(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 578 779 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
02.07.2025 Bulletin 2025/27

(21) Application number: **23857736.5**

(22) Date of filing: **23.08.2023**

(51) International Patent Classification (IPC):
B63H 21/21 *(2006.01)* ***B63H 21/17*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
B63H 21/17; B63H 21/21

(86) International application number:
PCT/KR2023/012513

(87) International publication number:
WO 2024/043704 (29.02.2024 Gazette 2024/09)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

(30) Priority: **23.08.2022 KR 20220105459**

(71) Applicant: **HD KOREA SHIPBUILDING &OFFSHORE ENGINEERING CO., LTD.**
Gyeonggi-do 13553 (KR)

(72) Inventors:
- **CHO, Young-Ho**
  Ulsan 44032 (KR)
- **BAIK, Joon-Shik**
  Busan 48058 (KR)
- **KIM, Jae-Woo**
  Ulsan 44032 (KR)
- **KIM, Sang-Hyun**
  Ulsan 44032 (KR)
- **PARK, Woo-Jae**
  Ulsan 44032 (KR)
- **JANG, Soon-Sik**
  Busan 48058 (KR)

(74) Representative: **Maiwald GmbH**
Elisenhof
Elisenstraße 3
80335 München (DE)

(54) ELECTRIC PROPULSION CONTROL SYSTEM FOR VESSEL

(57) The objective of the present invention is to provide an electric propulsion control system that has improved acceleration/deceleration and control performance and that can be linked to an autonomous navigation system. The electric propulsion control system for a vessel, according to one embodiment of the present invention, may comprise: an acceleration/deceleration control unit which receives a speed command so as to control acceleration on the basis of the power change rate of an engine of a vessel, and which limits a torque command value according to the speed command within a safety driving region so as control deceleration; and a regenerative energy control unit for estimating the generation amount of regenerative power on the basis of the propeller speed of the vessel and a torque command generated by means of the acceleration/deceleration control unit, and controlling torque limitation of the acceleration/deceleration control unit such that the estimated generation amount of regenerative power is less than or equal to the current load amount.

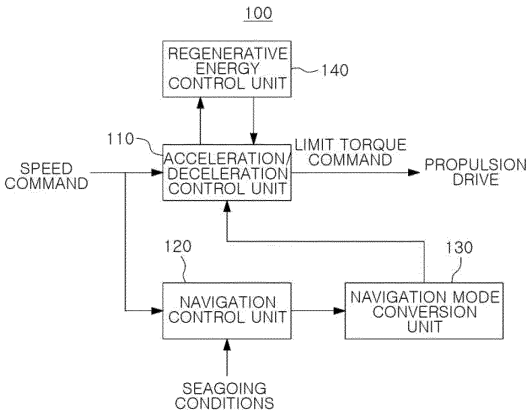

FIG. 1

EP 4 578 779 A1

Description

Technical Field

[0001] The present disclosure relates to an electric propulsion control system for a vessel.

Background Art

[0002] Recently, electric propulsion systems are being adopted for vessels for reasons such as environmental protection and the like.

[0003] In the speed control device that controls a vessel propulsion system of the related art, control is performed based on the speed change rate during acceleration control, and thus when viewed from the engine power perspective, there is a problem in which engine performance cannot be optimally utilized because there is a margin, compared to the engine power change rate performance, and free-wheeling is applied for safety region seagoing during deceleration control, but there is a problem in which a braking distance increases because deceleration may not be performed during a free-wheeling operation.

[0004] In addition, vessels are configured in various navigation modes, and since the output increase amount, maximum propeller speed and the like change depending on respective navigation modes, a process is required to check whether it is possible to perform under the current seagoing conditions when output fluctuations are required, and if it is fixed to a specific operation condition during autonomous operations, there may be a problem that the desired level of propulsion performance may not be implemented in a timely manner, and if regenerative energy exceeding the load is generated during a low-load operation, the surplus regenerative energy should be consumed using a braking resistor or the like, so the installation of a braking resistor is essential, but since the braking resistor is expensive, there is a problem that manufacturing costs increase if many are employed.

[0005] (Patent Document 1) Republic of Korea Publication of Patent Publication No. 10-2019-0081151

Summary of Invention

Technical Problem

[0006] An aspect of the present disclosure is to provide an electric propulsion control system having improved acceleration/deceleration and control performance and capable of linking with an autonomous navigation system.

Solution to Problem

[0007] According to an aspect of the present disclosure to resolve the above-described problem, an electric propulsion control system for a vessel includes an acceleration/deceleration control unit receiving a speed command, controlling acceleration based on a rate of change in power of an engine of the vessel, and controlling deceleration by limiting a torque command value according to the speed command to a safety driving region; and a regenerative energy control unit estimating an amount of regenerative power generated based on a propeller speed of the vessel and a torque command generated by the acceleration/deceleration control unit, and controlling a torque limitation of the acceleration/deceleration control unit so that an estimated amount of the regenerative power generated is less than or equal to a current load amount.

Advantageous Effects of Invention

[0008] According to an embodiment of the present disclosure, there is an effect of improving acceleration/-deceleration performance and minimizing the installation of a braking resistor.

Brief Description of Drawings

[0009]

FIG. 1 is a schematic diagram of an electric propulsion control system for a vessel according to an embodiment of the present disclosure.

FIG. 2 is a schematic diagram of an acceleration/-deceleration control unit of an electric propulsion control system for a vessel according to an embodiment of the present disclosure.

FIG. 3 is a graph illustrating the technical effect of an acceleration/deceleration control unit of an electric propulsion control system for a vessel according to an embodiment of the present disclosure.

FIG. 4 is a schematic block diagram of a navigation control unit and a navigation mode conversion unit of an electric propulsion control system for a vessel according to an embodiment of the present disclosure.

FIG. 5 is a schematic diagram of a regenerative energy control unit of an electric propulsion control system for a vessel according to an embodiment of the present disclosure.

FIG. 6 is a diagram illustrating a technical effect of a regenerative energy control unit of an electric propulsion control system for a vessel according to an embodiment of the present disclosure.

FIG. 7 is a diagram illustrating an example computing environment in which an electric propulsion control system for a vessel according to an embodiment of the present disclosure may be implemented.

Detailed Description for Invention

[0010] Hereinafter, with reference to the attached

drawings, a preferred embodiment will be described in detail so that a person having ordinary knowledge in the technical field to which the present disclosure pertains may easily practice the present disclosure.

[0011] FIG. 1 is a schematic configuration diagram of an electric propulsion control system for a vessel according to an embodiment of the present disclosure.

[0012] Referring to FIG. 1, an electric propulsion control system (100) for a vessel according to an embodiment of the present disclosure may include an acceleration/deceleration control unit (110) and a regenerative energy control unit (140), and may further include a navigation control unit (120) and a navigation mode conversion unit (130).

[0013] The acceleration/deceleration control unit (110) may receive a speed command and control acceleration based on the power change rate of the vessel's engine, and may control deceleration by limiting a torque command value according to the received speed command to a safety driving region set in advance.

[0014] The regenerative energy control unit (140) may estimate the amount of regenerative power generated based on the propeller speed of the vessel and the torque command generated from the acceleration/deceleration control unit (110), and may control the torque limitation of the acceleration/deceleration control unit (110) so that the estimated amount of regenerative power generated is less than or equal to the current load amount.

[0015] The navigation control unit (120) may calculate an power change rate per unit time based on a current output amount to a target power amount when receiving a speed command, and may determine an optimal navigation mode among a plurality of navigation modes set in advance based on the calculated power change rate.

[0016] The navigation modes conversion unit (130) may convert the navigation mode into a corresponding navigation mode among the plurality of navigation modes, according to the navigation mode determined by the navigation control unit (120), and transmit the same to the acceleration/deceleration control unit (110).

[0017] FIG. 2 is a schematic configuration diagram of the acceleration/deceleration control unit of the electric propulsion control system for a vessel according to an embodiment of the present disclosure.

[0018] Referring to FIG. 2 together with FIG. 1, the acceleration/deceleration control unit (110) of the electric propulsion control system (100) for a vessel according to an embodiment of the present disclosure may include a speed controller (111), an power change rate limiter (112), and a safety driving region setting device (113).

[0019] The speed controller (111) may receive the speed command. The speed command may be a propeller speed command (RPM) of the vessel. The speed controller (111) may generate a torque command that controls the torque of a propulsion drive that drives a propeller according to the current propeller speed and the propeller speed command (RPM) of the vessel.

[0020] The power change rate limiter (112) may output a modified torque command that limits the power change rate so that the power does not exceed the performance of the engine, by reflecting the generator power, current navigation mode and engine power characteristics (Ramp characteristic) of the vessel, for the torque command from the speed controller (111).

[0021] The safety driving region setting device sets the safety driving region by considering the vessel's construction specifications, current navigation mode, and operation conditions, and determines whether the corrected torque command from the power change rate limiter (112) exists within the safety driving region. If the torque command falls outside the safety driving region, the torque command is limited to a value within the safety driving region and then the torque command is transmitted to the propulsion drive. At this time, the safety driving region may vary depending on the vessel's seagoing conditions, and the safety driving region may be adjusted by the regenerative energy control unit so that the regenerative power does not exceed the target value.

[0022] FIG. 3 is a graph illustrating a technical effect of the acceleration/deceleration control unit of the electric propulsion control system for a vessel according to an embodiment of the present disclosure.

[0023] Referring to FIG. 3 together with FIG. 2, first, by performing control based on an power change rate (kW/s) of an engine during acceleration control according to the speed command, the engine power performance may be utilized at maximum, and as illustrated in the upper part of FIG. 3, the engine power may be improved compared to the speed change rate-based control, thereby improving the acceleration performance.

[0024] Next, by controlling the torque so that driving is possible within the safety zone without free-wheeling through the torque limitation function during deceleration control, the deceleration performance may be improved because there is no free-wheeling section.

[0025] FIG. 4 is a schematic configuration diagram of the navigation control unit and the navigation mode conversion unit of the electric propulsion control system for a vessel according to an embodiment of the present disclosure.

[0026] Referring to FIG. 4 together with FIG. 1, first, the navigation control unit (120) may include an power change rate calculation unit (121) and an optimal navigation mode selection unit (122).

[0027] When the speed command is input, the power change rate calculation unit (121) may calculate an power change rate per unit time based on the current power amount to a target power amount.

[0028] The optimal navigation mode selection unit (122) may compare and select the power change rate calculated by the power change rate calculation unit (121) with power change rates that may be performed in respective modes to check whether it is an power change rate that may be performed in the current navigation mode, and may determine an optimal navigation mode through the power change rate comparison. In

addition, the optimal navigation mode selection unit (122) may check the current operation conditions and determine an optimal navigation mode suitable for the conditions when conversion in the navigation mode is necessary.

[0029] The navigation mode conversion unit (130) may automatically perform navigation mode conversion according to the determination of the optimal navigation mode selection unit (122).

[0030] The navigation mode conversion unit (130) may include a navigation mode unit (131) by an power characteristic having a normal mode (131a) and a fast mode (131b) set in advance according to engine power characteristics, a navigation mode unit (132) by engine fuel having a fuel mode (132a) and a gas mode (132b) set in advance according to engine fuel, and a navigation mode unit (133) by vessel location having a normal seagoing mode (133a) and a port mode (133b) set in advance according to vessel location.

[0031] The navigation mode conversion unit (130) may convert a navigation mode into an appropriate navigation mode among respective modes of the navigation mode unit (131) by a power characteristic, the navigation mode unit (132) by engine fuel, and the navigation mode unit (133) by vessel location, according to the navigation mode determined by the optimal navigation mode selection unit (122), and may transmit the converted navigation mode to the safety driving region setting device (113). The safety driving region setting device (113) may set an appropriate safety driving region for each navigation mode, determine whether the corrected torque command from the power change rate limiter (112) exists within the safety driving region, and, if the torque command falls outside the safety driving region, may limit the torque command to a value within the safety driving region and then transmit the torque command to the propulsion drive.

[0032] FIG. 5 is a schematic block diagram of the regenerative energy control unit of the electric propulsion control system for a vessel according to an embodiment of the present disclosure.

[0033] Referring to FIG. 5, the regenerative energy control unit (140) of the electric propulsion control system (100) for a vessel according to an embodiment of the present disclosure may include a regenerative power estimation unit (141), a comparison unit (142), and a torque control unit (143).

[0034] The regenerative power estimation unit (141) may estimate the regenerative power based on the current propeller speed and the torque command calculated by the speed controller (111).

[0035] The comparison unit (142) may then compare the regenerative power estimated by the regenerative power estimation unit (141) with a current total load amount.

[0036] The torque control unit (143) may control the torque limitation of the safety driving region setting device (113) so that the estimated regenerative power amount does not exceed the current total load amount.

[0037] FIG. 6 is a drawing illustrating the technical effect of the regenerative energy control unit of the electric propulsion control system for a vessel according to an embodiment of the present disclosure.

[0038] Referring to FIG. 6 together with FIG. 5, the current load amount is monitored in real time and the amount of regenerative energy generated during sudden braking is controlled so that it does not become larger than the current load amount, thereby minimizing the energy to be processed and minimizing an installation capacity of the braking resistor, which is a regenerative energy processing device.

[0039] FIG. 7 is a drawing illustrating an example computing environment in which the electric propulsion control system for a vessel according to an embodiment of the present disclosure may be implemented.

[0040] Referring to FIG. 7, an example of a system (1000) including a computing device (1100) configured to implement one or more of the above-described embodiments is illustrated. For example, the computing device (1100) may include, but is not limited to, a personal computer, a server computer, a handheld or laptop device, a mobile device (for example, a mobile phone, a PDA, a media player, or the like), a multiprocessor system, a consumer electronic device, a minicomputer, a mainframe computer, a distributed computing environment including any of the aforementioned systems or devices, or the like.

[0041] The computing device (1100) may include at least one processing unit (1110) and a memory (1120). In this case, the processing unit (1110) may include, for example, a central processing unit (CPU), a graphics processing unit (GPU), a microprocessor, an application specific integrated circuit (ASIC), field programmable gate arrays (FPGAs), and the like, and may have multiple cores. The memory (1120) may be a volatile memory (for example, a RAM or the like), a nonvolatile memory (for example, a ROM, a flash memory or the like), or a combination thereof.

[0042] Additionally, the computing device (1100) may include additional storage (1130). The storage (1130) may include, but is not limited to, magnetic storage, optical storage, and the like. The storage (1130) may store computer-readable instructions for implementing one or more embodiments disclosed herein, and may also store other computer-readable instructions for implementing an operating system, application programs, and the like. The computer-readable instructions stored in the storage (1130) may be loaded into the memory (1120) for execution by the processing unit (1110).

[0043] Additionally, the computing device (1100) may include input device(s) (1140) and output device(s) (1150). In this case, the input device(s) (1140) may include, for example, a keyboard, a mouse, a pen, a voice input device, a touch input device, an infrared camera, a video input device, any other input device, or the like. Additionally, the output device(s) (1150) may include, for

example, one or more displays, speakers, printers, any other output devices, or the like. Additionally, the computing device (1100) may also use input devices or output devices provided in other computing devices as the input device(s) (1140) or the output device(s) (1150).

[0044] Additionally, the computing device (1100) may include communication connection(s) (1160) enabling communicate with another device (for example, the computing device (1300)) via the network (1200). In this case, the communication connection(s) (1160) may include a modem, a network interface card (NIC), an integrated network interface, a radio frequency transmitter/receiver, an infrared port, a USB connection, or other interfaces for connecting the computing device (1100) to other computing devices. Additionally, the communication connection(s) (1160) may include wired or wireless connections.

[0045] Respective components of the computing device (1100) described above may be connected by various interconnections (for example, peripheral component interconnect (PCI), USB, firmware (IEEE 1394), optical bus structure, or the like), such as buses or the like, and may also be interconnected by a network.

[0046] As used in this specification, terms such as "acceleration/deceleration control unit," "speed controller," "power change rate limiter," "safety driving region setting device," "navigation control unit," "power change rate calculator," "optimal navigation mode selection unit," "navigation mode conversion unit," "navigation mode unit by an output characteristic," "navigation mode unit by engine fuel," "navigation mode unit by vessel location," "regenerative energy control unit," "regenerative power estimation unit," "comparison unit," "torque control unit," and the like, generally refer to hardware, a combination of hardware and software, software, or a computer-related entity that is running software. For example, a component may be, but is not limited to, a process running on a processor, a processor, an object, an executable, a thread of execution, a program, and/or a computer. For example, both an application running on a controller and the controller may be a component. One or more components may exist within a process and/or thread of execution, and the components may be localized on one computer or distributed between two or more computers.

[0047] As described above, according to the present disclosure, the acceleration and deceleration performance of the vessel is improved and the installation of the braking resistor may be minimized.

[0048] The present disclosure described above is not limited by the above-described embodiments and the attached drawings, but is limited by the scope of the patent claims described below, and it will be readily apparent to those skilled in the art to which the present disclosure pertains that the configuration of the present disclosure may be variously changed and modified within a scope that does not depart from the technical idea of the present disclosure.

Claims

1. An electric propulsion control system for a vessel, comprising:

an acceleration/deceleration control unit receiving a speed command, controlling acceleration based on a rate of change in an output of an engine of the vessel, and controlling deceleration by limiting a torque command value according to the speed command to a safety driving region; and

a regenerative energy control unit estimating an amount of regenerative power generated based on a propeller speed of the vessel and a torque command generated by the acceleration/deceleration control **unit,** and controlling a torque limitation of the acceleration/deceleration control unit so that an estimated amount of the regenerative power generated is less than or equal to a current load amount.

2. The electric propulsion control system for a vessel of claim **1,** further comprising:

an navigation control unit calculating an power change rate per unit time based on a current power amount to a target power amount when the speed command is received, and determining an optimal navigation mode among a plurality of navigation modes set in advance based on a calculated power change rate; and

a navigation mode conversion unit converting a navigation mode into a corresponding navigation mode among the plurality of navigation modes according to the navigation mode determined by the navigation control unit, and transmitting the navigation mode to the acceleration/-deceleration control unit.

3. The electric propulsion control system for a vessel of claim 1, wherein the acceleration/deceleration control unit includes,

a speed controller comparing a current propeller speed of the vessel with a target propeller speed and outputting the torque command value;

an power change rate limiter modifying the torque command value from the speed controller according to engine power characteristics of the vessel, a generator power of the vessel, and a current navigation mode; and

a safety driving region setting device limiting a modified torque command value from the power change rate limiter to the safety driving region.

4. The electric propulsion control system for a vessel of claim **2,** wherein the navigation control unit includes,

an power change rate calculation unit calculating the power change rate per unit time based on the current power amount to the target power amount when the speed command is received; and

an optimal navigation mode selection unit comparing the power change rate calculated by the power change rate calculation unit with a power change rate capable of being performed by each of the plurality of navigation modes and determining whether the power change rate is performable in a current navigation mode, and determining the optimal navigation mode among the plurality of navigation modes through comparison of the power change rates.

5. The electric propulsion control system for a vessel of claim **4,** wherein the navigation mode conversion unit includes,

a navigation mode unit by a power characteristic having a normal mode and a fast mode set in advance;

a navigation mode unit by engine fuel having a fuel mode and a gas mode set in advance; and

a navigation mode unit by vessel location having a normal seagoing mode and a port mode set in advance, and

the navigation mode conversion unit transmits a converted navigation mode to the safety driving region setting device by conversion into an appropriate navigation mode among respective modes of the navigation mode unit by an power characteristic, the navigation mode unit by engine fuel, and the navigation mode unit by vessel location, according to the navigation mode determined by the navigation control unit.

6. The electric propulsion control system for a vessel of claim 1, wherein the regenerative energy control unit includes,

a regenerative power estimation unit estimating an amount of regenerative power generated based on a current propeller speed and a torque command calculated by the speed controller;

a comparison unit comparing the amount of the regenerative power estimated by the regenerative power estimation unit with the current load amount; and

a torque control unit controlling a torque limitation of the safety driving region setting device so that the estimated amount of regenerative power generated is less than or equal to the current load amount.

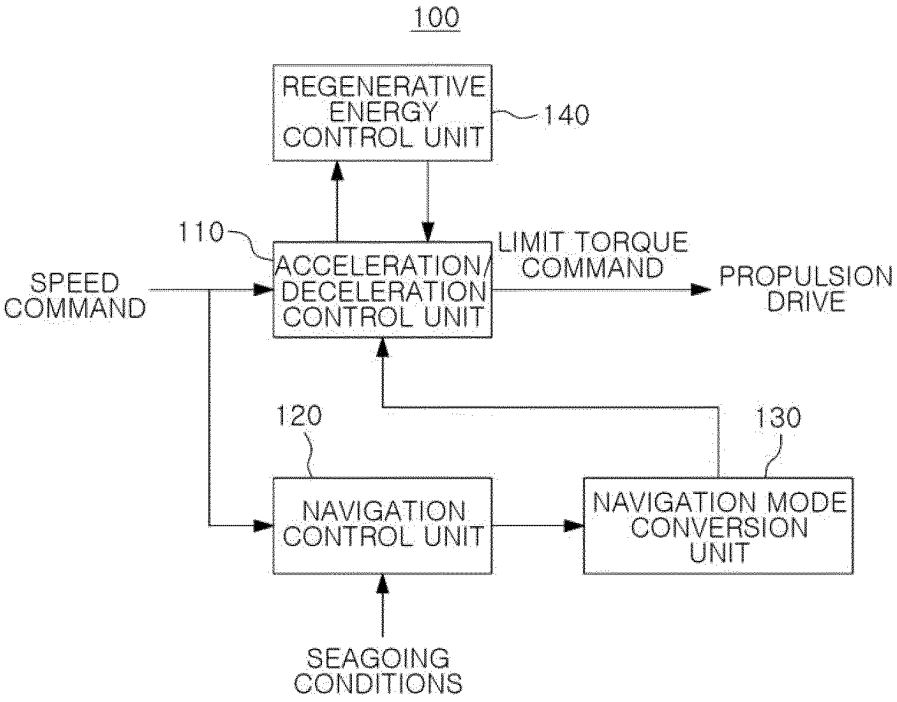
100
REGENERATIVE ENERGY CONTROL UNIT
140
110
ACCELERATION/ DECELERATION CONTROL UNIT
LIMIT TORQUE COMMAND
PROPULSION DRIVE
SPEED COMMAND
120
130
NAVIGATION CONTROL UNIT
NAVIGATION MODE CONVERSION UNIT
SEAGOING CONDITIONS

FIG. 1

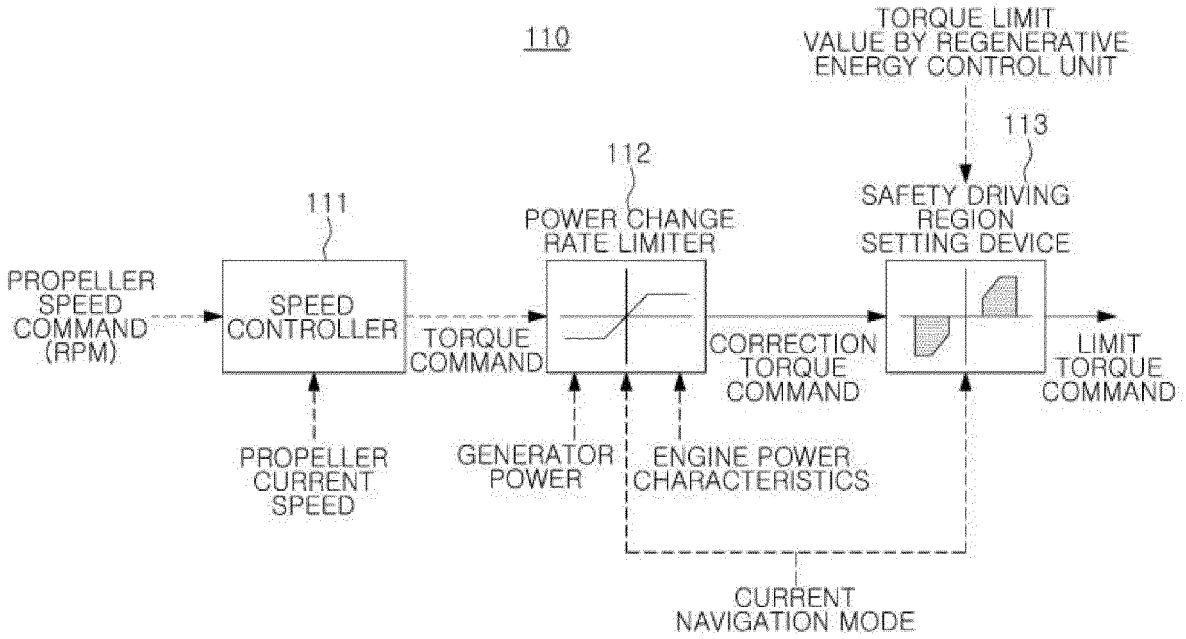
110
TORQUE LIMIT VALUE BY REGENERATIVE ENERGY CONTROL UNIT
113
112
111
POWER CHANGE RATE LIMITER
SAFETY DRIVING REGION SETTING DEVICE
PROPELLER SPEED COMMAND (RPM)
SPEED CONTROLLER
TORQUE COMMAND
CORRECTION TORQUE COMMAND
LIMIT TORQUE COMMAND
PROPELLER CURRENT SPEED
GENERATOR POWER
ENGINE POWER CHARACTERISTICS
CURRENT NAVIGATION MODE

FIG. 2

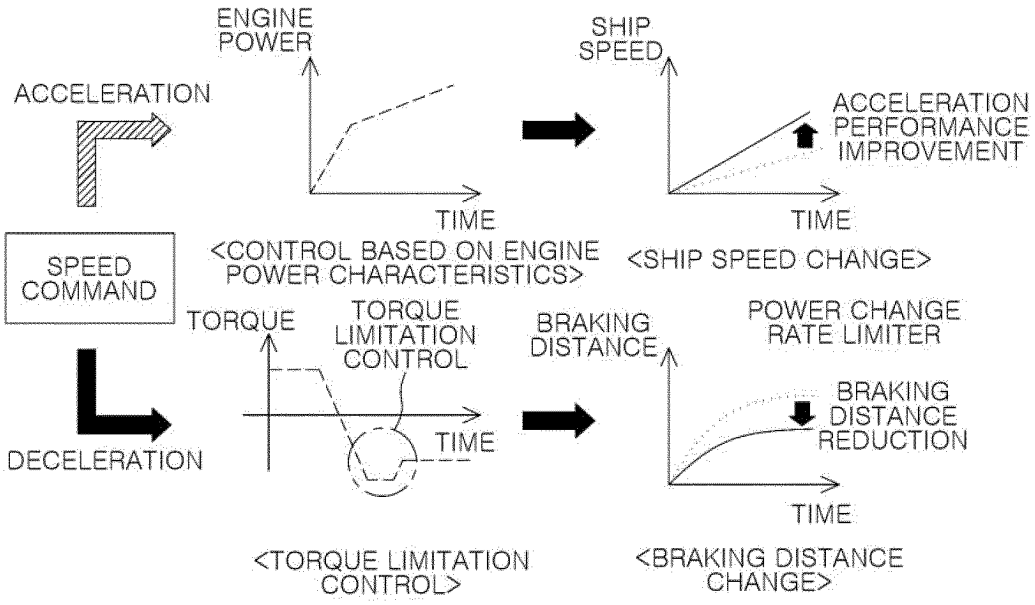
ACCELERATION
SPEED COMMAND
DECELERATION
ENGINE POWER
TIME
<CONTROL BASED ON ENGINE POWER CHARACTERISTICS>
SHIP SPEED
ACCELERATION PERFORMANCE IMPROVEMENT
TIME
<SHIP SPEED CHANGE>
TORQUE
TORQUE LIMITATION CONTROL
TIME
<TORQUE LIMITATION CONTROL>
BRAKING DISTANCE
POWER CHANGE RATE LIMITER
BRAKING DISTANCE REDUCTION
TIME
<BRAKING DISTANCE CHANGE>

FIG. 3

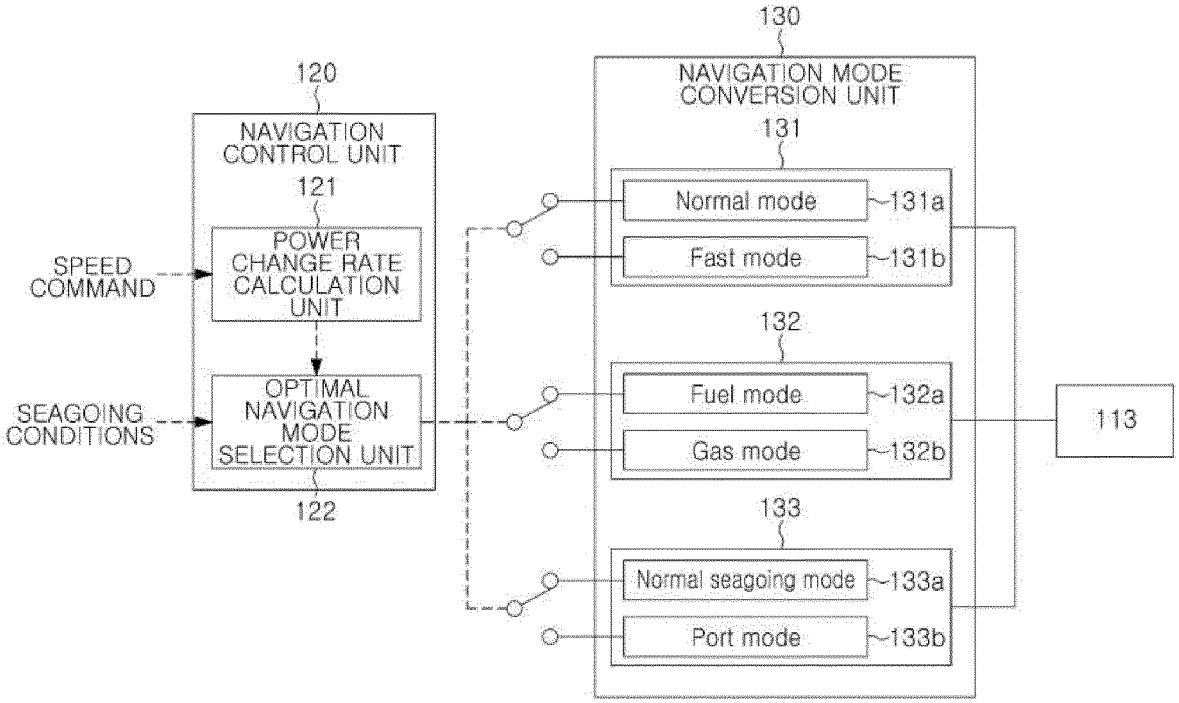
130
NAVIGATION MODE CONVERSION UNIT
120
NAVIGATION CONTROL UNIT
121
POWER CHANGE RATE CALCULATION UNIT
SPEED COMMAND
SEAGOING CONDITIONS
OPTIMAL NAVIGATION MODE SELECTION UNIT
122
131
Normal mode
131a
Fast mode
131b
132
Fuel mode
132a
Gas mode
132b
133
Normal seagoing mode
133a
Port mode
133b
113

FIG. 4

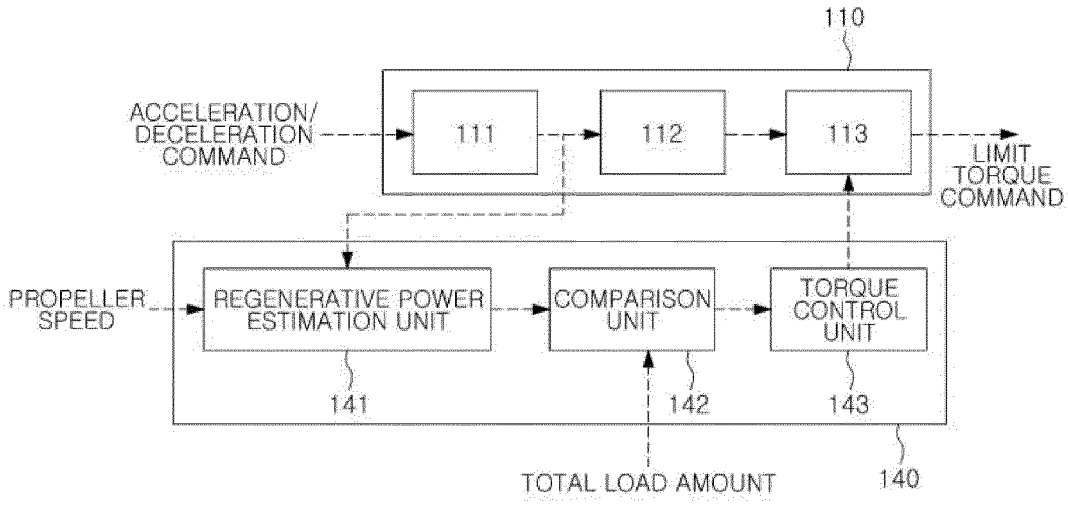
110
ACCELERATION/
DECELERATION
COMMAND
111
112
113
LIMIT
TORQUE
COMMAND
PROPELLER
SPEED
REGENERATIVE POWER
ESTIMATION UNIT
COMPARISON
UNIT
TORQUE
CONTROL
UNIT
141
142
143
TOTAL LOAD AMOUNT
140

FIG. 5

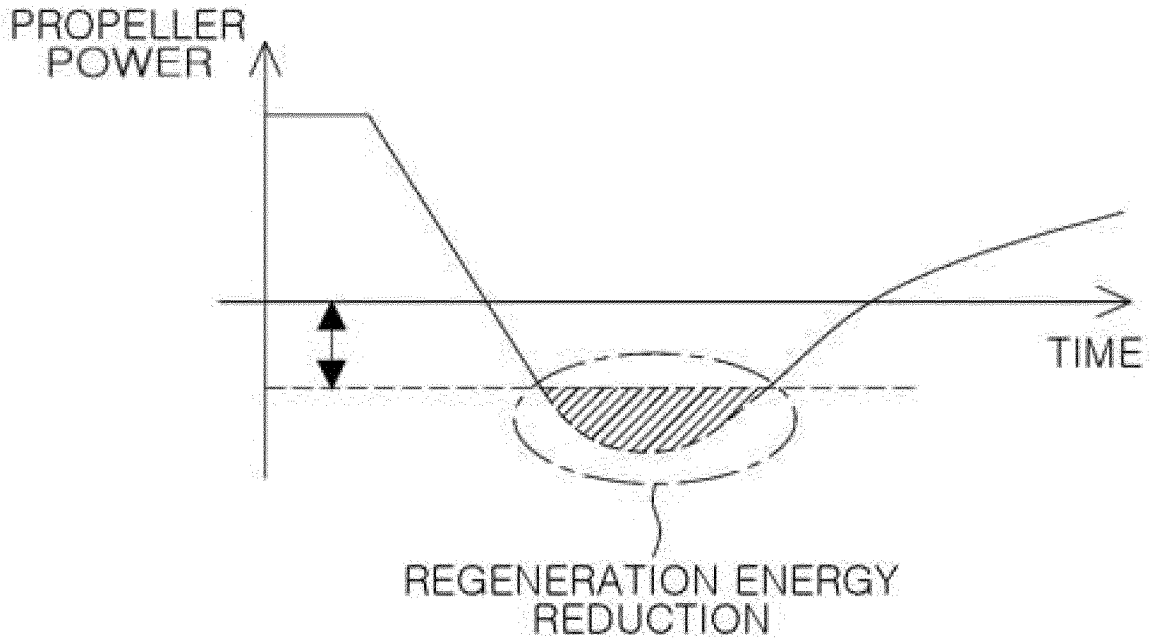

FIG. 6

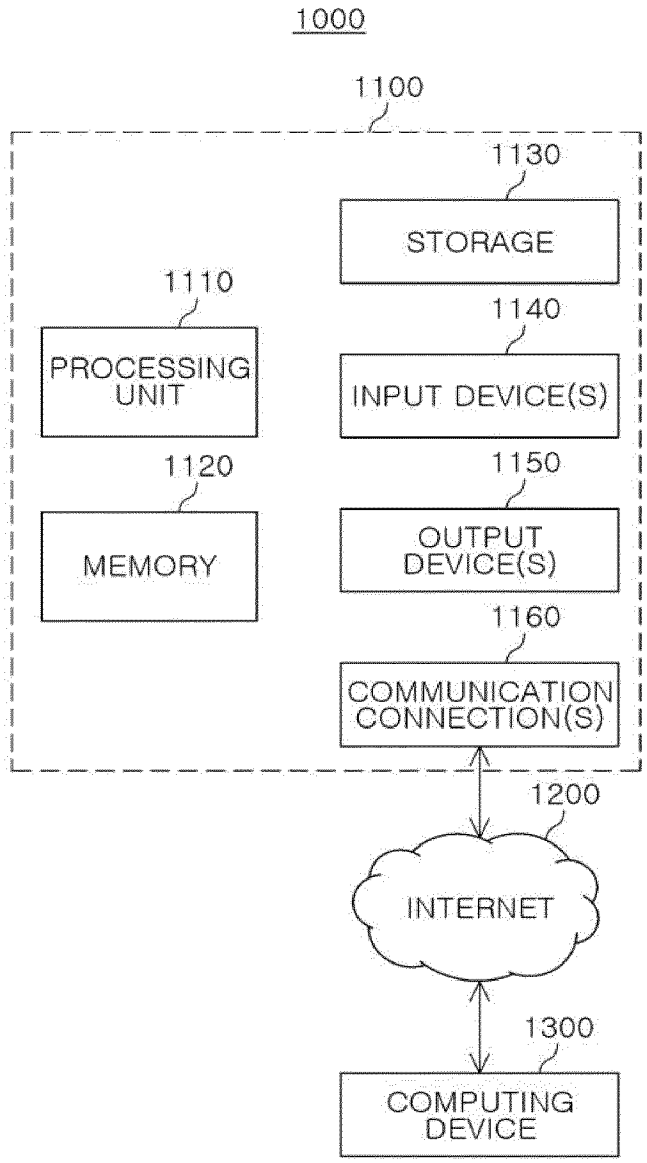
1000
1100
1130
STORAGE
1110
PROCESSING UNIT
1140
INPUT DEVICE(S)
1120
MEMORY
1150
OUTPUT DEVICE(S)
1160
COMMUNICATION CONNECTION(S)
1200
INTERNET
1300
COMPUTING DEVICE

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2023/012513

A. CLASSIFICATION OF SUBJECT MATTER

B63H 21/21(2006.01)i; **B63H 21/17**(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B63H 21/21(2006.01); B60L 11/18(2006.01); B60L 7/10(2006.01); B60W 20/13(2016.01); B60W 20/14(2016.01); B60W 40/105(2012.01); B60W 50/10(2012.01); F02D 41/22(2006.01); F02D 41/26(2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models: IPC as above
Japanese utility models and applications for utility models: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS (KIPO internal) & keywords: 선박(ship), 속도(velocity), 엔진(engine), 출력(output), 가속(acceleration), 감속(deceleration), 토크(torque), 회생에너지(regenerated energy), 추진(propel), 제어(control)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	KR 10-2013-0054330 A (GENERAL ELECTRIC COMPANY) 24 May 2013 (2013-05-24) See paragraphs [0047], [0051] and [0084].	1-6
A	KR 10-1610121 B1 (HYUNDAI MOTOR COMPANY) 08 April 2016 (2016-04-08) See paragraph [0030]; and claim 1.	1-6
A	KR 10-2018-0124197 A (HYUNDAI MOTOR COMPANY) 21 November 2018 (2018-11-21) See claim 1.	1-6
A	KR 10-2018-0067300 A (HYUNDAI MOTOR COMPANY) 20 June 2018 (2018-06-20) See paragraph [0014].	1-6
A	KR 10-2017-0063103 A (HYUNDAI MOTOR COMPANY) 08 June 2017 (2017-06-08) See paragraph [0012].	1-6

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 November 2023	**20 November 2023**
Name and mailing address of the ISA/KR **Korean Intellectual Property Office** **Government Complex-Daejeon Building 4, 189 Cheongsa-ro, Seo-gu, Daejeon 35208** Facsimile No. **+82-42-481-8578**	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2022)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2023/012513

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
KR 10-2013-0054330 A	24 May 2013	EP 2598740 A1	05 June 2013
		US 2013-0032299 A1	07 February 2013
		US 2013-0213344 A1	22 August 2013
		US 9726108 B2	08 August 2017
		WO 2012-016155 A1	02 February 2012
KR 10-1610121 B1	08 April 2016	US 2016-0105132 A1	14 April 2016
		US 9660558 B2	23 May 2017
KR 10-2018-0124197 A	21 November 2018	None	
KR 10-2018-0067300 A	20 June 2018	KR 10-2406114 B1	07 June 2022
		US 10532727 B2	14 January 2020
		US 2018-0162352 A1	14 June 2018
KR 10-2017-0063103 A	08 June 2017	KR 10-1755498 B1	27 July 2017

Form PCT/ISA/210 (patent family annex) (July 2022)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- KR 1020190081151 **[0005]**