TURBYLEC
Development and experimental validation of an innovative centrifugal oil – water separator

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Summary

• Partners involved in the development

• Context: the European HOVERSPILL project

• Oil / Water separation: specific requirements

• Suggested/retained alternative solution

• Experimental validation

• Conclusion – ways forward
Involved partners

- **YLEC Consultants** is a French small consulting company specialized in **Fluid Mechanics** with a strong specialization in **multiphase flows**

- **CEDRE** (France): non-profit-making association dealing with accidental Oil Spill and Chemical (HNS) Spill on waters

- **SOA** (Italy): SME specialised in environmental services and studies on advanced technologies by operating with compact dimensions hovercrafts
Context of development

- **HOVERSPILL** European project: MultiEnvironment Air Cushion Oil Spill Fast Response & Post Emergency Remediation System
- Funding from the European Commission’s 7th Framework Program

vacuum pump

O/W emulsion in

to oil tank

water outlet

containment boom

floating hydrocarbons

Skimmer
Separation requirements

• Separated Water: highest possible quality (<1000 ppm)

• Separated HC: low water content (< 5%) to minimize storage volumes

• “Flexible” separator: large ranges/variations of operating conditions (HC quality, inlet emulsion water content, air ingestion)

• Separator must be easily dismountable on board for rapid cleaning

• Weight (with liquid) < 100 kg for 7 m³/h max inlet flow rate
Alternative solution

• Existing solutions: non suitable for very specific requirements

• It has been decided to equip the HOVERSPILL™ platform with a new dedicated rotating separator

• As simple, as flexible and as light as possible

Skimming and pumping system

Variable inlet conditions

HC and air contents, density contrast, flow rate,…

HC: water content < 5%

High quality water

Simple, flexible and light

HC/Water separator
Alternative solution: TURBYLEC

- Design of a new patented separation device: **TURBYLEC** (international patent application WO 2013/113903)

- Some innovative characteristics:
  - Motorised rotating separator
  - Limited speed (1500 RPM)
  - Solid rotation flow
  - No inlet emulsification
  - Rotating weirs
  - Integrated pumps
  - Possible use under vacuum
Prototyping

- Experimental prototype:
  - Rotor: rapid prototyping
  - Electrical motor

- Preliminary qualification:
  - Mechanical behavior:
    - Balancing
    - Structural resistance
  - Hydraulic performances:
    - Integrated pumps
    - Operation under vacuum

Prototype realized by our partner SOA
Experimental validation

• Separation tests at CEDRE’s facilities (Brest – FRANCE)

• Marsh – May 2013

• Tested configurations:
  ▪ low viscosity engine oil / moderate viscosity HC
  ▪ fresh water / sea water
  ▪ Inlet O/W emulsion: pumped by a volumetric pump / sucked under vacuum
  ▪ coarsely mixed or finely dispersed Oil in Water emulsion

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Experimental validation

• Focus on one experimental configuration:
  ▪ Skimmer: mechanical self-adjusting weir skimmer (DESMI Terrapin)
  ▪ Pump: volumetric hydraulic driven lobe pump (BORGER AL25)
  ▪ TURBYLEC: 1500 RPM - 2.7 m³/h
  ▪ Upstream tank:
    10 m³ sea water
    50 Liters HC (940 kg/m³ – 1000 cSt)
Experimental validation

• Test procedure:
  ▪ 5 mm initial thick HC layer progressively skimmed
  ▪ HC layer thickness and inlet HC content decrease with time
  ▪ Samples collected every one minute:
    – at separator inlet for characterization of inlet O/W emulsion
    – at water outlet for measurement of HC residual content
Experimental validation

Simulating Oil Spill scenario

Water outlet

HC outlet

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TURBYLEC Oil/Water Separator
Experimental validation

- Evolutions of inlet HC content and residual HC content at water outlet

![Graph showing evolutions of inlet HC content and residual HC content at water outlet](image)
Experimental validation

- Residual HC content at water outlet versus inlet oil content

![Graph showing the relationship between residual HC content at water outlet and inlet HC content.](image-url)
Experimental validation

- TURBYLEC separation efficiency vs. inlet oil content

\[
\eta_{\text{sep}} = \frac{OC_{\text{in}} - OiW_{\text{out}}}{OC_{\text{in}}}
\]

<table>
<thead>
<tr>
<th>Inlet HC content (%)</th>
<th>Separation efficiency (%)</th>
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<tbody>
<tr>
<td>0</td>
<td>99.9%</td>
</tr>
<tr>
<td>5</td>
<td>99.9%</td>
</tr>
<tr>
<td>10</td>
<td>99.8%</td>
</tr>
<tr>
<td>15</td>
<td>99.8%</td>
</tr>
<tr>
<td>20</td>
<td>99.7%</td>
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<tr>
<td>25</td>
<td>99.7%</td>
</tr>
<tr>
<td>30</td>
<td>99.6%</td>
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</table>
Conclusion about performances

- TURBYLEC prototype tested at CEDRE has a size and weight compatible with integration within HOVERSPILL™ platform.

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
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<tbody>
<tr>
<td>Height</td>
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<tr>
<td>Diameter</td>
<td>0.380 m</td>
</tr>
<tr>
<td>Dry weight</td>
<td>50 kg</td>
</tr>
<tr>
<td>Weight with liquid</td>
<td>80 kg</td>
</tr>
<tr>
<td>Liquid volume</td>
<td>30 l</td>
</tr>
<tr>
<td>Retention time</td>
<td>30 s</td>
</tr>
<tr>
<td>Rotational speed</td>
<td>1500 rpm</td>
</tr>
<tr>
<td>Electrical or hydraulic motor power</td>
<td>2 kW</td>
</tr>
</tbody>
</table>
Ways forward

• Current status:
  ▪ Innovative concept patented
  ▪ Experimental prototype tested and approved for Oil Spill

• Next steps:
  ▪ New industrial prototype to be built and tested, including:
    – Further improvements (hydraulic sealing, automatic adaptation to any density contrast)
    – Additional industrial constraints for other potential applications (crude oil production, water tables treatment, waste waters,…)
  ▪ Look for industrial/sales partners

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