Development of a new evaluation method for the influences of catalyst fines on abrasive wears of marine diesel engines burning heavy fuel oil

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Introduction

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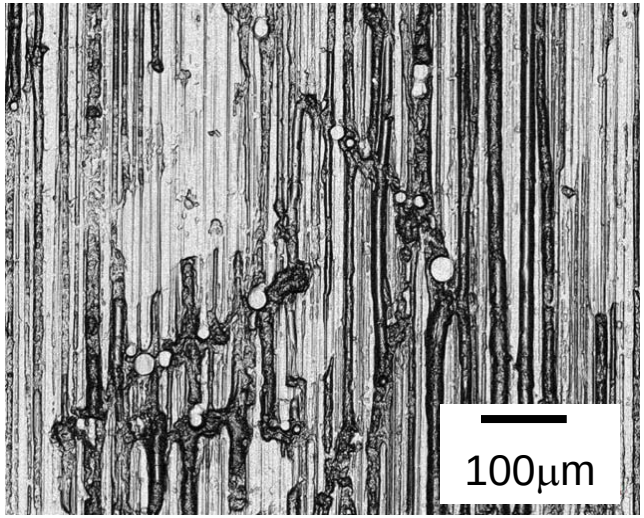
Advantages of our new method

New evaluation method for risk of abrasive wear by hard particles in HFO



Cylinder liner surface

Advantages

- **Easy operation, and done on board**
- **Direct evaluation of risk of abrasive wear**

It is able to prevent the abrasive wear on cylinder liner and piston ring.

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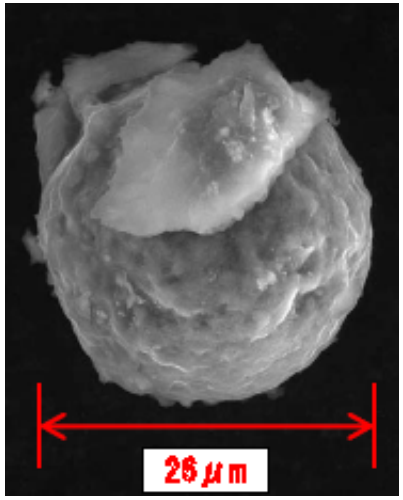
Background of this research

At present, Al+Si content is an index to evaluate the risk of abrasive wear by hard particles in HFO.



FCC catalyst fine in HFO

Basis components are Al_2O_3,SiO_2

Present method

-Focus on FCC catalyst fines in HFO

-Analyzing quantity of Al+Si element

-Evaluation of the risk of abrasive wear according to Al+Si density

It is indirect method to evaluate risk of abrasive wear and, we have experiences abrasive wear on cylinder liner and piston ring with low Al+Si density HFO.

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Detail of experiment

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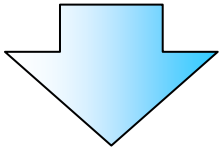
Our approach to develop new evaluation method

Our approach

There is direct correlation between worn iron density and risk of abrasive wear.



Focus on worn iron powder density by abrasive wear.

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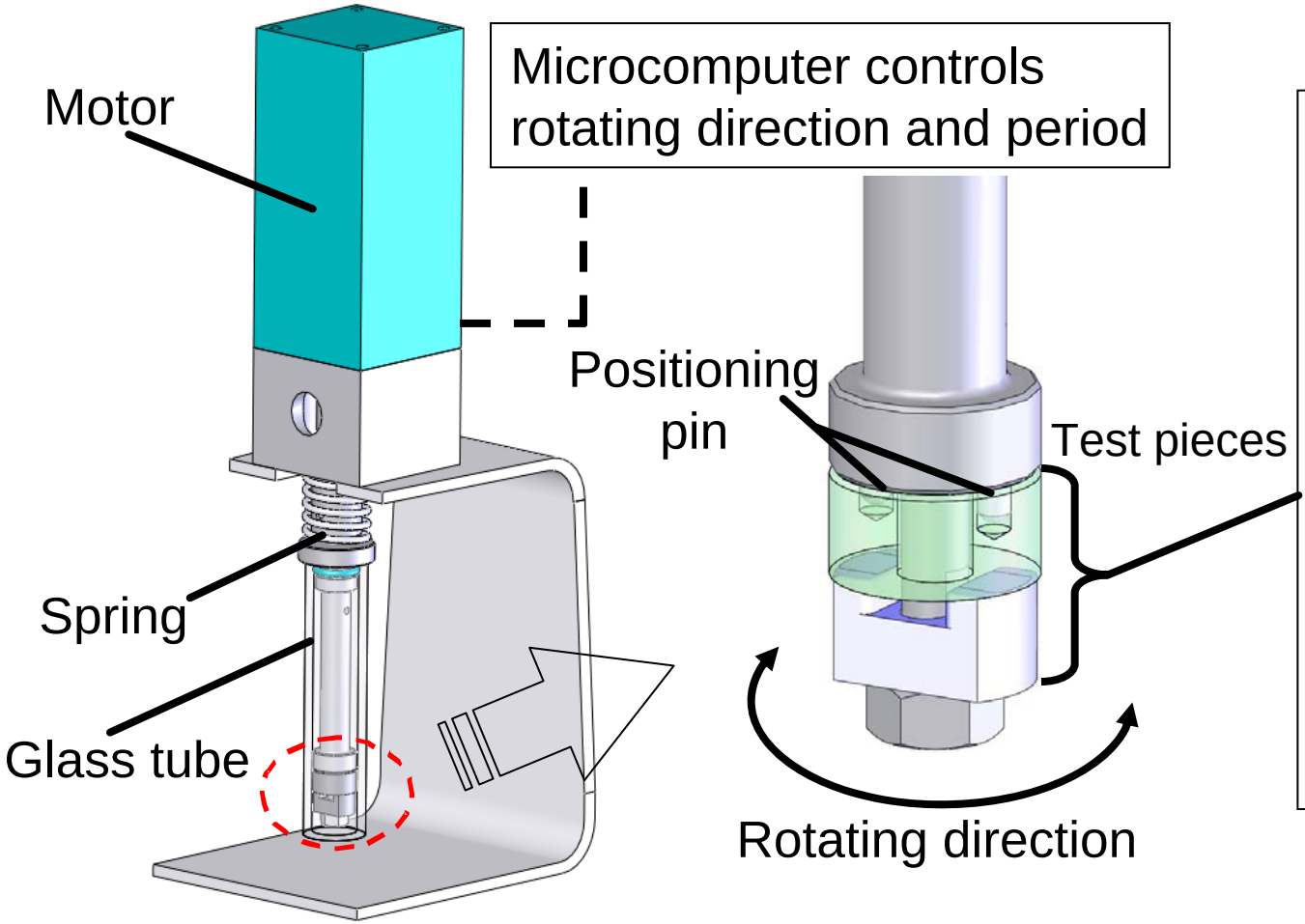
Simulation of cylinder liner and piston ring running

The sliding kit simulates cylinder liner and piston ring running.



Pair of test pieces

Fixing side

Rotation side

ϕ 12mm

11mm

-Material: Mild steel SS400 (JIS)

-Surface finish:Polish

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Operation procedure

Easy operation, and done on board

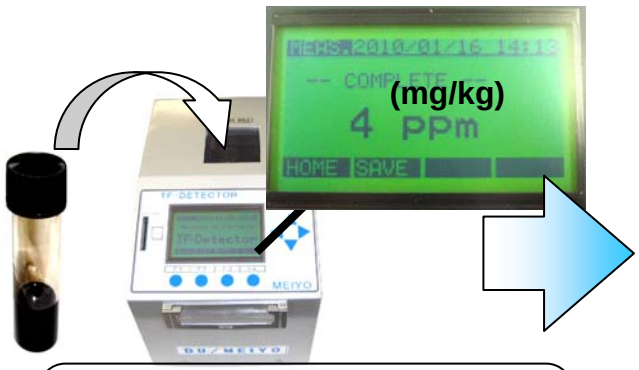
Step.1 Simulating piston running in HFO.

Step.2 If HFO include some hard particles, test pieces will be worn by abrasion.

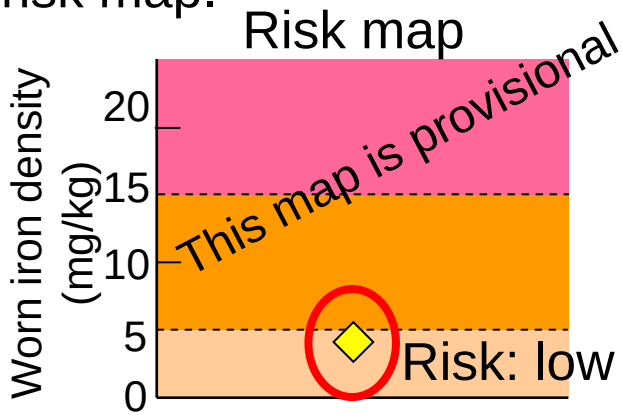
Step.3 Measuring worn iron density in HFO.

Step.4 Evaluate risk of abrasive wear by using risk map.

Simulating piston running



Measuring worn iron density.



Evaluate the risk of abrasive wear.

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Results of experiment

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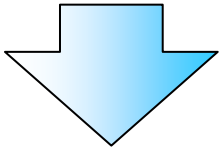
Case 1

High Al+Si density and the HFO caused serious damage on cylinder liner and piston ring by abrasive wear.



Proposed method can catch the risk.

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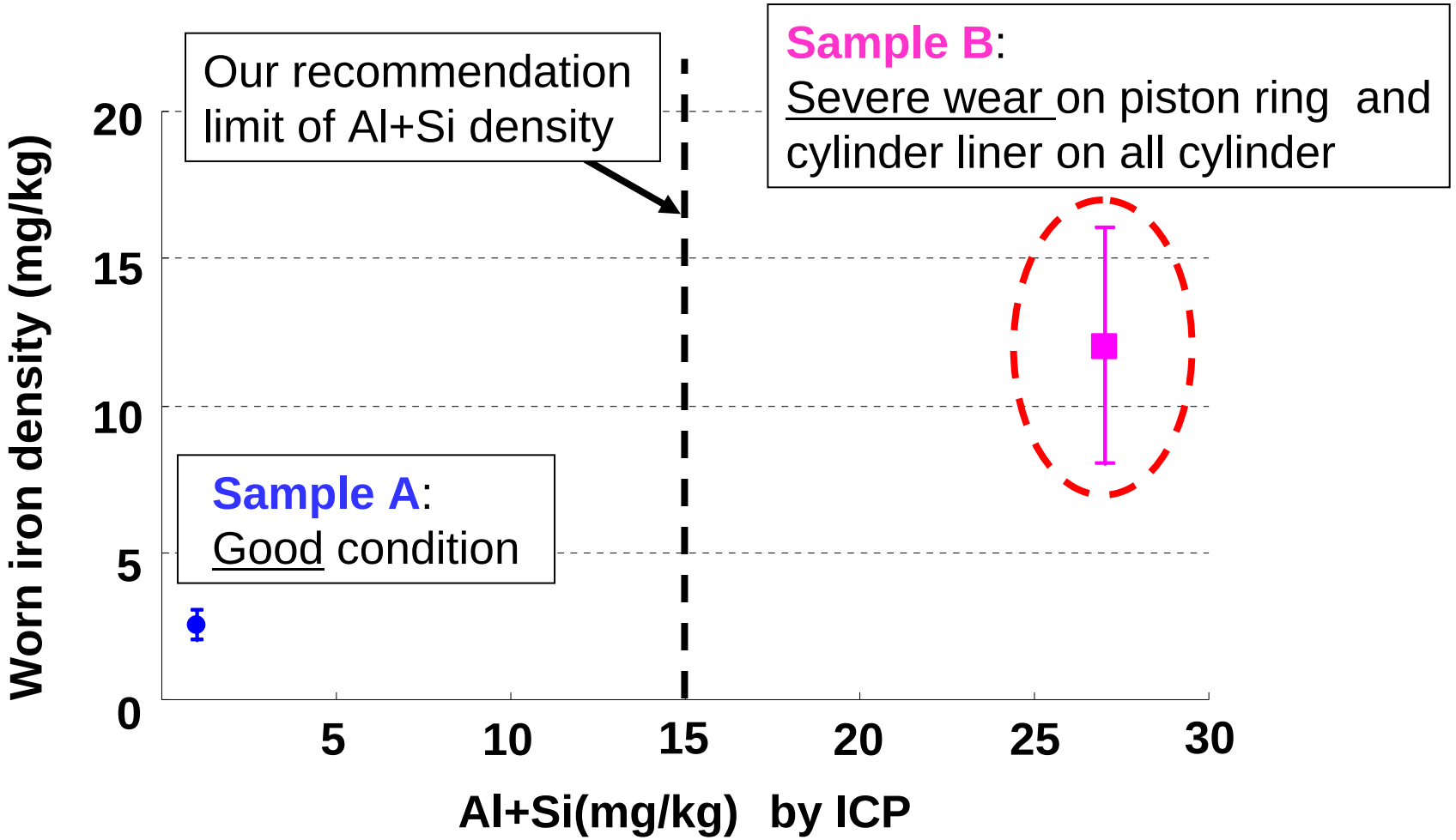
Case1. Result of high Al+Si density HFO which have high risk of abrasive wear

Worn iron density is definitely high by troubled HFO.



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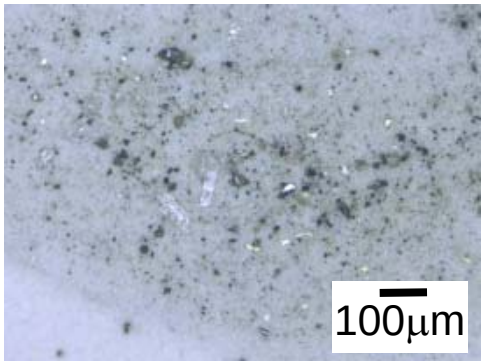
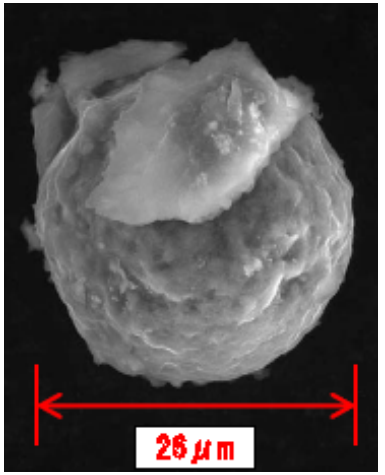
Case1. Hard particles in sample B HFO

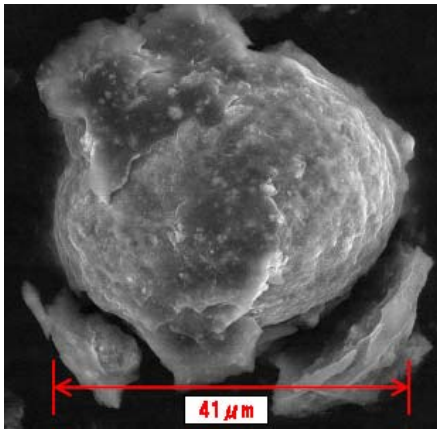
We found some FCC catalyst fines and particles in the HFO.

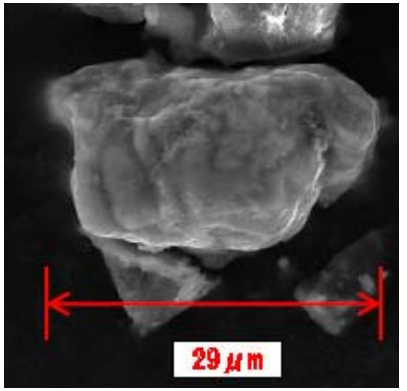
Microscope picture of particles in sample C HFO



SEM
EDS







Basis components			
	-Al:8.3%/wt	**-Al:17.5%/wt**	**Fe:31.6%/wt**
	-Si:13.9%/wt	**-Si:7.7%/wt**	

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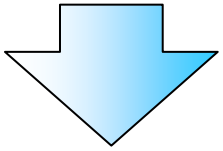
Case 2

Low Al+Si density, but the HFO has certain risk of abrasive wear



Proposed method can catch the risk.

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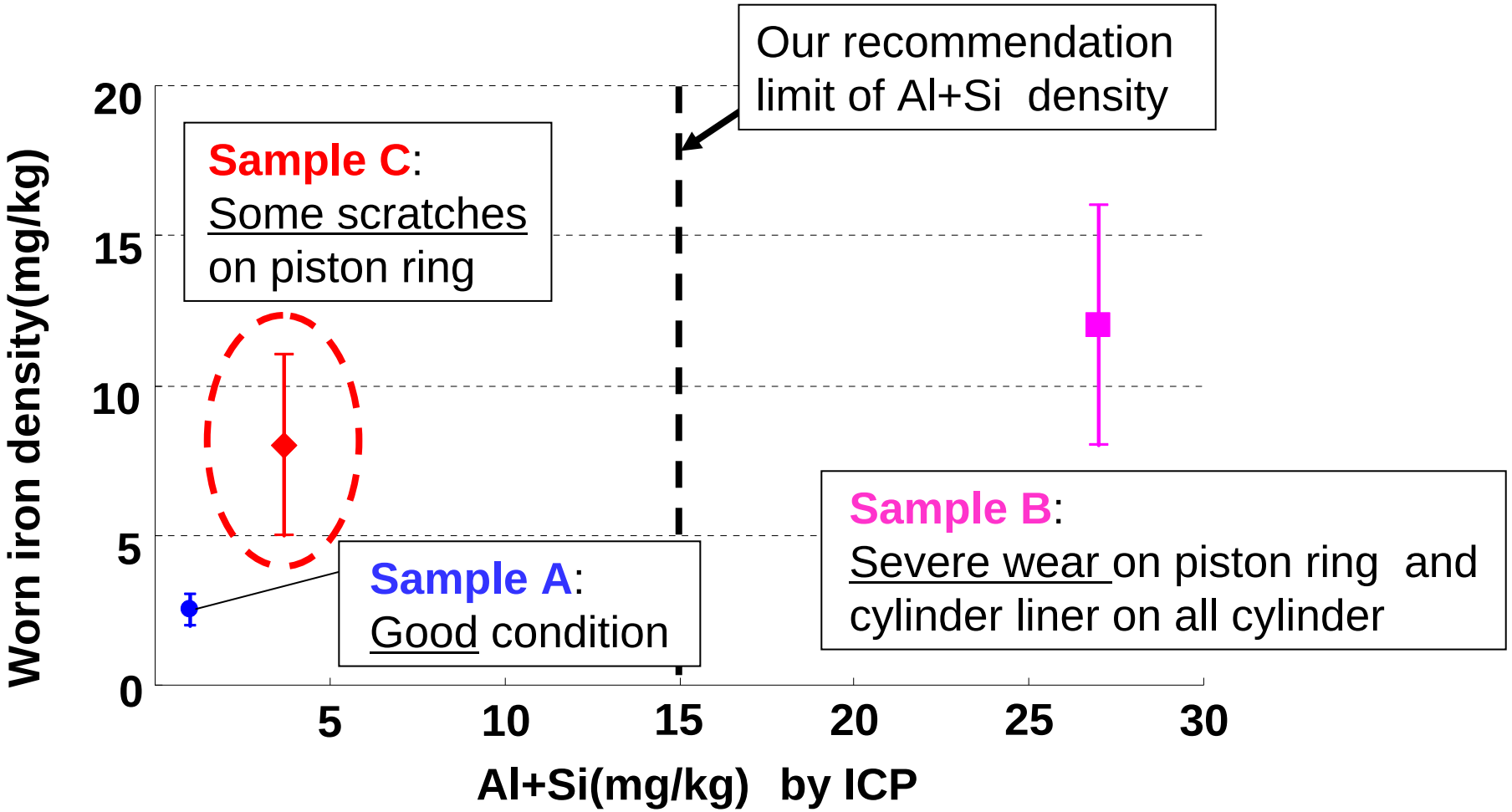
Case2. Result of low Al+Si density HFO which have high risk of abrasive wear.

Worn iron particle density correspond to piston ring and cylinder liner condition.



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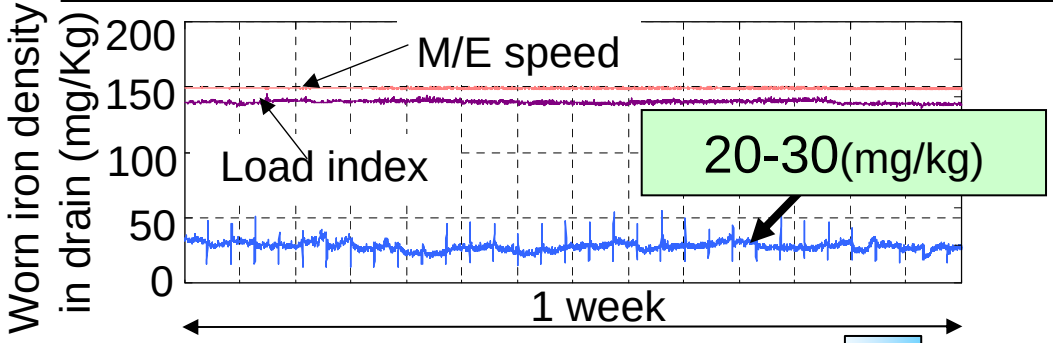
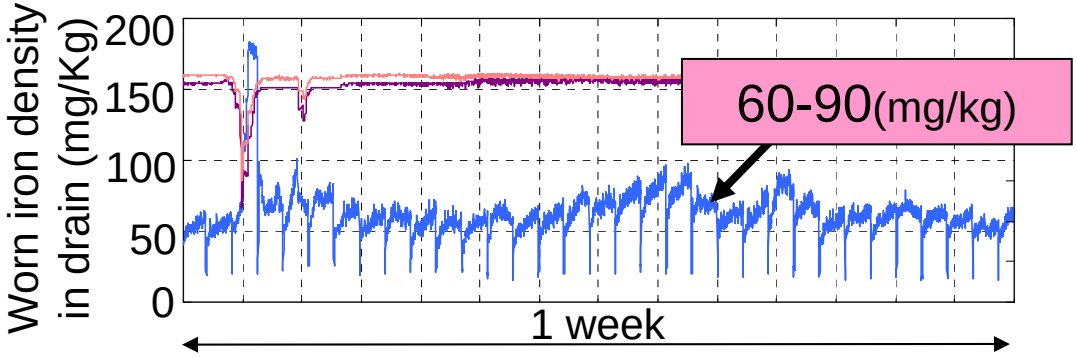
Case2. Worn iron density in cylinder drain oil of sample C HFO

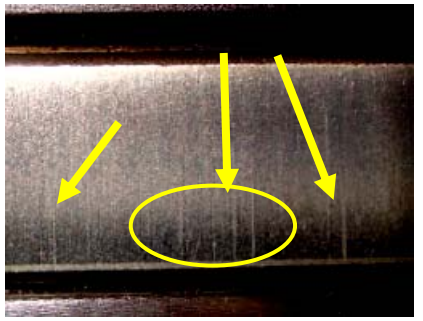
Normal worn iron density in drain and good condition on piston ring.



It changed to **sample C HFO** that Al+Si density is **3.7 mg/kg** at engine inlet.

Worn iron density increased, and scratches were observed on piston ring.





After 800 running hours

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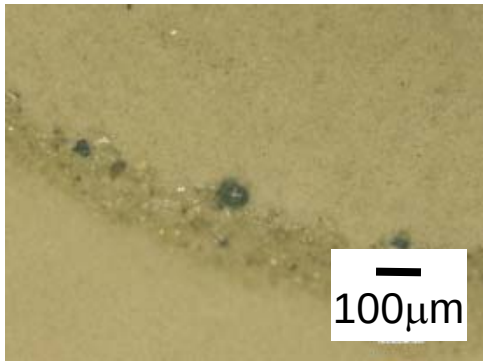
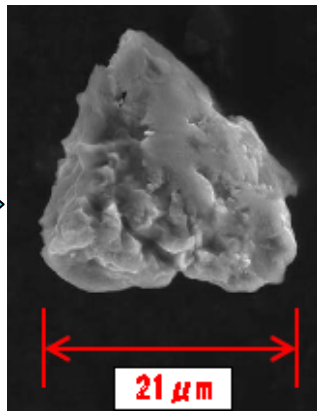
Case2. Hard particles in sample C HFO

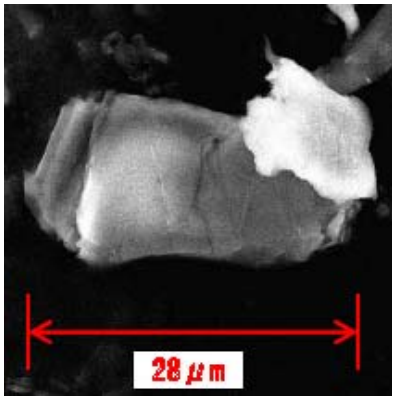
We found some particles in HFO,
but **FCC catalyst fines weren't found**.

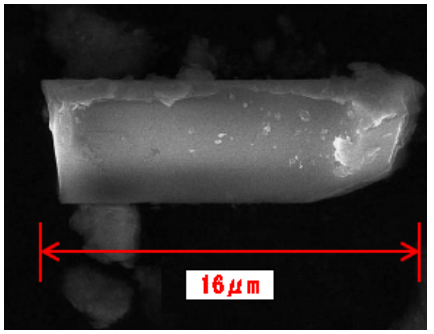
Microscope picture of
particles in sample B HFO



SEM
EDS







Basis components	Fe:36.8%/wt	-Mg:11.6%/wt -Si:17.1%/wt	-Ca:9.2%/wt -Si:14.6%/wt -Al:4.7%/wt

The example shows that **not only FCC catalyst fines but also hard particles in HFO can cause abrasive wear**.

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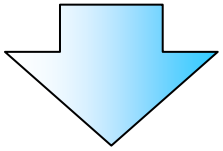
Case 3

Evaluation of the risk of bigger hard particle in HFO.



Proposed method can catch the risk.

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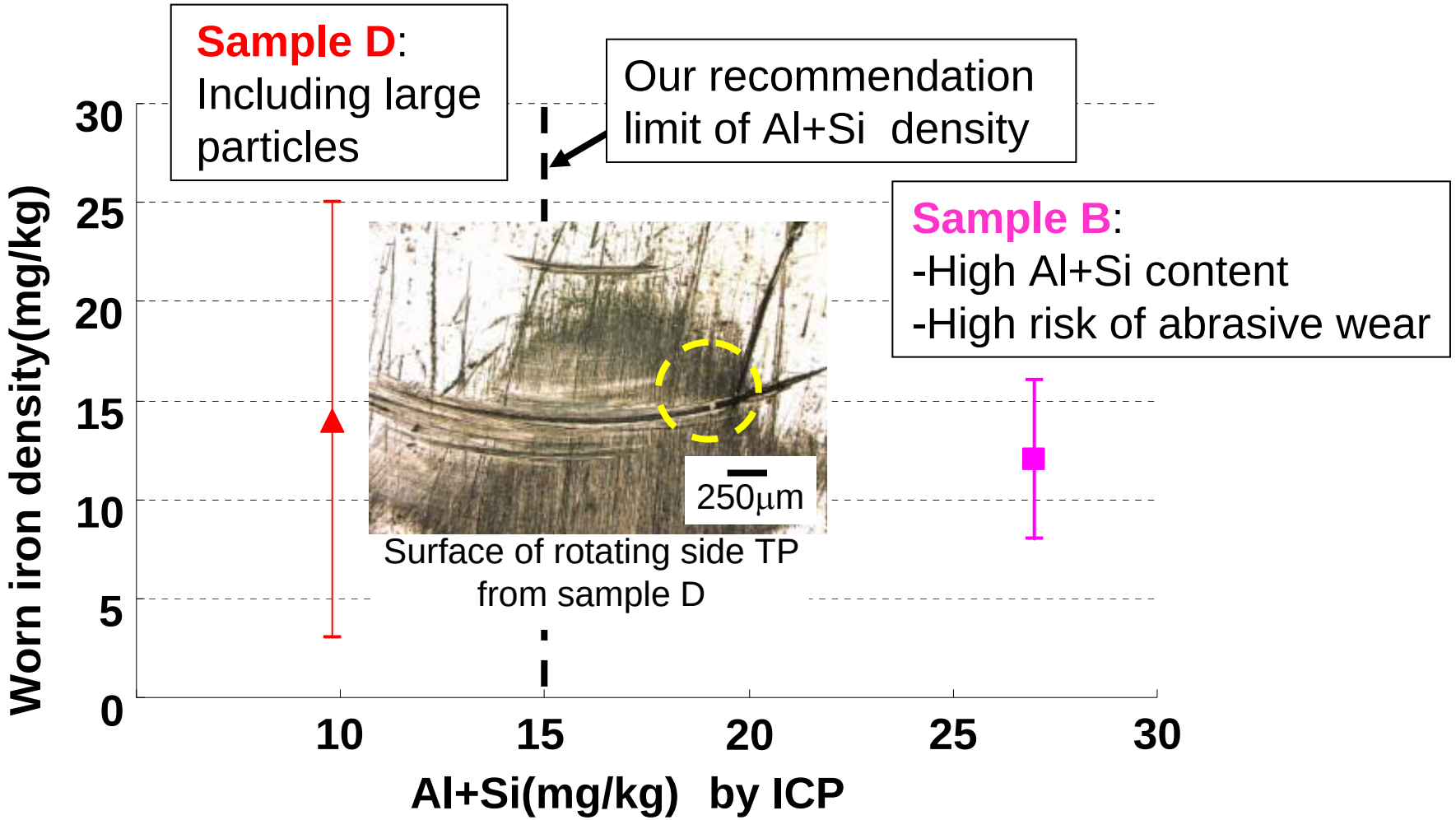
Case3. Result of HFO include large particles

High risk of abrasive wear of HFO including large particles



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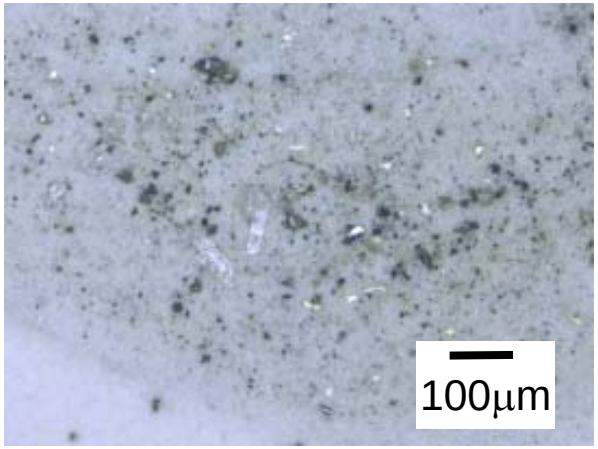
Case3. Some particles in sample B and D HFO

There are some large particles in sample D, but Al+Si density is 9.8mg/kg, and it is within permissive limit.

Sample B heavy fuel oil

-Al+Si content: 27(mg/kg)

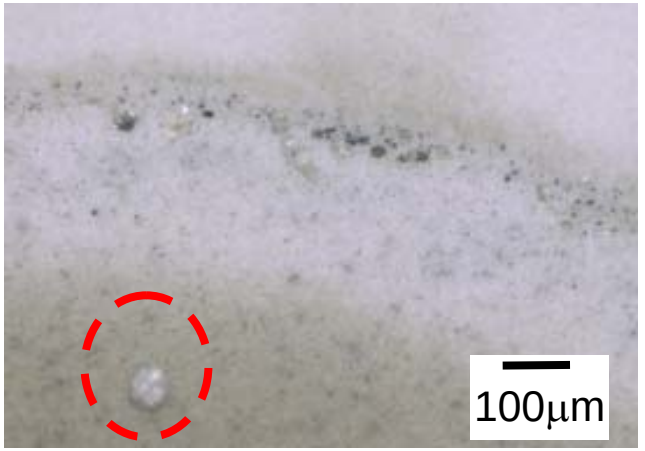


Sampling position: Engine inlet

Sample D heavy fuel oil

-Al+Si content: 9.8(mg/kg)

- Higher risk of abrasive wear



Sampling position: Before purifier

Microscope picture of particles in sample HFO

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Summary of experimental results

Case1:

- **Worn iron density is definitely high by troubled HFO.**

Case2:

- **Not only FCC catalyst fines but also hard particles in HFO can cause abrasive wear.**

Case3:

- **High risk of abrasive wear of HFO which include large particles.**

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Conclusion

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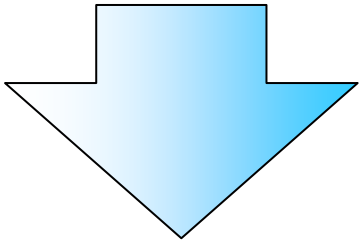
Conclusion

- **Proposed method can evaluate the risk of abrasive wear directly.**

- **It is easy operation, and done on board.**



<u>Our proposal method will contribute safer operation.</u>

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Acknowledgment

Thank you very much for your attention!