Gate Rudder .

The president Takayuki Imoto of Imoto line ordered the next generation container fitted with the gate rudder after recognizing the remarkable fuel savings by his first gate rudder ship 'Shigenobu'

Following the first gate rudder ship Shigenobu operated by Imoto line, two gate rudder ships were ordered from different ship owners. A cargo ship 'Kohsin maru', which entered service in June 2020, was designed to increase ship space, the propeller was installed further aft from the original position. On the contrary, the third vessel ' Shinmon maru' has the same stern shape except the sole piece. This vessel will give us many valuable information for EEXI application which will be in force from the beginning of 2023. Addition to three vessels mentioned above, two vessels are under construction. The second generation 670TEU container is under construction at Kyokuyo shipyards and delivered in the beginning of 2022.

Feb. 2021, Gaters project was launched. The project is already running and preparing all the design work and manufacturing work for the gate rudder which will be installed on a cargo ship "Erge" in mid of 2022.

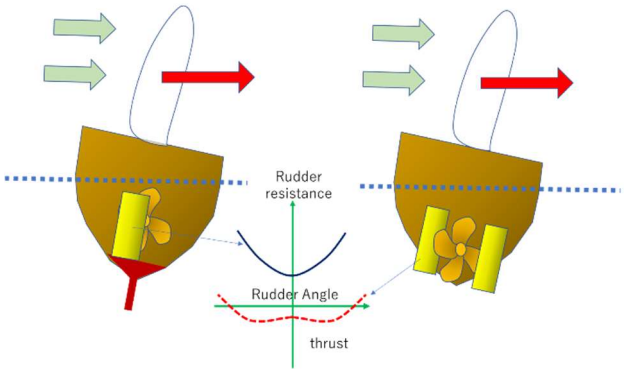
Three exciting topics of this year will be a joint sea trial, Wartsila's exclusive license and Gaters launching. Through the joint sea trial, many excellences of gate rudder were revealed.

Gate rudder is under-water sails

"The wind assisted propulsion to prepare for the IMO's ever-stricter requiremts such as EEDI and EEOI, has been considered among European ship owners. However wind force could generate large drifting force and healing force on the ship, concequently we need a large helm to keep the ship course avoiding so called leeway.

Sasaki said “the conventional rudder is generating only resistance, and the total hull resistance will be much amplified by ship motions such as yawing, rolling and healing. The gate rudder is **Under Water Sails** which can generate thrust as if it works as a sail in the air”.

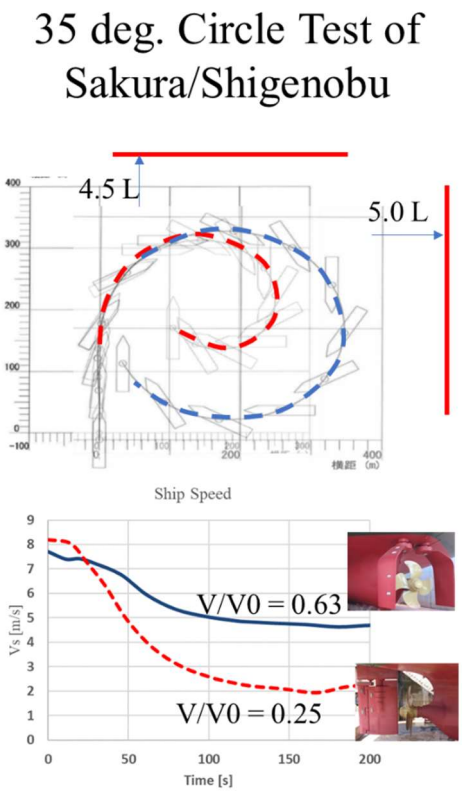
Sasaki added “The resitance produced by the conventional rudder is huge. It easily goes up 30% of ship resistance by only 15 degree steering, it easily kill the valuable thrust obtained from the sail on the deck. Sometimes the wind assisted ship need to equip with a large bottom keel to resist to this large drifting force and healing force. It means that energy saving figures by the sail assisted ship should take this handicap into account addition to the additional maintenance tasks and design restrictions for their deck arrangement.“



The gate rudder can compensate this drifting force and healing force by the lift force produced by the gate rudder based on the same mechanizm as the sail on the deck. The difference is only fluid dencity, i.e. water is 800 times larger than air, which guarantees very effective under water sails.

Safety Turning

Turning ability is important to avoid the accident such as a collision. IMO regulates two performances as standards which are advance and tactical dimeter.On the other hand, turning ablility has strong relationship with her course keeping ability and her rudder type. It is well known fact that the excellent turning ability can be obtained by the vessel with poor course keeping ability. The excellent tactical diameter can be obtained by the vessel with high lift type rudders such as a flap rudder because of higher rudder resistance.



Recent study of sea keeping ability in severe following-quartring sea revealed that the turning charcteristics such as maximum turning rate has dominant effect on the ship safety fom the aspect of capsizing.

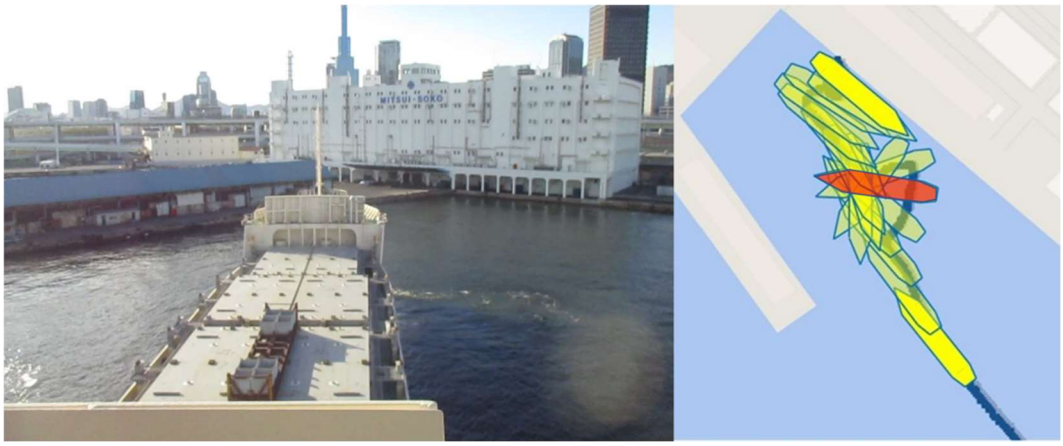
The ship speed at the steady turning condition is also imoportant. The excessive ship heeling angle, the exessive rudder resistance are the main sorse of sudden speed loss of the vessel at the turning motion. The sudden speed loss or remarkable speed loss will introduce the large turning rate and change of ship attitude which is not preferable from the safety view point.

Gate rudder gives us remakable safety turning ability without excessive speed loss.The speed of a gate rudder ship at the same turning rate (the same tactical diameter) is 20-30% higher than a ship with conventional rudder.

The excellent turning ability at port

Crabbing mode and pivot turn can increase operational efficiency in the port. The joint sea trial proved this clearly. Under the same weather conditions, Shigenobu showed her excellence without doubt. By the combination of two rudder angles, 55deg and 110 deg,, Shigenobu succeeded in showing the best berthing using a pivot turn and a crabbing at the extremely narrow port. On the contrary, Sakura decided to use her anchor and head in mode which will require another turning operation at her departure from the quey.

It is well known fact that the efficient port operation for coastal vessel is very important to save fuel. For example, a typical coastal ferry case running 25kts with 30min. duration time, the vessel can save 50% fuel by minimizing the port operation time from 18min. to 13 min. by gate rudder. The same saving can be obtained by stern thruster, however the gate rudder will be more cost-effective.

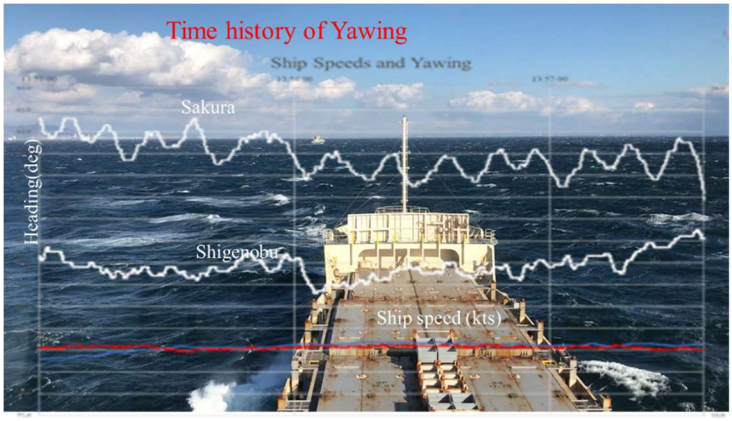


Safety Navigation

Recent study about the cargo loss and damage of RORO vessel in the severe following quatering wave reveals two remarkable features. The first trend is sudden speed loss due to increased hull resistance. Second, large turning rate due to the excessive turning motion.

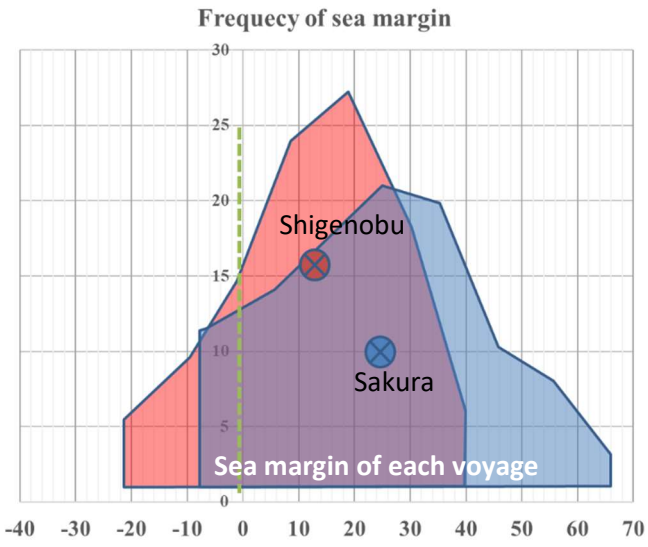
Gate rudder can protect these trend during the turning motion. In other words, the gate rudder can offer not only fuel saving but also safety operation, Sasaki added.

Sasaki added, we obtained clear evidnce from joint sea trial of Sakura and Shigenobu where the wave and wind were coming from following quatrering direction. The gate rudder showed remarkable damping effect on the ship motions during their running period on the same track . The ship conditions of two vessels can be assumed exactly the same because of short distance of two vessel (about 300m). The yawing and rolling amplitude of Shigenobu showed more than half of Sakura..



Sea Margin

Sea margin (power margin) is not identical for all ships. However, ship operator will accept the same sea margin for sister ships if they are operated in the same route as Sakura and Shigenobu (two vessels have the same hull form and engine and the same navigation route). 30months voyage data of Shigenobu was compared with those of Sakura from the aspect of frequency of sea margin. The result shows 11% difference of two vessels sea margin clearly.



The zero sea margin conditions of both ships are different because of Shigenobu showed 14% less power at her speed trial condition. This accurate power save of gate rudder can be calculated by summation of the difference of sea margin and 14% as a bios.

Actual fuel saving = Fuel saving (calm sea) + Fuel saving (difference of sm)

For example, 14% + 11% = 25 % is Shigenobu's case

Structural design

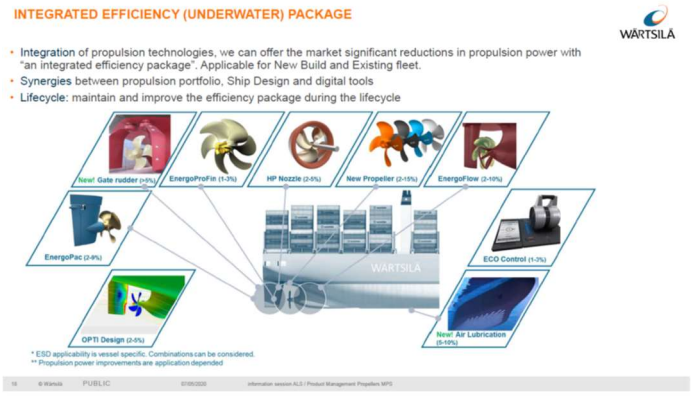
The inspections of rudder itself, rudder shaft, rudder trunk and steering gears have been conducted frequently and continuously. The all data obtained from the inspections seems very healthy. Addition to this, the vessels are very quiet, no vibrations and noise. Three captains are surprising to the remarkable damping effect on the ship motion specially rolling.

Sasaki explained, "Our rudder design is very safe because we have a lot of margin by applying conventional rudder strength calculations. The most critical aspect for the conventional rudder is fatigue failure due to a propeller periodic force including propeller cavitation attack. The exciting force occurring on the gate rudder is extremely low compared with conventional rudders thank to the positions. We believe the structural design

rule for the gate rudder can be much relaxed in the future. We have no limitation for the size of gate rudder. The larger the size, the higher cost-effectiveness can be expected.”.

Commercial activity

Irias Boletis of director of Wartsila propulsion said “Wartsila is only one company that has an exclusive license of gate rudder technology except Japan. As Wartsila is leading company, we continuously develops energy efficiency solutions that help improve customers vessel performance, achieve significant fuel savings and reduce emissions. Gate rudder is quite new idea and we noticed its difference from other ESDs. We expect Gate rudder can be a game changer for ESD world.



Kazuki Itazawa, director of Kamome propeller said “Kamome propeller Ltd. is one of patent holders of gate rudder technology. We have delivered three gate rudder systems to different ship owners. The performance data we obtained from these vessels is more than we expected. We believe the gate rudder is very promising technology for a solution of IMO EEDI , EEXI requirement.

Itazawa added, “We have any inquiries from our customers after delivering three gate rudder systems, some of customers are scheduling the model tests soon. This is good news for us because the research and development phase are over, and our customers are thinking real application to their new building vessels.”

Academic activity

The GATERS project led by the University of Strathclyde under the Horizon 2020 Fund (€6 million), will see the ‘gate rudder’ – a novel propulsion and steering system – retro-fitted to a commercial vessel as part of a trial.

Professor Mehmet Atlar, who is the project coordinator from Department of Naval Architecture and Marine Engineering (NAOME) at Strathclyde, said: "GATERS demonstrates significantly reduced emissions from ships particularly within coastal and port areas, challenging and even exceeding the current and future legislative requirements of the International Marine Organization and local regulations for emissions.

“As a propulsor-based solution, the gate rudder offers a significant amount of power-saving that cannot be achieved by any other single energy-saving device which is currently available in the market.

“An important advantage of the gate rudder system is highly-effective manoeuvrability within coastal and port areas as well as navigating more efficient in waves during oceangoing operations. In addition, the gate rudder system is simple, generic and flexible that can be

installed on new-built ships or retrofitted to existing ships, as well as integrated easily with other fuel-saving and emission reduction technologies. Based on these features, the gate rudder design presents a great prospect of replacing conventional design.”

Delivered ships

Shigenobu (470TEU Container Loa =111m)

Koshin maru (509 Cargo Laoa =)

Shimon maru (499 Cargo Loa =)

Under construction

2nd generation Container ship of Imoto line

Loa = 136.3 m

B = 21.0 m

Capacity 670 TEU

Main Engine

Propeller-Rudder Gate Rudder system