SOx Emissions Innovation Challenge

Three elements for an even playingfield

- Hannelore, Jens, Lina & Rasmus
Agenda

- Overview
- The Three Elements
  1. Measuring SOx
  2. Data Analysis
  3. Soot Sample
- Next Steps
Who we are

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Mathematical Modelling
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Environmental Technology
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Naval Architecture
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Engineering Design and Applied Mechanics
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Bunker fuel
- Lubrication and bunker fuel tells about sulphur content
- Requires cooperation and monitoring in all ports

Storage and combustion on-board
- Tamperproof solution
- Hard to do spot check at high seas
- Traces left in the engine and stack

Emission in high seas
- Monitor directly in high seas
- International waters.
- Regulation concerned with emission not fuel type.
Combine elements enough to get a functional solution

Make solution tamper proof OR remove incentive to tamper with it

Solution should be applicable world wide and work in high seas

Limiting cost
On-board sensors measuring emission from passing ships

Data mining

Targeting of suspected vessels

High Sea Compliance

Port State Control
1. The sensor gets a signal to turn and measure on a nearby ship.

2. The sensor measures SOx in exhaust from a passing ship.

3. Sensor measurement and GPS data is sent to a land-based server.
On-board sensors measuring emission from passing ships

Targeting of suspected vessels

Soot sample included in port state control
Key points

- Solution is a combination of known technologies
- Designed to gradually narrow down the pool of vessels that should be investigated for non-compliance
- Little incentive to tamper with the solution
  - Counter productive
  - Difficult due to multiple measurements
Measuring SOx
Measuring SOx

- Difference between Optical sensors and Sniffing systems
Current optical systems

- DOAS
  - Spectrometer either mounted on ship or helicopter
  - When based on ship it looks ”up” at the plume

- LIDAR
  - Two laser pulses with different wavelength.
  - One is absorbed by the plume

- UV-CAM
  - Photosensors, with a focus on UV (280-320 nm) can estimate SOx
Current projects

- Great Belt Bridge
Current projects

- Great Belt Bridge
- Port of Rotterdam
Current projects

- Great Belt Bridge
- Port of Rotterdam
- Göteborg
Challenges

- Range
- Accuracy (Optical systems = Absolute SOx, not relative to air)
- Stabilization
Data Analysis
Data Analysis

- Measuring SOx
  - Accuracy not essential, but of course beneficial
- Identify non-compliant vessels
Laser Measurements

Pros

- Speed
- Range

Cons

- Only measures SOx
Which Vessels to Target

1. High SOx Emissions
2. Undetected Vessels
3. Detection Avoidance
Targeted Port Control
Targeted Port Control

- Specific: non-compliant and suspicious ships
- Extention of port control:
  - Soot sample from stack
  - Heat resistant sampler
  - Chemical analysis
Soot

- SOx in exhaust gas deposits on PM
- PM deposits in stack

  Relationship SO₂ concentration/adsorption: OK

  ▸ Relationship soot deposition: ?

  Back calculation: ?

(Fig. 6 SO₂ adsorption as a function of SO₂ concentration

O; coal combustion fly ash, ●; coal combustion soot,
×; oil combustion fly ash, ○; Liberti et al.,
△; Tartarelli et al.
The number presents relative humidity

(Murao et al., 1983)
Sampling

- Heat resistant sampler
  - Vulcano sampler

- No need to stop engine
  + Time and money saving
Analysing

- Standard oil/fuel analyser?
  e.g. SpectrOil®, MiniLab® (Spectro Scientific)
    +: portable, in situ analysis
    fast
    -: solid (soot) vs fluid (oil)

- Lab analysis - spectroscopy
  e.g.: ICP-MS, IR, ....
  +: established methods
  -: slower
Conclusions & Prospect
Cost Guestimate

One-time costs

- Laser: 50,000 DKK
- Stabilisation: 50,000 DKK
- Installation: 50,000 DKK
- Port receiver: 20,000 DKK

Total cost of equipping entire Maersk Line fleet of 605 vessels and 343 ports:

98 mio DKK

Annual cost

- Maintenance: ?
- Data center: ?
What is next?

- Assess viability
  - Passing distance and frequency
  - Estimate SOx contents without CO₂ measurements
- Develop soot test
- Partner up!
  - Ports
  - Insurance
  - Tech
Thank you, questions?