



Design optimisation of an
onboard ballast water treatment
system

TREBAWA

A European consortium comprising engineering companies, research institutions and ship owners



Project Objectives

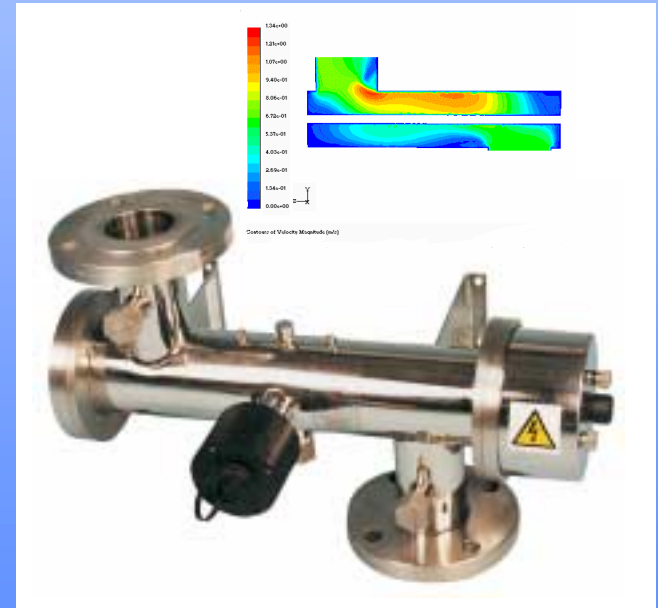
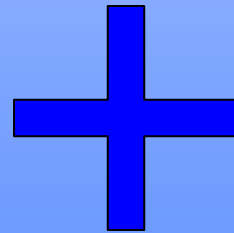
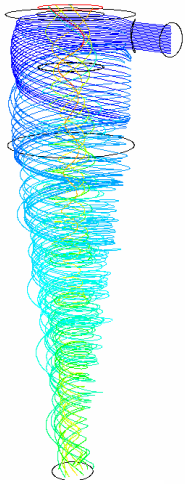
- Select a promising treatment process - Hydrocyclone and UV Treatment.
- Utilise CFD modelling to enhance the system for ballast water treatment.
- Design and build a system based on these computer models.
- Operate the new designs on selected vessels.

Key Parameters

- A design flowrate of $125\text{m}^3.\text{hr}^{-1}$
- A maximum velocity of $< 3\text{m}.\text{s}^{-1}$
- A high percentage of 'clean' flow.
- Short circuiting and backflow to be minimised.
- Smallest practical pressure drop.
- Smallest equipment footprint

Hydrocyclone & UV

- Design improvements to existing technologies for use on ballast water treatment



Hydrocyclones

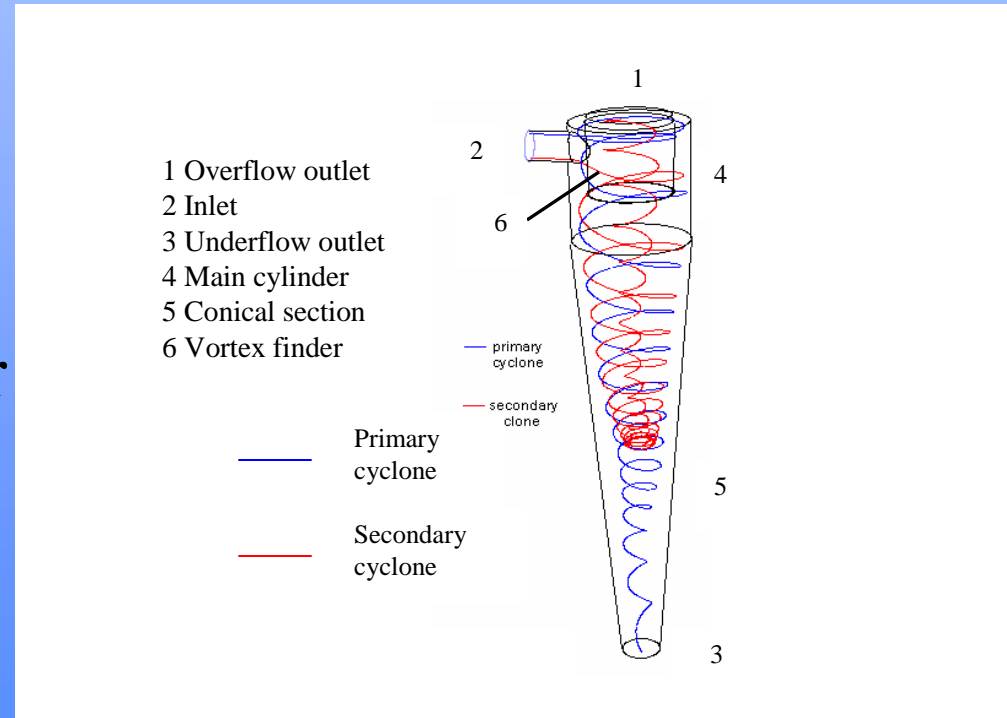
- Well established technology, extensively used in a number of industries including petrochemical and food processing.
- No moving parts and very low maintenance.

Key Design parameters

- Maintain low pressure drop
- High removal efficiency of solids
- Maximise % of flow to overflow (clean) outlet.

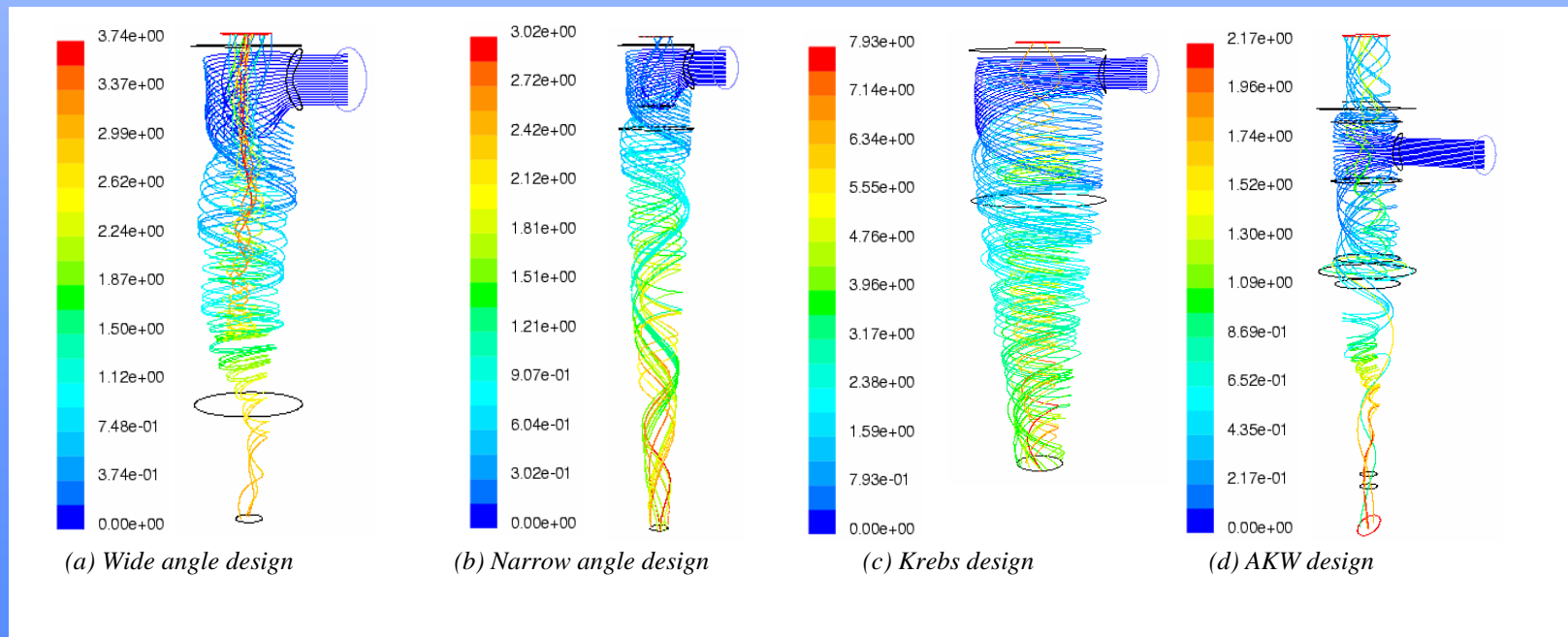
Optimisation

- Focuses on relationship between key elements.
 - Inlet Size
 - Vortex Finder
 - Conical Separator
 - Underflow



Test Cases

- >30 separate cyclone configurations considered.



Test Cases

- A compromise between removal efficiency and % clean flow must be reached.
- A design with a low % of 'clean' water is impractical.
- Final design utilised four hydrocyclone with a high % flow to outlet.

UV Treatment

- Another well established technology.
- Used in drinking water, bottled water, brewing, pharmaceutical and other industries
- Very low maintenance.
- Non chemical treatment.
- Utilised for effluent in coastal discharges since the 1980's

UV Treatment

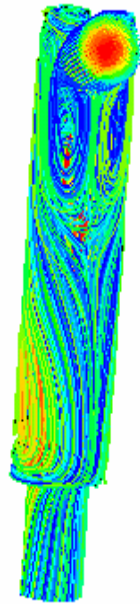
- Physical process - treatment within the cell only
- Damages the DNA of micro-organisms
- Lethality of effect based on dose (mj.cm^{-2})

Key Parameters

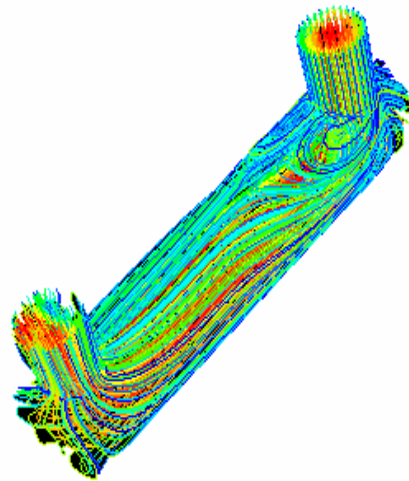
- Design based on a dose of $>250\text{mj. cm}^{-2}$
- Assumes 90% Transmission in a 1cm cell.
- Hydraulic efficiency $> 75\%$
- Pressure Drop $< 50\text{mbar}$
- Size - as small as possible

Initial Models

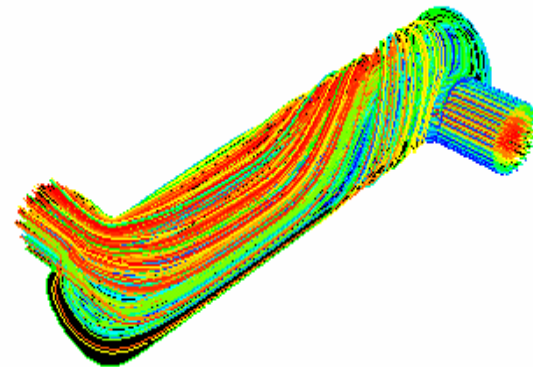
- Over 75 configurations of commercially available systems analysed.



(a) normal/inline branch



(b) normal/normal branch

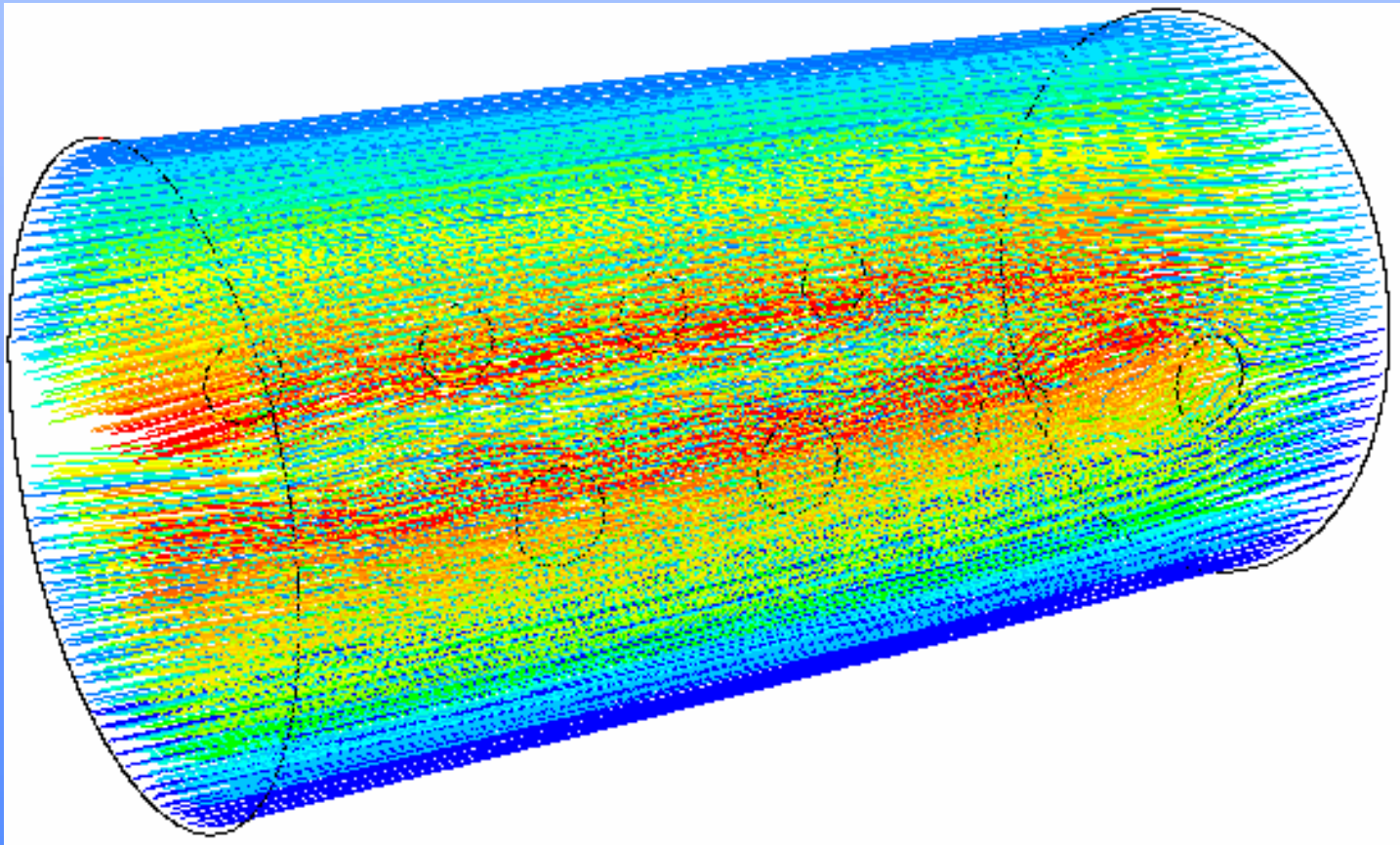


(c) normal/normal branch

Conclusions

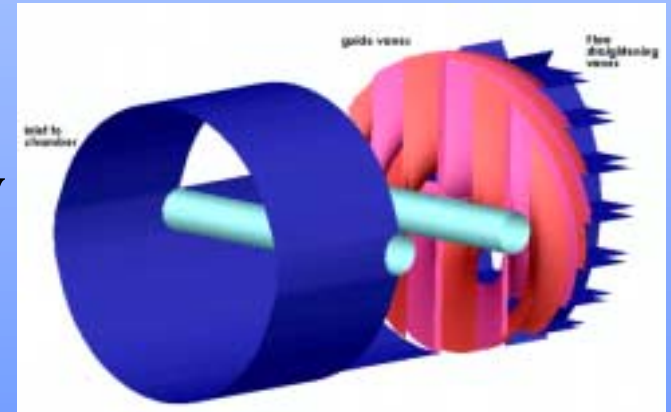
- Many systems had poor hydraulic efficiencies (50%-55%)
- In-line designs had better efficiencies (65%)
- A new design based on sequential in-line lamps and a smooth bore chamber had higher efficiencies (85% - 90%)
- Pressure drop $< 20\text{mbar}$

Trebawa in-line chamber



Flow control valves

- For poor water radiation geometry may be a problem
- Baffles have performed poorly in UV units in the past
- A new flow-rotator designed
 - Moves the flow around the chamber
 - No dramatic increase in pressure drop
 - No decrease in hydraulic efficiency



Equipment



TREBAWA inline UV Chamber



TREBAWA parallel separators

Testing - Millport Scotland

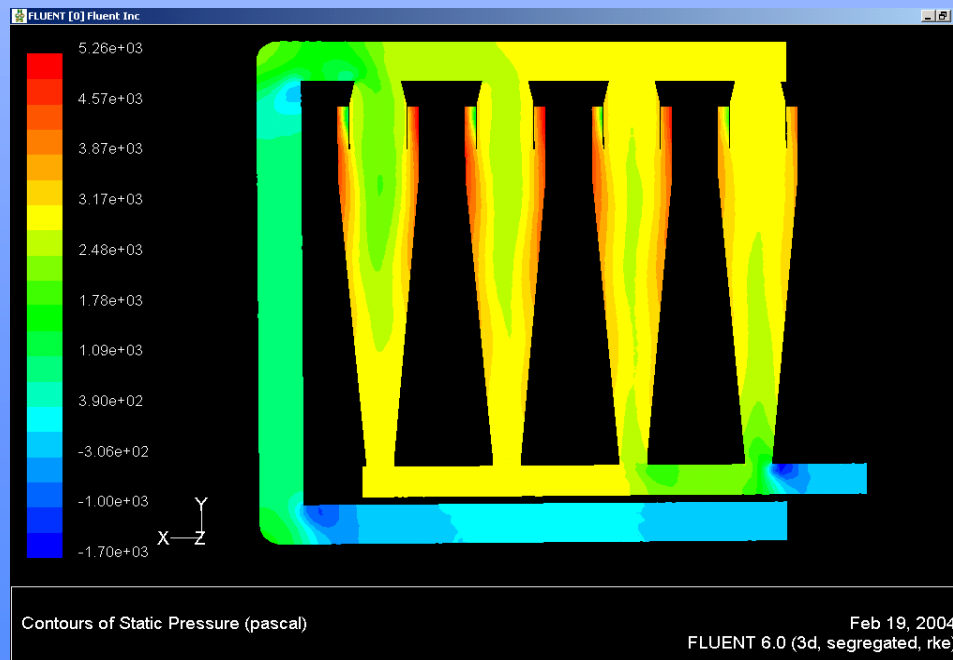
- Initial hydrocyclone testing
- Flow rate between 83 - 167 m³.hr⁻¹
- Flow rate controlled to allow 70% clean flow

Initial Results

- Sand > 50micron 89% removal efficiency
- Pressure drop 200mbar
- Reduction in micro-organisms (hydrocyclone only) was negligible
- Results in line with CFD predictions

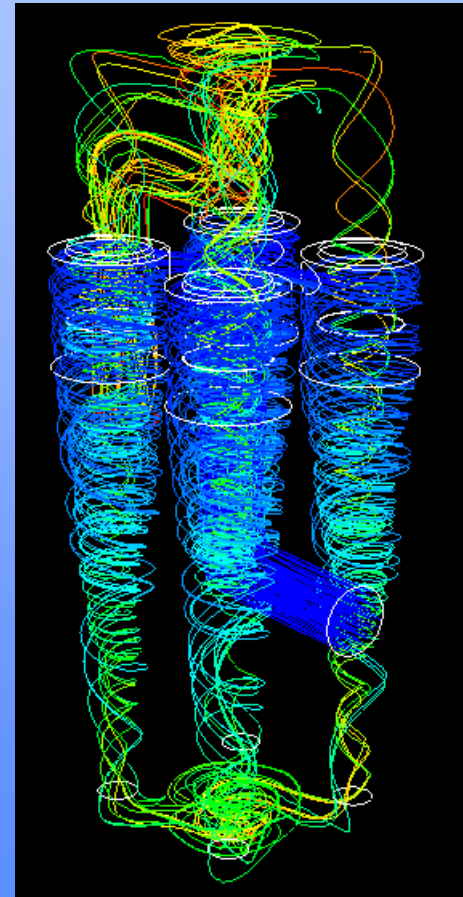
Initial Results

- Testing identified problems with the initial design.



On-Going Programme

- New design.
- Minimises space required
- Even distribution of flow.
- Reduction in short circuiting



Further Testing

- The Trebawa system (Hydrocyclone + UV) is installed on a vessel in the Baltic Sea.
- The system is currently under full testing.

Information

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