Coatings for marine renewable energy applications

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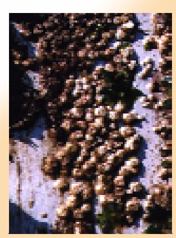
Coatings

- Coatings serve a number of purposes
- Aesthetics
  - Decorative
- Functional
  - Visibility, hazard identification
  - Physical abuse – abrasion and impact resistance
  - Protection against substrate degradation – corrosion of steel
  - Hygienic purposes – anti-bacterial, anti-fungal, anti-fouling
- Generally multilayer systems or 'schemes'



Wave and tidal power installations

- Wave and tidal power installations are emerging technology
- Wide range of designs under evaluation – oscillating water columns, articulated devices and turbines – made from a variety of materials of construction – primarily steel
- Operate in hostile environments – severe corrosion challenge, fouling, mechanical damage
- Expectation is a long lifetime – potentially with no maintenance
- Coatings systems for these devices are currently based on existing technology used in the marine and offshore industries
- Not certain whether these schemes will provide the anticipated design lifetime

Paint selection for wave and tidal energy installations

- Power generating wave and tidal installations are similar to offshore structures like rigs and ships
- Significant difference in that they are unmanned
- Some designs may be extremely difficult to monitor/assess
- Implies that extremely robust paint schemes with good track record required – protection and survivability of prime importance

Paint selection for wave and tidal energy installations

- Schemes can be selected by first using the methodology described in ISO 12944-2
- This defines the corrosion category of the site by the rate of steel loss
  - Corrosion rates are fastest in the splash zone – 25 years 1cm loss
- Combine the category with the required durability lifetime to select general coating schemes
  - Non-immersed areas C5-M applies – coastal and offshore areas with high salinity
  - Immersed areas Im-2 applies – sea or brackish water
  - ISO 20340 further defines requirements for high durability systems

Zone	mm/yr
Immersed	0.2
Tidal	0.25
Splash	0.4

Typical generic paint schemes

C5 Category	Im-2 Category
3-6 coats epoxy + PU Total dft 3-500 microns	1-2 coats of solvent free epoxy Total dft 800 microns
3-5 coats zinc silicate + epoxy + PU Total dft 300-400 microns	2-3 coats high solids epoxy Total dft 800 microns
1-2 coats solvent free epoxy Total dft 800 microns	2 coats glass flake epoxy Total dft 1000 microns

No active anticorrosive pigment in coatings for immersed areas – osmotic blistering
Protection achieved by barrier properties
Compatible with cathodic protection
Surface preparation critical to achieving long service lifetimes with minimum maintenance

Functional paint schemes

- Take into account
  - Design features
  - Production processes
  - Assembly sequence
  - Climate
  - Operational procedures
  - Target lifetime (as per generic schemes)

- They are quantified
- They do not contain phrases such as:
  - 'more bodied'
- They would state instead:
  - C&P Viscosity of 2-3 poise at 25C+/-1C

Functional requirements

- Many issues raised, two examples discussed
  - Film thickness

  - Fouling issues

Film thickness control

- Spray application does not lay down an even film thickness
- Complex structures can make this variation even more extreme
- Thin films break down prematurely
- Thick films crack – better barrier properties but film stresses can dominate

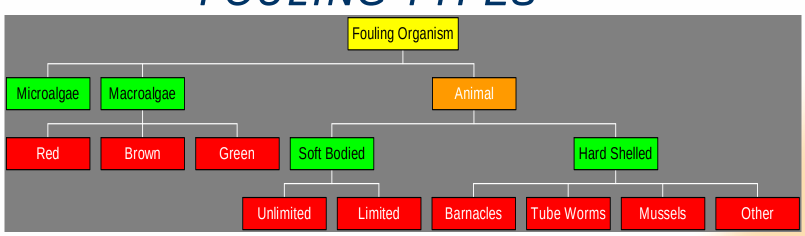
Film thickness control – cost implications

- Major wind turbine manufacturer -100m towers
- Paint scheme C4 internally, C5 externally
- Paint cost €12000 per tower, 400 towers in 2009
  - Total cost €4.8m
- Study revealed poor film thickness control on internal area of tower – 70% over target thickness
- Better control cut costs by approximately €1.2m without increased risk of failure

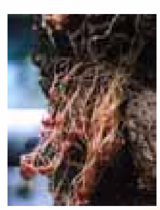
Fouling of marine structures

- Fouling of marine structures takes many different forms
- Extent of fouling dependent on many variables and is generally not predictable
- Process begins with protein and polysaccharide fragments attaching to the surface
- Followed by bacterial growth
- Micro and macrofouling attachment
- Process takes place over a period of up to 4 weeks

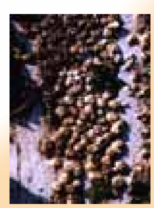
FOULING TYPES



Weed
(Enteromorpha intestinalis)



Hydroids
(Tubularia indivisa)



Barnacles
(Cthalamus stellatus)

Impact of fouling

- Fouling adds weight – up to 150kg/m2
- Average density 1.0 -1.4 tonnes per cubic metre
- Increases drag by up to 50-70%
- Animal fouling – barnacles – can cause damage to coatings leading to corrosion
- Fouling will accumulate up to a certain level then slough off under its own weight

Dealing with the fouling challenge

- Long term impact of fouling on wave and tidal power installations is unclear
- Adequate operation may be possible regardless of fouling
- In the event that it is a problem, solutions will have to be developed
- These may include:
  - Conventional antifouling technology has limited lifetime – environmental impact to be assessed
  - Foul release – mechanically weak
  - Mechanical cleaning may be built into the design
  - More exotic options – biomimetic coatings

Summary

- Current coatings for wave and tidal energy installations derive from existing technology used in marine and offshore industries
- It would be reasonable to expect these coatings to perform perfectly adequately in the medium to long term
- Renewable energy generating technology is in its relatively early stages
- All of the challenges are not yet fully understood
- History of technology development has shown that getting it right first time does not generally happen and it is possible that unforseen difficulties will manifest themselves in the longer term

Summary

- New products or technologies generally evolve into successful products via responses to unexpected failures
- Issues arise from a less than complete understanding of all of the relevant issues from application requirements to performance expectation
- Timescales can be significantly reduced if the complete functional specification can be defined and quantified early in the process and the required test protocols are put in place
- Safinah (www.safinah.co.uk) can provide independent advice on the development and construction of more accurate and meaningful functional specifications to help minimise development time

QUESTIONS?