Performance Monitoring and Analysis for Operational Improvements

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Outline

1. Background

2. Performance monitoring and data collection

3. Performance monitoring tool

4. Performance analysis

5. Examples

6. Concluding remarks
1. Background
1-1. GHG emissions regulations

- SEEMP (Ship Energy Efficiency Management Plan)
  - MEPC 62 adopted revisions of MARPOL Annex VI introducing EEDI and SEEMP
- Entry into force date: 1 January 2013

Operational measures
- slow steaming
- weather routing
- hull and propeller maintenance

Plan | Do | Check | Act

Continuous monitoring & improvement

EEOI trend

Voy. 1 | Voy. 2 | Voy. 3 | Voy. 4 | Voy. 5 | Voy. 6 | Voy. 7 | Voy. 8

EEOI [g/ton-mile]
1-2. Shipping companies’ efforts for fuel saving

- According to increased cost of bunker, shipping companies have made efforts for fuel saving by operational and technical measures
  - Slow steaming
  - Weather routing
  - Performance monitoring
  - Applying energy saving devices

<table>
<thead>
<tr>
<th></th>
<th>Slow steaming</th>
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</thead>
<tbody>
<tr>
<td>Ship speed</td>
<td>24 knot</td>
</tr>
<tr>
<td>M/E fuel consumption</td>
<td>225 ton/day</td>
</tr>
<tr>
<td>M/E fuel cost (@ 600 USD/MT)</td>
<td>134,800 USD/day</td>
</tr>
<tr>
<td>CO2 emission</td>
<td>696 ton/day</td>
</tr>
</tbody>
</table>

Cost benefit and emission reduction by slow steaming

e.g. 8,000 TEU container

- Slow steaming

<table>
<thead>
<tr>
<th></th>
<th>Slow steaming</th>
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<tbody>
<tr>
<td>Ship speed</td>
<td>20 knot</td>
</tr>
<tr>
<td>M/E fuel consumption</td>
<td>130 ton/day</td>
</tr>
<tr>
<td>M/E fuel cost (@ 600 USD/MT)</td>
<td>78,000 USD/day</td>
</tr>
<tr>
<td>CO2 emission</td>
<td>403 ton/day</td>
</tr>
</tbody>
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- 16 %

- 42 %
1-3. Example of actual fuel consumption - same service and same size of vessel

Comparison of total fuel consumption per voyage
Same ship size and same voyage

- Total fuel consumption per voyage largely differs -> Why?

![Bar chart showing comparison of fuel consumption per voyage.](image)
1-4. Base performance + additional factors

- Break down analysis is necessary to identify cause of fuel consumption

- Effect of distance increase
- Effect of speed allocation
- Effect of speed increase
- Effect of weather
- Generator use
- Effect of ship hull condition
- Effect of draft and trim
- Ship base performance
2. Performance monitoring and data collection
2-1. How can we improve operation?

- "Monitoring" is the key function - Basis of evaluation and action planning
2-2. Performance monitoring for right awareness

- If awareness is wrong, decision making and action will be wrong

- What is necessary for right awareness
  - **Provide correct and necessary information in right time**
2-3 Monitor ship performance
- Every 1 hour data is necessary for right awareness

• Existing data collection approaches
  – Manual reporting (every 24 hrs)
  – Automatic data collection (sampling can be every 1 sec)

• Every 1 hour data give detail information about performance
  – Speed increasing profile and effect of current can be seen in the 1 hour interval graph.

• Manual logging is inherently difficult for OG and wind.
  – Values of OG speed and wind are changing rapidly. Better to rely on computer power.
2-4. Automatic data collection onboard

• Requirements
  • Interface to existing onboard equipment, such as engine D/L, ECDIS, VDR, flow meter and etc.
  • Automatic data processing and transferring to shore
  • Least additional load on crews
  • High reliability ... 24 hrs, 365 days work
  • Lower cost of implementation
  • Flexibility of customization
3. Performance monitoring tool
3-2. Onboard performance monitoring

- **FUELNAVI**
  - Real time performance indicator in bridge
  - Performance index
    - OG speed / fuel consumption [NM/MT]
    - Fuel consumption [MT/day]
  - Trip meter function for onboard performance trial
    - Energy efficiency evaluation
3-3. Performance monitoring at shore

- Comparison plan with actual
  - Speed
  - RPM
  - Buffer time (speed margin)
  - M/E load
  - Fuel consumption
3-4. Performance monitoring by weather routing provider

- Monitoring data is also sent to weather routing provider

- Comparison between voyage plan and actual
  - Ship performance (rpm, speed, fuel consumption)
  - Weather condition (wind and ship motion)

- Corrective action
  - Update voyage recommendation

(part of voyage plan sheet)
3-5. Performance analysis report

- Help action planning for operation improvement and information sharing between operators and vessels

- Consists of 10 pages
  - Summary of voyage data
  - Analysis of FOC increase causes
  - Comparison with the other vessel record
  - Evaluation of weather routeing
  - Advice for fuel saving
4. Performance analysis
4-1. Voyage overview

- Overview how vessel operated from departure port to arrival port

Encounter rough sea

- Higher M/E load

- Optimum M/E load

- Slip as weather index

- Drifting

- M/E RPM

- Speed (log, SOG)

- M/E load [%], Slip [%]
4-3. Quantify and evaluate FOC increase factors

- Compare each FOC increase factors with past record

![Graph showing FOC increase factors for Distance, Speed, Weather, and Speed allocation.]

- Speed allocation
  - Voy. 45: 32.9
  - Average: 35.7
- Weather
  - Voy. 45: 148.4
  - Average: 77.5
- Distance
  - Voy. 45: 10.5
  - Average: 47.1
- Speed
  - Voy. 45: 27.8
  - Average: 15.4

"Performance Monitoring and Analysis for Operational Improvements", Hideyuki Ando, MTI, NYK Group
International Conference on Ship Efficiency 2011, 26-27 Sep 2011 in Hamburg by STG
4-4. Identify base performance from collected data

Oakland to Tokyo 10 days leg

Data interval: 1 hour (about 240 data)

- All data
- Less than Beaufort 2
- Less than 2° pitch
4-5. Identify FOC increase by weather

Voyage: 41
Leg: Trans-Pacific

Speed - fuel consumption curve

FOC increase by weather

Base - calm sea performance

Pro forma speed

- Green dots: All data (226 hours)
- Blue line: Calm (Beaufort 2 or less)
- Green line: Best condition
- Red line: Worst condition
- Purple line: Average condition
4-7. Review of weather routing

- Longer voyage distance causes large FOC increase
  - Requires speed up to keep schedule
- Review of weather routing and discussion with its provider
4-8. Coaching comments for corrective action planning

- Coaching comments for fuel saving are attached
- It helps understanding data and supports corrective actions of parties who concern

Example

- **Total FOC was 950 tons, which is the second largest value among past records.**
- **The main cause of FOC increase is 500 miles longer distance than plan, which caused 80 tons FOC increase.**
- **But FOC was saved 100 tons by reducing speed, schedule changed in advance.**
5. Examples
5-1. Share good practice

- Share good practice between operators and vessels
  - Keep averaged engine load until end of voyage
5-2. Example of operation improvement (1)

- There is 12 knot speed restriction area within 40 miles from a port
- Slow down too early timing was observed
- Approach to port was advised to captain and improved in the following voyage
5-3. Example of operation improvement (2)

- After T/C cut, the M/E can be continuously operated under 50%.
- However, there was a case that a C/E was still combining 10% low load and higher M/E load to operate shaft generator instead of diesel generator.
- This operation was less energy efficient in terms of total optimization and operation rule was changed after discussion.
6. Concluding remarks
Another reason for automatic data collection
- Feedback to Weather Routing Provider

- Voyage plan
  + course, speed, rpm, FOC, weather
  + ship performance model

- Voyage actual
  + actual speed – rpm
  + actual weather

Ship model and weather forecast are inherently include errors.
But feedback loop by monitoring can make this system work.
Concluding remarks

- For further improvement of ship energy efficiency in operation, detail information by using automatic data collection and analysis are necessary.

- There are several feedback loops for operation performance improvement. Providing right awareness to them is necessary.

- Especially the combination between weather routing and performance monitoring is important and it is our next things to do.

- It is organizational improvement process for energy efficient fleet operation. This direction will be in line with coming SEEMP.
Roadmap of performance monitoring

Weather Routing & SIMS Monitoring
2010 -

Onboard Weather Routing Trial
2005 - 2006

Fleet Monitoring
Ship Monitoring
SIMS 2008 -

Fuel Consumption Monitor FUELNAVI
2007 - 2008

Electronic Ablog SPAS
2006 -

Performance Monitoring
2010 -

NYK e-Missions’ 2009 -

Optimum Weather Routing Safety + Economy + Schedule 2009 -

Real time Weather Routing & Monitoring
• Real time communication
• Precise ship performance model
• Onboard sea-keeping simulation 2012 -

Technical Performance Analysis
• Ship appendages
• Paint
• M/E governor
• New design propeller 2008 -

Performance Validation of Low Emission Machineries
• Hybrid Turbo Charger
• Battery (Giga Cell)
• W.H.R 2011 -

Accurate Performance Monitoring and feedback to Ship Design
• Accurate wave and wind measurement
• Accurate torque and thrust measurement
• Accurate log speed measurement
• Accurate fuel consumption measurement
• Ship performance model 2012 -

Smart Ship 2014 -
• Minimize emissions
• Integration of navigation equipment and weather routing
• Automatic performance model identification

SEEMP package
• Voyage planning
• Monitoring
• Evaluation and action 2012 -

Best balance S.E.E.
Optimum Fleet Management
• C/B maximize with weather routing and monitoring
• Minimum emissions with SEEMP
• Safety management at rough sea 2014 -

CO2 minimize

To Achieve Best Balance of Safety, Economy and Environment

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Thank you very much for your attention