―低燃費型船底塗料―
3次元粗度解析による
船体摩擦抵抗の可視化

中国塗料株式会社

SEA JAPAN 2016
Ships and Marine Technology Seminar [C-8]
at Tokyo Big Sight Exhibition Center

Visualization of friction resistance by 3D hull roughness analysis

April 15, 2016 / 10:40-11:10

Anti-Fouling Tech. Dept.
CHUGOKU MARINE PAINTS,LTD.

Introduction

This research and development has been adopted as a project supported by MLIT's "Technical development support project regarding next generation marine environment", and has been a joint research and development with Nippon Kaiji Kyokai (ClassNK).

* MLIT : Ministry of Land, Infrastructure, Transport and Tourism.

MLIT Ministry of Land, Infrastructure, Transport and Tourism

ClassNK R&D PROJECT

Background

- Anti-fouling paints (AF) are used for the application of ship bottom to prevent the fouling by marine organisms.
- In recent years, Fuel Saving AF is being focused in marine market, and hull roughness of coating is recognized to be very important.
- Hull roughness is normally measured by using a *BSRA type hull roughness analyzer*.

Background

- CMP has proposed unique "FIR Theory".
- "FIR" means "Friction Increase Ratio", which is friction increase compared to friction of smooth surface like mirror.
- "FIR Theory" can estimate the friction resistance and fuel saving efficiency by both of roughness and wavelength of hull surface.

About FIR Theory

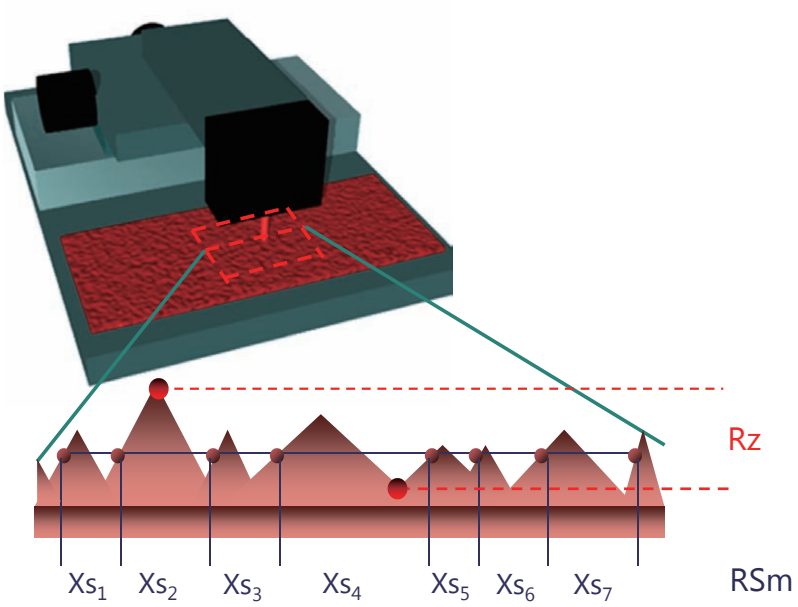
The “FIR value” can be estimated from roughness (Rz) and wavelength (RSm) profiles as follows;

$$FIR = 2.62 \times \frac{Rz^2}{RSm}$$

Rz : Roughness of film surface
RSm : Wavelength of film surface

About FIR Theory

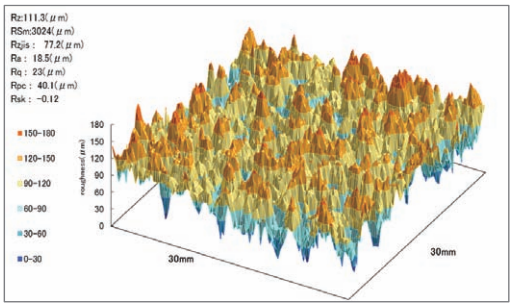
Measure Roughness (Rz) & Wavelength (RSm) of the coating surface by Laser equipment



About FIR Theory

The relation of FIR with roughness and wavelength;

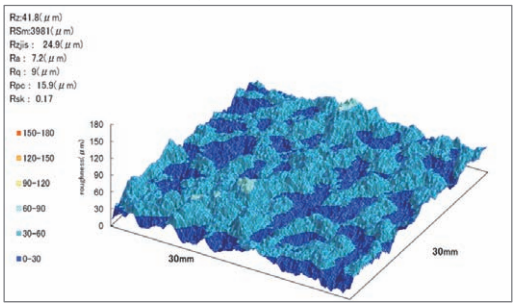
Conventional AF paint



Rz : 111um, RSm : 3024um

FIR $=2.62\times(111)^2\div3024$
$= 10.7\%$

Low friction type AF paint



Rz : 42um, RSm : 3980um

FIR $=2.62\times(42)^2\div3980$
$= 1.2\%$

Expected fuel saving efficiency (compared to conventional AF) is;
(10.7% - 1.2%) × 0.6～0.8 = <u>5～8 %</u> * *Value in product catalogue*

Research results

Following results have been obtained in this project, and joint research theme with ClassNK.

1) *Advanced FIR theory with speed factor*

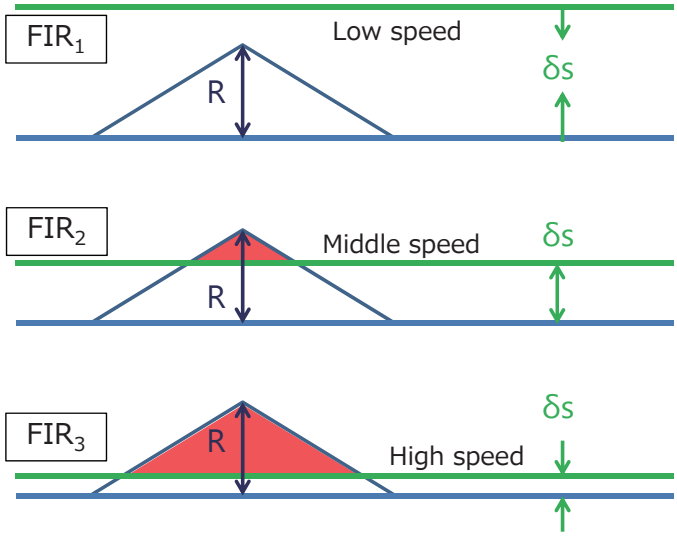
2) *Invention of new 3D hull roughness analyzer*

MLIT Ministry of Land, Infrastructure, Transport and Tourism

ClassNK R&D PROJECT

1) Advanced FIR Theory

Difference of vessel's speed on the same surface roughness;



R; Roughness
δs; Viscous sublayer

Viscous sublayer thickness depends on vessel's speed.

R – δs ; **"*effective roughness*"**

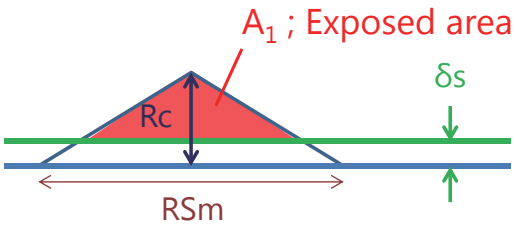
$R < \delta s \rightarrow FIR_1$
$R > \delta s \rightarrow FIR_2$
$R >> \delta s \rightarrow FIR_3$

$FIR_1 = 0 < FIR_2 << FIR_3$

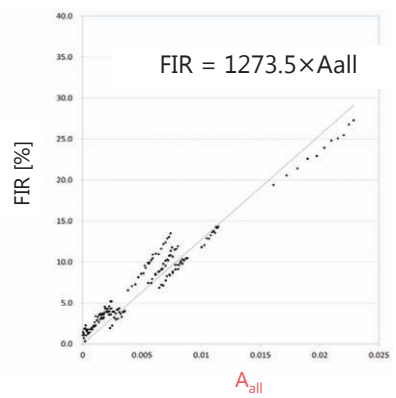
Relation between FIR at maximum speed (1000 rpm) and roughness parameters (maximum Rz and RSm) were evaluated by double rotating cylinder test in a previous report of Chugoku Marine Paints *.

* Website; http://www.cmp.co.jp/global/Technologies/FIR_theory.html

This time, speed effect on FIR was confirmed by speed variation test. Good correlation between FIR and total exposed area of the effective roughness (Aall) which was calculated from average peak height of roughness (Rc), wavelength (RSm) and viscous sublayer (δs/speed factor).



$A_{all} = A_1 + A_2 + A_3 + \ldots + A_n$



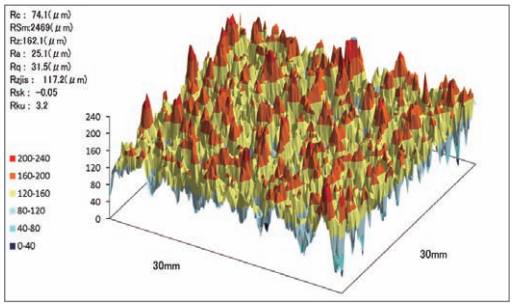
The "ν-FIR value" can be estimated from roughness (Rc), wavelength (RSm) and the viscous sublayer (δs/speed factor) as follows;

$$\nu\text{-FIR}(\%) = 637 \times \frac{(Rc-\delta s)^2}{Rc \times RSm}$$

About ν-FIR Theory

In case of 15kts (δs=19.2μm) ;

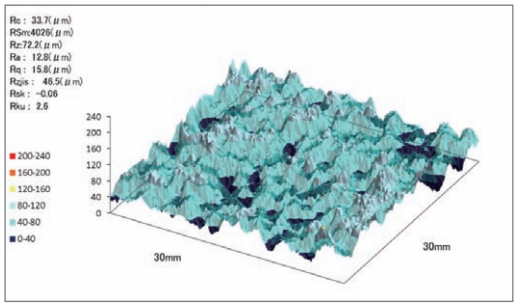
Conventional AF



Rc : 74.1um, RSm : 2469um

$$\nu\text{-FIR}(\%) = 637 \times \frac{(74.1-19.2)^2}{74.1 \times 2469} = 10.5$$

Low friction type AF



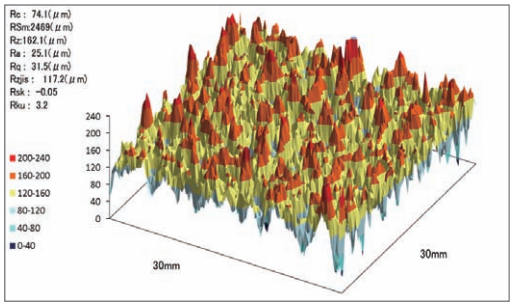
Rc : 33.7um, RSm : 4026um

$$\nu\text{-FIR}(\%) = 637 \times \frac{(33.7-19.2)^2}{33.7 \times 4026} = 1.0$$

Expected fuel saving efficiency (compared to conventional AF) is ;
(10.5% - 1.0%) × 0.6～0.8 = 5.7～7.6 %

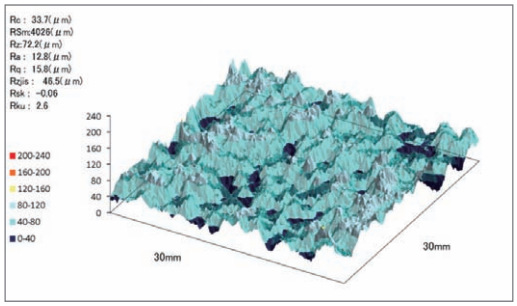
About ν-FIR Theory

Conventional AF



Rc : 74.1um, RSm : 2469um

Low friction type AF



Rc : 33.7um, RSm : 4026um

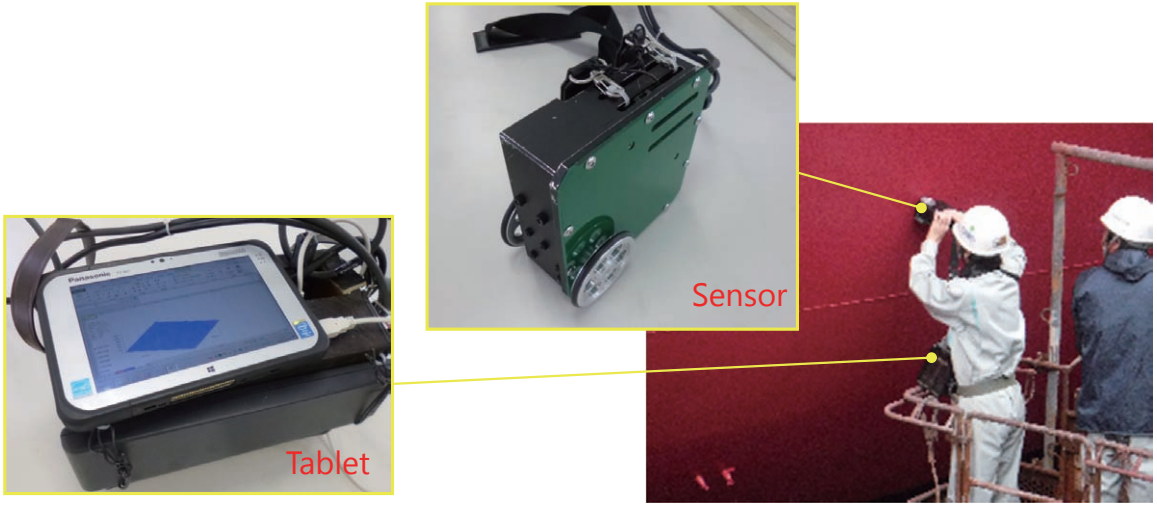
Speed [kt]	15	20	25
δs [um]	19.2	14.7	11.9
ν-FIR [%]	10.5	12.3	13.5

Speed [kt]	15	20	25
δs [um]	19.2	14.7	11.9
ν-FIR [%]	1.0	1.7	2.2

Speed [kt]	15	20	25
⊿ ν-FIR [%]	9.5	10.6	11.3
Expected fuel saving	5.7～7.6%	6.4～8.5%	6.8～9.0%

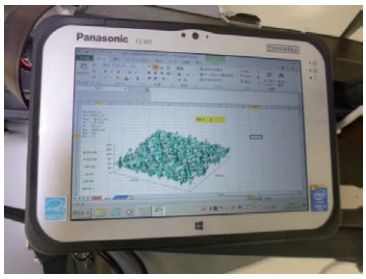
2) New 3D hull roughness analyzer

To analyze the surface roughness and wavelength at actual site, CMP has invented the ***new 3D hull roughness analyzer***.

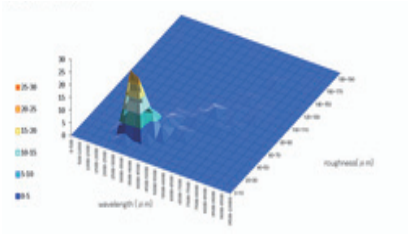


Measurement of hull surface

Results in the tablet



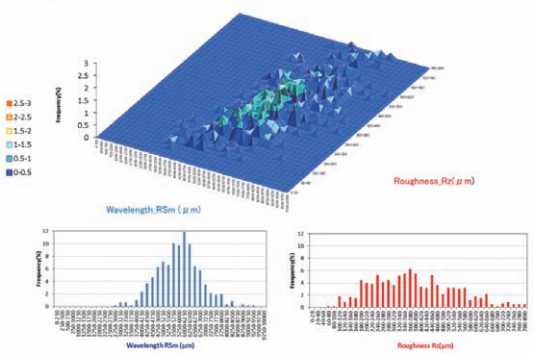
Distribution of Roughness & wavelength profile



Visualization of friction resistance

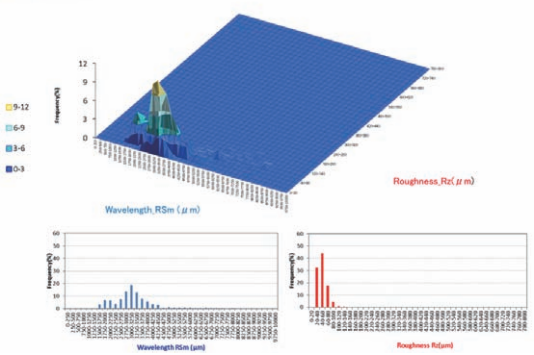
ν-FIR calculation by 3D hull roughness analysis

Conventional AF (Arrival condition)



Rc=186.2 μm RSm =5867μm

Low friction type AF (After completion)



Rc=19.3μm RSm =3187μm

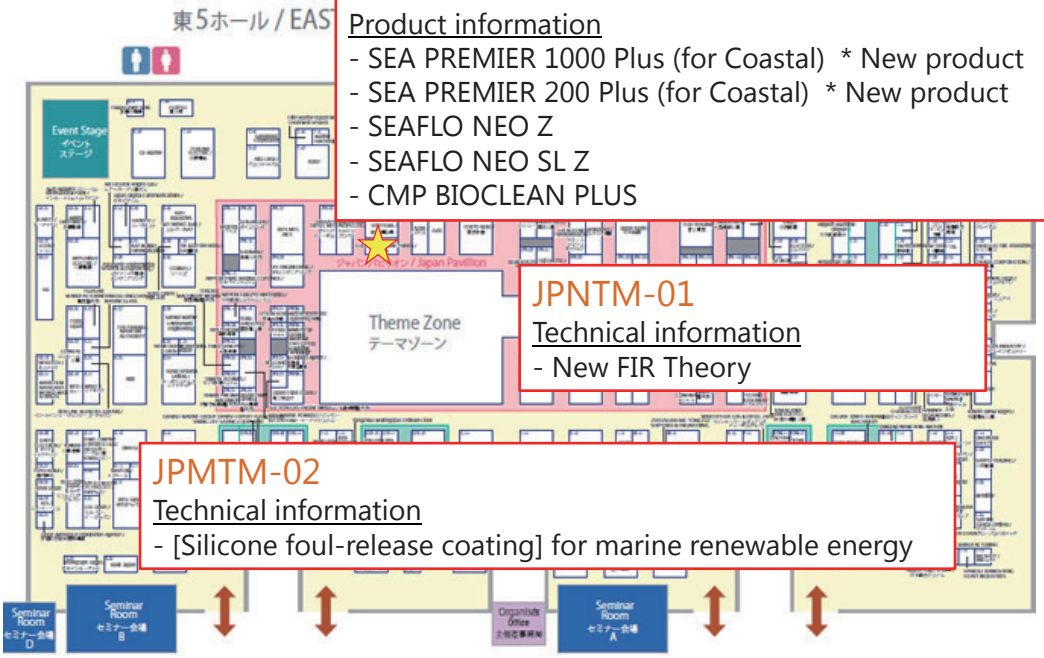
In case of 15kts (δs=19.2μm);

$$\nu\text{-FIR}(\%) = 637 \times \frac{(186.2-19.2)^2}{186.2\times5867} = 16.3$$

$$\nu\text{-FIR}(\%) = 637 \times \frac{(19.3-19.2)^2}{19.3\times3187} = 0.0$$

Expected fuel saving = (16.3-0) × 0.6 = 9.8%

SEA JAPAN 2016, CMP Information



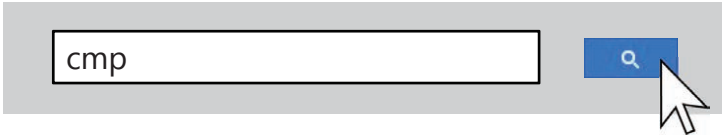
JPN-40
Product information
- SEA PREMIER 1000 Plus (for Coastal) * New product
- SEA PREMIER 200 Plus (for Coastal) * New product
- SEAFLO NEO Z
- SEAFLO NEO SL Z
- CMP BIOCLEAN PLUS

JPNTM-01
Technical information
- New FIR Theory

JPMTM-02
Technical information
- [Silicone foul-release coating] for marine renewable energy

SEA JAPAN 2016
Ships and Marine Technology Seminar [C-8]
at Tokyo Big Sight Exhibition Center

Thank you very much for your attention.



CMP CHUGOKU MARINE PAINTS, LTD.