

AIR LUBRICATION SYSTEM FOR SHIPS

FIELD

[0001] The present invention relates to an air lubrication system for ships, and more particularly to an air lubrication system for ships, which can achieve high energy efficiency, as compared with a typical air lubrication system driven by a power generation engine.

BACKGROUND

[0002] During navigation of a ship, a hull of the ship is subjected to wave resistance, viscous resistance, and air resistance. In order to reduce such resistance, most ships are streamlined.

[0003] Wave resistance is due to regular waves created by the bow of the ship during propulsion thereof through the water and acts perpendicular to the entire region of the hull, causing energy loss of the ship. Viscous resistance is due to viscosity of water and is generally classified into frictional resistance and form resistance. Thereamong, frictional resistance refers to drag force hindering travel of a ship, which is due to viscous adhesion of seawater to a wetted surface of the hull.

[0004] In order to reduce frictional resistance, there have been proposed various solutions, such as design of a hydrofoil adapted to minimize a contact area between seawater and the hull, design of an air lubrication ship adapted to improve conditions of the wetted surface and bottom of the hull, and design of a supercavitating underwater vehicle.

[0005] As another solution to reduce frictional resistance, there has been proposed an air lubrication system that can reduce energy loss due to viscosity of seawater by forming an air layer on a hull surface to prevent the hull surface from contacting seawater.

[0006] A general air lubrication system reduces frictional resistance by creating an air cavity on the surface of the hull to reduce a wetted surface area of the ship, and thus is very environmentally friendly and is easy to apply to actual ships.

[0007] FIG. 1 is a diagram of a typical air lubrication system.

[0008] Referring to FIG. 1, the air lubrication system includes an air ejector 11 disposed at the bow of a hull 20, two air compressors 13, 14 disposed adjacent to the air ejector 11, and two motors 15, 16 disposed adjacent to the air ejector 11 to drive the air compressors 13, 14. In addition, the air lubrication system may include a distribution board 17 to drive the motors 15, 16. Further, the air lubrication system includes an air delivery pipe AP connected between the air ejector 11 and the air compressors 13, 14.

[0009] A power generation engine GE is disposed at the stern of the hull. The distribution board 17 receives electricity from the power generation engine GE and distributes the received electricity to the motors 15, 16. In addition, a main engine ME may be disposed at the stern of the hull.

[0010] The power generation engine GE may include multiple power generation engines. Here, a switchboard SB may be provided to manage electricity generated by the power generation engines GE. That is, the switchboard SB may be electrically connected to the distribution board 17.

[0011] Although not shown, the air lubrication system may further include a device for regulating the amount of air discharged from the air ejector 11, as needed.

[0012] <Related Literature>

[0013] <Patent Document>

[0014] (Patent Document 1) Korean Patent Laid-open Publication No. 10-2020-0063398 (2020.06.05.)

SUMMARY

[0015] It is an object of the present disclosure to provide an air lubrication system for ships, which can achieve high energy efficiency, as compared with a typical air lubrication system driven by a power generation engine.

[0016] In accordance with one aspect of the present disclosure, an air lubrication system includes: a speed governor connected to a main propulsion shaft connected to a main engine of a ship, the speed governor changing rpm of the main propulsion shaft and outputting the changed rpm; at least one air compressor connected to the speed governor and rotated at the rpm output from the speed governor to supply compressed air through

compression of air; an air ejector disposed on a bow of the ship and discharging the compressed air supplied from the at least one air compressor to an outside of the ship; and an air delivery pipe through which the compressed air supplied from the at least one air compressor is delivered to the air ejector, wherein the air ejector is provided with an emergency stop valve to stop delivery of air to the air ejector in an emergency.

[0017] The speed governor may include at least one gear train adapted to change the rpm of the main propulsion shaft.

[0018] The speed governor may further include a clutch adapted to block output of the changed rpm.

[0019] The air lubrication system may further include: at least one control valve disposed on the at least one air compressor and regulating an air supply pressure of the at least one air compressor.

[0020] The air lubrication system may further include: a temperature regulator disposed on the air delivery pipe and regulating a temperature of the compressed air supplied from the at least one air compressor.

[0021] In accordance with another aspect of the present disclosure, an air lubrication system includes: a speed governor connected to a main propulsion shaft connected to a main engine of a ship, the speed governor changing rpm of the main propulsion shaft and outputting the changed rpm; at least one rotary compressor connected to the speed governor and rotated at the rpm output from the speed governor to supply compressed air through compression of air; at least one electrically driven compressor driven by electricity supplied from a power generation engine of the ship; an air ejector disposed on a bow of the ship and discharging the compressed air supplied from the at least one rotary compressor and the at least one electrically driven compressor to an outside of the ship; and an air delivery pipe through which the compressed air supplied from the at least one rotary compressor and the at least one electrically driven compressor is delivered to the air ejector, wherein the air ejector is provided with an emergency stop valve to stop delivery of air to the air ejector in an emergency.

[0022] The air delivery pipe may allow the compressed air supplied from the at least one rotary compressor to be joined with the compressed air supplied from the at least one electrically driven compressor before the compressed air is delivered to the air ejector.

[0023] The at least one electrically driven compressor may include a third air compressor and a fourth air compressor disposed at a stern of a hull, wherein the air

lubrication system may further include: a starter controlling current or voltage supplied to the third air compressor and the fourth air compressor.

[0024] According to the present disclosure, the air lubrication system is connected to the main propulsion shaft through the speed governor to be operated without electricity produced by a power generation engine, as in the related art, thereby achieving reduction in fuel consumption.

[0025] In addition, the air lubrication system can operate the air compressors without using a separate distribution board.

[0026] Further, the air lubrication system can provide better utilization of an internal space of a ship and reduction in shipbuilding cost through use of an engine having a relatively low output power, as compared with a typical air lubrication system, and can provide significant reduction in shipbuilding cost through reduction in cost for auxiliary equipment, for example, a fresh water coolant pump, a seawater coolant pump, a cooler, and a fuel oil pump, and an engine room blower fan.

[0027] Furthermore, the air lubrication system can provide reduction in weight of a ship and sufficient cargo space through use of an engine having a relatively low output power, as compared with a typical air lubrication system.

[0028] Furthermore, the air lubrication system can achieve fuel savings at low ship speed, as well as at high ship speed.

DRAWINGS

[0029] The above and other aspects, features, and advantages of the present invention will become apparent from the detailed description of the following embodiments in conjunction with the accompanying drawings:

[0030] FIG. 1 is a diagram of a typical air lubrication system;

[0031] FIG. 2 is a diagram of an air lubrication system for ships according to one embodiment of the present invention;

[0032] FIG. 3 is a diagram of the air lubrication system for ships according to the embodiment of the present invention, illustrating connection between an air compressor and an air ejector through an air delivery pipe;

[0033] FIG. 4 is an enlarged diagram of a part of the air lubrication system for ships according to the embodiment of the present invention;

[0034] FIG. 5 is a diagram of an air lubrication system for ships according to another example of the present invention;

[0035] FIG. 6 is a diagram of the air lubrication system for ships according to the other embodiment of the present invention, illustrating connection between an air compressor and an air ejector through an air delivery pipe; and

[0036] FIG. 7 is an enlarged diagram of a part of the air lubrication system for ships according to the other example of the present invention.

DETAILED DESCRIPTION

[0037] Hereinafter, embodiments of the present invention will be described with reference to the accompanying drawings.

[0038] Description of known functions and constructions which may unnecessarily obscure the subject matter of the present invention will be omitted.

[0039] In addition, when a certain component is referred to as being "on," "connected to," "supported by," or "coupled to" another component, it may be directly formed on, connected to, supported by, or coupled to the other component, or intervening component(s) may also be "interposed" therebetween. Further, when a fluid is referred to as "supplied to," or "delivered to" a certain component, it may be directly supplied to or delivered to the component, or may be supplied to or delivered to the component through intervening component(s).

[0040] Although specific terms are employed herein, they are used and are to be interpreted in a descriptive sense only and not for purposes of limitation. As used herein, the singular forms, "a," "an," and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise.

[0041] In addition, spatially relative terms, such as "beneath," "below," "above," "upper," "right," "left," and the like, are based on depiction in the drawings and may be expressed differently when the orientation of a corresponding object is changed. For the same reason, some components are exaggerated, omitted, or schematically

illustrated in the drawings and the depicted size of each component may not necessarily reflect the actual size thereof.

[0042] It should be understood that, although the terms "first," "second," and the like may be used herein to describe various components, these components should not be limited by these terms. These terms are only used to distinguish one component from another element.

[0043] Further, the terms "comprises," "comprising," "includes," and/or "including," as used herein, specify the presence of stated features, regions, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, regions, integers, steps, operations, elements, and/or components.

[0044] FIG. 2 is a diagram of an air lubrication system for ships according to one embodiment of the present invention, FIG. 3 is a diagram of the air lubrication system for ships according to the embodiment of the present invention, illustrating connection between an air compressor and an air ejector through an air delivery pipe, and FIG. 4 is an enlarged diagram of a part of the air lubrication system for ships according to the embodiment of the present invention.

[0045] An air lubrication system 100 for ships according to this embodiment discharges air generated by air compressors 130, 140 to an outside of a hull 200 through an air ejector 110.

[0046] Although the air lubrication system 100 according to this embodiment shown in FIG. 2 to FIG. 4 includes two air compressors 130, 140, it should be understood that the present invention is not limited thereto and the number of air compressors may be varied as needed.

[0047] For convenience of description, the two air compressors will be referred to as a first air compressor 130 and a second air compressor 140, respectively.

[0048] Referring to FIG. 2, the air lubrication system 100 according to this embodiment includes the air ejector 110, a speed governor 120, the first air compressor 130, the second air compressor 140, and an air delivery pipe AP.

[0049] The air ejector 110 discharges air generated by the first air compressor 130 and the second air compressor 140 to the outside of the hull 200. The air ejector 110

may be disposed at the bow of the hull 200. The air ejector 110 may be provided with a device for regulating the amount of air ejected through the air ejector 110.

[0050] Here, the air ejector 110 may be provided with an emergency stop valve 170 to stop delivery of air to the air ejector 110 in an emergency. The emergency stop valve 170 may block discharge of air to the outside of the hull 200 when the air ejector 110 fails to normally eject air due to, for example, abnormal pressure of air delivered through the air delivery pipe AP.

[0051] The speed governor 120 is connected to a main propulsion shaft MA connected to a main engine ME, as shown in FIG. 4.

[0052] The speed governor 120 changes rpm of the main propulsion shaft MA rotated by the main engine ME into required rpm for the first air compressor 130 and the second air compressor 140. To this end, the speed governor 120 may include a clutch 122 and a gear train 124.

[0053] The clutch 122 serves to cut off power transmission when the first air compressor 130 and the second air compressor 140 are not in operation.

[0054] The gear train 124 changes rpm of the main propulsion shaft MA into required rpm for the first air compressor 130 and the second air compressor 140. The gear train 124 may include multiple gears to change rpm. A gear ratio of the gear train 124 may be varied as needed.

[0055] In this embodiment, the present invention is described with reference to an example in which the speed governor 120 includes a total of four gear trains 124, one pair of gear trains 124 for each of the first air compressor 130 and the second air compressor 140. Here, a corresponding pair of gear trains 124 changes rpm of the main propulsion shaft MA into required rpm for the first air compressor 130 or the second air compressor 140 according to a gear ratio of each gear train 124.

[0056] In this embodiment, assuming that the main propulsion shaft MA is rotated at about 100 rpm, the speed governor 120 may allow the first air compressor 130 and the second air compressor 140 to be rotated at about 1,000 rpm to 3,000 rpm.

[0057] The gear train 124 may have a continuously variable gear ratio, or may have two or three gear ratios, as needed. Alternatively, the gear 124 may have a single fixed gear ratio, as needed.

[0058] Each of the first air compressor 130 and the second air compressor 140 is disposed at an output side of the speed governor 120 and is rotated at the rpm output from the speed governor 120 to supply compressed air to the air delivery pipe AP through compresses air.

[0059] In this embodiment, each of the first air compressor 130 and the second air compressor 140 may be provided in the form of a centrifugal compressor, a screw-type compressor, or a positive displacement compressor.

[0060] In addition, each of the first air compressor 130 and the second air compressor 140 may be provided at both inlet and outlet sides thereof with a cross-sectional area adjustment device (not shown), such as a guide vane, which changes inlet and outlet cross-sectional areas of the air compressor.

[0061] Alternatively, each of the first air compressor 130 and the second air compressor 140 may be provided with a device adapted to adjust internal rpm thereof.

[0062] Although the clutch 122 is disposed in the speed governor 120 in this embodiment, it should be understood that the present is not limited thereto. The clutch 122 may be disposed in each of the first air compressor 130 and the second air compressor 140, as needed.

[0063] The air lubrication system 100 may further include a temperature regulator 150 to adjust the temperature of the air supplied from the first air compressor 130 and the second air compressor 140. The temperature regulator 150 may reduce temperature-dependent changes in pressure through control over the temperature of the air supplied from the first air compressor 130 and the second air compressor 140.

[0064] Each of the first air compressor 130 and the second air compressor 140 may be provided with a control valve 160 to control an air supply pressure of the first air compressor 130 or the second air compressor 140. For example, the control valve 160 may be connected in parallel to the first air compressor 130, as shown in FIG. 3.

[0065] The air delivery pipe AP is adapted to deliver the air generated by the first air compressor 130 and the second air compressor 140 to the air ejector 110. To this end, the air delivery pipe AP may include a section connected to the air ejector 110 and two sections branched off of the section and connected to the first air compressor 130 and the second air compressor 140, respectively.

[0066] In this embodiment, since the first air compressor 130 and the second air compressor 140 are disposed at the stern of the hull 200 and the air ejector 110 is disposed at the bow of the hull 200, the air delivery pipe AP may extend from the stern of the hull 200 to the bow of the hull 200.

[0067] The air lubrication system 100 according to this embodiment can eject air at an air ejection rate according to a speed of the ship. To this end, the pressure of the air compressed by the first air compressor 130 and the second air compressor 140 may be determined according to a required air ejection rate.

[0068] Accordingly, the pressure of air compressed by the first air compressor 130 and the second air compressor 140 may be controlled by regulating the rpm output from the speed governor 120 connected to the main propulsion shaft MA.

[0069] In addition, the air supply pressure of the first air compressor 130 and the second air compressor 140 may be regulated by the cross-sectional area adjustment device, which changes the inlet and outlet cross-sectional areas of the first air compressor 130 and the second air compressor 140.

[0070] That is, the air lubrication system 100 according to this embodiment may further include a controller. The controller may change gear stages of the gear train 124 of the speed governor 120 to control the rpm output from the speed governor 120.

[0071] In addition, the controller may control the cross-sectional area adjustment device provided to each of the first air compressor 130 and the second air compressor 140 to change the inlet and outlet cross-sectional areas.

[0072] Further, the controller may control the control valve 160. That is, the controller may control the air supply pressure of the first air compressor 130 and the second air compressor 140 through control over the control valve 160.

[0073] The controller may control the emergency stop valve 170. Accordingly, upon occurrence of abnormal air pressure in the air delivery pipe AP, the controller may stop ejection of air through the air ejector 110 through control over the emergency stop valve 170.

[0074] The controller may be implemented by a computing device including a microprocessor, a memory, and the like. Since a method of implementing such a controller is well known to those skilled in the art, detailed description thereof will be omitted.

[0075] Next, a method of operating the air lubrication system for ships according to the embodiment of the present invention will be briefly described, wherein the air lubrication system further includes a control unit storing information about an optimum air ejection rate according to ship speed. The method includes: determining a required air ejection rate according to a ship speed based on the information stored in the control unit; determining an operating pressure of an air compressor according to the required air ejection rate; determining rpm of the air compressor or output rpm of a speed governor disposed on a main propulsion shaft; and adjusting a pressure of air to be ejected to an outside of a ship.

[0076] Here, the step of adjusting the pressure of the air to be ejected to the outside of the ship may be performed by controlling a guide vane disposed at both inlet and outlet sides of the air compressor and a control valve disposed on a pipe connected between an inlet and an outlet of the air compressor.

[0077] Thus, the air lubrication system according to this invention can be operated with high efficiency, as compared with a typical air lubrication system driven by a power generation engine, thereby providing improved fuel savings.

[0078] Fuel consumption comparison

[0079] The inventors of the present invention verified reduction in fuel consumption of ships due to use of the air lubrication system 100 according to this embodiment by calculating fuel efficiency upon applying the air lubrication system 100 according to this embodiment to an LNG carrier with an MEGI engine operating in gas mode.

[0080] The following is comparison between fuel consumption of a ship employing a typical air lubrication system driven by a power generation engine (Comparative Example) and fuel consumption of a ship employing the air lubrication system 100 according to this embodiment (Example).

[0081] Here, fuel efficiency was calculated for a ship speed of 18.5 knots.

[0082] In addition, calculations were made about fuel consumption of the ship employing the typical air lubrication system before operating the air lubrication system (Comparative Example 1) and after operating the air lubrication system (Comparative Example 2), and results are shown in Table 1.

[0083] Table 1

	Comparative Example 1	Comparative Example 2	Example 1
Fuel consumption (tons/day)	68.0	64.7	64.5
Fuel consumption reduction rate	--	4.853%	5.147%

[0084] In Comparative Example 1, fuel consumption of the ship before operating the typical air lubrication system was calculated for a ship speed of 18.5 knots. A shaft power of a main engine (ME) before operating the typical air lubrication system was calculated to be 16,950 kW (ME load: 67%). Specific fuel gas consumption (SGC) of the main engine calculated for an ME load of 67% was 129.0 g/kWh.

[0085] Accordingly, daily fuel consumption of the main engine was calculated to be 52.5 tons/day. In addition, power generation engines were calculated to consume 15.5 tons of fuel per day and thus the total daily fuel consumption of the ship was calculated to be 68.0 tons/day.

[0086] In Comparative Example 2, fuel consumption of the ship after operating the typical air lubrication system driven by the power generation engines was calculated at the same ship speed as in Comparative Example 1. A shaft power of the main engine was calculated to be 15,187.4 kW (ME load: 60.3%). That is, power saving of about 10.4% was recorded, as compared with before operating the air lubrication system.

[0087] SGC of the main engine calculated for an ME load of 60.3% was 129.2 g/kWh. Accordingly, daily fuel consumption of the main engine was calculated to be 47.1 tons/day.

[0088] In addition, in Comparative Example 2, the load of each power generation engine increased compared with Comparative Example 1 due to operation of the air lubrication system. Additional gas consumption of the power generation engines was calculated based on the increase.

[0089] There were 2 sets of power generation engines in operation. SGC of each power generation engine for loads before/after operation of the ALS was obtained. The obtained SGC values were multiplied by horsepower of each power generation engine and then subtracted from each other. As a result, additional fuel consumption of the power generation engines was calculated to be 2.1 tons/day. Accordingly, the total fuel

consumption of the ship after operating the typical air lubrication system was calculated to be 64.7 tons/day (47.1 tons/day+15.5 tons/day+2.1 tons/day).

[0090] In Example 1, fuel consumption of the ship upon applying the air lubrication system according to the embodiment of the present invention was calculated. In operation of the air lubrication system according to the embodiment, 705 (698/0.99) kW of power was added to drive the air compressor connected to the speed governor. For the given ship speed, a shaft power of the main engine was calculated to be 15,892.3 kW (15,187.3 kW+705 kW).

[0091] This value corresponded to an ME load of 63%. SGC of the main engine calculated for an ME load of 63% was 128.6 g/kWh.

[0092] Thus, daily fuel consumption of the main engine was calculated to be 49.0 tons/day. Since there was no difference in fuel consumption of the power generation engines between Example 1 and Comparative Examples, daily fuel consumption of the power generation engines was calculated to be 15.5 tons/day. Accordingly, the total daily fuel consumption of the ship was calculated to be 64.5 tons/day (49.0 tons/day+15.5 tons/day).

[0093] As shown in Table 1, it can be seen that fuel consumption of the ship employing the typical air lubrication system after operating the typical air lubrication system (Comparative Example 2) decreased by 4.853%, as compared with before operating the air lubrication system (Comparative Example 1).

[0094] In addition, it can be seen that use of the air lubrication system according to the embodiment (Example 1) can achieve reduction in fuel consumption since the air lubrication system is connected to the main propulsion shaft through the speed governor to be operated without using electricity produced by the power generation engines.

[0095] Further, it can be seen that fuel consumption upon using the air lubrication system according to the embodiment (Example 1) decreased by 0.3%, as compared with that upon using the typical air lubrication system (Comparative Example 2).

[0096] That is, use of the air lubrication system according to the embodiment of the present invention in a ship can eliminate a need to increase generator capacity to operate a compressor for an air lubrication system and a need for a separate starter, as in

the related art. In addition, since the air lubrication system according to the embodiment allows air suctioned from an engine room to be supplied to the air compressor unlike a typical air lubrication system in which an air compressor is disposed at the bow of the hull, an existing engine room fan (ER FAN) can be used to supply air to the air compressor, thereby allowing reduction in number of required equipment and thus better utilization of a space inside the ship.

[0097] FIG. 5 is a diagram of an air lubrication system for ships according to another embodiment of the present invention, FIG. 6 is a diagram of the air lubrication system for ships according to this embodiment, illustrating connection between an air compressor and an air ejector through an air delivery pipe, and FIG. 7 is an enlarged diagram of a part of the air lubrication system for ships according to this embodiment.

[0098] In description of the air lubrication system 100a for ships according to this embodiment, like components will be denoted by like reference numerals.

[0099] Referring to FIG. 5 to FIG. 7, like the air lubrication system according to the above embodiment, the air lubrication system 100a for ships according to this embodiment includes an air ejector 110, a speed governor 120, a first air compressor 130, a second air compressor 140, and an air delivery pipe AP.

[00100] Each of the first air compressor 130 and the second air compressor 140 may be a rotary compressor disposed at an output side of the speed governor 120, and is rotated at an rpm output from the speed governor 120 to supply compressed air to the air delivery pipe AP through compression of air, as described above.

[00101] The air lubrication system 100a according to this embodiment may further include at least one electrically driven compressor 180, 190 driven by electricity supplied from a power generation engine GE.

[00102] Although the air lubrication system will be described as including two electrically driven compressors, it should be understood that the present invention is not limited thereto and the number of electrically driven compressors may be varied as needed.

[00103] For convenience of description, the two electrically driven compressors will be referred to as a third air compressor 180 and a fourth air compressor 190, respectively.

[00104] The third air compressor 180 and the fourth air compressor 190 are driven by a first drive motor 182 and a second drive motor 192, respectively. Compressed air generated by the third air compressor 180 and the fourth air compressor 190 may be supplied to the air delivery pipe AP.

[00105] In this embodiment, the third air compressor 180 and the fourth air compressor 190 may be connected to the air delivery pipe AP connected to the first air compressor 130 such that the compressed air generated by the third air compressor 180 and the fourth air compressor 190 is supplied to the air delivery pipe AP.

[00106] The first drive motor 182 and the second drive motor 192 are driven by electricity generated by the power generation engine GE. The first drive motor 182 drives the third air compressor 180 and the second drive motor 192 drives the fourth air compressor 190.

[00107] To this end, the air lubrication system according to this embodiment further includes a starter STT controlling the voltage or current supplied to the first drive motor 182 and the second drive motor 192. The starter STT may be electrically connected to a switchboard SB of the power generation engine GE.

[00108] In this embodiment, the third air compressor 180 and the fourth air compressor 190 may be disposed at a stern of a hull 200, like the first air compressor 130. Accordingly, in the air lubrication system according to this embodiment, the starter STT may be located at a relatively short distance from the switchboard SB of the power generation engine GE, which is disposed at the stern of the hull 200, as compared with a typical air lubrication system.

[00109] The air lubrication system for ships according to this embodiment can achieve significant reduction in shipbuilding cost through use of an engine having a relatively low output power and reduction in cost for auxiliary equipment, for example, a fresh water coolant pump, a seawater coolant pump, a cooler, and a fuel oil pump, and an engine room blower fan, as compared with the air lubrication system according to the above embodiment.

[00110] In addition, the air lubrication system for ships according to this embodiment can provide reduction in weight of a ship and can secure sufficient cargo space through better utilization of an internal space of the ship.

[00111] Further, the air lubrication system for ships according to this embodiment can achieve fuel savings at low ship speed, as well as at high ship speed.

[00112] Next, a method of operating the air lubrication system for ships according to this embodiment will be briefly described, wherein the air lubrication system further includes a control unit storing information about an optimum air ejection rate according to ship speed. The method includes the steps of: determining a required air ejection rate according to a ship speed based on the information stored in the control unit; determining an operating pressure of air compressors according to the required air ejection rate; selecting at least one air compressor among the air compressors according to the ship speed and operating the selected air compressor; adjusting rpm of the air compressor or output rpm of a speed governor disposed on a main propulsion shaft; and adjusting a pressure of air to be discharged to a ship bottom.

[00113] For example, the step of adjusting the pressure of the air to be ejected to the ship bottom may be performed by controlling a guide vane at both inlet and outlet sides of the air compressor and a control valve disposed on a pipe connected between an inlet and an outlet of the air compressor.

[00114] In the step of selecting at least one air compressor and driving the selected air compressor, when a ship travels at a speed exceeding a predetermined value, a third air compressor 180 and a fourth air compressor 190, that is, electrically driven compressors, may be driven by electricity produced by an onboard power generation engine GE, and, when the ship travels at a speed lower than or equal to the predetermined value, a first air compressor 130 and a second air compressor 140 connected to the speed governor 120 may be driven.

[00115] Comparison of energy saving efficiency

[00116] Table 2 show results of comparison in fuel consumption and energy saving efficiency of a container ship equipped with a 66,200 kW 11-cylinder main engine before operating a typical air lubrication system (ALS) (Comparative Example 3) and after operating the ALS (Comparative Example 4).

[00117] Table 2

Ship speed (knots)	Fuel consumption (m ³ /h)		Energy saving efficiency (%)
	Comparative Example 3	Comparative Example 4	

	(Before ALS operation)	(After ALS operation)	
22.5	9.7	9.4	2.8
22	9.0	8.6	3.9
21	7.6	7.5	1.8
20	6.7	6.6	1.4
19	5.9	5.8	0.7
18	5.2	5.2	0.3
17	4.5	4.5	-0.1
16	3.9	4.0	-1.1
15	3.4	3.5	-1.7
14	2.9	3.0	-2.6
13	2.5	2.6	-3.9

[00118] Referring to Table 2, it can be seen that, at a ship speed of a certain value (18 knots) or higher, the ship recorded an energy saving of about 0.3% to 3.6%, whereas, at a ship speed of 17 knots or less, the ship recorded a negative energy saving, that is, the typical air lubrication system failed to provide energy-saving benefits.

[00119] Table 3 shows results of comparing fuel consumption of the same ship between a case in which the air lubrication system according to the embodiment was used (Example 2) and a case in which the typical air lubrication system was used (Comparative Example 4).

[00120] Table 3

Ship speed (knots)	Fuel consumption (m ³ /h)		Energy saving efficiency
	Comparative Example 4	Example 2	
22.5	9.7	9.5	2.3
22	9.0	8.8	2.3
21	7.6	7.2	5.8
20	6.7	6.3	6.3
19	5.9	5.5	6.1
18	5.2	4.9	6.0
17	4.5	4.3	5.7
16	3.9	3.7	5.6
15	3.4	3.2	5.4
14	2.9	2.8	5.2
13	2.5	2.4	5.3

[00121] Referring to Table 3, it can be seen that the air lubrication system according to the embodiment can achieve similar or significantly improved energy savings with reduced engine output power, as compared with Comparative Example 4 in which the

typical air lubrication system driven by electricity produced by the power generation engine was used.

[00122] In particular, the typical air lubrication system caused a negative energy saving at a ship speed of a certain value or less, whereas the air lubrication system according to the embodiment achieved a positive energy saving even at low ship speeds, thereby providing reduction in fuel consumption, as compared with the typical air lubrication system.

[00123] Although some embodiments have been described herein, it should be understood that the foregoing embodiments are provided for illustration only and are not to be in any way construed as limiting the present invention. Therefore, the scope of the present invention should be defined by the appended claims and equivalents thereto.

[00124]

[00125] <List of Reference Numerals>

100, 100a: Air lubrication system	110: Air ejector
120: Speed governor	122: Clutch
124: Gear train	130: First air compressor
140: Second air compressor	150: Temperature regulator
160: Control valve	170: Emergency stop valve
180: Third air compressor	182: First drive motor
190: Fourth air compressor	192: Second drive motor
200: Hull	AP: Air delivery pipe
MA: Main propulsion shaft	ME: Main engine
STT: Starter	SB: Switchboard

What is claimed is:

1. An air lubrication system comprising:
 - a speed governor connected to a main propulsion shaft connected to a main engine of a ship, the speed governor changing rpm of the main propulsion shaft and outputting the changed rpm;
 - at least one air compressor connected to the speed governor and rotated at the rpm output from the speed governor to supply compressed air through compression of air;
 - an air ejector disposed on a bow of the ship and discharging the compressed air supplied from the at least one air compressor to an outside of the ship; and
 - an air delivery pipe through which the compressed air supplied from the at least one air compressor is delivered to the air ejector,wherein the air ejector is provided with an emergency stop valve to stop delivery of air to the air ejector in an emergency.
2. The air lubrication system according to claim 1, wherein the speed governor comprises at least one gear train adapted to change the rpm of the main propulsion shaft.
3. The air lubrication system according to claim 2, wherein the speed governor further comprises a clutch adapted to block output of the changed rpm.
4. The air lubrication system according to claim 1, further comprising:
 - at least one control valve disposed on the at least one air compressor and regulating an air supply pressure of the at least one air compressor.
5. The air lubrication system according to claim 1, further comprising:
 - a temperature regulator disposed on the air delivery pipe and regulating a temperature of the compressed air supplied from the at least one air compressor.
6. An air lubrication system comprising:

a speed governor connected to a main propulsion shaft connected to a main engine of a ship, the speed governor changing rpm of the main propulsion shaft and outputting the changed rpm;

at least one rotary compressor connected to the speed governor and rotated at the rpm output from the speed governor to supply compressed air through compression of air;

at least one electrically driven compressor driven by electricity supplied from a power generation engine of the ship;

an air ejector disposed on a bow of the ship and discharging the compressed air supplied from the at least one rotary compressor and the at least one electrically driven compressor to an outside of the ship; and

an air delivery pipe through which the compressed air supplied from the at least one rotary compressor and the at least one electrically driven compressor is delivered to the air ejector,

wherein the air ejector is provided with an emergency stop valve to stop delivery of air to the air ejector in an emergency.

7. The air lubrication system according to claim 6, wherein the air delivery pipe allows the compressed air supplied from the at least one rotary compressor to be joined with the compressed air supplied from the at least one electrically driven compressor before the compressed air is delivered to the air ejector.

8. The air lubrication system according to claim 6, wherein the at least one electrically driven compressor comprises a third air compressor and a fourth air compressor disposed at a stern of a hull, the air lubrication system further comprising: a starter controlling current or voltage supplied to the third air compressor and the fourth air compressor.