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Introduction of HiMSEN DF Engine Control System and IoT Solution

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11th CIMAC CASCADE / 11th October, 2019.



- Introduction
- HiMECS : Knock Detection & Anti-knock Control
- HiMECS : Cylinder Balancing Control
- HiMECS : Software Reliability & Validation
- HiEMS : A Case Study about Operating Guidance
- Summary

Introduction

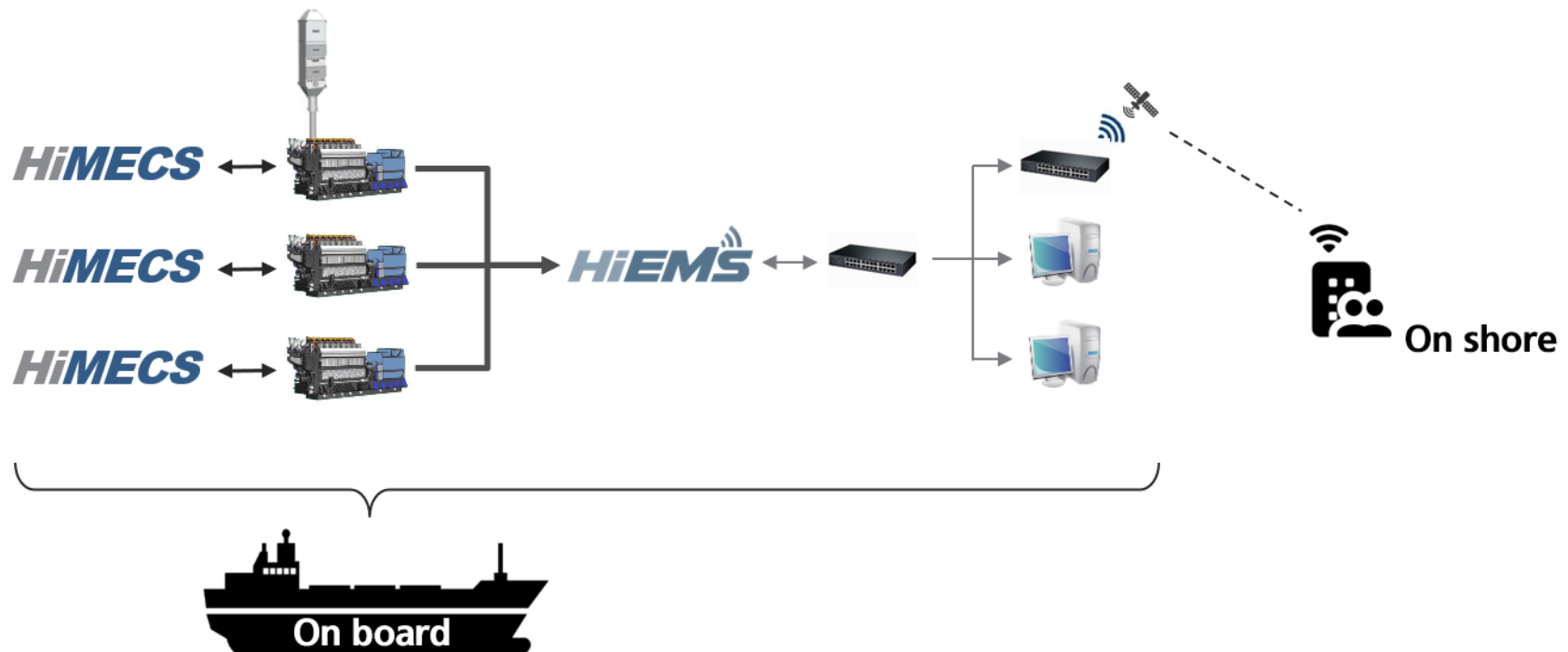
HiMSEN DF engine control system & IoT solution

HiMECS

Hyundai Intelligent Machinery & Equipment Control System

HiEMS

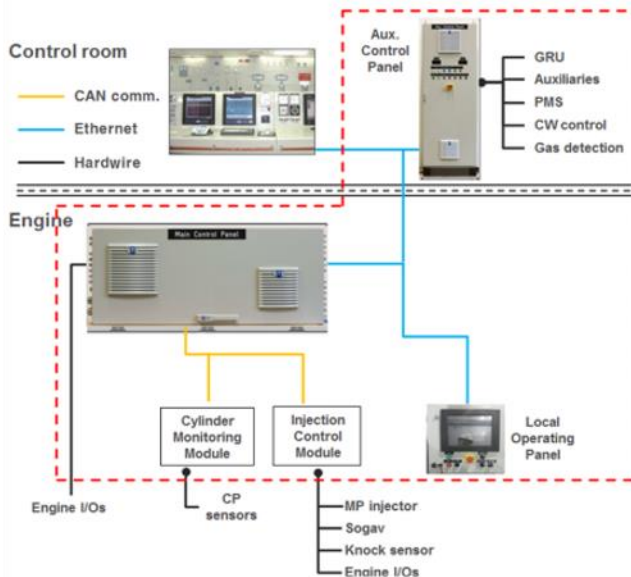
Hyundai Intelligent Equipment Management Solution



- Electronic control system for the HiMSEN dual-fuel/gas/clean engine, SCR system
- Consist of reliable hardware & software with SiLS & HiLS
- HMI, service software for setting/monitoring/analysis

HiMECS for DF Engine

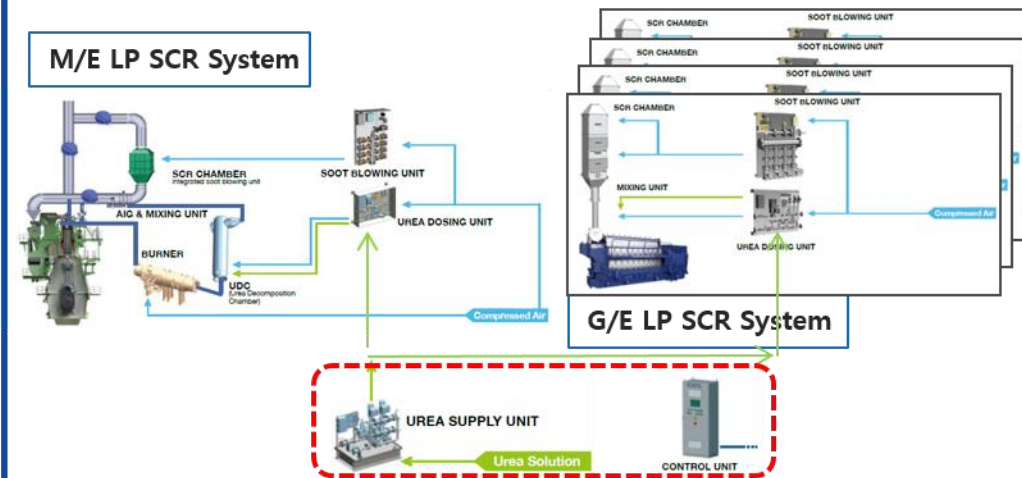
HiMECS System Configuration



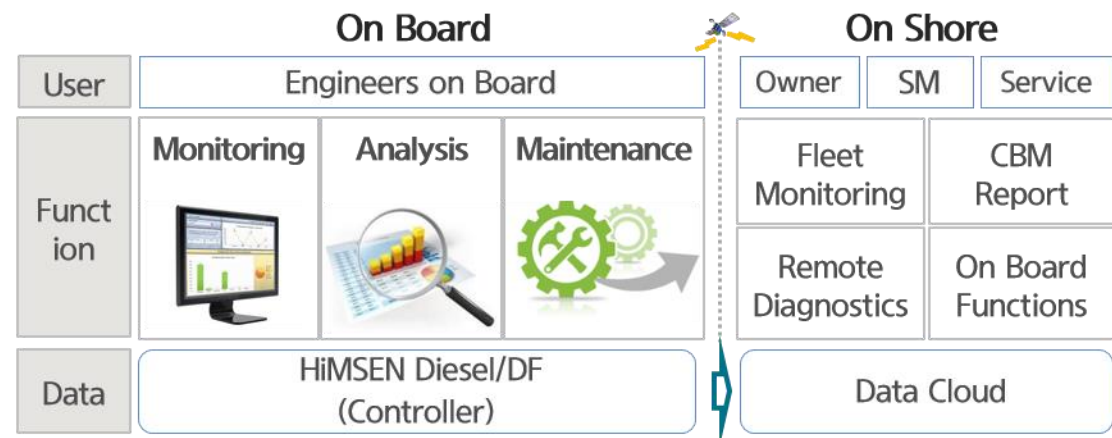
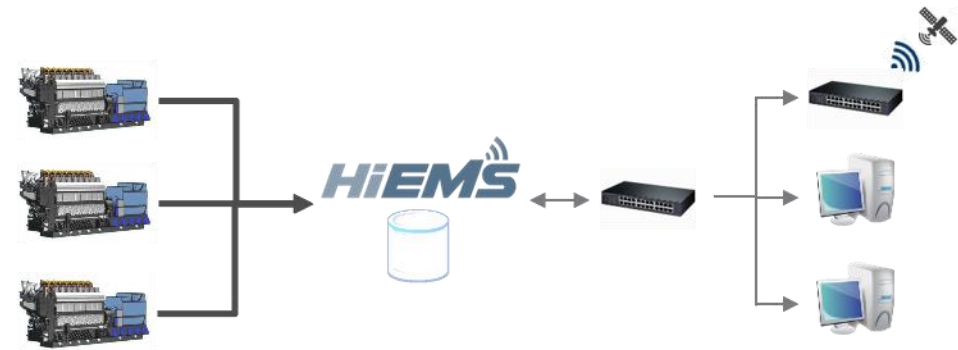
Control & Monitoring



HiMECS for SCR System



- HiEMS is a CBM total solution not only for Hyundai HiMSen engine but also other equipments
- Consist of IoT based edge computing system with on shore system
- Data acquisition, monitoring, Storing from the thing
- Provides a guidance of normal operation and trouble shooting
- Owners and operators can be supported with appropriate guidance on time
- System analysis report can be offered periodically



* CBM : Condition based maintenance

HiMECS

Knock Detection & Anti-knock Control

DF Engine & Electronic Engine Control System



DF engine

=

Conventional
Diesel combustion

+

Pre-mixed lean
combustion

- Diesel mode operation
- Meets IMO Tier II NOx regulation

- Gas mode operation
- Meets **IMO Tier III NOx regulation**



Electronic Engine Control System
is needed to operate DF engine

➤ System Requirements for DF Engine Control System

✓ Common

- Speed / power control
- Air-fuel ratio control
- Cooling water & lubrication oil control
- Interface with other auxiliary equipment for engine operation
- Communication
- Safety

✓ For gas mode operation

- Fuel change-over function
- Micro-pilot fuel injection control
- Gas admission valve control
- Gas regulation unit control
- Misfire detection
- Anti-knock control
- Cylinder balancing control

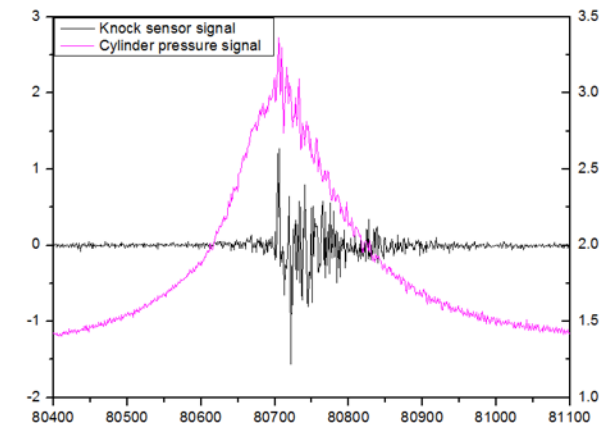
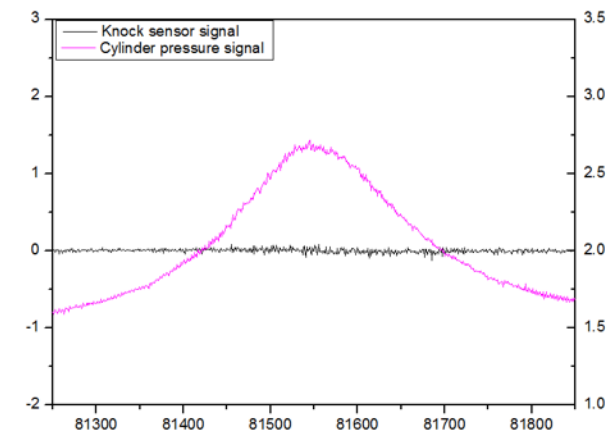
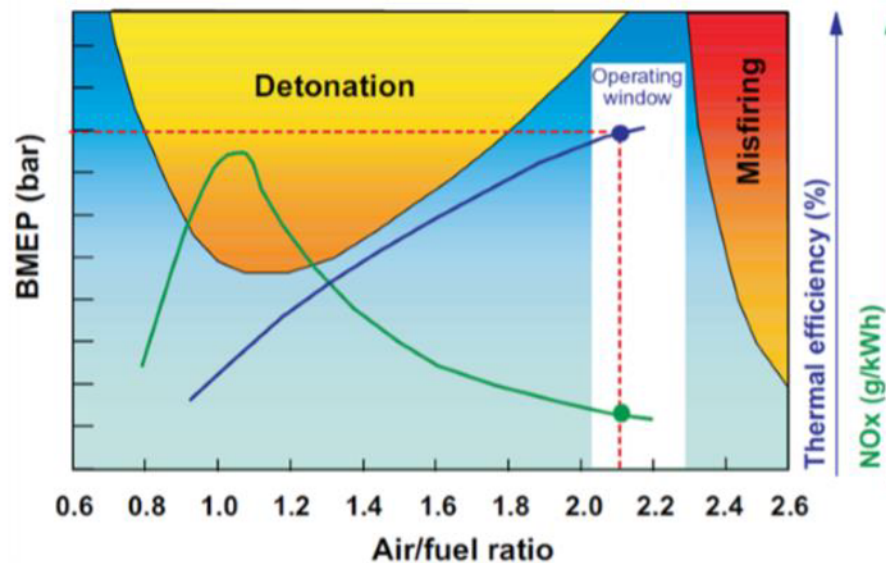
- For gas mode operation itself...
 - ✓ Micro-pilot timing and duration for fuel amount should be controlled
 - ✓ Gas admission value timing and duration should be controlled
 - ✓ Safety functions must be prepared

- To maintain the engine performance and durability along safety
 - ✓ **Anti-knock control**
 - ✓ Misfire detection and control
 - ✓ Cylinder balancing control

Knock Detection

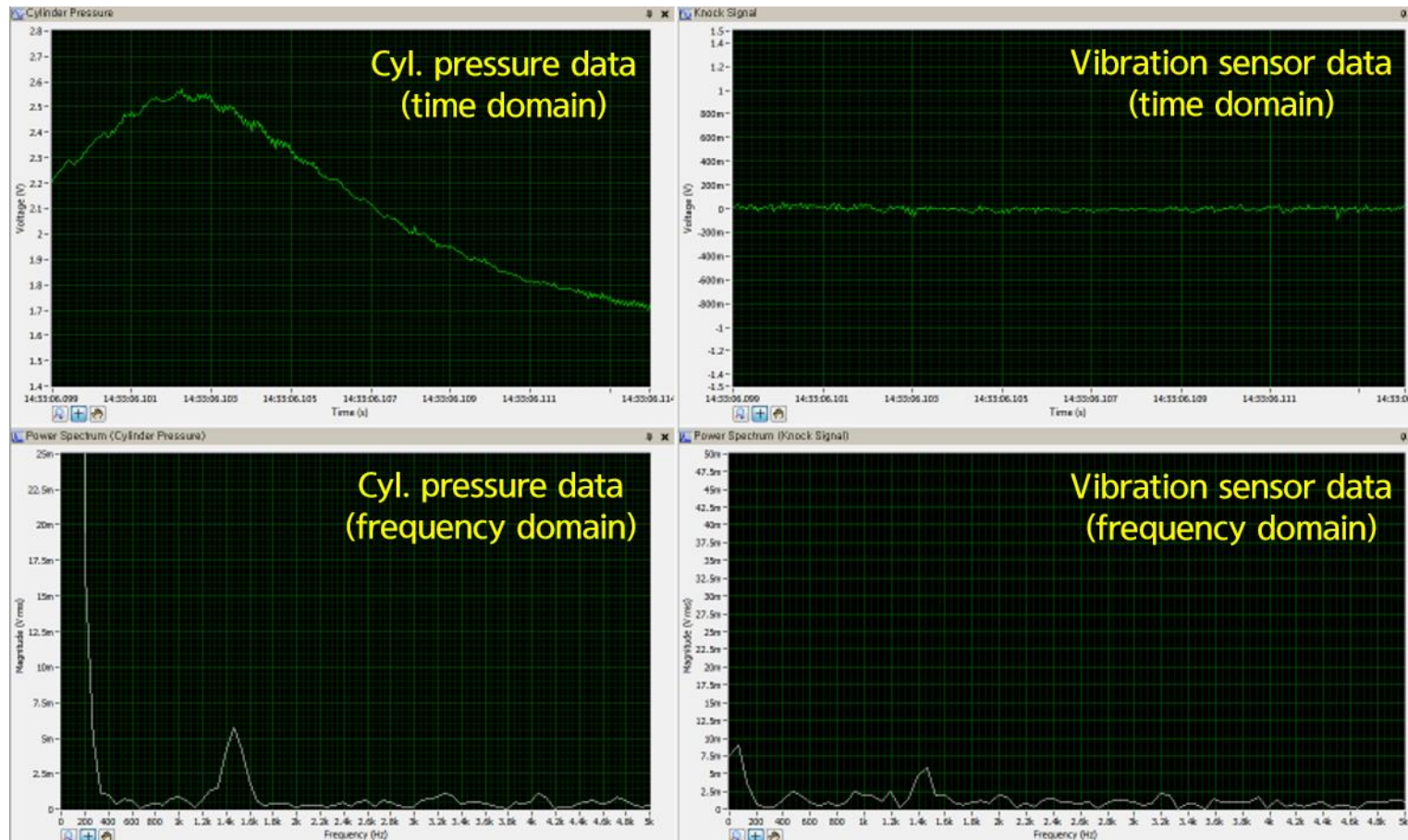
Engine Knocking

- Knock is a violent and damaging reactions to improper conditions during the cylinder combustion
- The cause of knock is assumed detonation or auto-ignition from hot spot
- Knock detection
 - ✓ Cylinder pressure sensor
 - ✓ Vibration sensor



Knock Detection

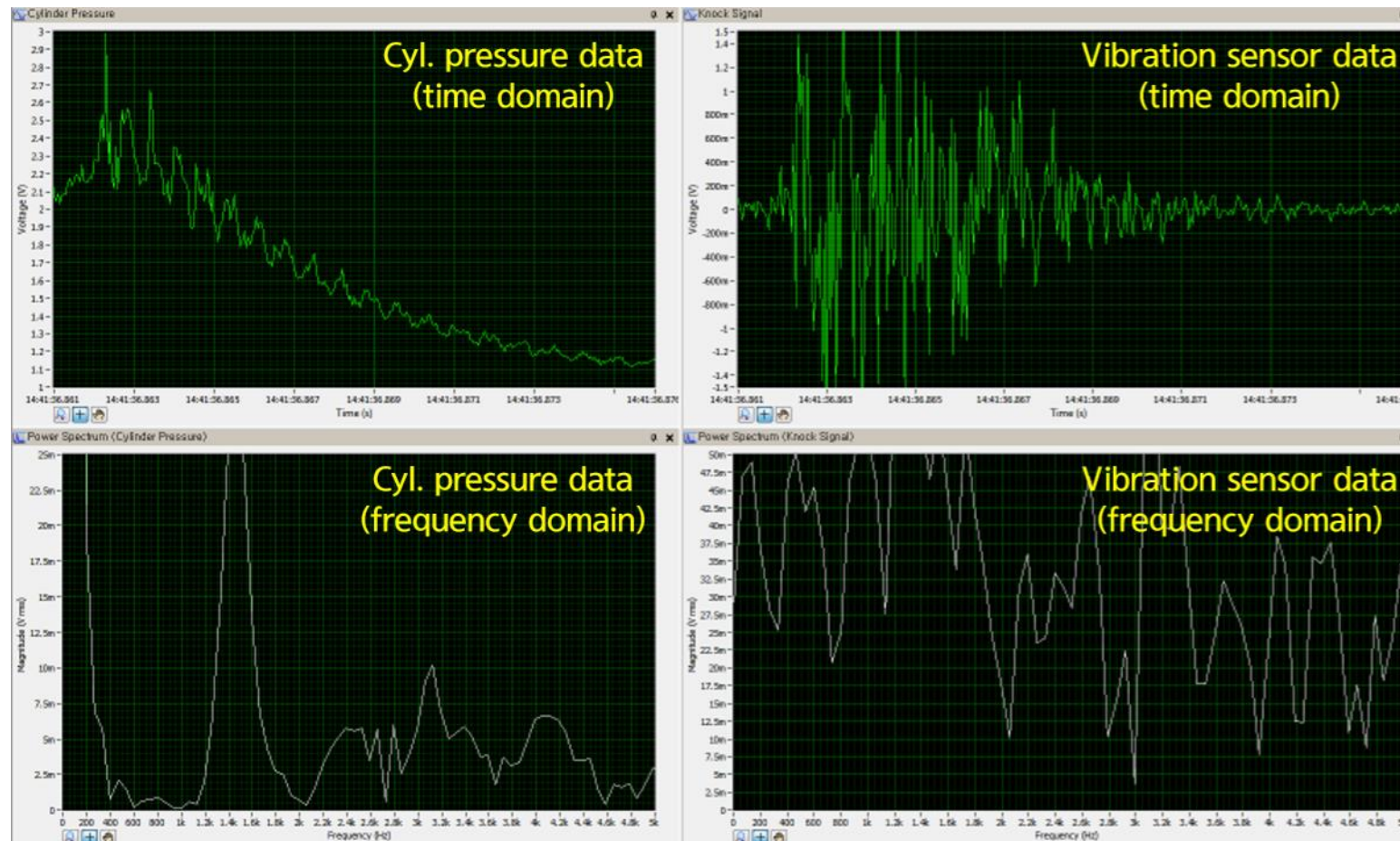
Measurement (normal combustion condition)



Pressure sensor Vs. vibration sensors using FFT

Knock Detection

Measurement (knocking condition)

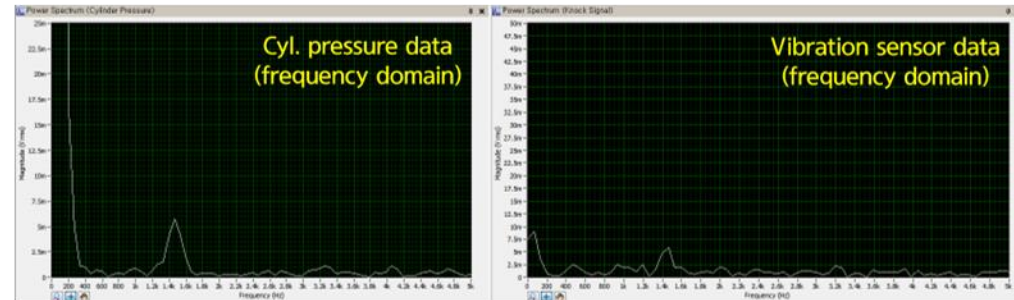


Pressure sensor Vs. vibration sensors using FFT

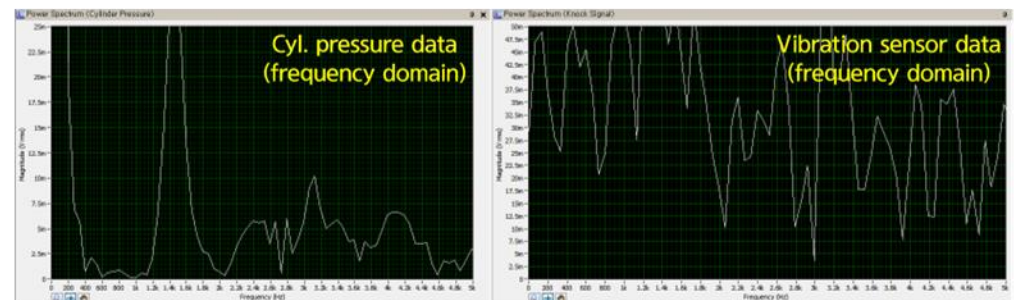
Knock Detection

Comparison

- Both sensor can be used to detect knocking
 - ✓ Magnitude spectrum is obviously increased in the knocking condition
- Pressure sensor
 - ✓ Easy to define knock bands and implement
 - ✓ Can't detect diesel knock
- Vibration sensor
 - ✓ Diesel knock can be detected
 - ✓ Knock intensity can be measured in time domain (CPU load will decreased)



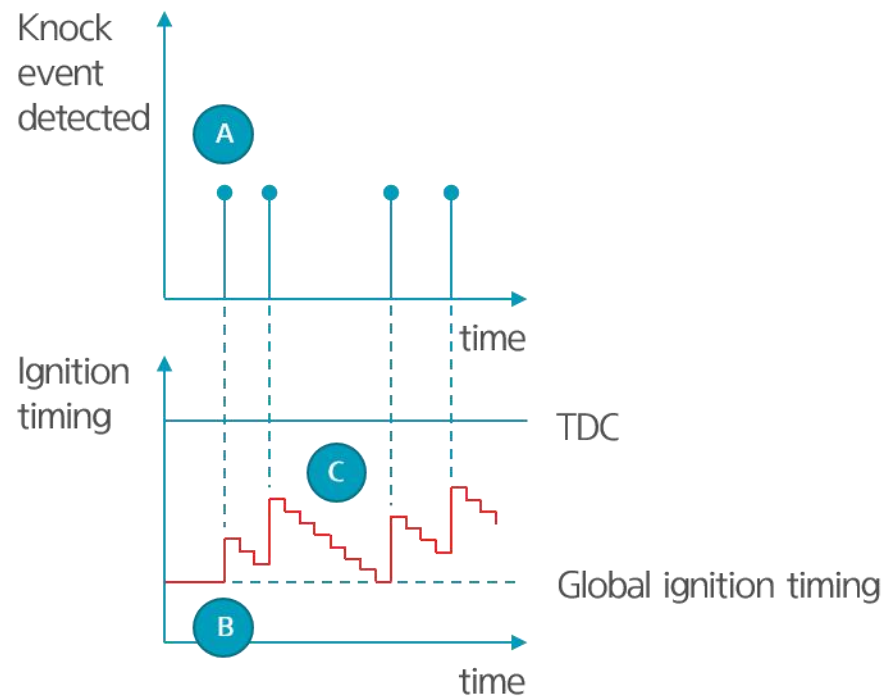
Spectrum for normal combustion



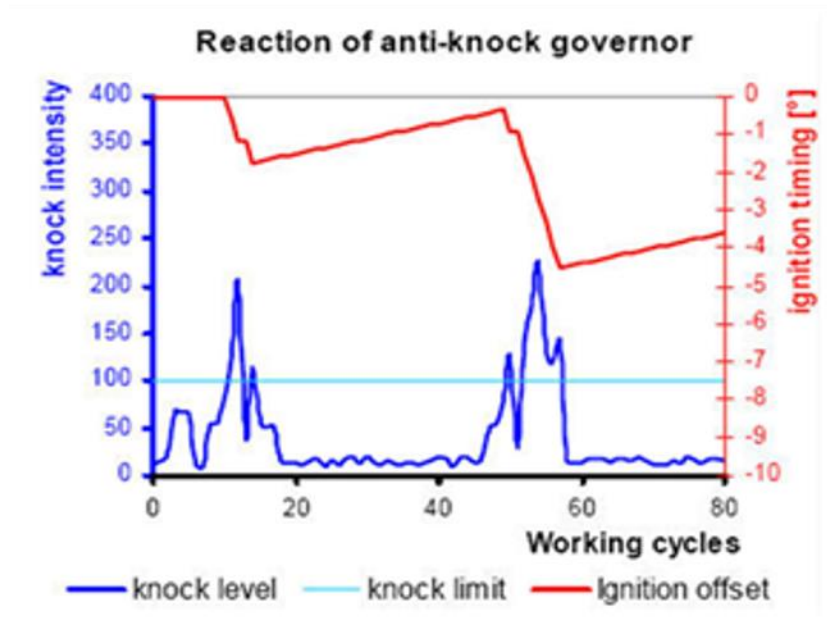
Spectrum for knock combustion

➤ Basic anti-knock control

[2016 | 040 Cylinder Individual Combustion Control of Gas and Dual Fuel Engines]



- A** Knock event detected
- B** Retard ignition timing
- C** Re-advanced ignition timing for each non-knocking working cycle

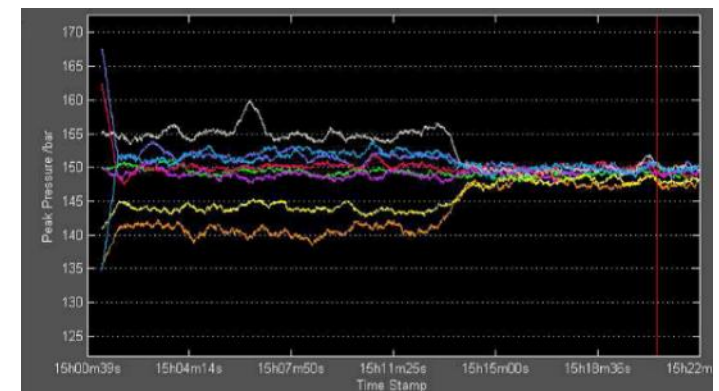
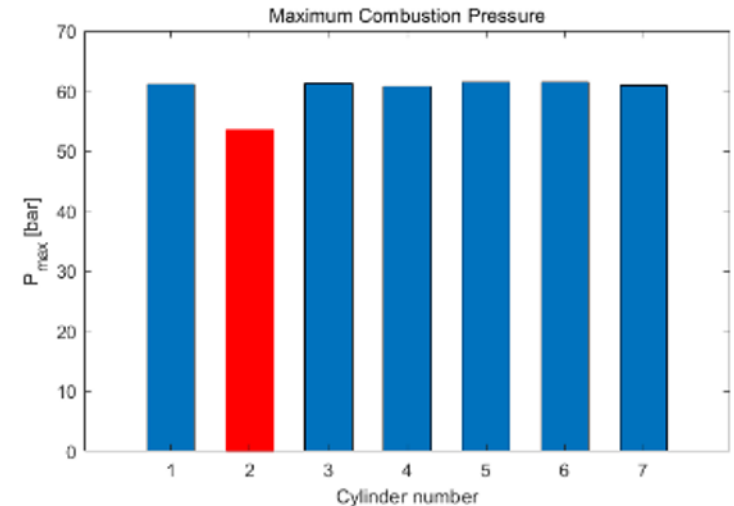


HiMECS

Cylinder Balancing Control

Cylinder Balancing Control

- Purpose
 - ✓ To avoid unwanted stress on mechanical parts from cylinder power deviation
- Constraints
 - Cylinder pressure sensor needed
- Options for cylinder balancing
 - P_{max} (Maximum combustion pressure)
 - IMEP (Indicated mean effective pressure)
 - EGT (Exhaust gas temperature)



HiMECS

SW Reliability & Validation

- HiLS (Hardware in the Loop Simulation)
 - ✓ System validation for engine control system
 - ✓ There are actual MP injectors and gas admission valves
 - ✓ Specific signal can be generated by manual
 - I/O check and monitoring test can be performed safely and easily
 - ✓ For customer & Internal education
 - ✓ It had been used for TAT of engine control system from DNV-GL



5th Dec. 2017
Krzysztof Aleksander JANKOWSKI
Senior Approval Engineer, DNV-GL



"HHI's simulator is very good and sufficient for a type approval testing such a Dual Fuel Engine automation system and it's very inlined with the DNV-GL policy regarding the using the model technology and the digitalization."



A Case Study of Operating Guidance with HiEMS

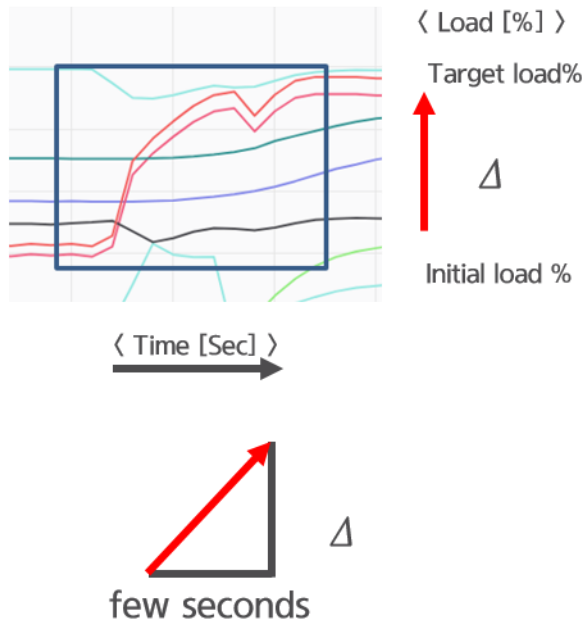
➤ Situation

- ✓ Gas trip had been occurred suddenly from an auxiliary DF engine
- ✓ Engineer who is in charge of periodic monitoring and reporting found this problem
- ✓ There was no complaint from customer about this issue, but investigation was needed to prevented this problem in the future

Case Study about Operating Guidance

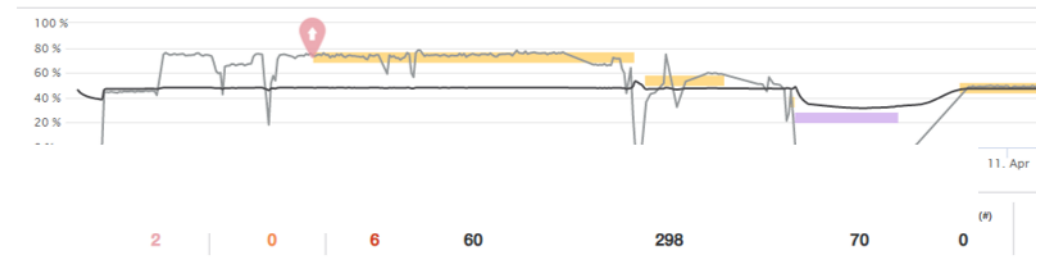
Violation of step load acceptance at gas mode

➤ Case analysis



➤ HiEMS evaluate the every operation of each engine

➤ Owner can establish their engine operation policy and manage their operation



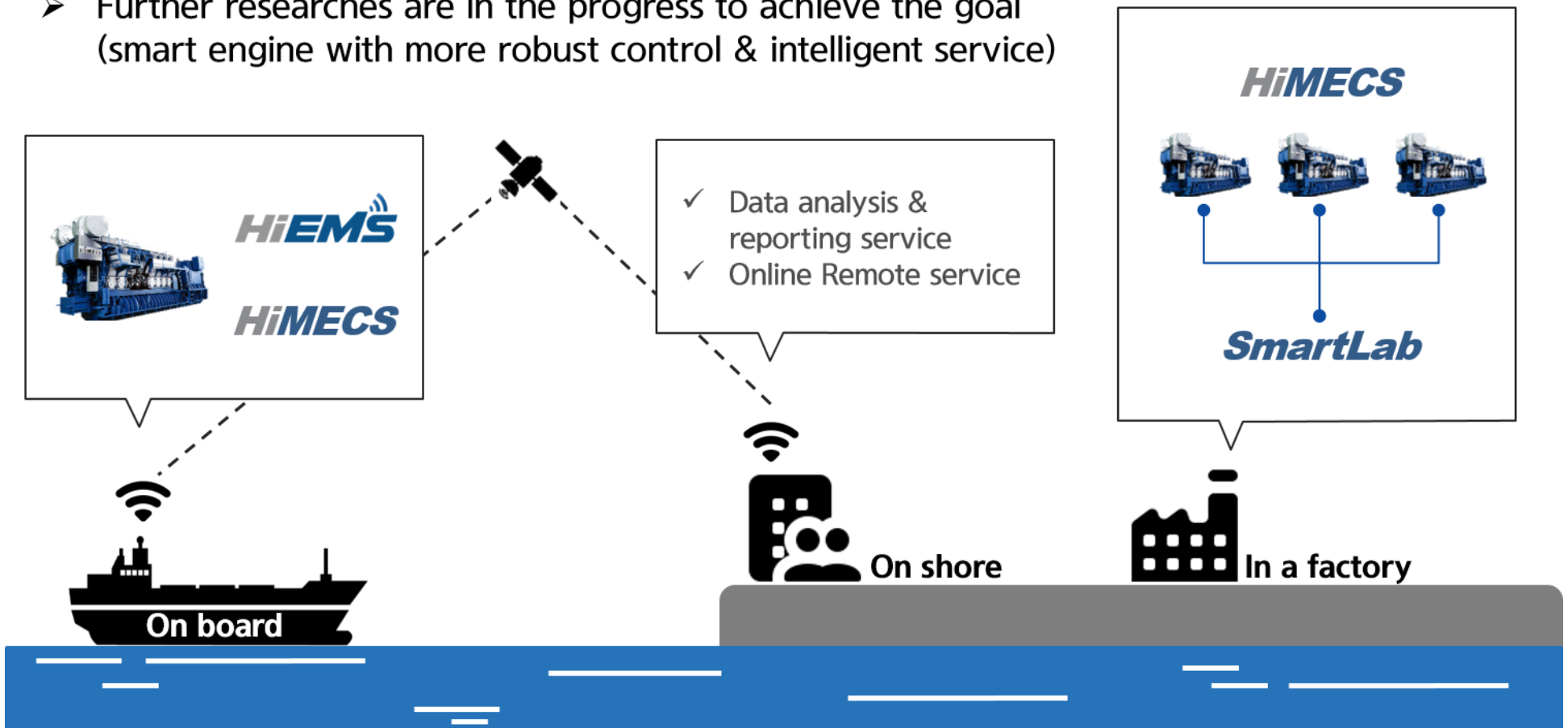
Summary

- HiMECS is a control system that is used not only for HiMSEN DF engine but also SCR system and so forth. HiEMS is IoT solution for management of HiMSEN DF engine and other systems.
- Knocking can be detected by cylinder pressure sensor or vibration sensor. Both sensors can be used to detect a knocking, but when we use vibration sensor we can get further information such as detecting diesel knock
- Basic algorithm for anti-knock control and cylinder balancing control discussed
- SiLS & HiLS are used to make more reliable and robust control system
- Case study of HiEMS was introduced how can be used the IoT based system to support customer

Summary

HiMSEN DF engine control system & IoT solution

- All system are well integrated with each other to serve appropriate service on time
- Further researches are in the progress to achieve the goal (smart engine with more robust control & intelligent service)



Thank you for your attention
