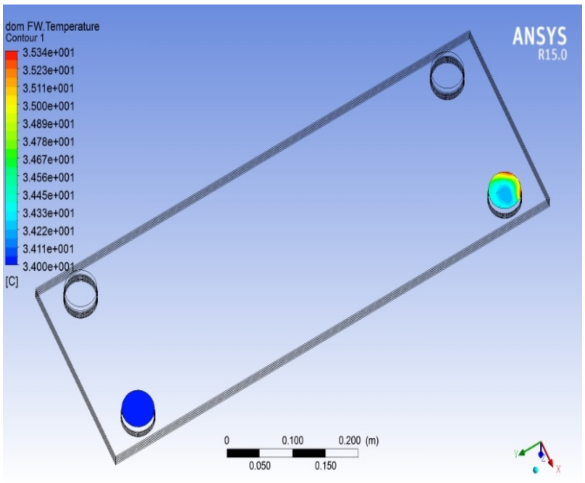

Fig.10. The temperature of the cooling water inlet and outlet

- **The inlet temperature of cooling water in heat exchanger 32ºC**
- **Oil inlet temperature of 47.2ºC heat exchanger**

Obtained results:

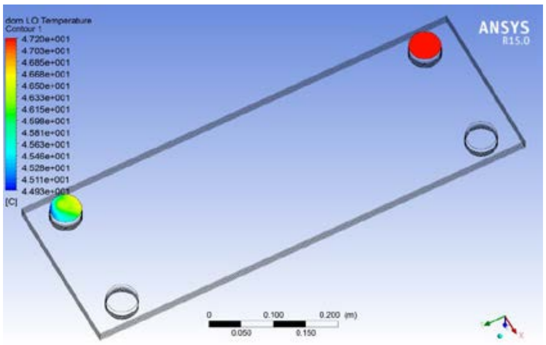

Fig. 11. Inlet and outlet temperature of lubricating oil

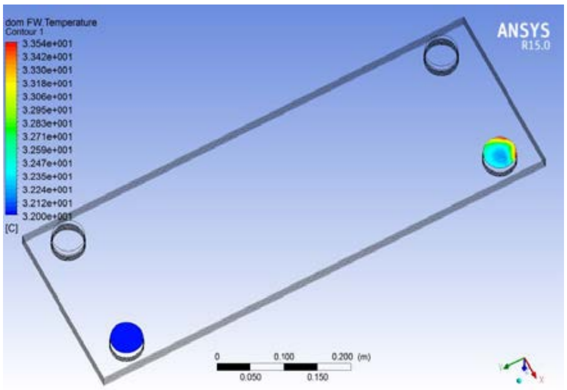

Fig. 12. The temperature of the cooling water inlet and outlet

All situations presented above (fig 3-12) are results from intensive thermal and fluid investigation on cooling systems and the results are similar to the presented data in technical documentation presented by producer.

Hypotheses for third case DNS calculation

CONCLUSIONS

This work has reviewed and reported the state of art in 2015 on the cooling system DNS simulation based on realistic design. In this analysis we have shown that coolers are investigated with strong Ansys software analysis.

This work has presented three different environmental parametersand results for each case. This work can help in coolers software simulations in ANSYS and helping to take a more informed decision in the coolers understanding and construction.

The analysis reported in this paper can be further explored to develop new coolers designs and thermal studies for any other thermal input values.

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