VOYAGE PLANNING SUPPORT SYSTEM AND VOYAGE PLANNING SUPPORT PROGRAM

TECHNICAL FIELD

[0001]

The present invention relates to a technique to create a voyage plan for a ship, and more specifically, the present invention relates to an effective technique to be applied to a voyage planning support system that supports calculation and simulation based on various kinds of information regarding weather forecasting and a ship.

BACKGROUND ART

[0002]

For example, a large ship as owned by a shipping company or the like is operated in accordance with a voyage plan. The voyage plan contains information on a course containing information on WPs (Way Point: course changing point), information on a schedule such as an estimated transit time of each of the WPs, and information on horsepower distribution, speed distribution, and the like with the schedule, for example. Further, for example, the voyage plan may also contain a scheme of an operation such as cooling down (hereinafter, referred to also as “C/D”) of a tank in an LNG carrier that carries LNG (Liquefied Natural Gas) as a cargo. Economic efficiency (to operate with a lower cost as much as possible), safety (to prevent an accident against a ship, a crew, or a cargo from occurring), punctuality (to observe ETA (Estimated Time of Arrival)) are required for the voyage plan, for example.

[0003]

An example of a conventional creating procedure for a general voyage plan is as follows. First, a rough course is created before a voyage. For example, the rough course is selected from existing

routes in past voyages, or newly created with a marine chart or an ECDIS (Electronic Chart Display and Information System). Then, an actual voyage plan is created by adjusting horsepower distribution, speed distribution, and a transit time of each of WPs on the basis of information on marine phenomena and weather forecasting on the rough course, which is acquired from an external weather data providing service or the like. Creation or adjustment of a voyage plan largely depends on personal elements such as experience and knowledge of a captain or a navigation officer, or know-how.

[0004]

As a technique related to creation of a voyage plan, for example, Japanese Patent Application Publication No. 2009-286230 (Patent document 1) describes that a service analyzing system analyzes service data and the like collected by an operation monitoring system to output data on information such as latest estimated performance, and an optimal course calculating system calculates data such as information on a voyage plan related to an optimal course on the basis of these data and data on information on weather estimated based on a course. By configuring the service analyzing system to input these data and data on information such as spot weather or marine phenomena into the operation monitoring system and calculate the service data, an analyzation cycle is formed by the operation monitoring system, the service analyzing system, and the optimal course calculating system.

RELATED ART DOCUMENTS

PATENT DOCUMENTS

[0005]

Patent Document 1: Japanese Patent Application Publication No. 2009-286230

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0006]

For example, by using a technique as described in Patent document 1, it is possible to create and adjust a voyage plan. On the other hand, there are many factors that could affect the voyage plan. In particular, for example, in an LNG carrier, LNG itself, which is a cargo, can become fuel, and there is a special operation such as C/D required to manage temperature of a tank. There is need to create and adjust the voyage plan in view of these special factors. In such a ship, accumulation of know-how is still small, and personality such as a captain greatly comes out. There are strong needs to support creation and adjustment of a voyage plan by simulation based on an estimation.

[0007]

It is thus an object of the present invention to provide a voyage planning support system and a voyage planning support program with high flexibility and high extendibility, which are capable of flexibly addressing differences in characteristics of a ship or a cargo and addressing modification or addition of a simulation method or addition of a factor for consideration in the future.

[0008]

The foregoing and other objects, and new features of the present invention will become more apparent from description of the present specification and the appending drawings.

MEANS FOR SOLVING THE PROBLEM

[0009]

An outline of representative invention of the present invention disclosed in the present application will briefly be explained as follows.

[0010]

A voyage planning support system according to a representative embodiment of the present invention is a voyage planning support system for supporting at least one of creation or

adjustment of a voyage plan for a ship, the voyage planning support system including: one or more exchangeable modules configured to execute predetermined calculation for each of factors for consideration in accordance with attribute or characteristics of the ship by using the voyage plan or other information as input information, and output a calculation result, each of the factors for consideration being able to affect the voyage plan that includes main engine output distribution on a course of the ship; and a control unit configured to execute each of the modules in a predetermined order, and cause each of the modules to output the calculation result relating to the voyage plan. In this case, the input information of the one or more modules executed by the control unit contains the calculation result outputted by execution of each of the one or more modules.

[0011]

Further, the present invention can also be applied to a voyage planning support program that causes a computer to operate as the voyage planning support system as described above.

EFFECTS OF THE INVENTION

[0012]

Effects obtained by representative invention of the present invention disclosed in the present application will briefly be explained as follows.

[0013]

Namely, according to the representative embodiment of the present invention, it becomes possible to flexibly address differences in characteristics of a ship or a cargo, and to flexibly address extension in the future such as modification or addition of a simulation method or addition of a factor for consideration.

BRIEF DESCRIPTIONS OF THE DRAWINGS

[0014]

FIG. 1 is a view illustrating an outline of a configuration example of a voyage planning support system according to one embodiment of the present invention;

FIG. 2 is a view illustrating an outline of an example of a flow of simulation processing for a voyage plan according to one embodiment of the present invention;

FIG. 3 is a view illustrating an outline of an output example of main engine output distribution according to one embodiment of the present invention;

FIG. 4 is a view illustrating an outline of an output example of a simulation result on a cooling down plan according to one embodiment of the present invention;

FIG. 5 is a view illustrating an outline of an output example of main engine output distribution to which a cooling down plan is reflected according to one embodiment of the present invention;

FIG. 6 is a view illustrating an outline of an output example of a calculation result of the risk of occurring sloshing according to one embodiment of the present invention; and

FIG. 7 is a view illustrating an outline of an example of the content set in module setting information according to one embodiment of the present invention.

DETAILED DESCRIPTION OF EMBODIMENT

[0015]

Hereinafter, an embodiment of the present invention will be described in detail with reference to the drawings. Note that in all of the drawings for explaining the embodiment, the same reference numeral is generally assigned to the same unit, and its repeated explanation will be omitted. On the other hand, a component has been explained in a certain drawing while applying a reference numeral thereto is not illustrated again when another drawing is to be explained, but the element may be referred to by applying the

same reference numeral thereto.

[0016]

<Outline>

In the embodiment described below, an LNG carrier that mainly carries LNG as a cargo will be described as a target of a ship that supports creation and adjustment of a voyage plan. As described above, in the LNG carrier, there are many unique factors for consideration, which could affect the voyage plan, due to specificity due to carry of LNG as the cargo.

[0017]

For example, since LNG vaporizes at about -160 °C, it is unavoidable that the LNG, which is a cargo, is vaporized in a tank during a voyage. Thus, a power source is obtained by burning a gas vaporized in the tank (Boil Off Gas: BOG) to rotate a turbine. Further, LNG in the tank may forcibly be vaporized to use it as fuel in place of burning of heavy oil that is a main fuel. By such a control, elements that could affect the voyage plan such as horsepower distribution or fuel oil consumption may change, and the amount of LNG that is the cargo may change. It is desirable for a customer (or an owner of the cargo) to carry LNG by the most economical voyage plan without reducing the LNG as much as possible while maintaining punctuality.

[0018]

Further, in a case where burning of the BOG is set to a factor for consideration, a composition ratio of the BOG is thought not to be the same because a composition ratio of methane, ethane, and the like, which are components of the LNG, is different from that of the LNG in another cargo, for example. Further, even in case of the same LNG, it is thought that easiness of vaporization of methane, ethane, and the like, which are components of the LNG, is different from each other. Thus, it is thought that a composition ratio of the LNG also changes with the lapse of time, and as a result,

the composition ratio of the BOG also changes. Therefore, it is thought that a calorific value obtained when the BOG is burned is also different from each other. By using this as a factor for consideration, the elements that could affect the voyage plan, such as fuel oil consumption, change.

[0019]

Further, in a case where the LNG is carried as the cargo and temperature of a tank is high, a large quantity of LNG vaporizes when the LNG is loaded in the tank at a loading port. Thus, there is a restriction that the temperature in the tank has to be a predetermined temperature or lower to load the LNG. For this reason, the tank is to be cooled so that the tank becomes the predetermined temperature or lower when an LNG carrier arrives at the loading port. At this time, there is a possibility that the tank is damaged in a case where the temperature is lowered rapidly. Therefore, it is necessary to gradually cool the tank. Thus, an operation of cooling down (C/D) in which the tank is cooled in a planned manner during a voyage to go toward the loading port.

[0020]

In the C/D, by spraying LNG (heel) left in the tank into the tank, the tank is cooled by the heat of vaporization. Therefore, when the LNG carrier unloads the LNG at a discharging port, the LNG carrier does not unload all of the LNG, but unloads the LNG in a state where heel to be used when going to a next loading port is left. At this time, by leaving a lot of heel, the operation of the C/D becomes easy. However, it is desirable for a customer to make heel smaller as much as possible in order not to reduce the amount of LNG that is the cargo. Such a scheme relating to the operation for C/D is also contained in the voyage plan, and has conventionally been executed on the basis of personality such as experience of a captain and the like.

[0021]

Further, in the LNG carrier, the LNG in the tank fluctuates by rolling or pitching of a ship during the voyage. In some cases, the fluctuation that damages the tank (sloshing) may occur. When the sloshing occurs, damage or overflowing of the tank occurs. Thus, it is necessary to avoid this. Heretofore, with respect to possibility that sloshing occurs, simple judgmental standards have been adopted. The possibility is low in a state where the LNG in the tank is substantially full-load (for example, 95% or more of the tank) or a substantially vacant state (for example, 5% or lower of the tank), for example. There is the possibility in case of the intermediate quantity other than the above states.

[0022]

However, even in case of the intermediate quantity, the risk of occurring sloshing is low so long as the ship is never fluctuated. Conversely, even in a substantially full-load state, the risk is not zero, and sloshing may occur in a case where fluctuation of the LNG and fluctuation of the ship coincide with each other. Therefore, for example, if the risk of occurring sloshing can be calculated in view of fluctuation of the ship by weather on the course, it is possible to optimize selection of the course and schedule in the voyage plan. Further, even in case of not leading to sloshing, it is assumed that the degree of vaporization of the LNG changes by the degree of fluctuation of the LNG in the tank.

[0023]

Thus, in the LNG carrier, there are many factors for consideration that could affect the voyage plan. How much these factors for consideration are to be considered actually may be differentiated in accordance with required accuracy of the voyage plan, a kind of information acquired as an input, and the like, and is thought to be not uniform. An influence that each of these factors for consideration is given to the voyage plan is thought to be able to be simulated by individually calculating each of the factors.

However, its calculation result may affect the other factors for consideration, and the respective factors for consideration may be associated mutually.

[0024]

Thus, in the present embodiment, a platform to implement functions to execute calculation and simulation for each of the factors for consideration as highly independent program modules, appropriately combine necessary modules to be introduced, and control a calculating process to organically coordinate these is provided. This makes it possible to flexibly address differences in characteristics of a ship or a cargo, and to address modification or addition of a simulation method or addition of a factor for consideration in the future.

[0025]

<System Configuration>

FIG. 1 is a view illustrating an outline of a configuration example of a voyage planning support system according to one embodiment of the present invention. A voyage planning support system 1 according to the present embodiment is an information processing system that realizes various kinds of functions to support creation and adjustment of the voyage plan by executing middleware such as an OS (Operating System) developed on a memory from a storage device such as an HDD (Hard Disk Drive) and various kinds of software programs by a CPU (Central Processing Unit, not illustrated in the drawings), for example.

[0026]

The voyage planning support system 1 may be implemented by a general-purpose information processing apparatus such as a PC (Personal Computer), for example, or may be implemented as a dedicated apparatus. Further, it is not limited to a case where the voyage planning support system 1 is implemented as an independent apparatus or equipment, and may be incorporated as a part of the

other apparatus or equipment. Further, in addition to a case where the voyage planning support system 1 is mounted on a target ship, the voyage planning support system 1 is configured to be installed at a base or facility on land and use data transmitted and received with the target ship by wireless communication.

[0027]

The voyage planning support system 1 according to the present embodiment uses the voyage plan that becomes a basis, marine phenomena and weather information, and information related to the ship hull as inputs, and executes processes of calculation and simulation for various kinds of factors for consideration in creation and adjustment of the voyage plan, thereby outputting various kinds of information for supporting creation and adjustment of the voyage plan. The creation and adjustment of the voyage plan may be executed. As described above, in the present embodiment, functions to execute the calculation and simulation for each of the factors for consideration are implemented as program modules with high independency, and necessary modules are appropriately combined to be introduced and are controlled so as to execute the calculating process by organically linking each other.

[0028]

The voyage planning support system 1 includes respective units such as a control unit 11, an input processing unit 12, a module managing unit 13, and an output processing unit 14, which are implemented as software,
for example. The control unit 11 has a function to control the whole operation of the voyage planning support system 1 by operating each of the other units. Namely, by using an instruction from a user such as the captain or an event generated on the ship as a trigger, or regularly every predetermined time interval to operate each of the other units, the control unit 11 operates each of the other units to a series of processing (will be described later), thereby

supporting the creation and adjustment of the voyage plan.

[0029]

The input processing unit 12 has a function for an interface to acquire various kinds of input information for the voyage planning support system 1 from the outside via a device as input means (not illustrated in the drawings). The input processing unit 12 has a function for communication with external equipment that is an information source and a function for issuance of a command or an instruction in addition to a function to operate various kinds of devices of the input means. The input processing unit 12 may have a function to record the acquired information in a recording medium (or a storage unit) such as a memory or HDD (not illustrated in the drawings).

[0030]

The input means is not limited particularly. Various kinds of means can be adopted appropriately in accordance with the input information or the information source. For example, an Ethernet (registered trademark) port for connecting to an onboard LAN (Local Area Network, not illustrated in the drawings) may be provided, or a function of mobile communication such as 3G or 4G, a wireless LAN, or near field communication such as Bluetooth (registered trademark) may be provided. Further, a serial interface such as a USB (Universal Serial Bus) or RS-232C may be provided. Further, a slot to read out the recording medium such as a nonvolatile memory may be provided to acquire the input information via the recording medium. Ones for receiving a direct input or an operation by the user, such as a keyboard, buttons, switches, or a touch panel may be provided.

[0031]

A rough voyage plan that becomes a basis of creation and adjustment is contained in the input information, for example. A voyage plan can be created from scratch. However, it is efficient

to adjust the plan or present a simulation result on the basis of the rough voyage plan. Further, with respect to the rough voyage plan, a plurality of candidates may be inputted, and can be compared by ranking them on the basis of the simulation result, for example.

[0032]

Moreover, information related to the various kinds of factors for consideration, which could affect the voyage plan is also contained. For example, information on marine phenomena and weather forecasting acquired from a weather data providing service or the like, the ship hull information containing a kind of the ship hull, a kind of propulsion plant, and various kinds of other attribute information, and cargo information containing attribute information on the number of tanks and a structure of each tank in the LNG carrier and attribute information such as composition of the LNG are contained. For example, by a VPMS (Vessel Performance Management System), which becomes widespread, and the like, dynamic state information acquired from many sensors installed in the ship, such as speed and horsepower of the ship, temperature and pressure of the tank, or the amount and composition of the LNG is also contained in the ship hull information and the cargo information. Further, information related to ship performance in actual seas, which is grasped in advance, is also contained.

[0033]

With respect to static master information and fixed information related to the ship hull and tank, the content set in advance may be held in a file or a database (not illustrated in the drawings), for example, in place of a case where the input processing unit 12 acquires them as the input information each time.

[0034]

The output processing unit 14 has a function to display information on results and/or output sound via a display device such as a display or the touch panel as output means (not illustrated

in the drawings) or a sound outputting device such as a speaker. The results are acquired by simulation or cooperation of the calculating process by various kinds of modules (will be described later), which are registered in the module managing unit 13. Data and signals may be outputted directly or indirectly to an external system such as a ship operation control system (not illustrated in the drawings).

[0035]

Information related to simulation results based on the various kinds of factors for consideration with respect to the inputted voyage plan is contained in output information. In a case where a plurality of candidates for the voyage plan is inputted, these may be ranked or compared. As the information related to the voyage plan, for example, a plan of main engine output distribution (horsepower distribution and speed distribution), a scheme related to the operation of C/D, information in which the risk of occurring sloshing is evaluated, and a comparison result about a plurality of courses may be contained. Further, as calculation results and detailed information about each of the factors for consideration, which become basis of these kinds of information, for example, information related to FOC (Fuel Oil Consumption) and schedule, a cargo state such as temperature or pressure of the tank, and a ship motion may also be contained.

[0036]

The module managing unit 13 has a function to: manage program modules for executing calculation or simulation for each of the various kinds of factors for consideration, which could affect the voyage plan; call a module and acquire a result on the basis of an instruction from the control unit 11. Since the function to execute calculation and simulation is modularized, it is possible to execute exchange, addition, or deletion dynamically and easily.

[0037]

The respective modules may be classified into basic modules introduced to every ship and option modules introduced in accordance with the kind of the ship or desire of the user, for example. A main engine output distributing module 132 that calculates and simulates a scheme of the main engine output distribution (horsepower distribution and speed distribution) is contained in the basic modules, for example. Further, a cargo state analyzing module 133, a sloshing predicting module 134, a ship motion analyzing module 135, and a lashing strength analyzing module 136 are contained in the option modules, for example. The cargo state analyzing module 133 analyzes states of the tank and the LNG therein in an LNG carrier having an independent spherical tank, and reflects them in the scheme of the C/D. The sloshing predicting module 134 predicts the risk of occurring sloshing in an LNG carrier having a tank of a membrane type. The ship motion analyzing module 135 analyzes fluctuation of the ship. The lashing strength analyzing module 136 analyzes strength required when a general cargo such as a container is fixed (lashing).

[0038]

Each of these modules is implemented independently, but they can execute processing while being mutually associated and cooperated under control of the control unit 11. For example, data related to fluctuation of the ship, the tank, and the LNG analyzed by the ship motion analyzing module 135 become an input parameter of each of the other modules such as the cargo state analyzing module 133, the sloshing predicting module 134, or the lashing strength analyzing module 136.

[0039]

Note that FIG. 1 indicates that the lashing strength analyzing module 136 can be added at a later time. Thus, by adding a new module at a later time, it is possible to easily extend a function related to adjustment of the voyage plan as needed.

[0040]

The kind of the module is not limited to one described above, and any of various kinds can be adopted. For example, a module for analyzing necessary hull strength, a module for analyzing behavior in a fuel tank of a ship using fuel, a module for analyzing the risk of developing a torque rich condition of an engine, and the like are thought. In the fuel ship that uses LNG or hydrogen as fuel, by means of the same or similar method of analyzing behavior in the tank of the LNG carrier, it is possible to build a module that calculates and simulates behavior of the fuel tank.

[0041]

Further, for example, with respect to the lashing strength analyzing module 136 that analyzes strength of lashing, in a case where cars are carried as cargos on a PCC (Pure Car Carrier), a PCTC (Pure Car & Truck Carrier), or a car ferry, in a case where containers are carried as cargos, or in case of cargos in a heavy weight ship or a work ship, then it is thought that a different calculation method is adopted in accordance with a kind of a general cargo to be carried. A module to analyze a seasickness risk in a ship that carries persons, such as a ferry or a passenger ship can be provided.

[0042]

The method of implementing each of the modules is not limited particularly. For example, a kind of a ship and a kind of a cargo may be parameterized with respect to the target factor for consideration, and the module may be implemented for general use so as to be able to address plural kinds of ships or cargos. The module may be implemented so as to specialize a specific kind of ship or cargo. In a case where the module is implemented as a module specialized for a specific kind, a plurality of modules is implemented for every kind of ship or cargo with respect to the target factor for consideration. In this case, when the voyage planning support system 1 is to be mounted on a target ship, only modules

corresponding to a kind of the target ship may be introduced. Alternatively, plural kinds of modules may be introduced in advance, and the module managing unit 13 may select and call modules corresponding to the kind of the target ship.

[0043]

The kind of each of the modules introduced in the voyage planning support system 1 mounted on the ship, the kind of each of the parameters inputted or outputted of each of the modules, and information related to cooperation among the modules are set in advance in module setting information 131 implemented as a configuration file or a memory table, for example. With respect to these kinds of information, for example, the module managing unit 13 may have an installer function for each module, and automatically set them when the module is installed. Alternatively, the user may manually set them. An example of the information set to the module setting information 131 will be described later.

[0044]

<Flow of Processing>

FIG. 2 is a view illustrating an outline of an example of a flow of simulation processing for a voyage plan according to the present embodiment. First, information on marine phenomena and weather forecasting encountered on the course is acquired from an external weather data providing service and the like on the basis of information on the course in a rough voyage plan and the transit time of each of the WPs (S1). In the configuration illustrated in FIG. 1 of the voyage planning support system 1 according to the present embodiment, this process is executed outside the system, and the acquired information on the marine phenomena and the weather forecasting is used as the input information to the voyage planning support system 1. However, the voyage planning support system 1 may execute the process at Step S1.

[0045]

Then, using information on a model of performance of the target ship in actual seas and numeral values in addition to information on the course and transit time of each WP and information on the marine phenomena and weather forecasting thus acquired as the input information into the voyage planning support system 1, the main engine output distributing module 132 executes calculation of main engine output distribution, which becomes a basis, under the control by the control unit 11 (S2). Here, a scheme of horsepower distribution (the most economical plan) for arriving at a destination by constant horsepower for each interval on the target course is first outputted. This plan does not consider the delay risk due to sudden change of weather or the like, whereby punctuality becomes low.

[0046]

Next, on the basis of the horsepower distribution calculated at Step S2, which is the most economical plan, the main engine output distributing module 132 recalculates horsepower distribution (a recommendation plan) in which a time margin is set to secure punctuality in order to hedge a weather change risk (S3). Specifically, for example, the time margin is secured in the beginning of the voyage by setting higher main engine output than horsepower in the most economical plan (main engine output). In a case where there is no disturbance such as sudden change of weather, the main engine output is gradually lowered. Namely, distribution in which a slope is provided in the main engine output is set as the recommendation plan. The degree of the slope is determined by how much the time margin is to be provided against the ETA (Estimated Time of Arrival). The user may be allowed to determine and input the degree of the slope. Further, FOC (Fuel Oil Consumption) when the calculated horsepower distribution is adopted is also calculated.

[0047]

FIG. 3 is a view illustrating an outline of an output example of main engine output distribution according to the present embodiment. Here, FIG. 3 schematically illustrates a screen image when a simulation result about main engine output distribution is displayed on a display or the like via the output processing unit 14. A horsepower constant plan (the most economical plan) is indicated by a dotted line, and a recommendation plan with a slope is indicated by a solid line. Further, the respective FOCs are also indicated. The example illustrated in FIG. 3 illustrates that in a case where the recommendation plan is adopted, the time margin can be secured, but the FOC becomes worse.

[0048]

Returning to FIG. 2, the ship motion analyzing module 135 then further calculates ship fluctuation by using, as the input information, the ship hull information containing a shape and a size of the ship hull, attribute information on draft, and state information of speed (S4). Here, for example, by using a predetermined mechanical calculation model or a known simulation technique, fluctuation of the ship at predetermined timing (a predetermined place on the course or date and time), in particular, fluctuation of the tank and the LNG therein in case of the LNG carrier is calculated.

[0049]

Then, in case of the LNG carrier, by using the acquired information on the ship fluctuation, the attribute information and the state information on the tank and the LNG therein as the input information, the cargo state analyzing module 133 calculates a state of the tank and the LNG therein at the predetermined timing (the cargo state) (S5). At this time, BOG to be burned in the main engine output distribution (horsepower distribution) calculated at Step S3 is considered. Further, it is thought that fluctuation of the LNG due to the ship fluctuation calculated at Step S4 could affect

a status of the vaporization of the LNG in addition to influence on a calculating process of the risk of occurring sloshing (not illustrated in the drawings). Therefore, this is considered as the input information.

[0050]

Moreover, in a case where the operation of the C/D is executed in a voyage to go toward a loading port, by further using basic information on a C/D plan as the input information, the cargo state analyzing module 133 executes simulation for the C/D plan on the basis of the cargo state calculated at Step S5 (S6). Various kinds of information such as a start date and time, and an end date and time of the operation, a tank pressure at a start time and an end time, and which tank and what order spray for the C/D is carried out may be contained in the basic information on the C/D plan, for example. Returning to Step S5, how the state of the tank and the LNG (the cargo state) becomes by executing the C/D is recalculated on the basis of these kinds of information. A final equatorial temperature of the tank and an amount used of LNG to be sprayed when the C/D is executed along the scheme are simulated. In a case where the final equatorial temperature does not go below a predetermined value, the C/D plan may be recalculated so as to be adjusted automatically or manually.

[0051]

FIG. 4 is a view illustrating an outline of an output example of a simulation result on a cooling down plan according to the present embodiment. An upper chart illustrates an example of a calculation result of a change in a tank pressure in a case where in accordance with a scheme, spray of the LNG is started at a time T1 with a tank pressure P1, and then, the spray is ended at a time T2 when the tank pressure becomes P2. In this case, at a point of time when the tank pressure then calms down, an amount of naturally vaporized BOG (NBOG: Natural Boil Off Gas) to be burned in a voyage in the nighttime is

determined so that the tank pressure becomes P1 at a time T3 on the next day. Further, a lower chart illustrates an example of a calculation result of a change in the equatorial temperature of the tank when the operation of the C/D as illustrated in the upper chart is executed. Here, by calculating how many degrees the equatorial temperature is finally lowered to, it is reflected to adjustment of the C/D plan.

[0052]

Returning to FIG. 2, execution of the C/D may affect the main engine output distribution so that the LNG is used for the spray and the main engine output changes due to consumption of the BOG vaporized by the spray. Thus, in a case where the simulation for the C/D plan is executed at Step S6, the processing flow returns to Step S3 to reflect its result to calculation of the main engine output distribution. Such a repetition process can be repeated, for example, until a value of the main engine output distribution or a value of the simulation result of the cooling down plan converges within a certain range, or until the number of repetitions reaches a predetermined number. Thus, by feedbacking the results respectively calculated by the modules corresponding to the factors for consideration to their own or the other modules so as to be cooperated and associated with each other, it is possible to improve accuracy of the calculation and the simulation.

[0053]

FIG. 5 is a view illustrating an outline of an output example of main engine output distribution to which a cooling down plan is reflected according to the present embodiment. Original horsepower distribution indicated by a dotted line has a slope in the similar manner to the recommendation plan illustrated in the example illustrated in FIG. 3. Horsepower distribution in case of further considering the operation of the C/D in the original horsepower distribution is indicated by a solid line. For example, after date

of January 10 (1/10), the vaporized BOG is consumed while the spray of the LNG for the C/D is carried out in the daytime. Therefore, FIG. 5 illustrates that the main engine output is set to higher. Further, FIG. 5 illustrates that the main engine output is set so as to be maintained at a fixed value or higher in the nighttime due to consumption of the NBOG.

[0054]

Note that the example illustrated in FIG. 2 illustrates a processing model in which the other factors for consideration such as the risk of occurring sloshing is not considered. However, by being cooperated and associated with the calculating process or the simulating process by the sloshing predicting module 134 or the lashing strength analyzing module 136 as needed, it is also possible to adjust the voyage plan.

[0055]

FIG. 6 is a view illustrating an outline of an output example of a calculation result of the risk of occurring sloshing according to the present embodiment. Here, information on the FOC (Fuel Oil Consumption) acquired in the voyage plan calculated by the processes as illustrated in the example illustrated in FIG. 2 is indicated for each of three courses displayed on a marine chart. The example illustrated in FIG. 6 indicates that a course “Route1” is the most economical course in which the FOC is the least. On the other hand, FIG. 6 indicates that the course “Route1” includes a sea area in which the risk of occurring sloshing on the course is higher than a predetermined value by simulation based on information on marine phenomena and weather forecasting and information on the ship fluctuation calculated on the basis of these kinds of information. A numeral value obtained by evaluating this risk may be displayed. The captain and the like can refer to these kinds of information, and judge or determine a course to be adopted, for example.

[0056]

Thus, the calculation and the simulation are executed with respect to each of a plurality of candidates for the course, whereby it is possible to compare the courses with each other. At that time, weighting or priority order may be set for each of the courses on the basis of predetermined conditions and criteria. Further, comparison based on such simulation may be executed before the voyage to select, determine, or adjust the voyage plan to be adopted. Recalculation may be dynamically executed on the basis of information on latest marine phenomena and weather forecasting and the latest state information of the ship, which are acquired during the voyage, to update the voyage plan.

[0057]

<Module Setting Information>

FIG. 7 is a view illustrating an outline of an example of the content set in the module setting information 131 according to the present embodiment. As described above, information on the kinds and the inputted or outputted parameters of the respective modules managed by the module managing unit 13 is contained in the information set in the module setting information 131, for example. The example illustrated in FIG. 7 illustrates information on inputted or outputted parameters for each of the main engine output distributing module 132 and the cargo state analyzing module 133. Note that the content of data is conceptually indicated by tables in FIG. 7. However, an actual data format can be set appropriately in accordance with specification of the module managing unit 13.

[0058]

In the main engine output distributing module 132, for example, three types of parameters including a parameter related to the “operation”, a parameter related to the “course”, and a parameter related to “disturbance” are set as input parameters. Information on ETD (Estimated Time of Departure) and ETA as initial values, draft A (after draft) and draft F (forward draft) is

contained in the parameter related to “operation”, for example. Further, information on latitude and longitude on the course in the rough voyage plan in time series is contained in the parameter related to “course”, for example. Further, information on a wind direction, a wind speed, a wave direction, a wave length, a wave height, a swell direction, a swell length, and a swell height on the course in time series is contained in the parameter related to “disturbance”, for example.

[0059]

Further, the parameter related to “course” and the parameter related to “operation” are set as output parameters, that is, information on the calculation result and the simulation result. Information on latitude and longitude on the course after adjustment, the course as the simulation result, or the recommendation course is contained in the parameter related to “course”, for example. Further, information on a vessel speed, horsepower, the number of revolutions, and the ship fluctuation on the course in time series is contained in the parameter related to “operation”, for example. Moreover, in case of the LNG carrier, information related to “motion of tank” such as acceleration or the maximum displacement of the tank may be contained.

[0060]

Further, respective types of parameters such as a parameter related to “operation (“Ope#1”)”, a parameter related to “tank fluctuation”, a parameter related to “disturbance”, a parameter related to “C/D setting”, a parameter related to “tank”, or a parameter related to “LNG” are set in the cargo state analyzing module 133, for example, as input parameters. Information on horsepower (in which the C/D is not considered), a combustion mode, and FOC, which are inputted from the main engine output distributing module 132, on the course in time series is contained in the parameter related to “Ope#1”, for example. Further, information on

acceleration and the maximum displacement of the tank, which are inputted from the main engine output distributing module 132, on the course in time series is contained in the parameter related to “tank fluctuation”, for example. Further, information on an outside temperature and an outside pressure, which are inputted from the information related to weather forecasting, on the course in time series is contained in the parameter related to “disturbance”, for example.

[0061]

Further, parameters related to “C/D setting” includes, for example, information such as a start date and an end date, a start time and a start tank pressure, or an end time and an end tank pressure in the C/D plan, which are inputted by the user. Further, information on an equatorial temperature, a Top temperature, a Bottom temperature, a liquid level, and a tank pressure of each tank, which are inputted from the VPMS as initial values, is contained in the parameter related to “tank”, for example. Further, information on the number of tanks, a wall heat capacity (because a thickness of an aluminum wall plate is different from those at an upper portion, a lower portion, and an intermediate portion of the tank), and thermal insulation performance, which are inputted by the user, is contained as fixed values. Further, information on liquid composition, a liquid temperature, vapor composition, and a vapor temperature of each tank, which are inputted from gas chromatography is contained in the parameter related to “LNG” as initial values, for example. In a case where the gas chromatography is not mounted in the tank, they are estimated from the composition of the LNG at the loading port, for example.

[0062]

Further, respective types of parameters such as a parameter related to “C/D consideration”, the parameter related to “tank”, or the parameter related to “LNG” are set as the output parameters,

that is, the information on the calculation result and the simulation result. Information on horsepower in view of the spray by the C/D on the course in time series is contained in the parameter related to “C/D consideration”, for example. Further, information on the equatorial temperature, the Top temperature, the Bottom temperature, the liquid level, and the tank pressure of each tank on the course in time series is contained in the parameter related to “tank”, for example. Further, information on the liquid composition, the liquid temperature, the vapor composition, and the vapor temperature of each tank on the course in time series is contained in the parameter related to “LNG”, for example.

[0063]

Note that the content set in the module setting information 131 illustrated in FIG. 7 is just one example, and another table configuration and another data configuration may be adopted so long as they are configured so that similar data can be held and managed.

[0064]

As explained above, according to the voyage planning support system 1 of one embodiment of the present invention, the function to execute calculation and simulation for each of the factors for consideration, which could affect the voyage plan, is implemented as the highly independent program module, necessary modules are appropriately combined to be introduced, and the calculating process to organically coordinate these is controlled. This makes it possible to flexibly address differences in characteristics of a ship or a cargo, and to address modification or addition of a simulation method or addition of a factor for consideration in the future.

[0065]

As described above, the invention made by inventors of the present application has been described specifically on the basis of the embodiment. However, the present invention is not limited

to the embodiment described above, and it goes without saying that the present invention may be modified into various forms without departing from the substance thereof. For example, the embodiment described above has been explained in detail for explaining the present invention clearly. The present invention is not necessarily limited to one that includes all configurations that have been explained. Further, a part of the configuration of the embodiment can be added with the other configuration, deleted or replaced thereby.

[0066]

Further, a part or all of the respective configuration described above, the functions, the processing units, processing means, and the like may be realized by hardware by designing it with an integrated circuit, for example. Further, the respective configuration described above and the functions may be realized by software by interpreting programs to realize and execute each of the functions by means of a processor. Information on the programs, the tables, and the files to realize the respective functions can be placed in a recording apparatus such as a memory, a hard disk, or an SSD (Solid State Drive), or a recording medium such as an IC card, an SD card, or a DVD.

[0067]

Further, in each of the drawings described above, the control lines and the information lines are illustrated as ones that are thought to be necessary for explanation. All of the control lines and the information lines on implementation are not necessarily illustrated in the drawings. In fact, it may be thought that almost all components are mutually connected to each other.

INDUSTRIAL APPLICABILITY

[0068]

The present invention is usable for a voyage planning support system and a voyage planning support program to support calculation

and simulation based on various kinds of information regarding weather forecasting and a ship.

REFERENCE SINGS LIST

[0069]

1 … voyage planning support system, 11 … control unit, 12 … input processing unit, 13 … module managing unit, 14 … output processing unit, 131 … module setting information, 132 … main engine output distributing module, 133 … cargo state analyzing module, 134 … sloshing predicting module, 135 … ship motion analyzing module, 136 … lashing strength analyzing module.

CLAIMS

1. A voyage planning support system for supporting at least one of creation or adjustment of a voyage plan for a ship, the voyage planning support system comprising:

one or more exchangeable modules configured to execute predetermined calculation for each of factors for consideration in accordance with attribute or characteristics of the ship by using the voyage plan or other information as input information, and output a calculation result, each of the factors for consideration being able to affect the voyage plan that includes main engine output distribution on a course of the ship; and

a control unit configured to execute each of the modules in a predetermined order, and cause each of the modules to output the calculation result relating to the voyage plan,

wherein the input information of the one or more modules executed by the control unit contains the calculation result outputted by execution of each of the one or more modules.

2. The voyage planning support system according to claim 1,

wherein the ship is an LNG carrier that carries LNG stored in tanks as a cargo,

wherein a first module is provided as the module, and

wherein the first module is configured to output, as the calculation result, information containing a ship motion at a predetermined point of time on the course by using information, which contains the voyage plan, weather information on the course in the voyage plan, and ship hull information, as the input information.

3. The voyage planning support system according to claim 2,

wherein a second module is further provided as the module, and

wherein the second module is configured to output, as the calculation result, information on at least one of a temperature or a pressure of each of the tanks at a predetermined point of time on the course by using information, which contains the weather information, information on the main engine output distribution, the information on the ship motion outputted by the first module, and information on an initial state of each of the tanks, as the input information.

4. The voyage planning support system according to claim 2,

wherein a third module is further provided as the module,

wherein the third module is configured to output, as the calculation result, information on a risk of sloshing in each of the tanks by using information, which contains the voyage plan, the weather information, and the information on the ship motion outputted by the first module, as the input information.

5. The voyage planning support system according to claim 3,

wherein the second module is further configured to output, as the calculation result, a scheme of an operation for cooling down by spraying the LNG in each of the tanks on a basis of the information on at least one of a temperature or a pressure of each of the tanks at the predetermined point of time.

6. The voyage planning support system according to claim 3,

wherein the second module is further configured to output, as the calculation result, a scheme of an operation to use NBOG from LNG in each of the tanks as fuel on a basis of the information on at least one of a temperature or a pressure of each of the tanks at the predetermined point of time.

7. The voyage planning support system according to claim 1,

wherein the ship is a ship that carries a general cargo,

wherein a first module and a fourth module are provided as the module,

wherein the first module is configured to output, as the calculation result, information containing a ship motion at a predetermined point of time on the course by using information, which contains the voyage plan, weather information on the course in the voyage plan, and ship hull information, as the input information, and

wherein the fourth module is configured to output, as the calculation result, information containing lashing strength of the general cargo by using information, which contains the weather information, information on the main engine output distribution, information on the ship motion outputted by the first module, and information on the general cargo, as the input information.

8. The voyage planning support system according to claim 1,

wherein the ship is a fuel ship that uses LNG or hydrogen as fuel,

wherein a first module and a fifth module are provided as the module,

wherein the first module is configured to output, as the calculation result, information containing a ship motion at a predetermined point of time on the course by using information, which contains the voyage plan, weather information on the course in the voyage plan, and ship hull information, as the input information, and

wherein the fifth module is configured to output, as the calculation result, information containing information on at least one of a temperature or a pressure of a fuel tank at a predetermined point of time on the course by using information, which contains the weather information, information on the main engine output

distribution, information on the ship motion outputted by the first module, and information on an initial state of the fuel tank, as the input information.

9. A voyage planning support program for causing a computer to execute processes so as to serve as a voyage planning support system for supporting at least one of creation or adjustment of a voyage plan for a ship,

wherein the voyage planning support program causes the computer to execute one or more exchangeable modules in a predetermined order, the modules being configured to execute predetermined calculation for each of factors for consideration in accordance with attribute or characteristics of the ship by using the voyage plan or other information as input information and output a calculation result, each of the factors for consideration being able to affect the voyage plan that includes main engine output distribution on a course of the ship,

wherein the voyage planning support program causes the computer to execute a control process to output the calculation result relating to the voyage plan by each of the modules, and

wherein in the control process, each of the modules is executed so that the input information of the one or more modules contains the calculation result outputted by execution of each of the one or more modules.