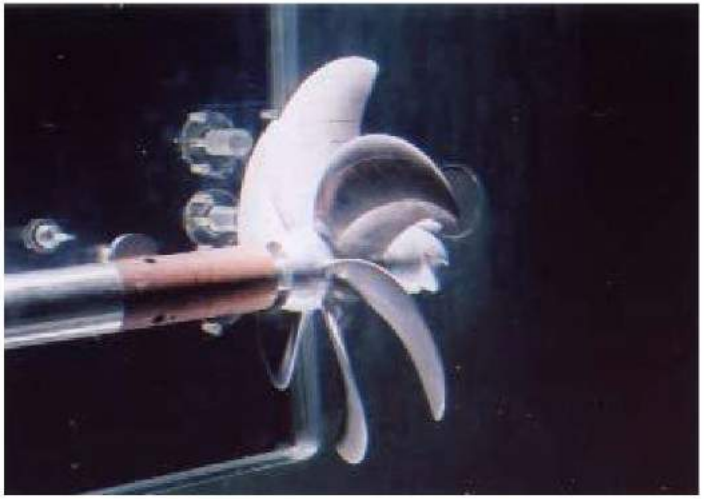
Energy saving Device

HVFC（Hub Vortex Free Cap)

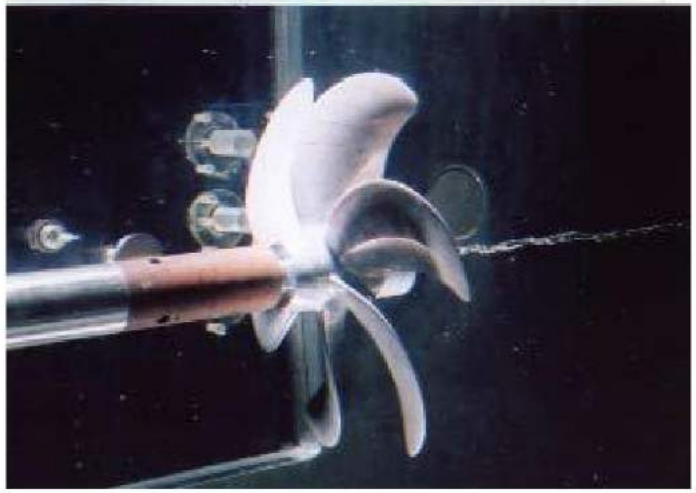
HVFC Technologyy

MITSUBISHI HEAVY INDUSTRIES
MARINE MACHINERY & EQUIPMENT

with HVFC



without HVFC



HVFC recover a loss
caused by hub vortex

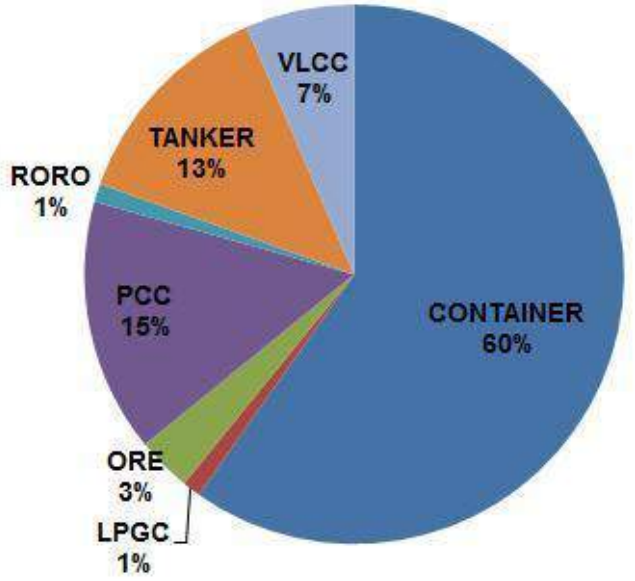
- ✓ The pressure in the center of hub vortex is low and it occurs the power which pulls ship back, which means the thrust of the propeller is reduced.
- ✓ HVFC have some grooves and they increase the core radius of hub vortex, as the result, HVFC reduce falls of the pressure.

1-3% Propulsive Efficiency Improvement !

MITSUBISHI HEAVY INDUSTRIES
MARINE MACHINERY & EQUIPMENT

HVFC Record

- MHI-MME manufactured about 150 HVFC since 1989 for new building vessel, and also for retrofitting
- Expect the improvement for all kinds of vessel
- No bad influence to the propulsive performance
- Decrease rudder erosion by the hub vortex cavitations



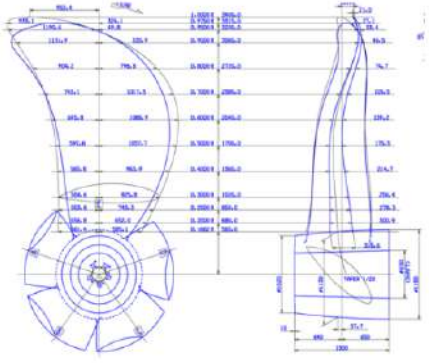
Please provide MHI-MME the **original propeller drawing (including the pitch value of blade root)** to design HVFC.

MOVE THE WORLD FORWARD

MITSUBISHI
HEAVY
INDUSTRIES
GROUP

Mitsubishi Retrofit Propeller

~ To reduce the fuel oil consumption and CO2 emission and recover the torque rich condition for your good vessel ~



February, 2020
SZ30-C0826

Proposal of Mitsubishi Propeller Retrofit

MITSUBISHI HEAVY INDUSTRIES
MARINE MACHINERY & EQUIPMENT CO., LTD.

- Mitsubishi latest propeller design is applied.
- Propeller design is based on vessel's condition considering fouling and aging.
- Propeller design is considered for low load operation by the limitation of main engine load.

Improvement of fuel efficiency with applying the suitable design for Low load operation.

- Trade in existing propeller with retrofit propeller

Minimization of Investment

Contract Record

MITSUBISHI HEAVY INDUSTRIES
MARINE MACHINERY & EQUIPMENT CO., LTD.

- After 2013 our contract record is total **70 projects**.

We have many experience!!!

- **Blue colored** propellers are manufactured by MHI-MME's Chinese partner's factory.
- Production in China is total **41 projects**.

As of Feb. , 2020

No.	Ship Type	TEU	M/E Output (Original)	Limitation of M/E load	Propeller Specification	Class	Delivery
1	AFRA TANKER	-	11,770kW	100%	7.3m × 4blades × 25,600kg	ABS	2013/7/29
2	BULK CARRIER	-	5,370kW	100%	5.3m × 4blades × 9,900kg	NK	2014/11/5
3	CONTAINER	4,950	43,600kW	70%	8.3m × 6blades × 58,000kg	NK	2015/1/18
4	CONTAINER	5,000	48,600kW	60%	8.0m × 6blades × 51,100kg	ABS	2015/2/10
5	CONTAINER	4,920	55,400kW	70%	8.4m × 5blades × 56,000kg	BV	2015/2/10
6	CONTAINER	6,200	62,600kW	54%	8.8m ×6blades × 67,700kg	NK	2015/2/12
7	LNGC	-	26,800kW	100%	8.8m × 5blades × 57,600kg	NK	2015/2/25
8	CONTAINER	6,200	62,600kW	54%	8.8m × 6blades × 67,700kg	NK	2015/2/28
9	CONTAINER	4,650	67,100kW	60%	8.2m × 6blades × 70,600kg	DNV-GL	2015/3/10
10	CONTAINER	4,800	51,400kW	51%	8.2m × 5blades × 59,100kg	NK	2015/4/2
11	CONTAINER	4,800	51,400kW	51%	8.2m × 5blades × 59,100kg	NK	2015/4/2
12	CONTAINER	4,800	51,400kW	51%	8.3m × 5blades × 59,100kg	NK	2015/5/23
13	CONTAINER	5,700	54,800kW	55%	8.4m × 6blades × 62,900kg	BV	2015/7/1
14	CONTAINER	5,700	54,800kW	55%	8.4m × 6blades × 62,900kg	BV	2015/7/1
15	CONTAINER	5,700	54,800kW	55%	8.4m × 6blades × 62,900kg	BV	2015/7/15
16	CONTAINER	4,700	41,100kW	60%	8.2m × 5blades × 53,900kg	DNV-GL	2015/7/25
17	CONTAINER	4,700	41,100kW	60%	8.2m × 5blades × 53,900kg	DNV-GL	2015/7/25
18	CONTAINER	6,000	61,400kW	50%	8.8m × 6blades × 69,700kg	NK	2015/7/31
19	CONTAINER	4,700	41,100kW	60%	8.2m × 5blades × 53,900kg	DNV-GL	2015/8/20
20	CONTAINER	4,700	41,100kW	60%	8.2m × 5blades × 53,900kg	DNV-GL	2015/8/30
21	CONTAINER	6,000	61,400kW	50%	8.8m × 6blades × 69,700kg	NK	2015/8/31
22	CONTAINER	4,700	41,10kW	60%	8.2m × 5blades × 53,900kg	DNV-GL	2015/9/15
23	CONTAINER	6,500	62,800kW	50%	8.5m × 6blades × 70,900kg	NK	2015/9/20
24	CONTAINER	6,500	62,800kW	50%	8.5m × 6blades × 70,900kg	NK	2015/10/30
25	CONTAINER	4,500	41,000kW	65%	8.2m × 5blades × 55,100kg	DNV-GL	2015/11/10
26	CONTAINER	4,800	42,400kW	70%	8.5m × 6blades × 57,600kg	DNV-GL	2015/11/22
27	CONTAINER	4,800	42,400kW	70%	8.5m × 6blades × 57,600kg	DNV-GL	2015/11/30
28	CONTAINER	6,000	61,400kW	50%	8.8m × 6blades × 69,700kg	NK	2015/12/4
29	CONTAINER	6,500	62,800kW	50%	8.5m × 6blades × 70,900kg	NK	2015/12/4
30	CONTAINER	5,760	54,900kW	50%	8.4m × 6blades × 61,500kg	DNV-GL	2015/12/20
31	CONTAINER	6,400	60,400kW	60%	8.7m × 6blades × 69,600kg	BV	2015/12/30
32	CONTAINER	5,760	54,900kW	50%	8.4m × 6blades × 61,500kg	DNV-GL	2016/1/10
33	CONTAINER	4,500	41,000kW	65%	8.2m × 5blades × 55,100kg	DNV-GL	2016/1/25
34	CONTAINER	6,000	61,400kW	50%	8.8m × 6blades × 69,700kg	NK	2016/1/30
35	CONTAINER	4,500	41,040kW	65%	8.2m × 5blades × 55,100kg	DNV-GL	2016/1/25
36	CONTAINER	6,000	61,350kW	50%	8.8m × 6blades × 69,700kg	NK	2016/1/30
37	CONTAINER	4,800	42,438kW	70%	8.5m × 6blades × 57,600kg	DNV-GL	2016/2/5
38	CONTAINER	6,000	61,350kW	50%	8.8m × 6blades × 69,700kg	NK	2016/2/20
39	CONTAINER	4,800	42,438kW	70%	8.5m × 6blades × 57,600kg	DNV-GL	2016/2/29
40	CONTAINER	6,500	62,810kW	50%	8.5m × 6blades × 70,900kg	NK	2016/3/20
41	CHEMICAL TANKER	-	7,060kW	100%	5.8m × 4blades × 13,300kg	BV	2016/4/4
42	CONTAINER	4,800	51,390kW	50.6%	8.2m × 5blades × 59,100kg	NK	2016/4/15
43	CONTAINER	8,100	64,030kW	69%	9.0m × 6blades × 86,700kg	NK	2016/4/29
44	CONTAINER	10,100	72,240kW	60%	8.8m × 6blades × 84,200kg	LR	2016/5/1
45	CONTAINER	8,100	64,030kW	69%	9.0m × 6blades × 86,700kg	NK	2016/5/13
46	CONTAINER	4,800	51,390kW	50.6%	8.2m × 5blades × 59,100kg	NK	2016/6/13
47	CONTAINER	8,100	64,030kW	69%	9.0m × 6blades × 86,700kg	NK	2016/7/15
48	CONTAINER	4,500	33,720kW	59%	8.0m × 6blades × 48,800kg	NK	2016/7/29
49	CONTAINER	8,100	64,030kW	69%	9.0m × 6blades × 86,700kg	NK	2016/6/13
50	CONTAINER	4,500	33,720kW	59%	8.0m × 6blades × 48,800kg	NK	2016/9/27
51	CONTAINER	8,600	65,210kW	61%	8.9m × 6blades × 75,000kg	NK	2016/11/9
52	CONTAINER	3,500	31,920kW	65%	7.7m × 5blades × 37,500kg	DNV-GL	2016/12/10
53	CONTAINER	7,000	57,200kW	65%	8.7m × 6blades × 73,000kg	DNV-GL	2017/4/21
54	CONTAINER	5,762	54,900kW	50%	8.4m × 6blades × 61,500kg	DNV-GL	2017/5/31
55	LNGC	-	28,700kW	100%	8.6m × 5blades × 60,500kg	DNV-GL	2017/8/23
56	LNGC	-	28,700kW	100%	8.6m × 5blades × 60,500kg	DNV-GL	217/9/6
57	LNGC	-	29,600kW	100%	8.6m × 6blades × 52,000kg	LR	2017/7/26
58	LNGC	-	29,600kW	100%	8.6m × 6blades × 52,000kg	LR	2017/8/9
59	LNGC	-	29,600kW	100%	8.6m × 6blades × 52,000kg	LR	2018/5/2
60	LNGC	-	29,600kW	100%	8.6m × 6blades × 52,000kg	LR	2018/5/2
61	CONTAINER	6,500	64,200kW	60%	8.9m × 6blades × 67,200kg	BV	2019/1/30
62	CONTAINER	6,500	64,200kW	60%	8.9m × 6blades × 67,200kg	BV	2019/2/15
63	CONTAINER	7,000	60,200kW	50%	8.5m × 6blades × 61,200kg	DNV-GL	2019/2/28
64	CONTAINER	7,000	60,200kW	50%	8.5m × 6blades × 61,200kg	DNV-GL	2019/3/31
65	LNGC	-	28,700kW	100%	8.6m × 5blades × 60,500kg	DNV-GL	2019/3/29
66	CONTAINER	4,000	36,473kW	60%	7.8m × 5blades × 47,900kg	DNV-GL	2019/9/30
67	CONTAINER	4,000	24,830kW	52%	7.8m × 5blades × 34,000kg	DNV-GL	2019/9/30
68	TANKER		9,480kW	100%	6.0m × 4blades × 15,700kg	ABS	2019/12/27
69	CONTAINER	4,700	41,107kW	30%	8.1m × 5blades × 39,700kg	CCS	2019/12/28
70	CONTAINER	8,600	68,640kW	65%	8.5m × 6blades × 73,000kg	KR	2020/3/25

Propeller Retrofit Saving Validation

MITSUBISHI HEAVY INDUSTRIES
MARINE MACHINERY & EQUIPMENT CO., LTD.

After propeller retrofit work, MHI-MME carries out the evaluation of the propeller retrofit for many projects which vessels only applied propeller retrofit not applied balboas bow modification and/or propeller duct fitted.

Ship Type	TEU	Ship Num.	M/E Output (Original)	New Power & MCR	After replacement Delivery	Retrofit Saving Validation by actual ships
CONTAINER	5,000	1ship	48,630kW	29,180kW (60%)	2015/Feb	more than 8%
CONTAINER	5,700	3ships	54,810kW	30,150kW (55%)	2015/Jul	more than 10%
TANKER	AFRAMAX	1ship	11,770kW	11,770kW (100%)	2013/Jul	More than 3～4%
LNGC	135,000m^3	1ship	26,800kW	26,800kW (100%)	2015/Feb	more than 4%

You can improve the vessel efficiency only for apply new design propeller !

Propeller Retrofit Saving Validation

MITSUBISHI HEAVY INDUSTRIES
MARINE MACHINERY & EQUIPMENT CO., LTD.

Application to 5,700TEU container vessels (3 vessels)

- **Example of the retrofit application for 5,700TEU**
  Limitation of main engine load ⇒ 55% of MCR

- **Measurement period**
  Before : Mar 2013 – Aug 2014
  Route Northern Europe ― Mediterranean Sea

  After : Sep 2015 – Jan 2016
  Route Northern Europe ― Mediterranean Sea

- **Object SHIP**
  3 series vessels (Propeller Retrofit)

Propeller Retrofit Saving Validation

MITSUBISHI HEAVY INDUSTRIES
MARINE MACHINERY & EQUIPMENT CO., LTD.

Application to 5,700TEU container vessels (3 vessels)

- MHI-MME designed the retrofit propeller in 2015 and replaced in 2016

- Retrofit propeller is designed following condition

  100%MCR　54,810kW × 104.0rpm

  ⇩

  Limitation of M/E load

  55%of MCR :　30,146kW × 85.2rpm

- Effect after retrofit propeller

  Evaluation of actual ship

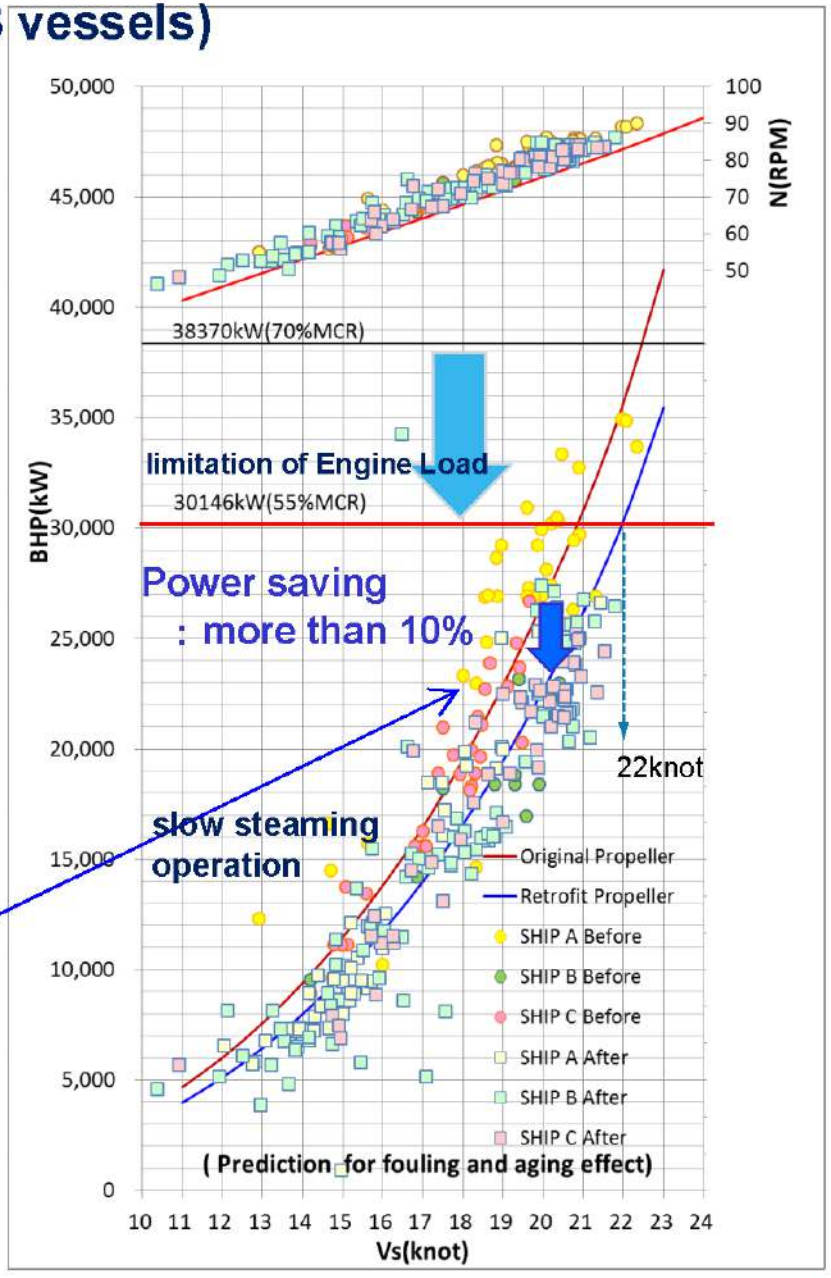
  BHP Power saving: More than 10%

  Fuel Cost Saving ＝ 872,000 USD/Year

  Price of fuel oil　: 500 USD/ton

  Operating time　: 6,000Hr/Year (utilization rates 68%)

  Average Power　: 16,000kW (30% of MCR)



Confidential

Propeller Retrofit Saving Validation

MITSUBISHI HEAVY INDUSTRIES
MARINE MACHINERY & EQUIPMENT CO., LTD.

Application to 10,000TEU container vessel

- Example of the retrofit application for 10,100TEU
  Limitation of main engine load ⇒ 65% of MCR

- Measurement period
  Pre modified : Jan 2014 – Jul 2015
  Route Europe — Middle East — Asia

  Post modified : Jun 2016 – Jul 2016
  Route Asia — North America

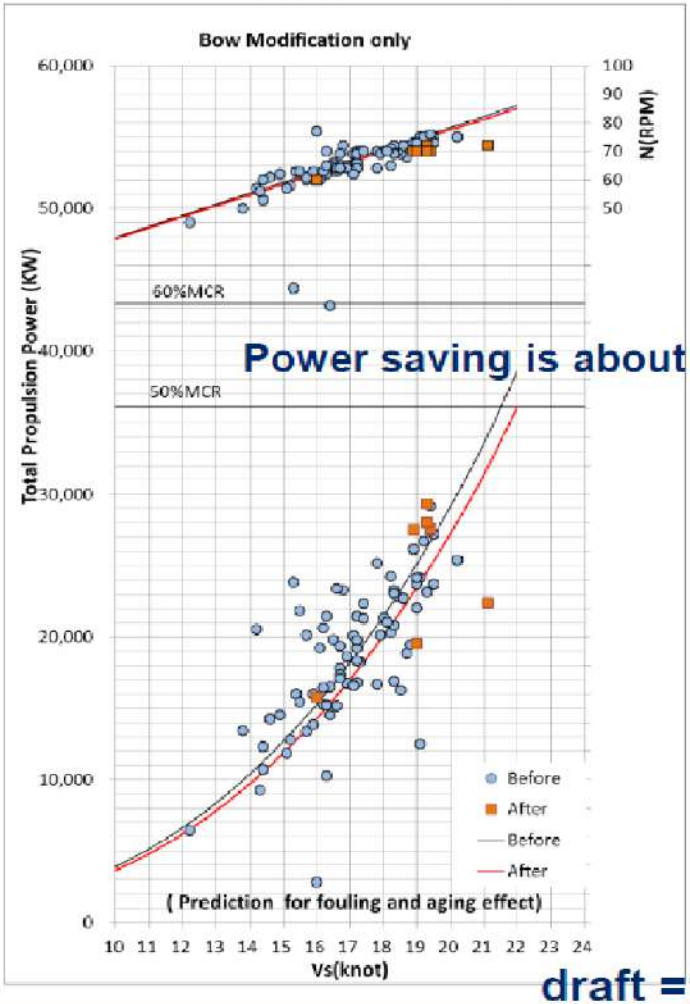
- Object Vessel
  Vessel A ; Bow Modification
  Vessel B ; Bow Modification +Propeller Retrofit

Propeller Retrofit Saving Validation

MITSUBISHI HEAVY INDUSTRIES
MARINE MACHINERY & EQUIPMENT CO., LTD.

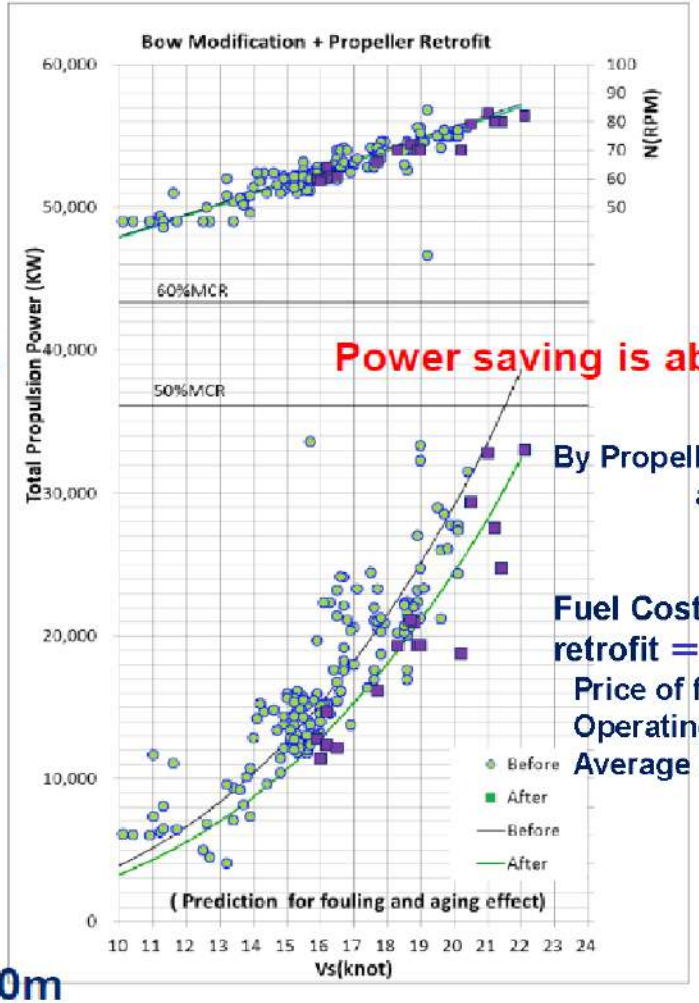
Application to 10,000TEU container vessel
We evaluate only balboas bow modification and bow modification plus propeller retrofit

Bow Modification only



Power saving is about 6%

Bow Modification + Propeller Retrofit



Power saving is about 16%

By Propeller retrofit
about 10% (16%-6%)

Fuel Cost Saving by propeller retrofit = 1,150,000 USD/Year
Price of fuel oil : 500 USD/ton
Operating time : 6,000Hr/Year
Average Power : 21,000kW
(30% of MCR)

draft =13.0m

Propeller Retrofit Saving Validation

MITSUBISHI HEAVY INDUSTRIES
MARINE MACHINERY & EQUIPMENT CO., LTD.

Application to AFRA TANKER

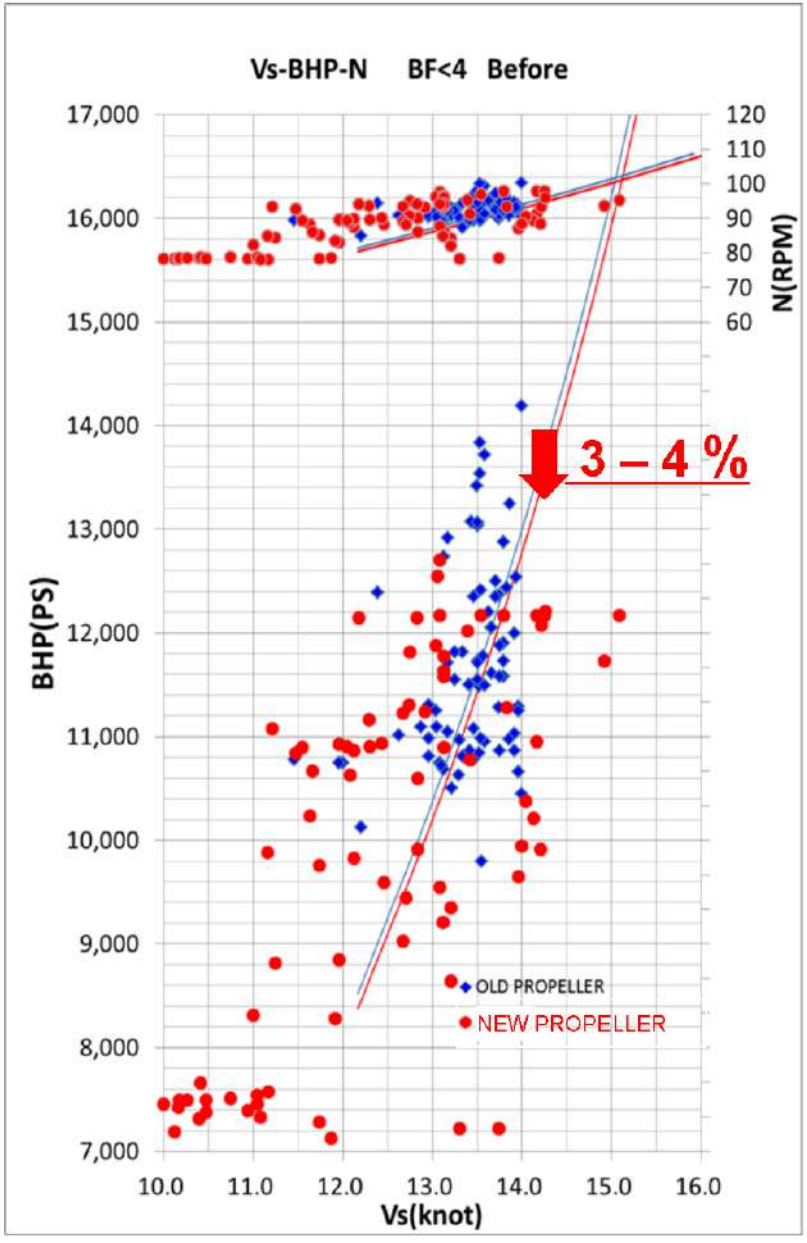
- MHI-MME predict the New-Building condition and Existing condition

- Retrofit propeller is designed following condition

  100%MCR 11,770kW × 101.0rpm

- Effect after retrofit propeller
  Evaluation of actual ship
  BHP Power saving : About 3 – 4 %
  Fuel Cost Saving ＝ 160,000USD/Year

  Price of fuel oil : 500 USD/ton
  Operating time : 6,000Hr/Year (utilization rates 68%)
  Average Power : 70% of MCR



Case study of Retrofit propeller for VLCC

Design data for retrofit propeller VLCC

MITSUBISHI HEAVY INDUSTRIES
MARINE MACHINERY & EQUIPMENT CO., LTD.

- Prediction of the New-Building condition and Existing condition
- MHI understand the performance of the original propeller
- Retrofit propeller is designed following condition

  100%MCR 19,976kW × 76.0rpm

  ⇩

  Limitation of M/E load

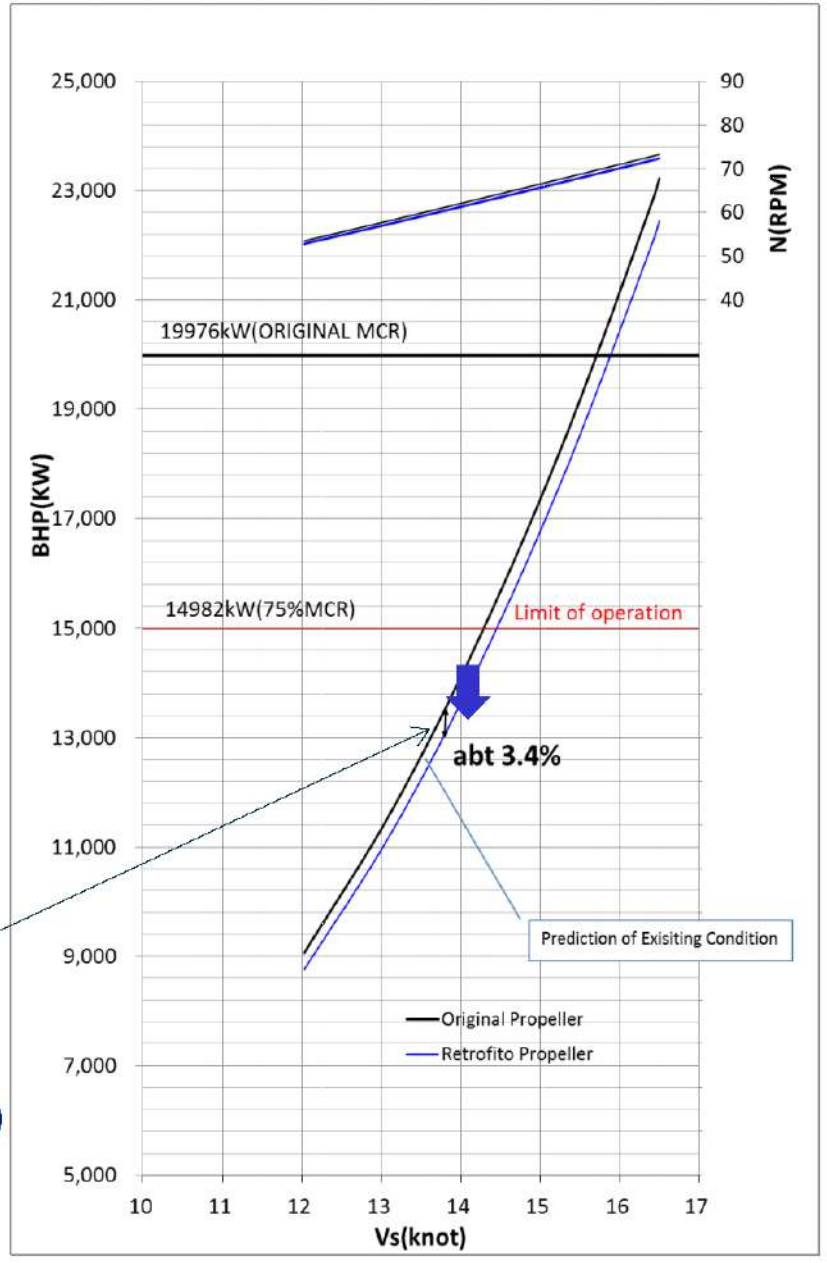
  75% of MCR 14,982kW × 67.2rpm

- Expected effect after retrofit propeller by design

  BHP Power saving : About 3.4%

  Fuel Cost Saving = 217,000USD/Year

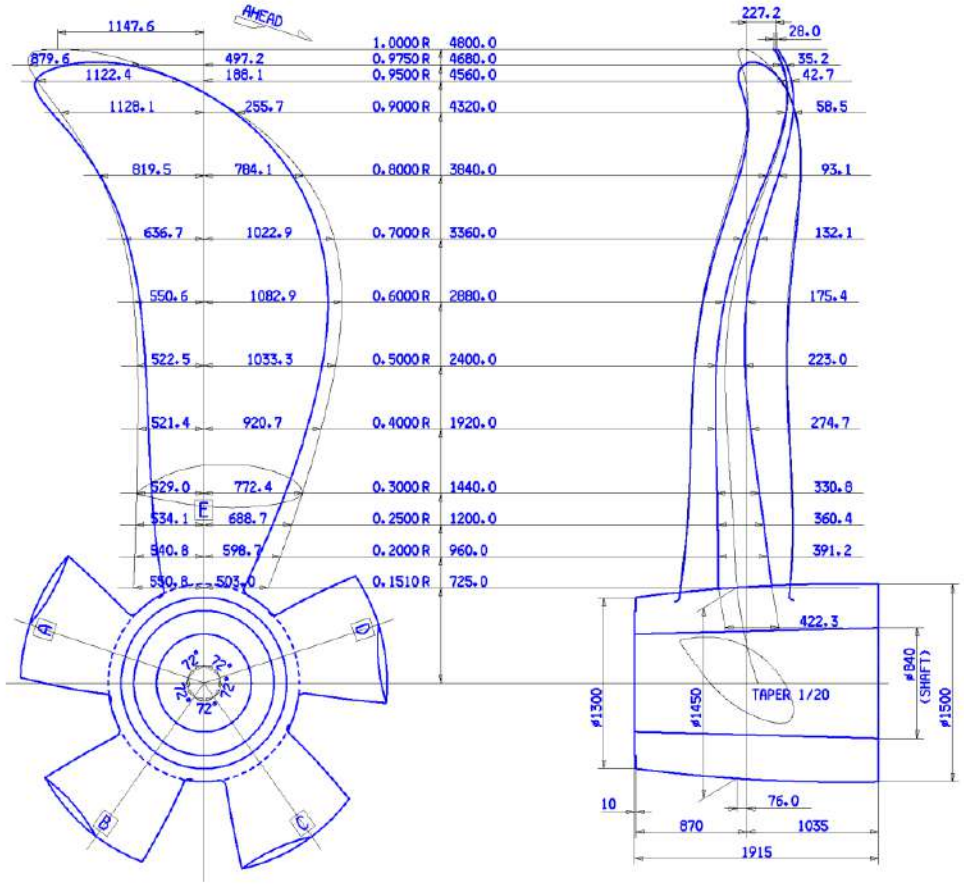
  Price of fuel oil : 500 USD/ton
  Operating time : 6,000Hr/Year (utilization rates 68%)
  Average Power : 60% of MCR (=12,000kW)



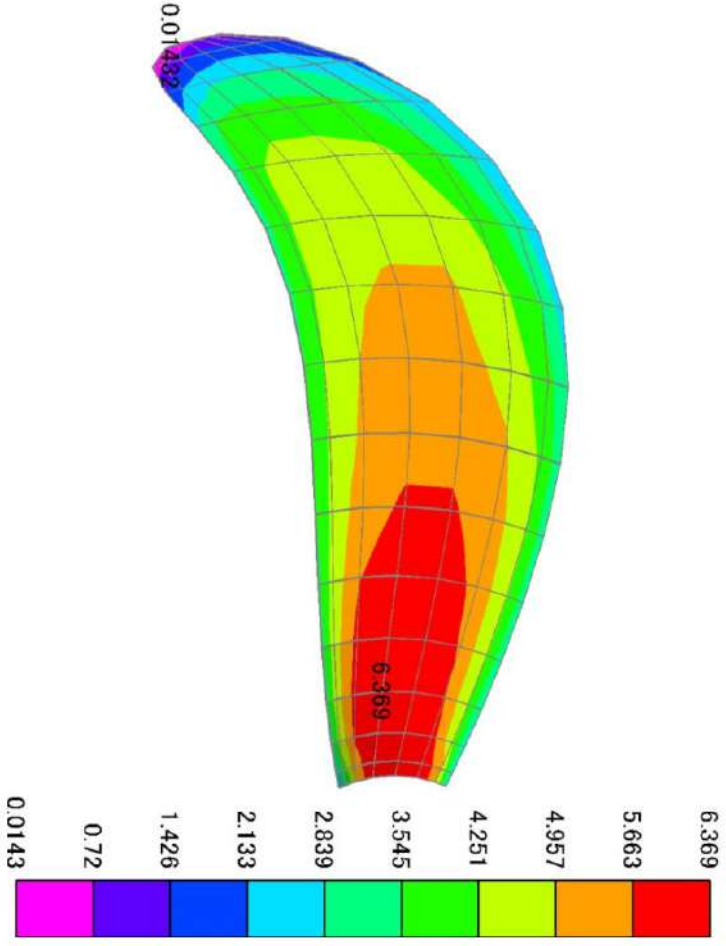
Design data for retrofit propeller VLCC

MITSUBISHI HEAVY INDUSTRIES
MARINE MACHINERY & EQUIPMENT CO., LTD.

Outline of retrofit propeller & blade strength



Outline



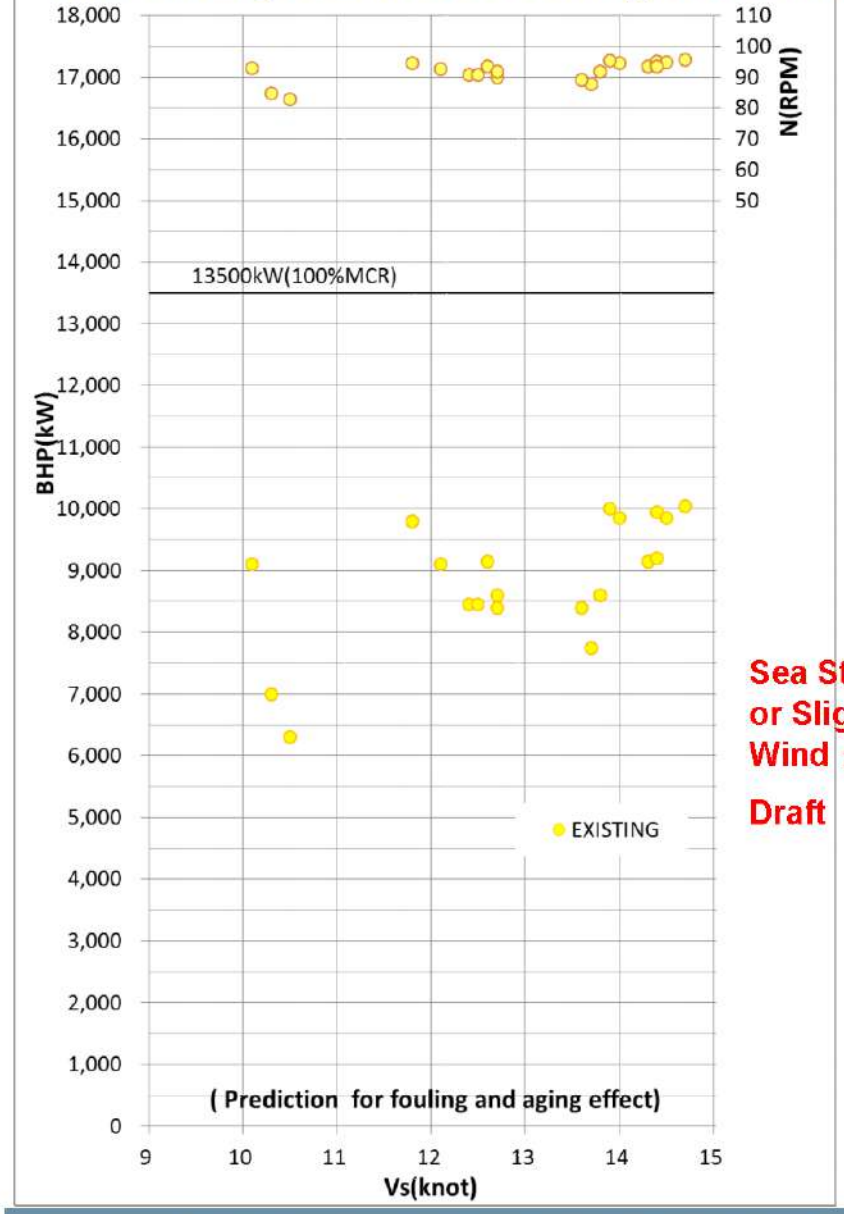
Result of FEM analysis
(75%MCR)

Case study of Retrofit propeller for Bulk carrier

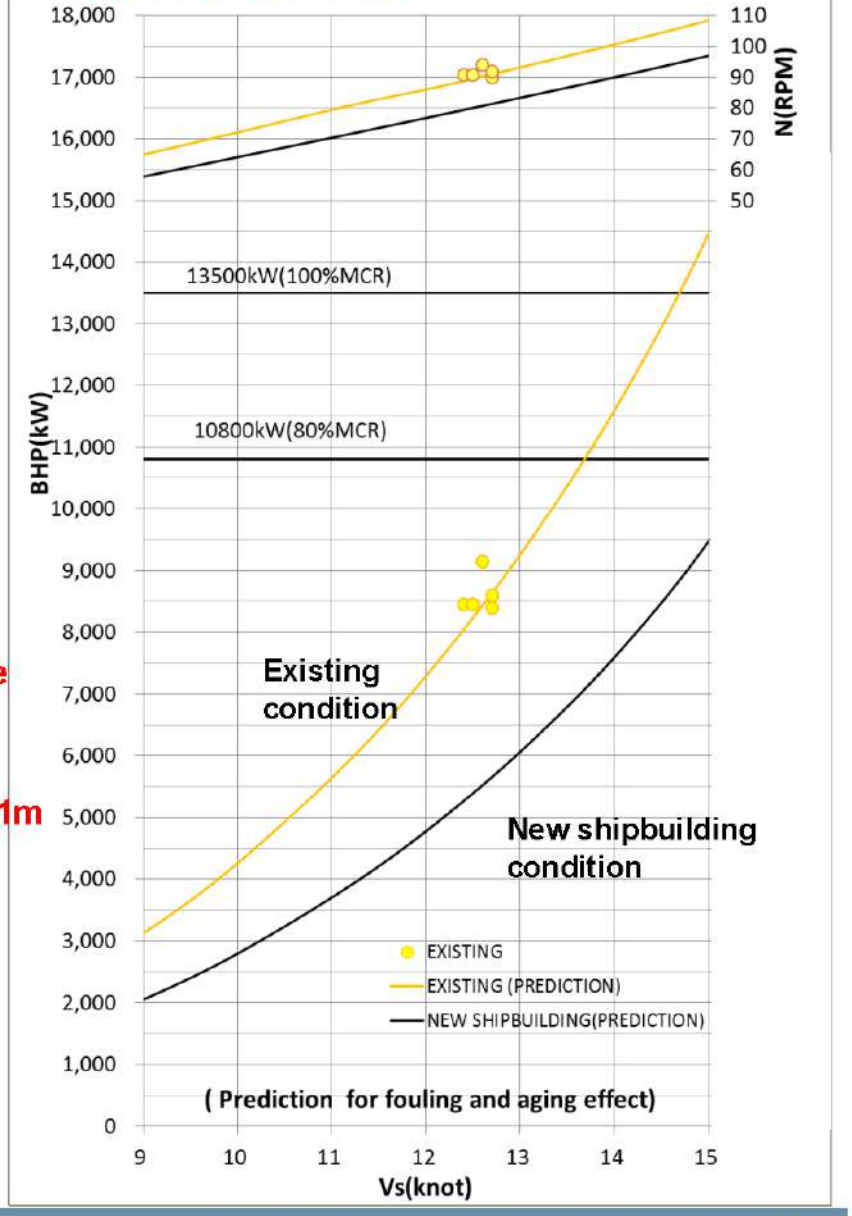
Existing Hull condition Bulk carrier

MITSUBISHI HEAVY INDUSTRIES
MARINE MACHINERY & EQUIPMENT CO., LTD.

MHI analyzed the existing conditions based on recent DATA



Sea State : Moderate or Slight
Wind : Less than 4
Draft : More than 11m



Design data for retrofit propeller

MITSUBISHI HEAVY INDUSTRIES
MARINE MACHINERY & EQUIPMENT CO., LTD.

- Prediction of the existing vessel condition after 7-year in service.
- The performance of the original propeller is estimated roughly by MHI.
- Retrofit propeller is designed following conditions

  100%MCR 13,500kW × 105.0rpm

Limitation of M/E load

Case-1 : 100% of MCR 13,500kW × 105.0rpm

Expected effect after retrofit propeller by design

BHP Power saving : About 2.6%

Fuel Cost Saving = 123,000USD/Year

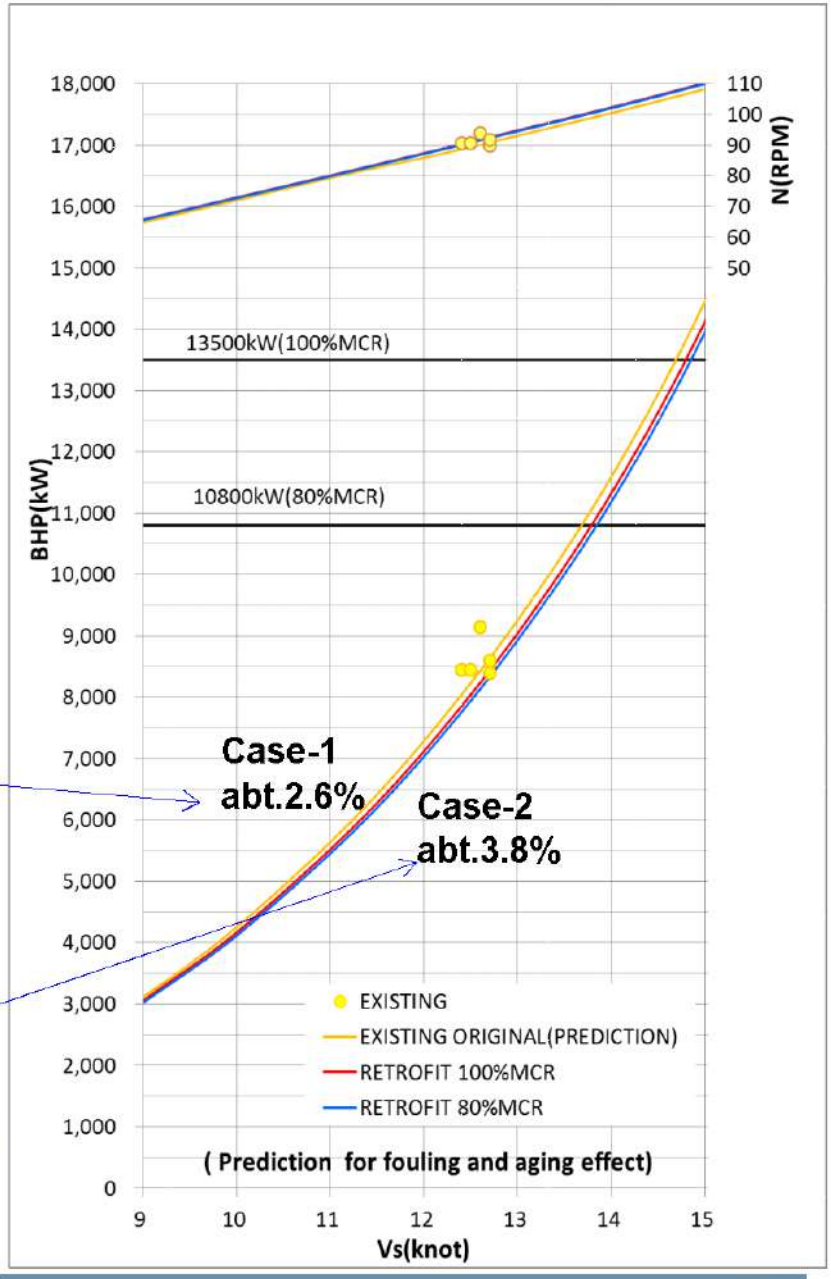
Case-2 : 80% of MCR 10,800kW × 97.5rpm

Expected effect after retrofit propeller by design

BHP Power saving : About 3.8%

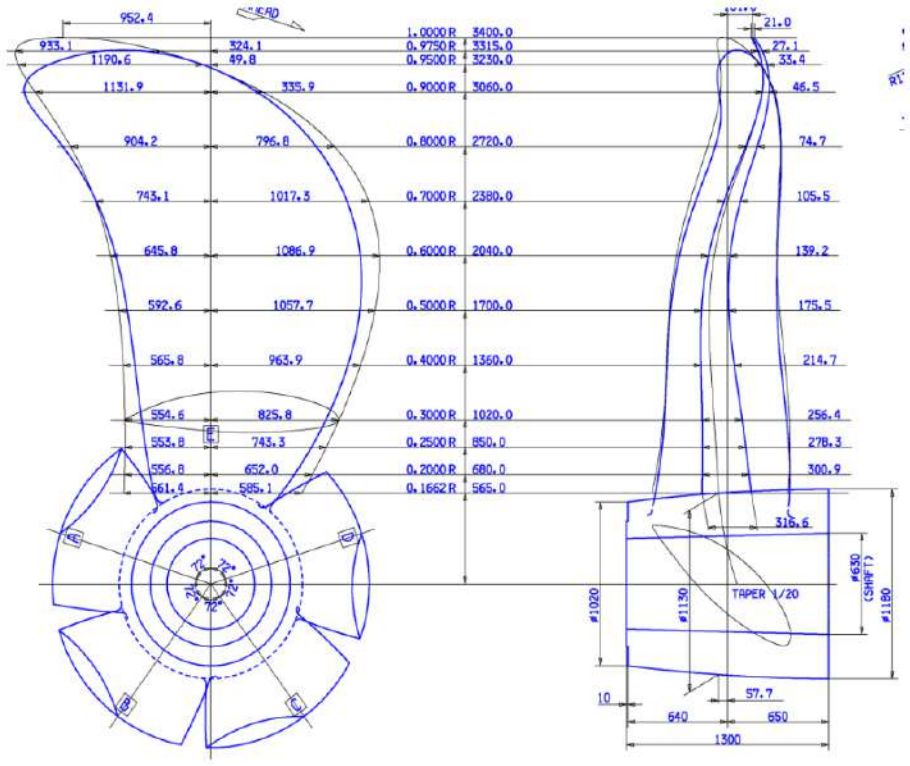
Fuel Cost Saving = 180,000USD/Year

Price of fuel oil : 500 USD/ton
Operating time : 6,000Hr/Year (utilization rates 68%)
Average Power : 60% of MCR (=12,000kW)

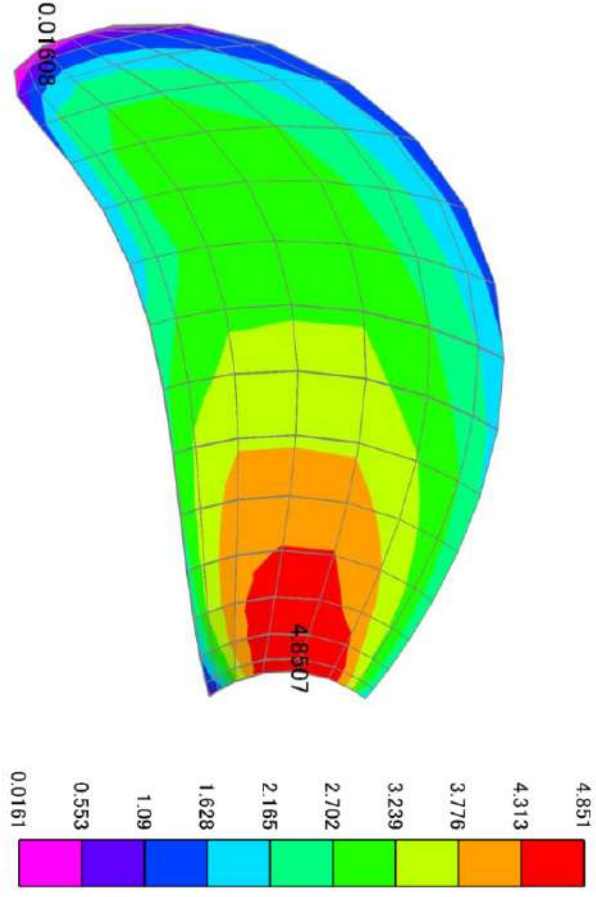


Design data for retrofit propeller Bulk Carrier

Outline of retrofit propeller & blade strength



DP=6.8m 5z 25.9ton
Outline



Result of FEM analysis
(100%MCR)

Propeller Replacement Work

MITSUBISHI HEAVY INDUSTRIES
MARINE MACHINERY & EQUIPMENT CO., LTD.

Work flow of the propeller replacement work

Old Propeller pullout and remove
One day

↓

Blue-Fitting test of New propeller
Two ~ four days

↓

New Propeller push-up
One day

Total four~six days for replacement work

Propeller Replacement Work

MITSUBISHI HEAVY INDUSTRIES
MARINE MACHINERY & EQUIPMENT CO., LTD.

Blue-Fitting test of propeller can be carried out without removing the propeller shaft.

(1/7)

Marine Machinery Division Engineering Department

TECHNICAL REPORT

SZ30-C0639

Date 01 Mar. 2016

ORDER NO. R7855 PROJECT NAME M/V [redacted]

SUBJECT Report of contact check of cone-part between propeller shaft and propeller for new-propeller replacement

1. General

This report shows the results of contact check of cone part between propeller shaft and propeller for new-propeller replacement of [redacted] at COSCO ZUOSHAN in Feb,2016.

2. Outline of the contact check work (blue fitting) and push-up work

・28 Feb. 2016

The first contact check (blue-fitting) carried out at mid-night (~02:00 AM)
The result of contact test was good.
The uniform contact are obtained in the shaft length direction
Judging from Superintendent of MSC and SV of MHI-MME, the contact area was more than 90%. The contact check has been completed.
The photos of the contact check are attached in attachment-1.

・29 Aug. 2016

Class (GL) Surveyor confirmed the results of contact check at 9:00 AM
The push-up work of propeller is carried out at 15:00-18:00
The photos and record of push-up diagram are attached in attachment-2
The result of push-up diagram and push-up work is quite normal.

Remarks,

The shipyard used the two hydraulic jacks instead of the original hydraulic Ring for contact check (Blue Fitting).
The ram area of these hydraulic jacks was about 126.8 cm^2/unit.

MHI-MME calculated the appropriate push-up pressure based on the above ram area.
The push-up pressure was 43MPa. The push-up load was 1090kN (about 110ton).

[redacted]	(No.)			Section		Conferred
	1			Approved	K.Kawamae	
		MHI-MME	1	Checkd		
		Total	3	Drawn		

MITSUBISHI HEAVY INDUSTRIES MARINE MACHINERY & ENGINE CO., LTD.

Attachment-1

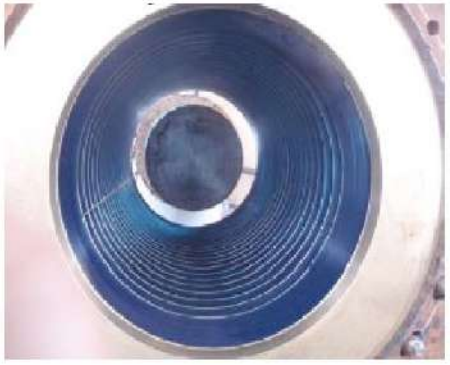
1st CONTACT CHECK (BLUE FITTING) AT COSCO ZHOUSHAN

1st CONTACT CHECK (BLUE FITTING) -BOSS INSIDE-

Propeller Replacement Work

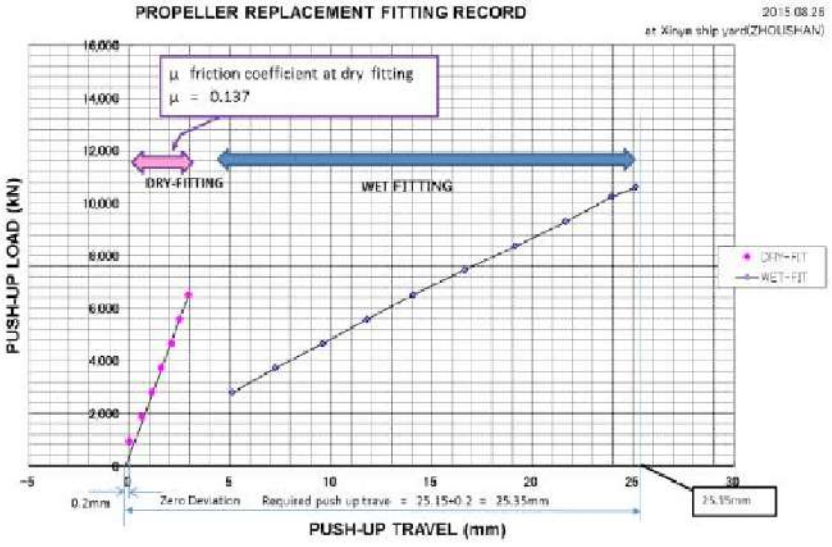
MITSUBISHI HEAVY INDUSTRIES
MARINE MACHINERY & EQUIPMENT CO., LTD.

Blue-Fitting test of propeller can be carried out without removing the propeller shaft.



Contact test carried out at Dry dock without bedding with propeller shaft.

The friction coefficient of the dry-fitting during the push-up propeller.
$\mu = 0.137$



Solution for Initial Cost Saving

MITSUBISHI HEAVY INDUSTRIES
MARINE MACHINERY & EQUIPMENT CO., LTD.

To minimize the initial cost;

(1) Exchange at Dry Dock

Retrofit(new) Propeller

(2) Trade in Existing Propeller for Retrofit Propeller

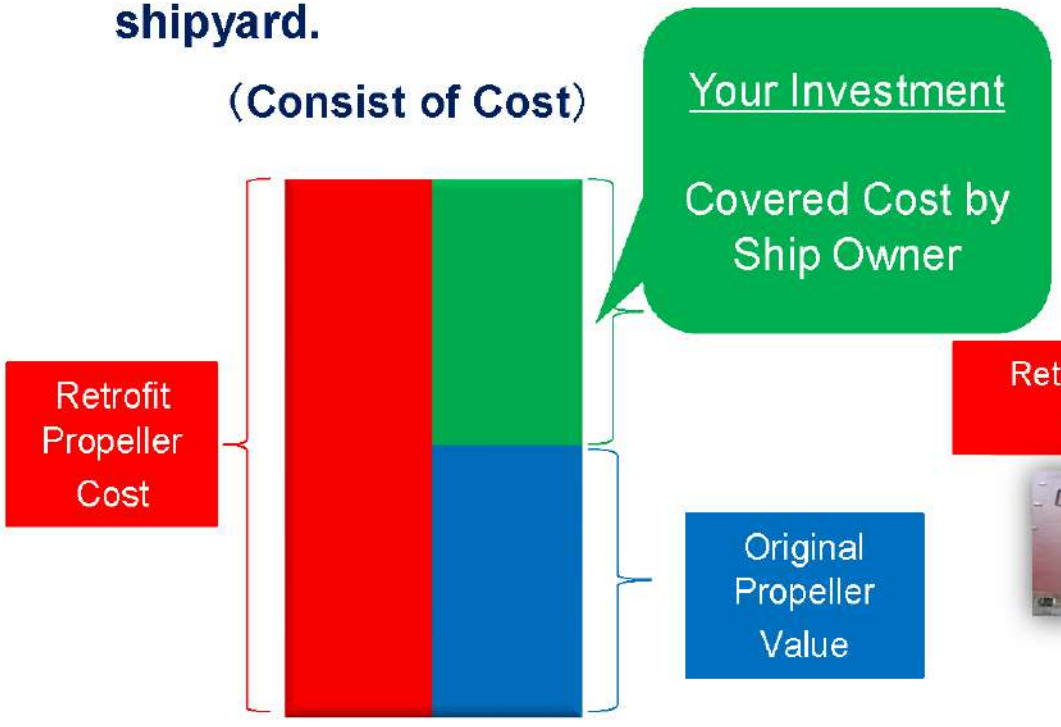
Existing(old) Propeller

Solution for Initial Cost Saving

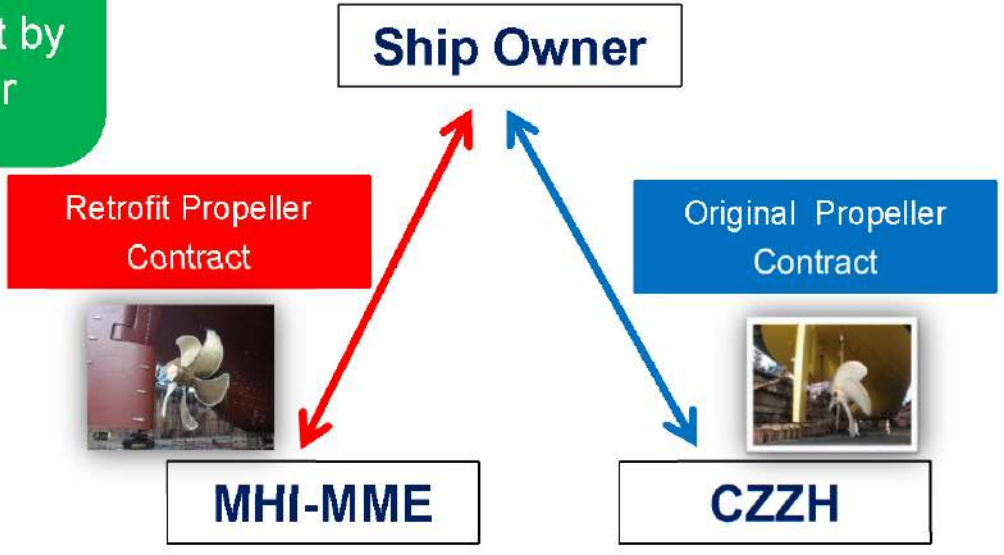
MITSUBISHI HEAVY INDUSTRIES
MARINE MACHINERY & EQUIPMENT CO., LTD.

- For Propeller Retrofitting Project, we MHI-MME manufacture the propellers in our Chinese partner's factory, "Changzhou Zhonghai Marine Propeller Co., Ltd" (CZZH).
- CZZH is MHI-MME's propeller licensee in China since 2014.
- If the vessel is docked at Chinese shipyard (excluding Shanghai area shipyard), CZZH can purchase the original propeller from Ship Owner. So Ship Owner do not need handling work of the original propeller after replacement work at the shipyard.

(Consist of Cost)



(Contract Scheme)



Our Chinese Licensee (CZZH)

MITSUBISHI HEAVY INDUSTRIES
MARINE MACHINERY & EQUIPMENT CO., LTD.

Company Name	常州市中海船舶螺旋桨有限公司 (Changzhou Zhonghai Marine Propeller Co.,Ltd :CZZH)
Address	Changzhou City
History	Established in 1992
Employee	180
Main product	Fixed Pitch Propeller etc.

New Factory Completed in 2014

Our Chinese Licensee (CZZH)

MITSUBISHI HEAVY INDUSTRIES
MARINE MACHINERY & EQUIPMENT CO., LTD.

Capacity

Maximum : 5,000ton

Casting weight : 120tons

Maximum Diameter : 11,000mm
Maximum Weight : 85.0ton

Marine shafting machining
length=16,000mm, weight=100 ton

Initial Study for propeller retrofit

MITSUBISHI HEAVY INDUSTRIES
MARINE MACHINERY & EQUIPMENT CO., LTD.

To make the propeller retrofit proposal
Please submit the following technical information to us.

- **Hull & main engine particulars.**
- **Hull resistance and self propulsion factor or model test report.**
- **Original propeller data.**
- **Actual operating condition of the vessel in service, for example “Log Data (one year)”.**