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ENHANCING SHIP FIREHYDRANT'S AND ELECTRICAL CABLE DUCT'S FIRE HEATTRANFER

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ABSTRACT

In case of fire, the temperature of the fire hydrants steel parts will increase accordingly which lead residue water to evaporate inside the fire hydrants causing high pressure stress to the internal parts. Also, electrical cable duct are subject for temperature increase, this incensements might melts electric cable covers and led to electric shocks catastrophe. In this research paper, a new inexpensive and resalable isolation blanket is proposed to reduce the effect of fire heat transfer. A Finite Element analysis of Heat Conduction simulation is carried out using ABAQUS CAE software to verify the effectiveness of the suggested blanket, the results shows that heat conductions are reduced by 65% with isolation blanket in comparison without isolation blanket.

KEYWORDS: Fire hydrants, electric cable covers, ABAQUS CAE.

INTRODUCTION

Fire is the most concerns for marine navigation and offshore operations since its causes a huge damage and loses; it is classified as the biggest threat to mariner. During fire, Heat conduction (diffusion) has big influences by its direct microscopic exchange of kinetic energy of particles through the boundary between two systems. Such spontaneous heat transfer always occurs from a region of high temperature to another region of lower temperature, as described in the second law of thermodynamics. Generalization of the heat conduction equation is obtained by considering the system of equations consisting of the energy balance equation and fractional-order constitutive heat conduction law,[1] The approach of considering generalized heat conduction equation through system of balance and constitutive equation is also adopted in[2] within the classical theory using the analogy with circuits and extending the results within the theory of fractional calculus in.[3] Anomalous transport processes through space and time fractional generalizations of the Cattaneo heat conduction law are studied in.[4] Time and space fractional heat conduction of Cattaneo type is studied, analytically on infinite domain in[5] and with physical justification for non-locality introduction in.[6–8] Heat conduction problem with the Riesz space fractional generalization of the Cattaneo–Christov heat conduction model is numerically treated in.[9] Heat conduction problems with different heat conduction laws in terms of the classical theory are reviewed in,[10] while in[11] there is a collection of heat conduction problems within the theory of fractional calculus. Heat convection occurs when bulk flow of a fluid (gas or liquid) carries heat along with the flow of matter in the fluid. The flow of fluid may be forced by external processes, or sometimes (in gravitational fields) by buoyancy forces caused when thermal energy expands the fluid (for example in a fire plume), thus influencing its own transfer.

Heat Transfer Methods

- **Conduction**: heat transfer that occurs across the medium and trough the molecules of the material.

$$\mathbf{q = k\ A\ (\Delta T/L)}$$

Where q is a rate of heat transfer in (watt), k is thermal conductivity in (w/m.k), L is thickness in (m) and A is wall area in (m^2) and ΔT is temperature difference in (Kelvin).

- **Convection:** heat transfer that occurs between a surface and a moving fluid when they are at different temperature. There are two types of convections which are:

1- Natural or free convection which occurs due to change in density and circulating of fluid.
2- Forced convection which occurs by using an external force like a fan to force a gases or a pump to force a liquid.

$$\mathbf{q = h\ A\ (T_s - T_\infty)}$$

Where h is a convection coefficient in ($w/m^2.k$), A is the area exposed to the convection in (m^2), T_s is surface temperature of the solid in (Kelvin) and T_∞ is fluid temperature in (Kelvin).

Table 1: Typical Values of the Convection Heat Transfer Coefficient.

Process		h ($w/m^2.k$)
Free Convection	Gases	2 - 25
	Liquid	50 - 1000
Forced Convection	Gases	25 – 250
	Liquid	100 – 100,000

- **Radiation:** all surfaces of finite temperature emit energy in the form of electromagnetic waves, in the absence of an intervening medium; there is net heat transfer by radiation between two surfaces at different temperatures.

$$q = \varepsilon \sigma A [(T_s^4) - (T_{surr}^4)]$$

Where ε is emissivity, σ is boltzman constant = $5.67*10^{-8}$ in ($w/m^2.\ k^4$), T_s is surface temperature in (Kelvin) and T_{surr} is surrounding temperature in (kelvin).

RESEARCH METHODOLOGY

The proposed qualitative research methodology is a method and that's is by run out Finite Element analysis of Heat Conduction by simulate Fire hydrant/ electrical cables with and without the ceramic fiber insulation blanket using ABAQUS CAE software to verify the effectiveness of the suggested blanket as a reducer for heat transferring . Such isolation blanket is recently used as a normal insulation for boiler refractories or as an insulation wrap for refrigeration pipes.

The blanket used in this research (Fig.1) is produced from exceptionally pure oxides of alumina and silica using the spinning process. Also it has been optimized for high handling strength, and offers excellent handle ability and high temperature stability.

Isolation blanket characteristic

- Low thermal conductivity (0.06w/m.k @ 260 ^{o}C until 0.34w/m.k @ 1093 ^{o}C).
- Excellent thermal shock resistance (maximum temperature 1315^{o}C).
- Low heat storage capacity.
- No organic binders.
- Low density (128 kg/m3).

Figure 1: Ceramic Fiber Insulation Blanket.

Recent applications of Blanket

- Furnace linings.
- Kiln linings.
- Boiler insulation.
- Furnace door seal.
- Duct lining.
- Pipe wraps insulation.
- Investment casting mold wrap.
- Field stress relieving.
- Removable thermal insulation pads.
- Steam and gas turbine insulation.

Simulation

Thermal simulation for isolated and non-isolated steel pipes using ceramic fiber blanket are carried out to simulate water boiling temperature and the effect of water vapor to inner layers and to prove the effeteness of proposed solution to prevent water residue to reach boiling point. Thermal simulation are illustrated at figure 2 & 3 below, assuming that part is exposed to a high temperature which is generated due to a fire occurred in the machinery space. Also, show the specifications of the pipe and the blanket in addition to the heat transferring condition for the model and the data of temperatures for isolated and non-isolated pipeline.

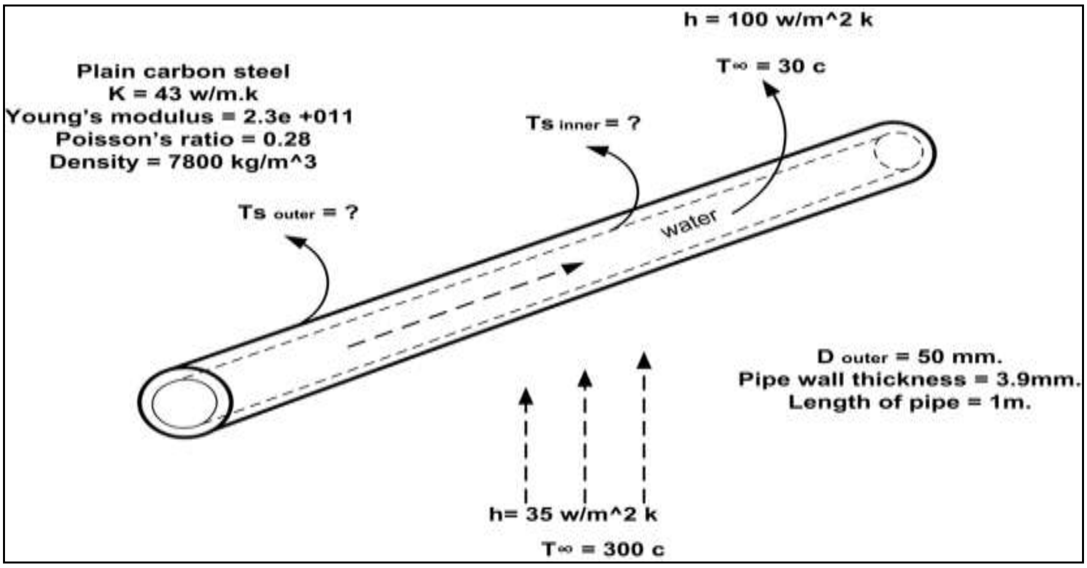

Figure 2: Case #1: Pipe with No Insulation.

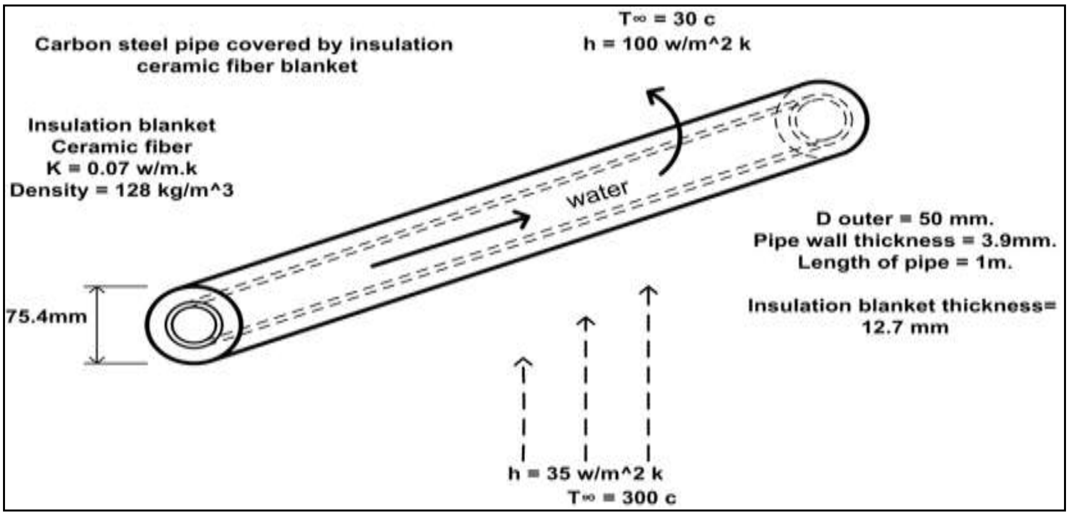

Figure 3: Case #2: Pipe with Insulation Blanket.

To obtain and verify the efficiency of the suggested blanket, a thermal simulation via FEA software which is AQAQUS/CAE on two models of pipes one of them is insulated by the suggested blanket and the other one is a normal with no insulation to obtain the results and compare between them. (Figures 4 & 5 below).

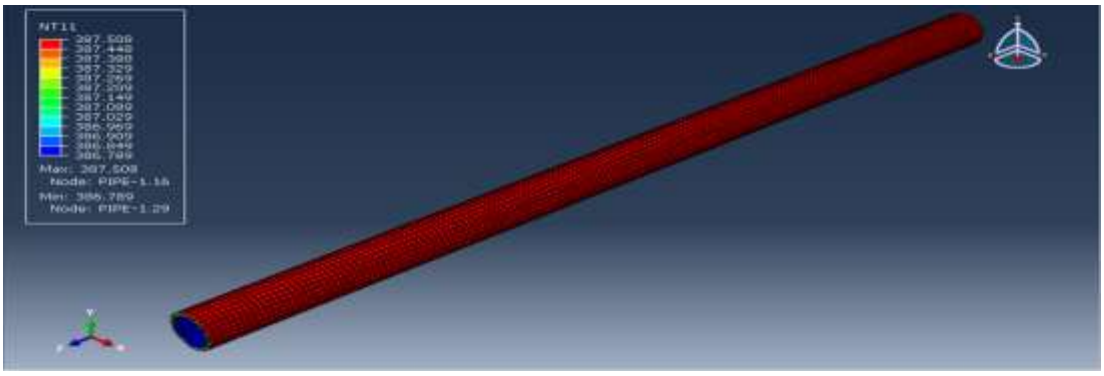

Figure 4: Without insulation.

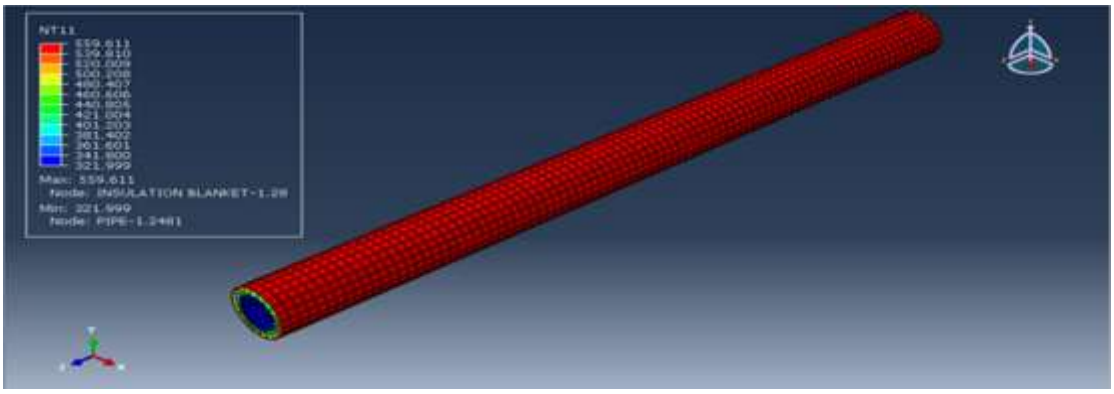

Figure 5: With insulation.

From the obtained results, the colors distribution of the temperature values is in the left box. The colors represent the amount of the heat. The temperatures (K) are for the inner surfaces which are the minimum values and the maximum values at the external surfaces of the two models.

According to the results of the simulations figure above, there are approximately 65 degrees as deference between the two results in the temperatures of the inner surfaces of the models; these results are done on half inch of the insulation blanket.

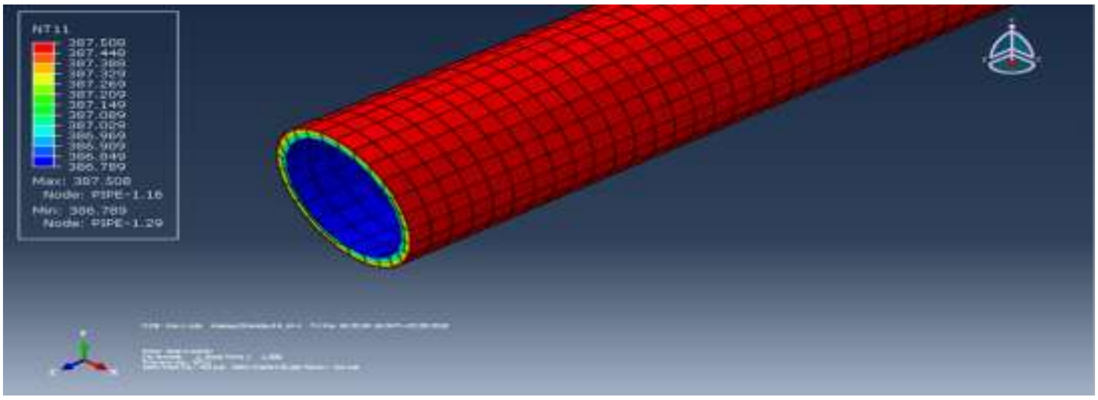

Figure 4 (ZOOM): Without insulation.

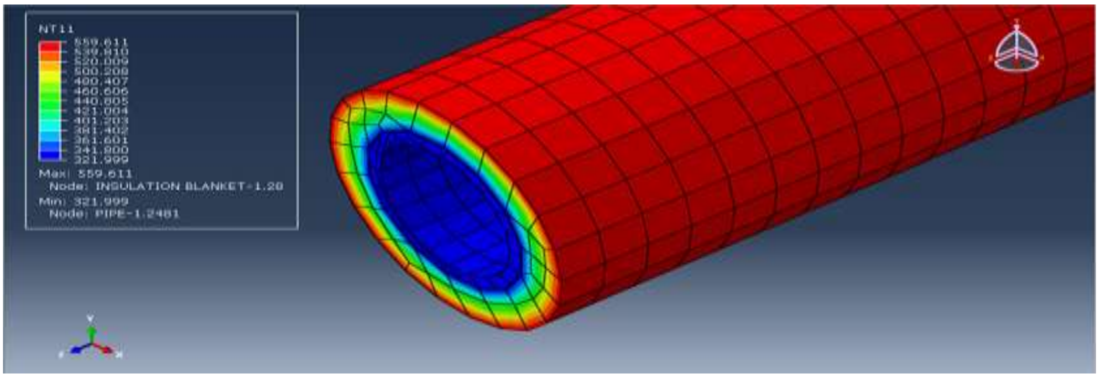

Figure 5 (ZOOM): With insulation.

To emphasize results, four more FEA simulation without insulation are carried out with different meshing numbers (.01, .003, .006, and .009) and the results shows small differences Figures (6,7,8,and 9).

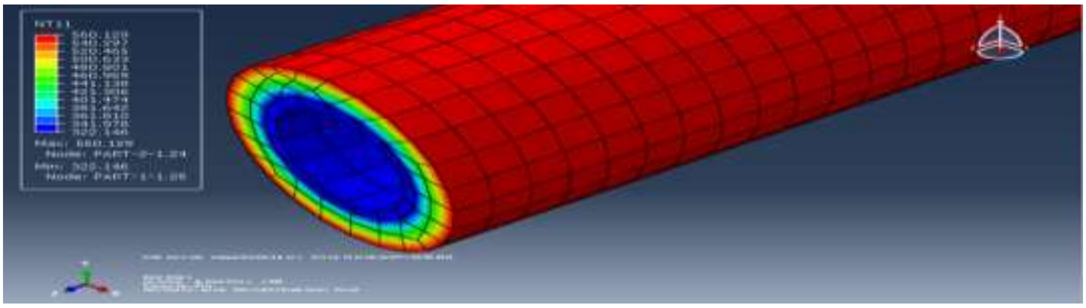

Figure 6: Without insulation (.01 meshing).

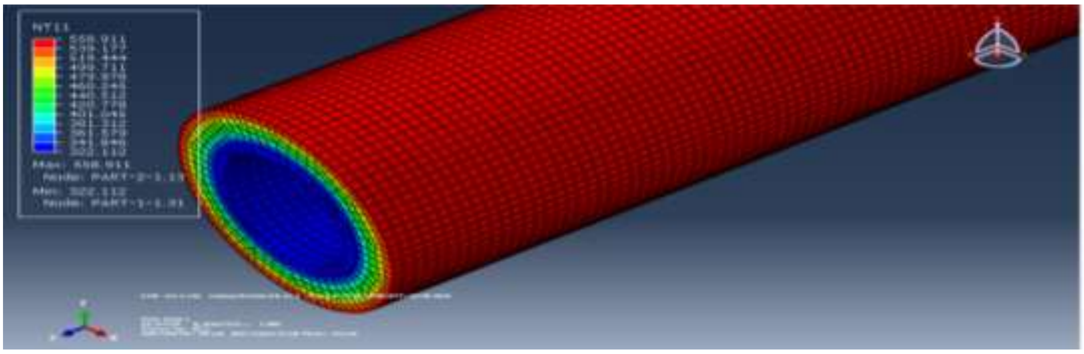

Figure 7: Without insulation (.003 meshing).

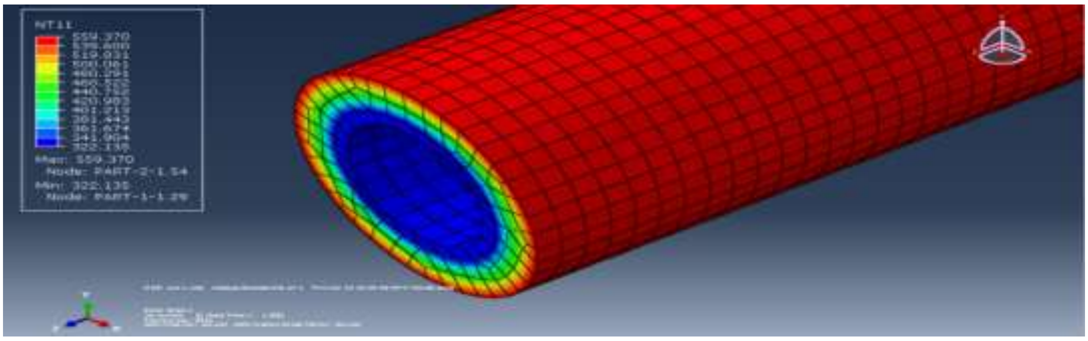

Figure 8: Without insulation (.006 meshing).

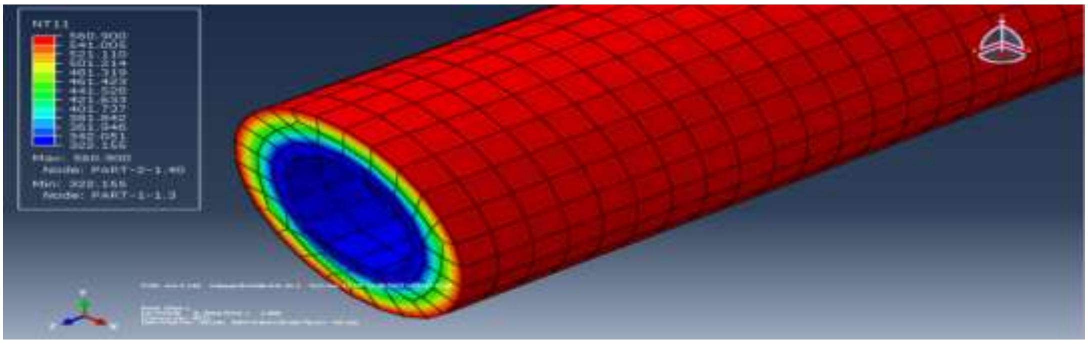

Figure 9: Without insulation (.009 meshing).

CONCLUSION

As it is shown in figure4, the temperature of the inner surface of the pipe has reached (114) ^{O}C thus the water will be boiling and it could cause damage either for the pipelines or the head nozzles.

In figure 5, the temperature of the inner surface of the pipe has reached (49) ^{O}C, it is a normal temperature for that water inside the pipe. So Findings are:

1. The heat transfer will be reduced by 57% when using the suggested blanket this ratio is subject to increase by increasing the blanket thickness.
2. The difference in temperature between the pipe without blanket and the other pipe with blanket is about 65^{O}C this will keep the water inside the pipelines with no boiling thus the internal wall of the pipelines is not going to expose to overpressure.

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