

Thermal characterization and thermal effect assessment of biofouling around a dynamic submarine electrical cable of floating offshore wind turbine

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Thermal characterization and thermal effect assessment of biofouling around a dynamic submarine electrical cable of floating offshore wind turbine.

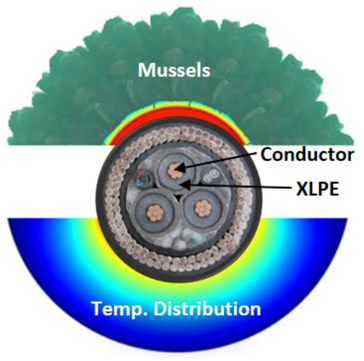
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Context

Introduction and problematic

- High voltage dynamic cable is a key component in the power transmission system of floating offshore wind turbine
- High voltage dynamic cables are dimensioned to remain below 90°C into the conductor and XLPE in normal operating conditions.
- Growth of biofouling, particularly mussels can modify the heat transfer around the cable.
- If the temperature of the conductor increases above 90°C, then the XLPE (cross-linked polyethylene) insulation system is damaged and the electrical conductor conductivity will decrease**.**
- Modelling the thermal effect of mussels on the high voltage dynamic cable is important however the thermal characteristics of mussels are unknown.



Objective

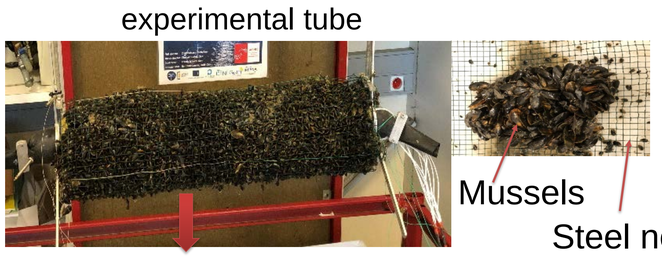
- Thermal characterization of different types of mussels (Juvenile, mix (Juvenile & Adult) and Adult) by estimating the effective thermal conductivity of mussels k_{biof} and the heat transfer coefficient of the water around the mussels h_w.
- Modelling the thermal effect of different ages of mussels on the dynamic submarine electrical cable.

Methodology

Stationary method (Analytical)

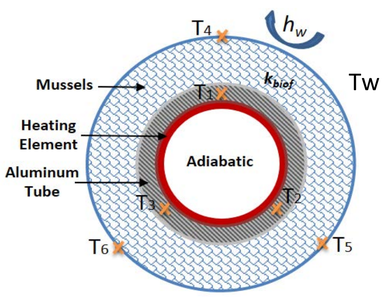
Uniform colonization of mussels around the experimental tube

Mussel's fixation on the experimental tube



Measurement in a water tank filled with sea water





Middle cross-section of the experimental tube covered with uniform colonization of mussels.

Thermal conductivity of biofouling (Fourier's law):

$$\lambda_{biof(W/m.K)} = \frac{\ln\left(\frac{re}{ri}\right) * \emptyset_r}{2\pi * L * (Tav1 - Tav2)}$$

Heat transfer coefficient of water around the mussels (Newton's law):

$$h_{water(W/m^2.K)} = \frac{\emptyset_r}{2\pi * re * L * (Tav2 - Tw)}$$

*** Tav1: average of (T1,T2 and T3)**
Tav2: average of (T4,T5 and T6)

Modelling the thermal effect of mussels (Finite Elements)

Juvenile (3-6 months)

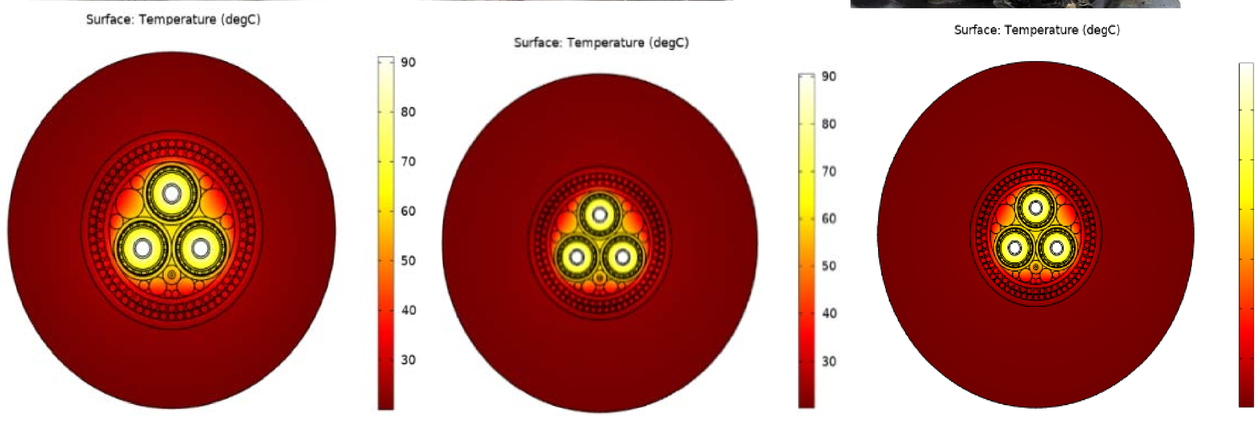


Mixed (6-12 months)



Adult (12-18 months)





Results

Thermal characterization of different ages of mussels – Uniform colonization.

1 Juvenile mussels 2 Mix(Adult & Juvenile)mussels 3 Adult mussels



$$k_{Juvenile} < k_{Mix} < k_{Adult}$$

Effective thermal conductivity of the mussels and heat transfer coefficient of the water around them.

Mussels type	*Porosity (Φ)*	k_{biof}	Absolute uncertainty	Relative uncertainty	h_w	Absolute uncertainty	Relative uncertainty
	%	$W.m^{-1}.K^{-1}$	$W.m^{-1}.K^{-1}$	%	$Wm^{-2}K^{-1}$	$Wm^{-2}K^{-1}$	%
Juvenile	15	4.4	± 0.4	9	3395	± 1123	33
Mix (juvenile &adult)	18	8	± 0.52	6.5	873	± 164	19
Adult	22.6	12.8	± 0.97	7.6	2682	± 1003	37

Conclusion

- Effective thermal conductivity of mussels depends on the age mussels (Juvenile, mix or adult) which has different percentage of water porosity.
- Convective resistance is smaller than the conductive resistance.
- Juvenile mussels have the smallest effective thermal conductivity compared to the mix (juvenile and adult) and adult mussels. Therefore, it has the highest thermal effect on the submarine electrical cable.

Thermal effect of different ages of mussels on the dynamic submarine electrical cable.



