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(54) **Title:** A METHOD AND SYSTEM FOR PRODUCING A LOW SULFUR FUEL

(57) **Abstract:** According to an embodiment of the invention, a method for producing a low sulfur fuel having a sulfur concentration of a predetermined value or within a predetermined range is disclosed. The method includes receiving, in a blender, a first volume or mass of a first fuel having a first sulfur concentration; receiving, in the blender, a second volume or mass of a second fuel having a second sulfur concentration, the second sulfur concentration being higher than the first sulfur concentration; and blending, in the blender, the first volume or mass with the second volume or mass for producing a blended fuel having a blended sulfur concentration of the predetermined value or within a predetermined range.



## A METHOD AND SYSTEM FOR PRODUCING A LOW SULFUR FUEL

### FIELD OF THE INVENTION

The present invention relates generally to a fuel composition. More specifically, the  
5 invention relates to a method and system for producing a low sulfur fuel.

### DESCRIPTION OF RELATED ART

Bunker fuel in general refers to class of marine transportation fuels. Traditionally, these fuels such as Heavy Fuel Oil (HFO) include highly viscous fluids primarily  
10 composed of heavy petroleum fractions designed to burn in large diesel engines or use in combustion engine or processes for large shipping vessels. This traditionally heavy type of bunker fuel is used in most of the world's merchant fleet or other ocean/ sea vehicle that utilize ocean routes. Although lighter components are typically added to bring the HFO to a useable consistency but the HFO is largely composed of thick  
15 residue from the crude oil refining process and contains high concentration of sulfur. As a result of combustion during running of the ship, HFO produces sulfur oxides (SO<sub>x</sub>) that are harmful to the environment. For example, SO<sub>x</sub> gases form particles that contribute to acid rain and cloud effects on regional climate.

Shipping's contribution to regional and global impacts from emissions such as  
20 CO<sub>2</sub>, NO<sub>x</sub> and SO<sub>x</sub> have been evaluated by scientists and shown to be significant enough to motivate policy action. For example, current Bunker fuel emission levels are projected to have significant contribution (> 20%) by 2020 to the overall transportation fuel-derived emissions inventory as other industry sectors (e.g. on-road, etc.) become more compliant around the world. Other studies include a 2009 report where the U.S.  
25 Environmental Protection Agency and its Canadian equivalent, Environment Canada, estimated that shifting to low-sulfur fuels near coasts could save as many as 8,300 lives per year in those two countries, and ease the acute respiratory symptoms faced by another 3 million.

The International Convention for the Prevention of Pollution from Ships  
30 (MARPOL) is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. Annex VI of the convention specifically deals with prevention of air pollution from Ships, entered into

force 19 May 2005. It sets limits on sulfur oxide (SO<sub>x</sub>) and nitrogen oxide (NO<sub>x</sub>) emissions from ship exhausts and prohibits deliberate emissions of ozone depleting substances; designates emission control areas (ECAs) with a more stringent standards for SO<sub>x</sub>, NO<sub>x</sub> and particulate matter. The appendix of MARPOL list current ECAs -  
 5 Baltic Sea area, North Sea area, North American area, United States Caribbean Sea area and a possibility of inclusion of a Mediterranean sea area.

Under the revised MARPOL Annex VI, the global sulfur cap is to be changed progressively in accordance with the following tabular limits (expressed in terms of % m/m - that is by weight). The cap effective from 1 January 2020 is subject to a  
 10 feasibility review to be completed no later than 2018.

| Outside an ECA established to limit SO <sub>x</sub> and particulate matter emissions | Inside an ECA established to limit SO <sub>x</sub> and particulate matter emissions |
|--------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| 4.50% m/m prior to 1 January 2012                                                    | 1.50% m/m prior to 1 July 2010                                                      |
| 3.50% m/m on and after 1 January 2012                                                | 1.00% m/m on and after 1 July 2010                                                  |
| 0.50% m/m on and after 1 January 2020                                                | 0.10% m/m on and after 1 January 2015                                               |

**Table 1**

One way to reduce the SO<sub>x</sub> content of flue gases is to clean the flue gases before  
 15 emitting the gases. For this purpose, the conventional solutions include installing flue gas scrubbers in ships. One example includes a wet scrubber, where the flue gas from an engine is conveyed to a scrubber, where it is scrubbed with sea water. A problem of this solution is that the salty sea water causes corrosion in the scrubber and flue gas ducts. The problems of corrosion may be solved by using corrosion-resistant materials, but  
 20 their price is so high that the material expenses of the equipment and flue gas ducts will rise unreasonably high. In addition, the amount of scrubbing solution to be removed is large, because in order to reach a sufficient sulfur removal result, a large amount of scrubbing solution has to be used in the scrubbing. Furthermore, there may be issues around discharge of the waste water and scrubber maintenance. Thus, it is presently  
 25 difficult to meet the environmental requirements of gas exhaust and seawater discharge under acceptable cost, and energy consumption. Operating costs are also very high to meet discharging water regulation because of the large volume of scrubbing water and

diluting water required for this process. The cost will further increase if more stringent policy compliance is required in future and will further increase the price of the transported goods.

Other solutions include oil based solutions – utilizing fuel oils with low sulfur content such as Marine Diesel Oil (MDO) or Marine Gas Oil (MGO).

a) A straightforward way is to completely replacing use of HFO, typically having around 3% - 4%, by a low sulfur content fuel. However the low sulfur content fuels are far more expensive than the HFO, resulting in substantial increase in operational cost, thereby also increasing the prices of transported goods.

b) Most ships operating both outside and inside ECAs operate on different fuel oils in order to comply with the respective limits. Thus, prior to entry into the ECA, a change over to the ECA compliant low sulfur fuel oil such as to MDO or MGO is made. Similarly change-over to the HFO is not commenced until after exiting the ECA. The method has several drawbacks - the manual change over in relation to the ECA limit and geographic position of the ship makes the process inaccurate. Also, complete transition from HFO to substantially more expensive low sulfur fuel oil to comply with ECA or additional governmental requirements still keeps the operation cost noticeably high. Different batches of same oil stock may include different sulfur concentration and therefore, merely relying on sulfur concentration quote for the batch also allows for inaccuracy. Lastly, a sudden change over from one fuel to another may also produce sudden viscosity variation and thermal shock on the engine.

The reliability and accuracy of any of the earlier solutions become more pronounced when different sea areas and controlling areas may have different and additional environmental conditions and governmental control requirements because the characteristic of gas scrubber, amount of wastewater disposal, fuel change over, mixing proportion will have to be manually changed quite regularly.

In view of the above-mentioned technical-environmental-economic problems, and legal changes; there is a need for a solution that overcomes the limitations of conventional practices and also complies with the policies.

## SUMMARY OF THE INVENTION

According to an embodiment of the invention, a method for producing a low sulfur fuel having a sulfur concentration of a predetermined value or within a predetermined range is disclosed. The method includes receiving, in a blender, a first volume or mass of a first fuel having a first sulfur concentration; receiving, in the blender, a second  
5 volume or mass of a second fuel having a second sulfur concentration, the second sulfur concentration being higher than the first sulfur concentration; and blending, in the blender, the first volume or mass with the second volume or mass for producing a blended fuel having a blended sulfur concentration of the predetermined value or within a predetermined range.

10 According to another embodiment of the invention, a system for producing a low sulfur fuel having a sulfur concentration of a predetermined value or within a predetermined range is disclosed. The system includes a first tank for providing a first volume or mass of a first fuel having a first sulfur concentration; a second tank for providing a second volume or mass of a second fuel having a second sulfur  
15 concentration, the second sulfur concentration being higher than the first sulfur concentration; and a blender for blending the first volume or mass with the second volume or mass for producing a blended fuel having a blended sulfur concentration of the predetermined value or within a predetermined range.

According to yet another embodiment of the invention, a method for switching to a  
20 low sulfur fuel in an off road vehicle is disclosed. The method includes comparing a geo-position of the off-road vehicle with a restriction map, the restriction map defining geographical limits of a plurality of sulfur requirement areas; and providing an engine(s) of the off-road vehicle with the low sulfur fuel by performing a complete changeover from one fuel such as a second fuel to the low sulfur fuel such that the off-  
25 road vehicle uses the low sulfur fuel as an operating fuel within the sulfur requirement area. The flow of low sulfur fuel from the blender to the engine(s) may be controlled using a blender valve, which is manually or automatically operable by the feedback and control mechanism.

According to another embodiment of the invention, a system for switching to a low  
30 sulfur fuel in an off road vehicle is disclosed. The system includes a feedback and control mechanism or a computing unit for comparing a geo-position of the off-road vehicle with a restriction map, the restriction map defining geographical limits of a

plurality of sulfur requirement areas; and a blender for producing a low sulfur fuel and providing an engine(s) of the off-road vehicle with the low sulfur fuel by performing a complete changeover from a one fuel like second fluid to the low sulfur fuel such that the off-road vehicle uses the low sulfur fuel as an operating fuel within the sulfur requirement area.

According to another embodiment of the invention, a method for tracking fuel sulfur concentration in an off-road vehicle is disclosed. The method includes determining sulfur concentration of an operating fuel used in the off-road vehicle; identifying geo-position of the off-road vehicle at the instance of the determination of the sulfur concentration; and recording the blended sulfur concentration along with corresponding tracked geo-position and optionally, with time details for such recording.

According to yet another embodiment of the invention, a system for tracking fuel sulfur concentration in an off-road vehicle is disclosed. The system includes a sulfur analyzer for determining sulfur concentration of an operating fuel used in the off-road vehicle; a positioning unit for identifying geo-position of the off-road vehicle at the instance of the determination of the sulfur concentration; and a computing unit or recorder for recording the blended sulfur concentration along with corresponding tracked geo-position and optionally, with time details for such recording.

According to yet another embodiment, an off-road vehicle comprising a system for producing a low sulfur fuel having a sulfur concentration of a predetermined value or within a predetermined range is disclosed. The system includes a first tank for providing a first volume or mass of a first fuel having a first sulfur concentration; a second tank for providing a second volume or mass of a second fuel having a second sulfur concentration, the second sulfur concentration being higher than the first sulfur concentration; and a blender for blending the first volume or mass with the second volume or mass for producing a blended fuel having a blended sulfur concentration of the predetermined value or within a predetermined range.

## **BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWING**

The embodiments of the invention, together with its advantages, may be best understood from the following detailed description taken in conjunction with the accompanying figures in which

Figure 1 illustrates a method for producing a low sulfur fuel having a sulfur concentration of a predetermined value or within a predetermined range according to an embodiment of the invention;

Figure 2 illustrates a method for producing the low sulfur fuel having a sulfur  
5 concentration of a predetermined value or within a predetermined range according to another embodiment of the invention;

Figure 3 illustrates a method for initiating production of the low sulfur fuel according to an embodiment of the invention;

Figure 4 illustrates a system diagram for producing a low sulfur fuel having a sulfur  
10 concentration of a predetermined value or within a predetermined range according to an embodiment of the invention; and

Figure 5 illustrates a detailed system diagram for producing a low sulfur fuel having a sulfur concentration of a predetermined value or within a predetermined range according to an embodiment of the invention.

## 15 DETAILED DESCRIPTION OF THE INVENTION

The description and accompanying figures represent different components; where same components in different figures share same numeral. Furthermore, some words are used interchangeably such as fluid and fuel.

### 20 Method for producing the low sulfur fuel

According to an embodiment of the invention, as illustrated in the Figure 1, a method for producing a low sulfur fuel having a sulfur concentration of a predetermined value or within a predetermined range is disclosed. The method includes receiving at 105, in a blender, a first volume or mass of a first fuel having a first sulfur  
25 concentration; receiving at 110, in the blender, a second volume or mass of a second fuel having a second sulfur concentration, the second sulfur concentration being higher than the first sulfur concentration; and blending at 115, in the blender, the first volume or mass with the second volume or mass for producing a blended fuel having a blended sulfur concentration of the predetermined value or within a predetermined range. The  
30 concentrations are typically expressed in terms of % m/m - that is by weight.

The first fuel is selected from a group consisting of marine diesel oil and marine gas oil. The first fuel may also be selected from other engine compatible fuel having the

first sulfur concentration low enough in comparison to the second sulfur concentration level and the predetermined value/ predetermined range such that when the first volume or mass is mixed with the second volume or mass, an amount of low sulfur fuel that is sufficient as an operating fuel for an engine(s) is produced, and the percentage of

5 second volume or mass to the first volume or mass in the low sulfur fuel is substantial for providing economic advantage of blending the first fuel and the second fuel. The second fuel is typically a fuel having substantially higher sulfur concentration in comparison to that of the first fuel and higher than the predetermined value or higher concentration value of the predetermined range, such as a heavy fuel oil. The blended

10 sulfur fuel having blended sulfur concentration, that is sulfur concentration in the blended sulfur fuel, of the predetermined value/ within the predetermined range is the low sulfur fuel.

The first fuel is received from a first tank and the second fuel is received from a second tank. The tanks are usually refers to a source of the first fuel and the second fuel.

15 The predetermined value or the predetermined range defines the sulfur concentration of the low sulfur fuel. The predetermined value or predetermined range is typically based on the fuel sulfur concentration limits, as set by law/ conventions/ regulations/ policies. For example, the background section refers to the revised MARPOL Annex VI that sets one such sulfur concentration limits corresponding to

20 emission control areas. The predetermined value or the predetermined range may include any sulfur concentration allowance that is permissible within the law/ conventions/ regulations/ policies. For example, if an allowance of x% in sulfur concentration is permissible, then the predetermined value includes values within a range of predetermined value  $\pm$  x%. However, the predetermined value defining the

25 blended sulfur concentration or a predetermined range for the blended sulfur concentration may also be set based on various parameters either manually by a system operator or automatically based on earlier entered parameters. In different embodiments, such parameters may include fuel cost, allowed sulfur concentration limits in a region, engine requirement based on its condition, performance required out

30 of the engine etc. and a combination thereof.

The blending comprises mixing the received first fluid and the second fluid typically under controlled physical conditions of temperature, and/ or pressure and/ or mixing element (such as blender blades) speed or flow rates of fuels.

In different embodiments, the blended sulfur concentration defines the sulfur  
5 concentration in the blended fuel and for the low sulfur fuel; the value of the blended sulfur concentration is at or below the predetermined value/ within the predetermined range. The blended sulfur concentration is typically at or below 2.0% m/m, such as at or below 1.5%, such as at or below 1.00% m/m, such as at or below 0.5%, such as at or below 0.1%. It is understandable that different sulfur concentration percentages may be  
10 produced using the principle of the present invention. For example, the sulfur concentrations are determined by the permissible sulfur concentration limit of a sulfur requirement area such as an ECA. The permissible sulfur concentration may determine the predetermined value and, the permissible allowance along with the permissible sulfur concentration may determine the predetermined range.

15

#### Controlling Relative Volume or mass

Additional steps to the earlier embodiment are illustrated in the Figure 2 that illustrates yet another method of producing a low sulfur fuel having sulfur concentration of the pre-determined value or within the pre-determined range. At 205, a determination  
20 is made whether the blended sulfur concentration of pre-determined value or within the predetermined range. If the blended sulfur concentration does not satisfy the predetermined value or predetermined range, then at 210, relative volume or mass of the first fuel and the second fuel received in the blender is controlled based on the determined blended sulfur concentration and the predetermined value or the  
25 predetermined range. This is achieved by adjusting relative flow rate of the first fuel and the second fuel using a first valve and/ or second valve. The first valve adjusts the flow rate of the first fuel and the second valve controls the flow rate of the second fuel.

It is comprehensible that the relative flow rate is the difference in flow rate between the flow rate of one fuel with respect to flow rate of another fuel and thus may be  
30 adjusted by controlling either the first valve or the second valve or both. Therefore, the relative flow rate is adjusted by controlling the first valve alone or by controlling the second valve alone or by controlling both the first valve and the second valve

simultaneously or sequentially such that the relative volume or mass received in the blender is changed in order to produce the blended fuel having the blended sulfur concentration of the predetermined value or within the predetermined range.

In one embodiment, relative flow rate of the first fuel with respect to the second fluid is increased, if the blended sulfur concentration is higher than the predetermined value or upper concentration value of the predetermined range until the blended sulfur concentration is of the predetermined value or within the predetermined range. In a contrasting embodiment, relative flow rate of the second fluid with respect to the first fluid is increased, if the blended sulfur concentration is lower than the predetermined value or lower concentration value of the predetermined range until the blended sulfur concentration is of the predetermined value or within the predetermined range.

#### Blended Sulfur Analysis and feedback & control

The determination at 205 is made by a sulfur analyzer that is connected with a first valve and a second valve via a feedback and control mechanism (refer Figure 4, 430). Based on the predetermined value/ predetermined range and the blended sulfur concentration as received from the sulfur analyzer, the feedback and control mechanism adjusts the first valve and/ or the second valve. The adjustment of the valve refer to closing or partial/ full opening of a valve in order to stop or allow fuel to be received in the blender.

#### *Fully automatic control – First Valve & Second Valve*

In one embodiment, the feedback and control mechanism includes a programmable machine that is adapted to compute an optimum relative flow rate of the first fuel and the second fuel based on the first sulfur concentration, second sulfur concentration, and the predetermined value or the predetermined range such that the blended fuel of the blended sulfur concentration of predetermined value or the predetermined range is produced; and instruct the first valve to open and the second valve to open according to the computed optimum relative flow rate.

A blended fuel is produced in accordance with the optimum relative flow. Thereafter, the sulfur analyzer determines the blended sulfur concentration. The feedback and control mechanism is also adapted to compare the blended sulfur

concentration with the predetermined value or the predetermined range. Based on the comparison, the feedback and control mechanism instructs the first valve and/ or the second valve for increasing relative flow rate of the second fluid with respect to the first fluid if the blended sulfur concentration is lower than the predetermined value or lower  
5 concentration value of the predetermined range; or instruct the first valve and/ or the second valve for increasing relative flow rate of the second fluid with respect to the first fluid if the blended sulfur concentration is lower than the predetermined value or lower concentration value of the predetermined range.

The feedback and control mechanism is adapted to compute a revised relative flow  
10 rate of the first fuel and the second fuel based on the first sulfur concentration, second sulfur concentration, received blended sulfur concentration and the predetermined value or the predetermined range such that the blended fuel of the blended sulfur concentration of predetermined value or the predetermined range is produced; and instruct the first valve to open and/ or the second valve to open according to the  
15 computed revised relative flow rate.

*Partially automatic control – First Valve & Second Valve*

In another embodiment, the feedback and control mechanism includes a programmable machine that is adapted to compute an optimum relative flow rate of the  
20 first fuel and the second fuel based on the first sulfur concentration, second sulfur concentration, and the predetermined value or the predetermined range such that the blended fuel of the blended sulfur concentration of predetermined value or the predetermined range is produced; and manually open the respective first valve and the second valve is manually adjusted in accordance with the computed optimum relative  
25 flow rate.

A blended fuel is produced in accordance with the optimum relative flow. Thereafter, the sulfur analyzer determines the blended sulfur concentration. The feedback and control mechanism is adapted to compare the blended sulfur concentration with the predetermined value or the predetermined range. Following this, the first valve  
30 and/ or the second valve is manually adjusted for increasing relative flow rate of the second fluid with respect to the first fluid if the blended sulfur concentration is lower than the predetermined value or lower concentration value of the predetermined range.

Alternatively, the first valve and/ or the second valve is manually adjusted for increasing relative flow rate of the second fluid with respect to the first fluid if the blended sulfur concentration is lower than the predetermined value or lower concentration value of the predetermined range.

- 5        The feedback and control mechanism is also adapted to compute a revised relative flow rate of the first fuel and the second fuel based on the first sulfur concentration, second sulfur concentration, received blended sulfur concentration and the predetermined value or the predetermined range such that the blended fuel of the blended sulfur concentration of predetermined value or the predetermined range is  
10   produced; and the first valve is manually adjusted to open and/ or the second valve is manually adjusted to open according to the computed revised relative flow rate.

#### Blender Unit – Integrated Actuated Valve

- According to an embodiment, an actuator driven valve, integrated within the  
15   blender, for controlling relative volume or mass of the first fuel and the second fuel received in the blender. The relative volume or mass is defined by the volume or mass of one fuel with respect to the volume or mass of another fuel, as received in the blender. Instead of the first valve and the second valve controlling the flow rates, as described in the previous embodiments, the first valve and second valve in this  
20   embodiment may simply act as ON-OFF valves. When the first valve and the second valve are in the OFF state, neither first fuel nor second fuel is received in the blender. Whereas, in the ON state of the first valve, the first fuel is received in the blender and the in the ON state of the second valve, the second fuel is received in the blender. As the first valve and the second valve are merely ON-OFF valves, the actuator driven  
25   valve is used to control relative volume or mass of the first fuel and the second fuel received in the blender. Thus, the blender includes the actuator driven valve.

- The actuator driven valve may include a movable means, wherein positioning the movable means allows for receiving the first fuel in the blender through a first inlet at the blender and receiving the second fuel in the blender through a second inlet at the  
30   blender. A change in positioning of the movable means allows for increasing/ decreasing a volume or mass of one fuel through the one inlet and for simultaneously decreasing/ increasing the volume or mass of another fuel through another inlet. For

example, if the movable means is positioned such that there is an increase in volume or mass of the received first fuel, then there is a simultaneous decrease in the volume or mass of the received second fuel. Similarly, if the movable means is positioned such that there is an increase in volume or mass of the second fuel, then there is a simultaneous decrease in the volume or mass of the received first fuel.

More particularly, a percentage increase in the volume or mass of one fuel in the blender simultaneously decreases percentage volume or mass of another fuel in the blender by same percentage and vice versa. For example, if change in position of the movable means increases the volume or mass of first fuel in the blender by 20% with respect to the total fuel volume or mass received in the blender, then there is a simultaneous decrease in the volume or mass of second fuel in the blender by 20% with respect to the total fuel volume or mass received in the blender. This allows for ensuring that relative volume or mass of the first fuel and the second fuel are simultaneously changed with one controlled action, i.e. positioning of the movable means, thus allow less control variables and higher system accuracy.

An actuator such as a motor is adapted to position the movable means for allowing receiving the first fuel in the blender through the first inlet at the blender and receiving the second fuel in the blender through the second inlet at the blender.

#### *Fully Automatic Control of the Movable Means*

The actuator is typically communicatively linked with the feedback and control mechanism, the feedback and control mechanism adapted to instruct the actuator to adjust the movable means such that the received volumes or masses of the first fuel and the second fuel produces blended fuel having the blended sulfur concentration of the predetermined value or within a predetermined range is produced.

In one embodiment, the feedback and control mechanism include a programmable machine that is adapted to compare the blended sulfur concentration with the predetermined value or the predetermined range. Based on the comparison, the feedback and control mechanism is adapted to either instruct the movable means to position for increasing relative volume or mass of the second fluid with respect to the first fluid if the blended sulfur concentration is lower than the predetermined value or lower concentration value of the predetermined range; or instruct the movable means to

position for increasing relative volume or mass of the second fluid with respect to the first fluid if the blended sulfur concentration is lower than the predetermined value or lower concentration value of the predetermined range.

5        In another embodiment, the feedback and control mechanism is a programmable machine that is adapted to compute an optimum relative volume or mass of the first fuel and the second fuel based on the first sulfur concentration, second sulfur concentration, and the predetermined value/ predetermined range such that the blended fuel of the predetermined value or the predetermined range is produced; and instruct the movable  
10       means to position according to the computed optimum relative volume or mass.

         In another embodiment, the feedback and control mechanism include a programmable machine that is adapted to compute a revised relative volume or mass of the first fuel and the second fuel based on the first sulfur concentration, second sulfur concentration, received blended sulfur concentration and the predetermined value or the  
15       predetermined range such that the blended fuel of the blended sulfur concentration of predetermined value or the predetermined range is produced; and instruct the movable means to position according to the computed revised relative volume or mass.

#### *Partial Automatic Control of Movable Means*

20       In one embodiment, the feedback and control mechanism include a programmable machine that is adapted to compare the blended sulfur concentration with the predetermined value or the predetermined range. Based on the comparison, the movable means is manually positioned either for increasing relative volume or mass of the second fluid with respect to the first fluid if the blended sulfur concentration is lower  
25       than the predetermined value or lower concentration value of the predetermined range; or for increasing relative volume or mass of the second fluid with respect to the first fluid if the blended sulfur concentration is lower than the predetermined value or lower concentration value of the predetermined range.

         In another embodiment, the feedback and control mechanism include a  
30       programmable machine that is adapted to compute an optimum relative volume or mass of the first fuel and the second fuel based on the first sulfur concentration, second sulfur concentration, and the predetermined value or the predetermined range such that the

blended fuel of the blended sulfur concentration of predetermined value or the predetermined range is produced; and the movable means is manually positioned according to the computed optimum relative flow rate.

- 5        In yet another embodiment, the feedback and control mechanism include a programmable machine that is adapted to compute a revised relative volume or mass of the first fuel and the second fuel based on the first sulfur concentration, second sulfur concentration, received blended sulfur concentration and the predetermined value or the predetermined range such that the blended fuel of the blended sulfur concentration of  
10        predetermined value or the predetermined range is produced; and the movable means is manually positioned according to the computed revised relative volume or mass.

#### In-line blending

- 15        The method for producing the blended fuel, as described above, is a continuous in-line blending with the first fuel and second fuel received from the first tank and the second tank respectively. In-line blending describes real time measurement of fuel components using a series of flow meter to automatically control the flow rate at proper ratio. In line blending allows for a high throughput production and works based on real time measuring of blended sulfur concentration. The first fuel and the second fuel are  
20        mixed at the blender and may be routed to specific destinations such as to an engine. This unique in-line mixing capability speeds up the rate of production, and making on-spec low sulfur fuel.

#### Geographic based fuel production

- 25        The foregoing method is performed and corresponding system is installed in an off-road vehicle such as a marine vessel or ship or bunkering facility or bunkering barge. The use of term off-road vehicle refers to non-land vehicle. In particular, the term refers to water borne vehicles.

- 30        Figure 3 illustrates a method for initiating production of the low sulfur fuel according to an embodiment of the invention and the same is described below.

The sulfur analyzer, determining the blended sulfur concentration, is communicatively connected with a positioning unit of the off-road vehicle. The

positioning unit is adapted to track geo-position of the off-road vehicle and includes a Global Positioning System (GPS) or other geo-spatial positioning system.

In an embodiment, the blended sulfur concentration from the sulfur analyzer along with corresponding tracked geo-position from the positioning unit is recorded.

5     Optionally time details for such recording are also made. This may be achieved by communicatively connecting the sulfur analyzer with a positioning unit of the off-road vehicle. The recording allows keeping a reliable and accurate log of fuel sulfur concentration with respect to positioning of the off-road vehicle, thus indicating potential of sulfur based pollution from the fuel. This logging technique is particularly  
10    useful in scenarios where sulfur requirement areas like ECAs are designated with more stringent pollution control.

The recording may be performed after regular time intervals, for example after every 1 second, after every 15 seconds, after every 30 seconds, after every 45 seconds, after every 1 minute, after every 5 minutes, after every 10 minutes, after every 30  
15    minutes, etc. Furthermore, the recording may also be performed when the off-road vehicle enters or leaves the geographic limit of a sulfur requirement area.

In order to ensure reliability of data, according to an embodiment, the recording is data locked to avoid tampering of the recording. Tampering of the record is defined as any activity that alters the recording, i.e. alteration of blended sulfur concentration  
20    reading of the sulfur analyzer, and/ or corresponding geographic position reading of the off-road vehicle, and/ or the time of the recording. Typically the data locking method includes protecting the recording using a password, or generating the recording in a read file format only, or corrupting the recording if an attempt to tamper the recording is made, and a combination thereof.

25     The blender, the sulfur analyzer, feedback and control mechanism, and related flow system may be retrofitted with the fuel system currently used in off-road vehicles. One or more listed components may be calibrated in order to produce accurate recordings and may even be certified by a standard certification body or authorities. For reliable recordings; the components may be required to be unit locked to avoid tampering, i.e.  
30    the components are not modified in order to make incorrect recordings. Therefore according to another embodiment, one or more component such as the sulfur analyzer is unit locked to avoid tampering of the analyzer. A few method that are employed may

include allowing access to the sulfur analyzer using a password clearance, raising indication signal such as an alarm if an unauthorized attempt to access the sulfur analyzer is made and a combination thereof.

In one embodiment, the positioning unit is communicatively connected directly to the feedback and control mechanism. In another embodiment, the position system is  
5 connected with a computing unit that is communicatively connected with the feedback and control mechanism. In these embodiments, at 305 the feedback and control mechanism or the computing unit is adapted to compare the geo-position of the off-road vehicle, received from the positioning unit, with a restriction map. The restriction map  
10 defines geographical limits of a plurality of sulfur requirement areas. The geographical limits may be expressed in a format that is directly comparable with the information received from the positioning unit or is expressed in a data set that is converted into a format that is comparable with the information received from the positioning unit. The geographical limit of a specific sulfur requirement area separates the area where use of  
15 low sulfur fuel of defined sulfur concentration is mandatory and areas where the second fuel alone may be used.

The comparison with the restriction map identifies the sulfur requirement area at 310, forming the basis for determining fuel sulfur limits. Furthermore, the comparison allows for determining the distance to geographical limit of the identified sulfur  
20 requirement area and time needed to reach the sulfur requirement area. If no imminent sulfur requirement area is identified, then the off-road vehicle continues to use the second fuel at 315.

At 320, the feedback and control mechanism or the computing unit, communicatively connected with the feedback and control mechanism, is adapted to  
25 access the sulfur limit of each of the sulfur requirement areas or the predetermined value/ the predetermined range. In one embodiment, the feedback and control mechanism is adapted to initiate production of the low sulfur fuel at 325 by allowing receipt of the first volume or mass and the second volume or mass in the blender based on the geo position-map comparison (as described earlier) and accessed sulfur limit or  
30 the accessed predetermined value/ predetermined range. In another embodiment, the computing unit is adapted to instruct the feedback and control mechanism, which is adapted to initiate production of the low sulfur fuel at 325 by allowing receipt of the

first volume or mass and the second volume or mass in the blender based on the geo position-map comparison and accessed sulfur limit or predetermined value/ predetermined range.

At 330, the blended fuel having sulfur concentration of a predetermined value or within a predetermined range is provided as an operating engine fuel to an engine(s) of the off-road vehicle. The operating fuel is the fuel that is utilized by the engine(s) of the off-road vehicle and is considered as the fuel responsible for producing sulfur based pollution. The blended low sulfur fuel may be heated to a viscosity that is suitable for engine(s) of the off-road vehicle.

In an embodiment, the computing unit or the feedback and control mechanism is adapted to calculate a time duration required from initiation of production to complete changeover to low sulfur fuel of required sulfur concentration as the operating fuel for the engine(s). The complete changeover refers to switching completely or almost completely from using a fuel that is currently being used as an operating fuel such as the second fuel or low sulfur fuel of one sulfur concentration to using the produced low sulfur fuel or low sulfur fuel of another sulfur concentration as the operating engine fuel. This may also include scenarios where low sulfur fuel of one predetermined sulfur concentration is replaced by low sulfur fuel of another predetermined sulfur concentration. For example, 2020 onwards, switching between low sulfur fuel having 0.5% outside ECA sulfur limit to 0.1% inside ECA sulfur limit (refer Table 1).

The calculation of the time duration is typically based on at least one or more of the first sulfur concentration, second sulfur concentration, area specific sulfur limit or predetermined value/ predetermined range, engine(s) specification, speed of the off-road vehicle, volume or mass of low sulfur fluid required; and initiate production of the low sulfur fuel in accordance with the calculated time duration. Therefore, time duration calculation along with low sulfur fuel initiation based on geo-position and restriction map comparison allows for ensuring that the off-road vehicle operates in accordance with any geographically limited sulfur limits. Furthermore, recording of sulfur concentration with corresponding geo-position and time of the recording allows for maintaining reliable and accurate records.

Fail-Safe mechanism

In an embodiment, fail-safe mechanism is also provided such that the engine(s) of the off-road vehicle may be supplied with the first fuel alone, or the second fuel alone or the produced low sulfur fuel. In particular, the method includes bypassing the production of the low sulfur fuel and providing the engine(s) with the first fluid and/or second fluid as the operating fuel. It is understandable that the “or” condition defines a scenario where either the first fuel or the second fuel are provided to the engine individually. Whereas the “and” condition defines a scenario where the first fuel and the second fuel are provided to the engine simultaneously – for example while gradually changing the supply from the first fuel to the second fuel and vice-versa, but without the use of the blender and the sulfur analyzer.

a) if a technical problem is identified with the production of low sulfur system. The technical problem may be notified by a notification means such as an alarm; or

b) when the low sulfur fuel production mode is substantially inactive and beyond geographical limits of any of the sulfur requirement areas.

Within the geographical limits of the sulfur requirement area, the engine is provided with the produced low sulfur fuel, the control of the low sulfur fuel being controlled by a blender valve, unless there is the technical problem as described in the preceding part. In the technical problem scenario, the engine(s) is supplied with the first fuel from the first tank using the bypass circuit. Thus within the geographical limits, the production of low sulfur fuel is typically always active. It is understandable, that in situations where enough volume or mass of the low sulfur fuel with respect to volume or mass required within the sulfur requirement area is available, then the production mode is made inactive. Similarly, beyond the sulfur requirement area, bypass circuit may be used in order to provide the engine(s) with the second fuel and the sulfur fuel production mode is substantially inactive because the production of the low sulfur fuel is typically not required. The word substantially refers to scenarios when the off-road vehicle is still beyond the geographic limits of the sulfur requirement area but produces the low sulfur fuel (active mode) closer to and prior to entering the sulfur requirement area.

Usually, the bypass circuit includes a high valve for controlling flow of the first fluid and a low valve for controlling flow of the second fluid directly to the engine(s). This may include controlling either automatically by the feedback and control

mechanism or manually, the control of the high valve and the low valve based on identification of technical problem and/ or determination of low sulfur production mode and geo-positioning of the off-road vehicle. It is understandable that the blender valve is closed when the bypass circuit is in active mode and opened when the bypass circuit is in inactive mode. The bypass circuit is in the active mode when the first fuel and/ or the second fuel is provided to the engine(s) directly from the first tank and/ or second tank. The bypass circuit is in the inactive mode when neither the first fuel nor the second fuel is directly provided to the engine(s) from the first tank and/ or second tank respectively. In the inactive mode, the engine(s) is provided only with the low sulfur fuel.

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#### System for producing the low sulfur fuel

According to an embodiment, as illustrated in Figure 4 a system diagram for producing a low sulfur fuel having a sulfur concentration of a predetermined value or within a predetermined range is disclosed. The system includes a first tank 410 for providing a first volume or mass of a first fuel having a first sulfur concentration and a second tank 405 for providing a second volume or mass of a second fuel having a second sulfur concentration. The second sulfur concentration of the second fuel is higher than the first sulfur concentration of the first fuel. The concentrations are typically expressed in terms of % m/m - that is by weight. The system also includes a blender 415 for blending the first volume or mass with the second volume or mass for producing a blended fuel having a blended sulfur concentration of the predetermined value or within a predetermined range.

The outward flow from the blender, typically to an engine(s) through a fuel tank 460, may be controlled by a blender valve 455. Furthermore, a plurality of physical controllers (refer Figure 5, 530) may be employed for controlling physical conditions of temperature, and/ or pressure, and / or mixing element speed during the mixing in the blender.

The blender is connected with a sulfur analyzer 425 either directly or via a sample outlet unit 420 that receives a sample volume or mass of blended fuel. The sulfur analyzer determines the sulfur concentration of the blended fuel, i.e. blended sulfur concentration.

30

The determined blended sulfur concentration and the predetermined value or the predetermined range is used to control the relative volume or mass of the first fuel and the second fuel received in the blender. This allows for increasing or decreasing the volume or mass of one fuel with respect to another such that the blended sulfur  
5 concentration is changed towards the predetermined value or to reach within the predetermined range. A first valve 440 associated with the first fluid and/ or a second valve 435 associated with the second fluid are used for controlling the relative volume or mass received in the blender by adjusting relative flow rate of the first fuel and the second fuel. The flow rate is defined by the volume or mass of fuel that enters the  
10 blender per unit time. Therefore, the first flow path for the first fluid includes the first tank 410, the first valve 440 and the blender 415 and the second flow path for the second fluid includes the second tank 410, the second valve 440 and the blender 415. In an embodiment, the flow rate of the first fuel is observable in a first flow meter 470 and the flow rate of the second fuel is observable in a second flow meter 465. The flow  
15 meters 470, 465 are placed in the respective flow paths after the first valve 440 and the second valve 435 respectively.

As mentioned earlier in the description, in one embodiment, the feedback and control mechanism is adapted to adjust the first valve and/ or the second valve based on the predetermined value/ predetermined range and the blended sulfur concentration, as  
20 received from the sulfur analyzer.

The system also includes a bypass circuit that includes a high valve 445 for controlling flow of the first fluid and a low valve 450 for controlling flow of the second fluid directly to the engine(s). This may include controlling either automatically by the feedback and control mechanism or manually, the control of the high valve and the low  
25 valve based on identification of technical problem and/ or determination of low sulfur production mode and geo-positioning of the off-road vehicle. It is understandable that the blender valve is closed when the bypass circuit is in active mode and opened when the bypass circuit is in inactive mode. The bypass circuit is in the active mode when the first fuel and/ or the second fuel is provided to the engine(s) directly from the first tank and/ or second tank. The bypass circuit is in the inactive mode when neither the first  
30 fuel nor the second fuel is directly provided to the engine(s) from the first tank and/ or

second tank respectively. In the inactive mode, the engine(s) is provided only with the low sulfur fuel.

The fuel tank 460 is adapted to receive any of the first fuel from the first tank 410, second fuel from the second tank 405 and the low sulfur fuel, which is produced in and  
5 received from the blender unit 415.

In an embodiment, the system may also include a temperature transmitter 515 that is typically part of fuel delivery mechanism or main engine fuel system and connected to other components of the fuel delivery mechanism (refer Figure 5). The transmitter is adapted to measure temperature of fuel unconsumed by the engine. The measured  
10 temperature reading of the temperature transmitter may be provided to the feedback and control mechanism 430 that in provides instructions such that low sulfur fuel heated to a desired temperature is obtained.

Other embodiments, for example as illustrated in Figure 5, include a slightly different layout of the components but the skilled person would appreciate that both the  
15 layouts work on same working principle. As mentioned earlier, the components in Figure 5 indicated with numerals same as in Figure 4, represent the same component and thus, perform same function.

The additional components may include an outlet valve 525 connected with the blender in order to allow withdrawal of a sample amount of the blended fuel to the  
20 sample outlet 420. This is useful because the blender valve 455 may be kept closed and the sample may still be obtained for determination of the blended sulfur concentration. In addition, the flow meter 505 may also be connected between the blender and the fuel tank 460 in order to ensure that the flow rate at which the fuel is provided to the engine is at desired flow rate. Usually, the flow rate is dependent on the fuel consumption  
25 capacity of the engine(s) being supplied with the low sulfur fuel.

In an embodiment, further components may be included in the above disclosed system as part of a fuel delivery mechanism, a booster pump 510 is used to pump fuel from the fuel tank 460 and using a fuel deliver pump 520, the fuel is provided to the engine(s). The fuel that remains unconsumed by the engine(s) may be returned to a  
30 return tank 535 and the unconsumed fuel is again pumped back to the engine(s) using the booster pump 510 and the fuel delivery pump 520. Furthermore, a temperature transmitter 515 may also be used for measuring temperature of the unconsumed fuel.

The measured temperature reading may be provided to the feedback and control mechanism 430 that in provides instructions to the physical controllers 530 of the blender to produce low sulfur fuel heated to desired temperature.

Furthermore, in this illustrated embodiment, the blender 415 is integrated with an actuator driven valve, which is controlled by the actuator 530. In this embodiment, the valves 435 and 440 are typically ON-OFF valves and the relative volume or mass of the first fuel and the second fuel is controlled by the actuator driven valve through positioning of the movable means. The positioning of the movable means is controlled by the actuator 530. The actuator is usually communicatively connected to the feedback and control mechanism 430, which instructs the actuator to position the movable means in accordance with different scenarios and implementation methods like according to optimum relative volume or mass or revised relative volume or mass, etc., as discussed earlier. The positioning of the movable means using the instructions from the feedback and control means 430 allows for producing the blended fuel having blended sulfur concentration of the predetermined value or within the predetermined range. In order to arrive at the desired temperature, temperature cooling gradient may be set to ensure against problems in main engine fuel pumps.

#### Method & System for switching to a low sulfur fuel

According to yet another embodiment of the invention, a method for switching to a low sulfur fuel in an off road vehicle is disclosed. The method includes comparing a geo-position of the off-road vehicle with a restriction map, the restriction map defining geographical limits of a plurality of sulfur requirement areas; and providing an engine(s) of the off-road vehicle with the low sulfur fuel by performing a complete changeover from one fuel such as a second fuel to the low sulfur fuel such that the off-road vehicle uses the low sulfur fuel as an operating fuel within the sulfur requirement area. The flow of low sulfur fuel from the blender to the engine(s) may be controlled using a blender valve, which is manually or automatically operable by the feedback and control mechanism.

Before the complete changeover takes place, a predetermined sulfur concentration value/ a predetermined sulfur concentration range for the low sulfur fuel or a sulfur limit of a sulfur requirement area that the off-road vehicle is entering or is within is

accessed; and the production of the low sulfur fuel is initiated by allowing receipt of the first volume or mass and the second volume or mass in the blender based on the geo position-map comparison and accessed sulfur limit or the accessed predetermined value/ predetermined range.

5        In one embodiment, the feedback and control mechanism is adapted to initiate production of the low sulfur fuel by allowing receipt of the first volume or mass and the second volume or mass in the blender based on the geo position-map comparison and accessed sulfur limit or the accessed predetermined value/ predetermined range. In another embodiment, a computing unit is adapted to instruct the feedback and control  
10       mechanism, which is adapted to initiate production of the low sulfur fuel by allowing receipt of the first volume or mass and the second volume or mass in the blender based on the geo position-map comparison and accessed sulfur limit or predetermined value/ predetermined range.

15       The blended fuel having sulfur concentration of a predetermined value or within a predetermined range or at or below the sulfur limit is used as an operating engine fuel for the engine(s) of the off-road vehicle. The blended fuel may also be heated to a viscosity that is suitable for engine(s) of the off-road vehicle.

20       The computing unit or the feedback and control mechanism may also be adapted to calculate a time duration required from initiation of production to complete changeover to low sulfur fuel as the operating fuel for the engine(s). The calculation is typically based on at least one or more of the parameters such as first sulfur concentration, second sulfur concentration, area specific sulfur limit or predetermined value/ predetermined range, engine(s) specification, speed of the off-road vehicle, volume or mass of low sulfur fluid required; and lastly production of the low sulfur fuel is initiated  
25       in accordance with the calculated time duration.

30       In one embodiment, the changeover may include closing a high valve and a low valve in order to block flow of a first fuel and the second fuel to the engine(s); and switching to the produced low sulfur fuel by opening the blender valve. The low sulfur fuel is produced by opening a first valve and a second valve in order to allow receipt of a first fluid and the second fluid to the blender for production of low sulfur fuel, which is provided to the engine(s). In another embodiment, where the first valve and the second valve act as the ON-OFF valve, the low sulfur fuel is produced by positioning

the movable means for receiving the first fuel and the second fuel in the blender. The closing of the high valve and the low valve and opening of the blender valve may be either simultaneous or sequential. Eventually, once complete changeover has taken place, the supply of fuel in a fuel tank is only from the blender and not from the first  
5 tank or the second tank. When the off-road vehicle moves to an area where the second fuel meets the sulfur concentration requirement, then the changeover includes switching to the second fuel.

According to another embodiment of the invention, a system for switching to a low sulfur fuel in an off road vehicle is disclosed. The system includes a feedback and  
10 control mechanism or a computing unit for comparing a geo-position of the off-road vehicle with a restriction map, the restriction map defining geographical limits of a plurality of sulfur requirement areas; and a blender for producing a low sulfur fuel and providing an engine(s) of the off-road vehicle with the low sulfur fuel by performing a complete changeover from a one fuel like second fluid to the low sulfur fuel such that  
15 the off-road vehicle uses the low sulfur fuel as an operating fuel within the sulfur requirement area.

The method and system for switching to low sulfur fuel may also include features disclosed in any of the preceding sections.

#### 20 Method and System for tracking fuel sulfur concentration

According to an embodiment of the invention, a method for tracking fuel sulfur concentration in an off-road vehicle is disclosed. The method includes determining sulfur concentration of an operating fuel used in the off-road vehicle; identifying geo-position of the off-road vehicle at the instance of the determination of the sulfur  
25 concentration; and recording the blended sulfur concentration along with corresponding tracked geo-position and optionally, with time details for such recording.

The recording may be performed after regular time intervals, for example after every 1 second, after every 15 seconds, after every 30 seconds, after every 45 seconds, after every 1 minute, after every 5 minutes, after every 10 minutes, after every 30  
30 minutes, etc. Furthermore, the recording may also be performed when the off-road vehicle enters or leaves the geographic limit of a low sulfur concentration area.

In order to ensure reliability of data, according to an embodiment, the recording is data locked to avoid tampering of the recording. Tampering of the record is defined as any activity that alters the recording, i.e. alteration of blended sulfur concentration reading of the sulfur analyzer, and/ or corresponding geographic position reading of the off-road vehicle, and/ or the time of the recording. Typically the data locking method includes protecting the recording using a password, or generating the recording in a read file format only, or corrupting the recording if an attempt to tamper the recording is made, and a combination thereof.

The blender, the sulfur analyzer, feedback and control mechanism, and related flow system may be retrofitted with the fuel system currently used in off-road vehicles. One or more listed components may be calibrated in order to produce accurate recordings and may even be certified by a standard certification body or authorities. For reliable recordings; the components may be required to be unit locked to avoid tampering, i.e. the components are not modified in order to make incorrect recordings. Therefore according to another embodiment, one or more component such as the sulfur analyzer is unit locked to avoid tampering of the analyzer. A few method that are employed may include allowing access to the sulfur analyzer using a password clearance, raising indication signal such as an alarm if an unauthorized attempt to access the sulfur analyzer is made and a combination thereof.

According to another embodiment of the invention, a system for tracking fuel sulfur concentration in an off-road vehicle is disclosed. The system includes a sulfur analyzer for determining sulfur concentration of an operating fuel used in the off-road vehicle; a positioning unit for identifying geo-position of the off-road vehicle at the instance of the determination of the sulfur concentration; and a computing unit or recorder for recording the blended sulfur concentration along with corresponding tracked geo-position and optionally, with time details for such recording.

The method and system for tracking fuel sulfur concentration may also include features disclosed in any of the preceding sections.

It is important to note that Figures 1 to 5 illustrate specific applications and embodiments of the invention, and it is not intended to limit the scope of the present disclosure or claims to that which is presented therein. Throughout the foregoing

description, for the purposes of explanation, numerous specific details, etc. were set forth in order to provide a thorough understanding of the invention. It will be apparent, however, to one skilled in the art that the invention may be practiced without some of these specific details and by employing different embodiments in combination with one  
5 another. The underlying principles of the invention may be employed using a large number of different combinations.

Accordingly, the scope of the invention should be judged in terms of the claims which follow.

**CLAIMS:**

1. A method for producing a low sulfur fuel having a sulfur concentration of a predetermined value or within a predetermined range, comprising  
receiving, in a blender, a first volume or mass of a first fuel having a first  
5 sulfur concentration;  
receiving, in the blender, a second volume or mass of a second fuel having  
a second sulfur concentration, the second sulfur concentration being higher than the  
first sulfur concentration; and  
blending, in the blender, the first volume or mass with the second volume  
10 or mass for producing a blended fuel having a blended sulfur concentration of the  
predetermined value or within a predetermined range.
2. The method according to claim 1, wherein the first fuel is received from a first tank  
and the second fuel is received from a second tank.
- 15 3. The method according to any of the preceding claims, wherein the first fuel is  
selected from a group consisting of marine diesel oil and marine gas oil.
4. The method according to any of the preceding claims, wherein the second fuel is  
20 selected from a heavy fuel oil.
5. The method according to any of the preceding claims, wherein the blended sulfur  
fuel is the low sulfur fuel.
- 25 6. The method according to any of the preceding claims, further comprising  
determining whether the blended sulfur concentration is of the predetermined value  
or within the predetermined range.
7. The method according to any of the preceding claims, further comprising  
30 controlling relative volume or mass of the first fuel and the second fuel received in  
the blender based on the determined blended sulfur concentration and the  
predetermined value or the predetermined range.

8. The method according to any of the preceding claims, further comprising controlling the relative volume or mass received in the blender by adjusting relative flow rate of the first fuel and the second fuel using a first valve and/ or a second valve respectively.
9. The method according to any of the preceding claims, further comprising increasing relative flow rate of the first fuel with respect to the second fluid, if the blended sulfur concentration is higher than the predetermined value or upper concentration value of the predetermined range until the blended sulfur concentration is of the predetermined value or within the predetermined range.
10. The method according to any of the preceding claims, further comprising increasing relative flow rate of the second fluid with respect to the first fluid if the blended sulfur concentration is lower than the predetermined value or lower concentration value of the predetermined range until the blended sulfur concentration is of the predetermined value or within the predetermined range.
11. The method according to any of the preceding claims, wherein the relative flow rate is adjusted by controlling the first valve alone or by controlling the second valve alone or by controlling both the first valve and the second valve simultaneously or sequentially such that the relative volume or mass received in the blender is changed in order to produce the blended fuel having the blended sulfur concentration of the predetermined value or within the predetermined range.
12. The method according to any of the preceding claims, wherein an actuator driven valve, integrated with the blender, controls relative volume or mass of the first fuel and the second fuel received in the blender.
13. The method according to any of the preceding claims, wherein the blender comprises the actuator driven valve.

14. The method according to any of the preceding claims, wherein the actuator driven valve comprises a movable means.
15. The method according to any of the preceding claims, wherein positioning the  
5 movable means allows for receiving the first fuel in the blender through a first inlet and receiving the second fuel in the blender through a second inlet.
16. The method according to any of the preceding claims, wherein change in positioning of the movable means allows for increasing/ decreasing a volume or mass of one  
10 fuel through the one inlet and for simultaneously decreasing/ increasing the volume or mass of another fuel through another inlet.
17. The method according to any of the preceding claims, wherein a percentage increase in the volume or mass of one fuel simultaneously decreases percentage volume or  
15 mass of another fuel by same percentage and vice versa.
18. The method according to any of the preceding claims, wherein the positioning of the movable means is controlled by an actuator.
- 20 19. The method according to any of the preceding claims, wherein the actuator is communicatively linked with the feedback and control mechanism, the feedback and control mechanism adapted to instruct the actuator to adjust the movable means such that the received relative volume or mass of the first fuel and the second fuel produces the blended fuel having the blended sulfur concentration of the  
25 predetermined value or within a predetermined range is produced.
20. The method according to any of the preceding claims, wherein the feedback and control mechanism include a programmable machine that is adapted to  
compare the blended sulfur concentration with the predetermined value or  
30 the predetermined range;  
instruct the movable means to position for increasing relative volume or mass of the second fluid with respect to the first fluid if the blended sulfur

concentration is lower than the predetermined value or lower concentration value of the predetermined range; or

instruct the movable means to position for increasing relative volume or mass of the second fluid with respect to the first fluid if the blended sulfur  
5 concentration is lower than the predetermined value or lower concentration value of the predetermined range.

21. The method according to any of the preceding claims, wherein the feedback and control mechanism is a programmable machine that is adapted to  
10 compute an optimum relative volume or mass of the first fuel and the second fuel based on the first sulfur concentration, second sulfur concentration, and the predetermined value/ predetermined range such that the blended fuel of the predetermined value or the predetermined range is produced; and  
instruct the movable means to position according to the computed  
15 optimum relative volume or mass.

22. The method according to the preceding claim, wherein the feedback and control mechanism include a programmable machine that is adapted to  
compute a revised relative volume or mass of the first fuel and the second  
20 fuel based on the first sulfur concentration, second sulfur concentration, received blended sulfur concentration and the predetermined value or the predetermined range such that the blended fuel of the blended sulfur concentration of predetermined value or the predetermined range is produced; and  
instruct the movable means to position according to the computed revised  
25 relative volume or mass.

23. The method according to any of the preceding claims 1-19, wherein the feedback and control mechanism include a programmable machine that is adapted to  
compare the blended sulfur concentration with the predetermined value or  
30 the predetermined range;  
manually position the movable means for increasing relative volume or mass of the second fluid with respect to the first fluid if the blended sulfur

concentration is lower than the predetermined value or lower concentration value of the predetermined range; or

manually position the movable means for increasing relative volume or mass of the second fluid with respect to the first fluid if the blended sulfur  
5 concentration is lower than the predetermined value or lower concentration value of the predetermined range.

24. The method according to any of the preceding claims 1-19 or 23, wherein the feedback and control mechanism include a programmable machine that is adapted to  
10 compute an optimum relative volume or mass of the first fuel and the second fuel based on the first sulfur concentration, second sulfur concentration, and the predetermined value or the predetermined range such that the blended fuel of the blended sulfur concentration of predetermined value or the predetermined range is produced; and  
15 manually position the movable means according to the computed optimum relative flow rate.

25. The method according to any of the preceding claims 1-19 or 23-24, wherein the feedback and control mechanism include a programmable machine that is adapted to  
20 compute a revised relative volume or mass of the first fuel and the second fuel based on the first sulfur concentration, second sulfur concentration, received blended sulfur concentration and the predetermined value or the predetermined range such that the blended fuel of the blended sulfur concentration of predetermined value or the predetermined range is produced; and  
25 manually position the movable means according to the computed revised relative volume or mass.

26. The method according to any of the preceding claims, wherein the blending comprises mixing the received first fluid and the received second fluid.

27. The method according to any of the preceding claims, wherein the mixing is under controlled physical conditions of temperature, and/ or pressure and/ or mixing element speed or flow rates of fuels.
- 5    28. The method according to any of the preceding claims, wherein the blended sulfur concentration is at or below the predetermined value/ within the predetermined range, such as at or below 2.0% m/m, such as at or below 1.5%, such as at or below 1.00% m/m, such as at or below 0.5%, such as at or below 0.1%.
- 10    29. The method according to any of the preceding claims, wherein the blended sulfur concentration is determined by a sulfur analyzer, the sulfur analyzer being interconnected with the first valve and/ or second valve via a feedback and control mechanism.
- 15    30. The method according to any of the preceding claims 1-11 or 26-29, wherein the feedback and control mechanism adjusts the first valve and/ or the second valve based on the predetermined value/ predetermined range and the blended sulfur concentration, as received from the sulfur analyzer.
- 20    31. The method according to any of the preceding claims 1-11 or 26-30, wherein the feedback and control mechanism include a programmable machine that is adapted to compute an optimum relative flow rate of the first fuel and the second fuel based on the first sulfur concentration, second sulfur concentration, and the predetermined value or the predetermined range such that the blended fuel of the  
25    blended sulfur concentration of predetermined value or the predetermined range is produced; and  
instruct the first valve to open and the second valve to open according to the computed optimum relative flow rate.
- 30    32. The method according to any of the preceding claims 1-11 or 26-31, wherein the feedback and control mechanism include a programmable machine that is adapted to

compare the blended sulfur concentration with the predetermined value or the predetermined range;

instruct the first valve and/ or the second valve for increasing relative flow rate of the second fluid with respect to the first fluid if the blended sulfur

5 concentration is lower than the predetermined value or lower concentration value of the predetermined range; or

instruct the first valve and/ or the second valve for increasing relative flow rate of the second fluid with respect to the first fluid if the blended sulfur

10 concentration is lower than the predetermined value or lower concentration value of the predetermined range.

33. The method according to the preceding claim 1-11 or 26-32, wherein the feedback and control mechanism include a programmable machine that is adapted to

15 compute a revised relative flow rate of the first fuel and the second fuel based on the first sulfur concentration, second sulfur concentration, received blended sulfur concentration and the predetermined value or the predetermined range such that the blended fuel of the blended sulfur concentration of predetermined value or the predetermined range is produced; and

20 instruct the first valve to open and/ or the second valve to open according to the computed revised relative flow rate.

34. The method according to any of the preceding claims 1-11 or 26-30 or 33, wherein the feedback and control mechanism include a programmable machine that is adapted to

25 compute an optimum relative flow rate of the first fuel and the second fuel based on the first sulfur concentration, second sulfur concentration, and the predetermined value or the predetermined range such that the blended fuel of the blended sulfur concentration of predetermined value or the predetermined range is produced; and

30 manually open the respective first valve and manually open the second valve according to the computed optimum relative flow rate.

35. The method according to any of the preceding claims 1-11 or 26-30 or 33-34, wherein the feedback and control mechanism include a programmable machine that is adapted to
- compare the blended sulfur concentration with the predetermined value or
- 5       the predetermined range;
- manually adjust the first valve and/ or the second valve for increasing relative flow rate of the second fluid with respect to the first fluid if the blended sulfur concentration is lower than the predetermined value or lower concentration value of the predetermined range; or
- 10       manually adjust the first valve and/ or the second valve for increasing relative flow rate of the second fluid with respect to the first fluid if the blended sulfur concentration is lower than the predetermined value or lower concentration value of the predetermined range.
- 15   36. The method according to any of the preceding claims 1-11 or 26-30 or 33-35, wherein the feedback and control mechanism include a programmable machine that is adapted to
- compute a revised relative flow rate of the first fuel and the second fuel based on the first sulfur concentration, second sulfur concentration, received
- 20       blended sulfur concentration and the predetermined value or the predetermined range such that the blended fuel of the blended sulfur concentration of predetermined value or the predetermined range is produced; and
- manually adjust the first valve to open and/ or the second valve to open according to the computed revised relative flow rate.
- 25
37. The method according to any of the preceding claims, wherein the production of the blended oil is a continuous in-line blending with the first fuel and second fuel received from the first tank and the second tank respectively.
- 30   38. The method according to any of the preceding claims, wherein the method is performed on an off-road vehicle such as a marine vessel, ship, bunkering facility, bunkering barge.

39. The method according to any of the preceding claims, wherein the sulfur analyzer is communicatively connected with a positioning unit of the off-road vehicle, the positioning unit tracking geo-position of the off-road vehicle.

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40. The method according to any of the preceding claims, further comprising recording the blended sulfur concentration from the sulfur analyzer along with corresponding tracked geo-position from the positioning unit and optionally, with time details for such recording.

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41. The method according to any of the preceding claims, wherein the recording is made after regular time intervals such as after every 1 second, after every 15 seconds, after every 30 seconds, after every 45 seconds, after every 1 minute, such as after every 5 minutes, after every 10 minutes, after every 30 minutes.

15

42. A method according to any of the preceding claims, further comprising data locking the recording to avoid tampering of the recording.

43. The method according to any of the preceding claims, wherein the data locking is selected from a group comprising protecting the recording using a password, generating the recording in a read file format only, corrupting the recording if an attempt to tamper the recording is made, and a combination thereof.

20

44. The method according to any of the preceding claims, further comprising unit locking the sulfur analyzer to avoid tampering of the analyzer.

25

45. The method according to any of the preceding claims, wherein the unit locking is selected from a group of comprising allowing access to the sulfur analyzer using a password clearance, raising indication signal such as an alarm if an unauthorized attempt to access the sulfur analyzer is made and a combination thereof.

30

46. The method according to any of the preceding claims, wherein the positioning unit is communicatively connected to the feedback and control mechanism or a computing unit, which is communicatively connected with the feedback and control mechanism.

5

47. The method according to any of the preceding claims, wherein the computing unit or the feedback and control mechanism is adapted to compare the geo-position of the off-road vehicle with a restriction map, the restriction map defining geographical limits of a plurality of sulfur requirement areas.

10

48. The method according to any of the preceding claims, wherein the computing unit or the feedback and control mechanism is adapted to access the sulfur limit of each of the sulfur requirement areas or the predetermined value/ the predetermined range.

15

49. The method according to any of the preceding claims, wherein  
the feedback and control mechanism is adapted to initiate production of the low sulfur fuel by allowing receipt of the first volume or mass and the second volume or mass in the blender based on the geo position-map comparison and accessed sulfur limit or the accessed predetermined value/ predetermined range; or  
the computing unit is adapted to instruct the feedback and control mechanism, which is adapted to initiate production of the low sulfur fuel by allowing receipt of the first volume or mass and the second volume or mass in the blender based on the geo position-map comparison and accessed sulfur limit or predetermined value/ predetermined range.

20

25

50. The method according to any of the preceding claims, further comprising providing the blended fuel having sulfur concentration of a predetermined value or within a predetermined range as an operating engine fuel to an engine(s) of the off-road vehicle.

30

51. The method according to any of the preceding claims, further comprising heating the blended fuel to a viscosity that is suitable for engine(s) of the off-road vehicle.

52. The method according to any of the preceding claims, wherein the computing unit or the feedback and control mechanism is adapted to
- calculate a time duration required from initiation of production to
- 5 complete changeover to low sulfur fuel as the operating fuel for the engine(s), the calculation based on at least one or more of the first sulfur concentration, second sulfur concentration, area specific sulfur limit or predetermined value/
- predetermined range, engine(s) specification, speed of the off-road vehicle, volume or mass of low sulfur fluid required; and
- 10 initiate production of the low sulfur fuel in accordance with the calculated time duration.
53. The method according to any of the preceding claims, further comprising bypassing the production of the low sulfur fuel and providing the engine(s) with the first fluid
- 15 and/ or second fluid as the operating fuel
- if a technical problem is identified with the production of low sulfur system; or
- when the low sulfur fuel production mode is inactive and beyond geographical limits of any of the sulfur requirement areas.
- 20
54. The method according to any of the preceding claims, wherein the bypass circuit includes a high valve for controlling flow of the first fluid and a low valve for controlling flow of the second fluid directly to the engine(s).
- 25
55. The method according to any of the preceding claims, further comprising controlling, manually/ automatically by the feedback and control mechanism, the high valve and the low valve based on identification of technical problem and/ or determination of low sulfur production mode and geo-positioning of the off-road vehicle.
- 30
56. The method according to any of the preceding claims, further comprising controlling flow of low sulfur fuel from the blender to the engine(s) using a blender

valve, which is manually operable or automatically operable by the feedback and control mechanism.

57. The method according to any of the preceding claims, further comprising closing the  
5 blender valve when the bypass circuit is in active mode and opening when the bypass circuit is in inactive mode.

58. A system for producing a low sulfur fuel having a sulfur concentration of a predetermined value or within a predetermined range, comprising  
10 a first tank for providing a first volume or mass of a first fuel having a first sulfur concentration;  
a second tank for providing a second volume or mass of a second fuel having a second sulfur concentration, the second sulfur concentration being higher than the first sulfur concentration; and  
15 a blender for blending the first volume or mass with the second volume or mass for producing a blended fuel having a blended sulfur concentration of the predetermined value or within a predetermined range.

59. The system according to claim 58, wherein the first fuel is selected from a group  
20 consisting of marine diesel oil and marine gas oil.

60. The system according to any of the preceding claims 58-59, wherein the second fuel is selected from a heavy fuel oil.

25 61. The system according to any of the preceding claims 58-60, wherein the blended sulfur fuel is the low sulfur fuel.

62. The system according to any of the preceding claims 58-61, further comprising a sulfur analyzer for determining the blended sulfur concentration of the blended fuel.  
30

63. The system according to any of the preceding claims 58-62, further comprising controlling relative volume or mass of the first fuel and the second fuel received in

the blender based on the determined blended sulfur concentration and the predetermined value or the predetermined range.

64. The system according to any of the preceding claims 58-63, further comprising an  
5 actuator driven valve, integrated with the blender, for controlling relative volume or mass of the first fuel and the second fuel received in the blender.

65. The system according to any of the preceding claims 58-64, wherein the actuator driven valve comprises a movable means.  
10

66. The system according to any of the preceding claims 58-65, further comprising an actuator adapted to position the movable means for allowing receiving the first fuel in the blender through a first inlet and receiving the second fuel in the blender through a second inlet.  
15

67. The system according to any of the preceding claims 58-66, wherein change in positioning of the movable means allows for increasing/ decreasing a volume or mass of one fuel through the one inlet and for simultaneously decreasing/ increasing the volume or mass of another fuel through another inlet.  
20

68. The system according to any of the preceding claims 58-67, wherein a percentage increase in the volume or mass of one fuel simultaneously decreases percentage volume or mass of another fuel by same percentage.

69. The system according to any of the preceding claims 58-68, wherein the actuator is  
25 communicatively linked with the feedback and control mechanism, the feedback and control mechanism adapted to instruct the actuator to adjust the movable means such that the received volumes or masses of the first fuel and the second fuel produces blended fuel having the blended sulfur concentration of the predetermined value or within a predetermined range is produced.  
30

70. The system according to any of the preceding claims 58-69, wherein the feedback and control mechanism include a programmable machine that is adapted to

compare the blended sulfur concentration with the predetermined value or the predetermined range;

instruct the movable means to position for increasing relative volume or mass of the second fluid with respect to the first fluid if the blended sulfur  
5 concentration is lower than the predetermined value or lower concentration value of the predetermined range; or

instruct the movable means to position for increasing relative volume or mass of the second fluid with respect to the first fluid if the blended sulfur concentration is lower than the predetermined value or lower concentration value of  
10 the predetermined range.

71. The system according to any of the preceding claims 58-70, wherein the feedback and control mechanism is a programmable machine that is adapted to

compute an optimum relative volume or mass of the first fuel and the  
15 second fuel based on the first sulfur concentration, second sulfur concentration, and the predetermined value/ predetermined range such that the blended fuel of the predetermined value or the predetermined range is produced; and

instruct the movable means to position according to the computed optimum relative volume or mass.  
20

72. The system according to the preceding claim 58-71, wherein the feedback and control mechanism include a programmable machine that is adapted to

compute a revised relative volume or mass of the first fuel and the second fuel based on the first sulfur concentration, second sulfur concentration, received  
25 blended sulfur concentration and the predetermined value or the predetermined range such that the blended fuel of the blended sulfur concentration of predetermined value or the predetermined range is produced; and

instruct the movable means to position according to the computed revised relative volume or mass.  
30

73. The system according to any of the preceding claims 58-69, wherein the feedback and control mechanism include a programmable machine that is adapted to

compare the blended sulfur concentration with the predetermined value or the predetermined range;

manually position the movable means for increasing relative volume or mass of the second fluid with respect to the first fluid if the blended sulfur  
5 concentration is lower than the predetermined value or lower concentration value of the predetermined range; or

manually position the movable means for increasing relative volume or mass of the second fluid with respect to the first fluid if the blended sulfur concentration is lower than the predetermined value or lower concentration value of  
10 the predetermined range.

74. The system according to any of the preceding claims 58-69 or 73, wherein the feedback and control mechanism include a programmable machine that is adapted to  
compute an optimum relative volume or mass of the first fuel and the  
15 second fuel based on the first sulfur concentration, second sulfur concentration, and the predetermined value or the predetermined range such that the blended fuel of the blended sulfur concentration of predetermined value or the predetermined range is produced; and

manually position the movable means according to the computed optimum  
20 relative flow rate.

75. The system according to any of the preceding claims 58-69 or 73-74, wherein the feedback and control mechanism include a programmable machine that is adapted to  
compute a revised relative volume or mass of the first fuel and the second  
25 fuel based on the first sulfur concentration, second sulfur concentration, received blended sulfur concentration and the predetermined value or the predetermined range such that the blended fuel of the blended sulfur concentration of predetermined value or the predetermined range is produced; and

manually position the movable means according to the computed revised  
30 relative volume or mass.

76. The system according to any of the preceding claims 58-63, further comprising a first valve associated with the first fluid and a second valve associated with the second fluid for controlling the relative volume or mass received in the blender by adjusting relative flow rate of the first fuel and the second fuel.
- 5
77. The system according to any of the preceding claims 58-63 or 76, further comprising increasing relative flow rate of the first fuel with respect to the second fluid, if the blended sulfur concentration is higher than the predetermined value or upper concentration value of the predetermined range until the blended sulfur
- 10 concentration is of the predetermined value or within the predetermined range.
78. The system according to any of the preceding claims 58-63 or 76-77, further comprising increasing relative flow rate of the second fluid with respect to the first fluid if the blended sulfur concentration is lower than the predetermined value or
- 15 lower concentration value of the predetermined range until the blended sulfur concentration is of the predetermined value or within the predetermined range.
79. The system according to any of the preceding claims 58-63 or 76-78, wherein the relative flow rate is adjusted by controlling the first valve alone or by controlling the
- 20 second valve alone or by controlling both the first valve and the second valve simultaneously or sequentially such that the relative volume or mass received in the blender is changed in order to produce the blended fuel having the blended sulfur concentration of the predetermined value or within the predetermined range.
- 25 80. The system according to any of the preceding claims 58-79, wherein the blending comprises mixing the received first fluid and the received second fluid.
81. The system according to any of the preceding claims 58-80, further comprising a plurality of physical controllers for controlling physical conditions of temperature,
- 30 and/ or pressure and/ or mixing element speed during the mixing or flow rates of fuels.

82. The system according to any of the preceding claims 58-81, wherein the blended sulfur concentration is at or below the predetermined value/ within the predetermined range such as at or below 2.0% m/m, such as at or below 1.5%, such as at or below 1.00% m/m, such as at or below 0.5%, such as at or below 0.1%.
- 5
83. The system according to any of the preceding claims 58-82, wherein the sulfur analyzer is interconnected with the first valve and/ or second valve or the actuator via a feedback and control mechanism.
- 10
84. The system according to any of the preceding claims 58-83, wherein
- the feedback and control mechanism is adapted to adjust the first valve and/ or the second valve based on the predetermined value/ predetermined range and the blended sulfur concentration, as received from the sulfur analyzer; or
- the feedback and control mechanism is adapted to position the movable
- 15
- means based on the predetermined value/ predetermined range and the blended sulfur concentration, as received from the sulfur analyzer, using the actuator.
85. The system according to any of the preceding claims 58-63 or 76-84, wherein the feedback and control mechanism include a programmable machine that is adapted to
- 20
- compute an optimum relative flow rate of the first fuel and the second fuel based on the first sulfur concentration, second sulfur concentration, and the predetermined value or the predetermined range such that the blended fuel of the blended sulfur concentration of predetermined value or the predetermined range is produced; and
- 25
- instruct the first valve to open and the second valve to open according to the computed optimum relative flow rate.
86. The system according to any of the preceding claims 58-63 or 76-85, wherein the feedback and control mechanism include a programmable machine that is adapted to
- 30
- compare the blended sulfur concentration with the predetermined value or the predetermined range;

- instruct the first valve and/ or the second valve for increasing relative flow rate of the second fluid with respect to the first fluid if the blended sulfur concentration is lower than the predetermined value or lower concentration value of the predetermined range; or
- 5           instruct the first valve and/ or the second valve for increasing relative flow rate of the second fluid with respect to the first fluid if the blended sulfur concentration is lower than the predetermined value or lower concentration value of the predetermined range.
- 10    87. The system according to the preceding claims 58-63 or 76-86, wherein the feedback and control mechanism include a programmable machine that is adapted to
- compute a revised relative flow rate of the first fuel and the second fuel based on the first sulfur concentration, second sulfur concentration, received blended sulfur concentration and the predetermined value or the predetermined
- 15    range such that the blended fuel of the blended sulfur concentration of predetermined value or the predetermined range is produced; and
- instruct the first valve to open and/ or the second valve to open according to the computed revised relative flow rate.
- 20    88. The system according to any of the preceding claims 58-63 or 76-84, wherein the feedback and control mechanism include a programmable machine that is adapted to
- compute an optimum relative flow rate of the first fuel and the second fuel based on the first sulfur concentration, second sulfur concentration, and the predetermined value or the predetermined range such that the blended fuel of the
- 25    blended sulfur concentration of predetermined value or the predetermined range is produced; and
- manually open the respective first valve and manually open the second valve according to the computed optimum relative flow rate.
- 30    89. The system according to any of the preceding claims 58-63 or 76-84 or 88, wherein the feedback and control mechanism include a programmable machine that is adapted to

compare the blended sulfur concentration with the predetermined value or the predetermined range;

manually adjust the first valve and/ or the second valve for increasing relative flow rate of the second fluid with respect to the first fluid if the blended sulfur concentration is lower than the predetermined value or lower concentration value of the predetermined range; or

manually adjust the first valve and/ or the second valve for increasing relative flow rate of the second fluid with respect to the first fluid if the blended sulfur concentration is lower than the predetermined value or lower concentration value of the predetermined range.

90. The system according to any of the preceding claims 58-63 or 76-85 or 88-89, wherein the feedback and control mechanism include a programmable machine that is adapted to

compute a revised relative flow rate of the first fuel and the second fuel based on the first sulfur concentration, second sulfur concentration, received blended sulfur concentration and the predetermined value or the predetermined range such that the blended fuel of the blended sulfur concentration of predetermined value or the predetermined range is produced; and

manually adjust the first valve to open and/ or the second valve to open according to the computed revised relative flow rate.

91. The system according to any of the preceding claims 58-90, wherein the production of the blended oil is a continuous in-line blending with the first fuel and second fuel received from the first tank and the second tank respectively.

92. The system according to any of the preceding claims 58-91, wherein the system is installed in an off-road vehicle such as a marine vessel, ship, bunkering facility, bunkering barge.

93. The system according to any of the preceding claims 58-92, wherein the sulfur analyzer is communicatively connected with a positioning unit of the off-road vehicle, the positioning unit tracking geo-position of the off-road vehicle.
- 5 94. The system according to any of the preceding claims 58-93, further comprising a recording means adapted to record the blended sulfur concentration from the sulfur analyzer along with corresponding tracked geo-position from the positioning unit and optionally, with time details for such recording.
- 10 95. The system according to any of the preceding claims 58-94, wherein the positioning unit is communicatively connected to the feedback and control mechanism or a computing unit, which is communicatively connected with the feedback and control mechanism.
- 15 96. The system according to any of the preceding claims 58-95, wherein the computing unit or the feedback and control mechanism is adapted to compare the geo-position of the off-road vehicle with a restriction map, the restriction map defining geographical limits of a plurality of sulfur requirement areas.
- 20 97. The system according to any of the preceding claims 58-96, wherein the computing unit or the feedback and control mechanism is adapted to access the sulfur limit of each of the sulfur requirement areas or the predetermined value/ the predetermined range.
- 25 98. The system according to any of the preceding claims 58-97, wherein  
the feedback and control mechanism is adapted to initiate production of the low sulfur fuel by allowing receipt of the first volume or mass and the second volume or mass in the blender based on the geo position-map comparison and accessed sulfur limit or the accessed predetermined value/ predetermined range; or  
30 the computing unit is adapted to instruct the feedback and control mechanism, which is adapted to initiate production of the low sulfur fuel by allowing receipt of the first volume or mass and the second volume or mass in the

blender based on the geo position-map comparison and accessed sulfur limit or predetermined value/ predetermined range.

- 5 99. The system according to any of the preceding claims 58-98, further comprising providing the blended fuel having sulfur concentration of a predetermined value or within a predetermined range as an operating engine fuel to an engine(s) of the off-road vehicle.
- 10 100. The system according to any of the preceding claims 58-99, further comprising a heating element receiving blended fuel from the blender and adapted to heat the blended fuel to a viscosity that is suitable for engine(s) of the off-road vehicle.
- 15 101. The system according to any of the preceding claims 58-100, wherein the computing unit or the feedback and control mechanism is adapted to calculate a time duration required from initiation of production to complete changeover to low sulfur fuel as the operating fuel for the engine(s), the calculation based on at least one or more of the first sulfur concentration, second sulfur concentration, area specific sulfur limit or predetermined value/ predetermined range, engine(s) specification, speed of the off-road vehicle, volume or mass of low sulfur fluid required; and initiate production of the low sulfur fuel in accordance with the calculated time duration.
- 20 102. The system according to any of the preceding claims 58-101, further comprising a by pass flow circuit for bypassing the production of the low sulfur fuel and providing the engine(s) with the first fluid and/ or second fluid as the operating fuel
- 25 if a technical problem is identified with the production of low sulfur system; or
- 30 when the low sulfur fuel production mode is inactive and beyond geographical limits of any of the sulfur requirement areas.

103. The system according to any of the preceding claims 58-102, wherein the bypass circuit includes a high valve for controlling flow of the first fluid and a low valve for controlling flow of the second fluid directly to the engine(s).

5

104. The system according to any of the preceding claims 58-103, wherein the high valve and the low valve are adapted to be controlled manually/ automatically by the feedback and control mechanism based on identification of technical problem and/ or determination of low sulfur production mode and geo-positioning of the off-road vehicle.

10

105. The system according to any of the preceding claims 58-104, further comprising a blender valve, manually or automatically operable by the feedback and control mechanism, adapted to control the flow of low sulfur fuel from the blender to the engine(s).

15

106. The system according to any of the preceding claims 58-105, wherein the blender valve is closed when the bypass circuit is in active mode and opened when the bypass circuit is in inactive mode.

20

107. The system according to any of the preceding claims 58-106, comprising features included in any of the claims 1-57.

108. A method for switching to a low sulfur fuel in an off road vehicle, the method comprising

25

comparing a geo-position of the off-road vehicle with a restriction map, the restriction map defining geographical limits of a plurality of sulfur requirement areas; and

providing an engine(s) of the off-road vehicle with the low sulfur fuel by performing a complete changeover from one fuel such as a second fluid or low sulfur fuel of one sulfur concentration to the low sulfur fuel of another sulfur

30

concentration such that the off-road vehicle uses the low sulfur fuel of the another sulfur concentration as an operating fuel within the sulfur requirement area.

109. The method according to claim 108, further comprising prior to the  
5 complete changeover,  
accessing a predetermined sulfur concentration value/ a predetermined sulfur concentration range for the low sulfur fuel or a sulfur limit of a sulfur requirement area that the off-road vehicle is entering or is within; and  
initiating production of the low sulfur fuel by allowing receipt of the first  
10 volume or mass and the second volume or mass in the blender based on the geo position-map comparison and accessed sulfur limit or the accessed predetermined value/ predetermined range.

110. The method according to any of the claims 108-109, wherein  
15 a feedback and control mechanism is adapted to initiate production of the low sulfur fuel by allowing receipt of the first volume or mass and the second volume or mass in the blender based on the geo position-map comparison and accessed sulfur limit or the accessed predetermined value/ predetermined range; or  
a computing unit is adapted to instruct the feedback and control  
20 mechanism, which is adapted to initiate production of the low sulfur fuel by allowing receipt of the first volume or mass and the second volume or mass in the blender based on the geo position-map comparison and accessed sulfur limit or predetermined value/ predetermined range.

25 111. The method according to any of the preceding claims 108-110, further comprising providing the blended fuel having sulfur concentration of a predetermined value or within a predetermined range as an operating engine fuel to the engine(s) of the off-road vehicle.

30 112. The method according to any of the preceding claims 108-111, further comprising heating the blended fuel to a viscosity that is suitable for engine(s) of the off-road vehicle.

113. The method according to any of the preceding claims 108-112, wherein the computing unit or the feedback and control mechanism is adapted to calculate a time duration required from initiation of production to complete changeover to low sulfur fuel of required sulfur concentration as the operating fuel for the engine(s), the calculation based on at least one or more of the first sulfur concentration, second sulfur concentration, area specific sulfur limit or predetermined value/ predetermined range, engine(s) specification, speed of the off-road vehicle, volume or mass of low sulfur fluid required; and initiate production of the low sulfur fuel in accordance with the calculated time duration.
114. The method according to any of the preceding claims 108-113, wherein the changeover comprises closing a high valve and a low valve in order to block flow of a first fuel and the second fuel to the engine(s); and switching to the produced low sulfur fuel, which is produced by opening a first valve and a second valve in order to allow receipt of a first fluid and the second fluid to the blender for production of low sulfur fuel, which is provided to the engine(s).
115. The method according to any of the preceding claims 108-114, further comprising any of the features of claims 1 to 107.
116. A system for switching to a low sulfur fuel in an off road vehicle, comprising a feedback and control mechanism or a computing unit for comparing a geo-position of the off-road vehicle with a restriction map, the restriction map defining geographical limits of a plurality of sulfur requirement areas; and a blender for producing a low sulfur fuel and providing an engine(s) of the off-road vehicle with the low sulfur fuel by performing a complete changeover from one fuel such as a second fluid or low sulfur fuel of one sulfur concentration to the

low sulfur fuel of another sulfur concentration such that the off-road vehicle uses the low sulfur fuel as an operating fuel within the sulfur requirement area.

117. The system according to claims 116, wherein the feedback and control  
5 mechanism or the computing unit is adapted to  
access a predetermined sulfur concentration value/ a predetermined sulfur  
concentration range for the low sulfur fuel or a sulfur limit of a sulfur requirement  
area that the off-road vehicle is entering or is within; and  
initiate production of the low sulfur fuel by allowing receipt of the first  
10 volume or mass and the second volume or mass in the blender based on the geo  
position-map comparison and accessed sulfur limit or the accessed predetermined  
value/ predetermined range.

118. The system according to claim 116-117, wherein  
15 the feedback and control mechanism is adapted to initiate production of  
the low sulfur fuel by allowing receipt of the first volume or mass and the second  
volume or mass in the blender based on the geo position-map comparison and  
accessed sulfur limit or the accessed predetermined value/ predetermined range; or  
the computing unit is adapted to instruct the feedback and control  
20 mechanism, which is adapted to initiate production of the low sulfur fuel by  
allowing receipt of the first volume or mass and the second volume or mass in the  
blender based on the geo position-map comparison and accessed sulfur limit or  
predetermined value/ predetermined range.

25 119. The system according to claim 116-118, further comprising features of  
any of the claims 1-115.

120. A method for tracking fuel sulfur concentration in an off-road vehicle,  
comprising  
30 determining sulfur concentration of an operating fuel used in the off-road  
vehicle;

identifying geo-position of the off-road vehicle at the instance of the determination of the sulfur concentration; and

recording the blended sulfur concentration along with corresponding tracked geo-position and optionally, with time details for such recording.

5

121. The method according to claim 120, wherein the recording is made after regular time intervals such as after every 1 second, after every 15 seconds, after every 30 seconds, after every 45 seconds, after every 1 minute, such as after every 5 minutes, after every 10 minutes, after every 30 minutes.

10

122. The method according to any of the claims 120-121, wherein the recording is made when the off-road vehicle enters or leaves a geographic limit of a low sulfur concentration area.

15 123. A method according to any of the preceding claims 120-122, further comprising data locking the recording to avoid tampering of the recording.

124. The method according to any of the preceding claims 120-123, wherein the data locking is selected from a group comprising protecting the recording using a password, generating the recording in a read file format only, corrupting the recording if an attempt to tamper the recording is made, and a combination thereof.

20

125. The method according to any of the preceding claims 120-124, further comprising unit locking the sulfur analyzer to avoid tampering of the analyzer.

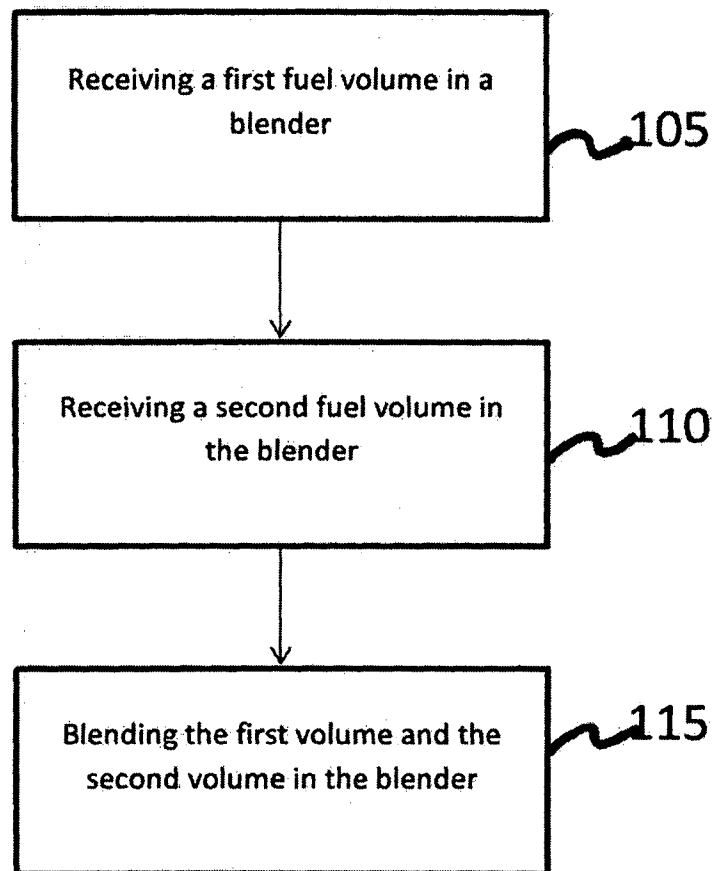
25

126. The method according to any of the preceding claims 120-125, wherein the unit locking is selected from a group of comprising allowing access to the sulfur analyzer using a password clearance, raising indication signal such as an alarm if an unauthorized attempt to access the sulfur analyzer is made and a combination thereof.

30

127. The method according to any of the claims 120-126, further comprising any of the features included in claims 1-119.
128. A system for tracking fuel sulfur concentration in an off-road vehicle,  
5 comprising  
a sulfur analyzer for determining sulfur concentration of an operating fuel used in the off-road vehicle;  
a positioning unit for identifying geo-position of the off-road vehicle at the instance of the determination of the sulfur concentration; and  
10 a computing unit or recorder for recording the blended sulfur concentration along with corresponding tracked geo-position and optionally, with time details for such recording.
129. The system according to claim 128, further comprising any feature  
15 included in claims 1-127.
130. An off-road vehicle comprising a system for producing a low sulfur fuel having a sulfur concentration of a predetermined value or within a predetermined range, the system comprises  
20 a first tank for providing a first volume or mass of a first fuel having a first sulfur concentration;  
a second tank for providing a second volume or mass of a second fuel having a second sulfur concentration, the second sulfur concentration being higher than the first sulfur concentration; and  
25 a blender for blending the first volume or mass with the second volume or mass for producing a blended fuel having a blended sulfur concentration of the predetermined value or within a predetermined range.
131. The off-road vehicle according to any of the preceding claims, further  
30 comprising any of the features included in claims 1-130.

1 / 5

**FIGURE 1**

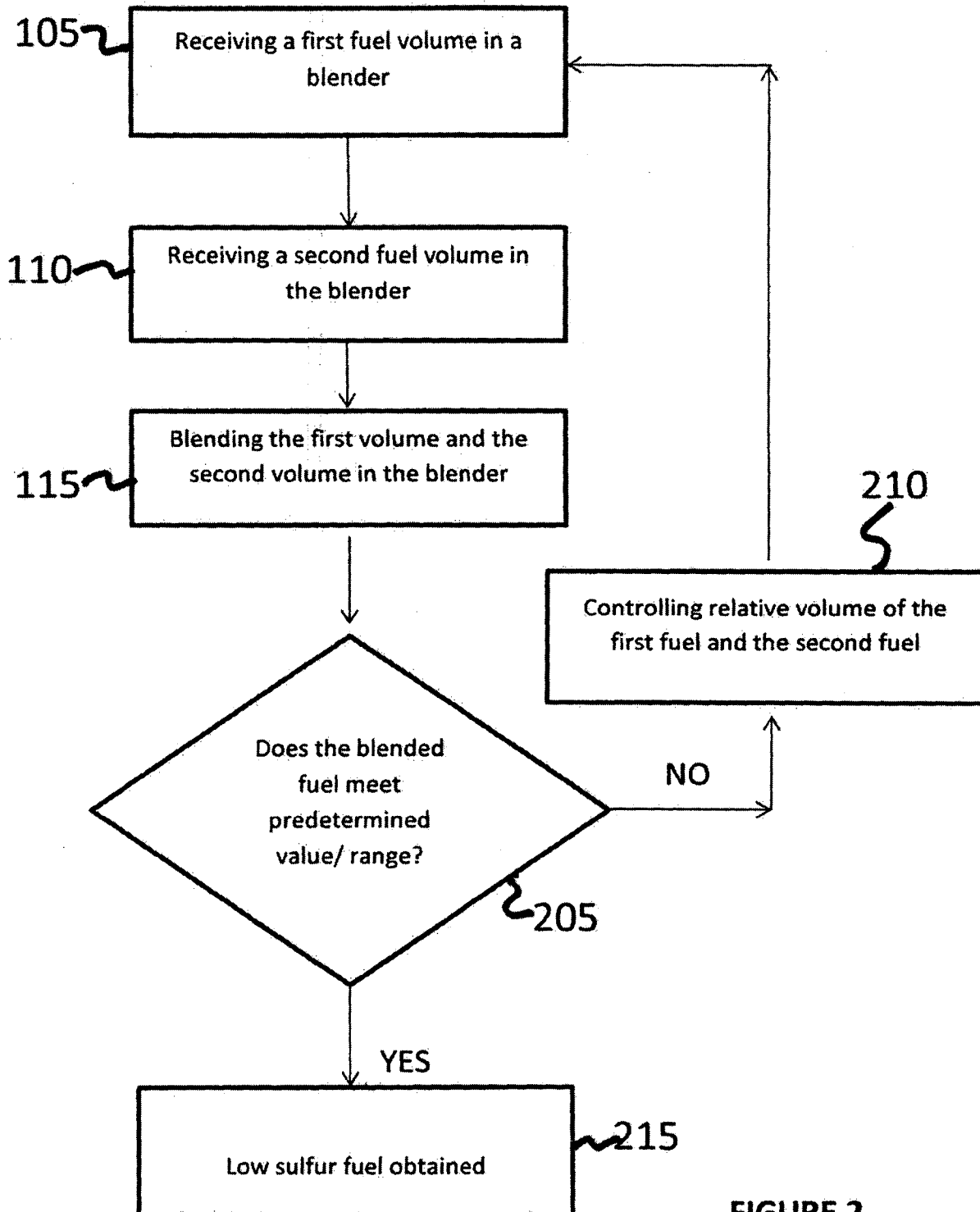


FIGURE 2

3 / 5

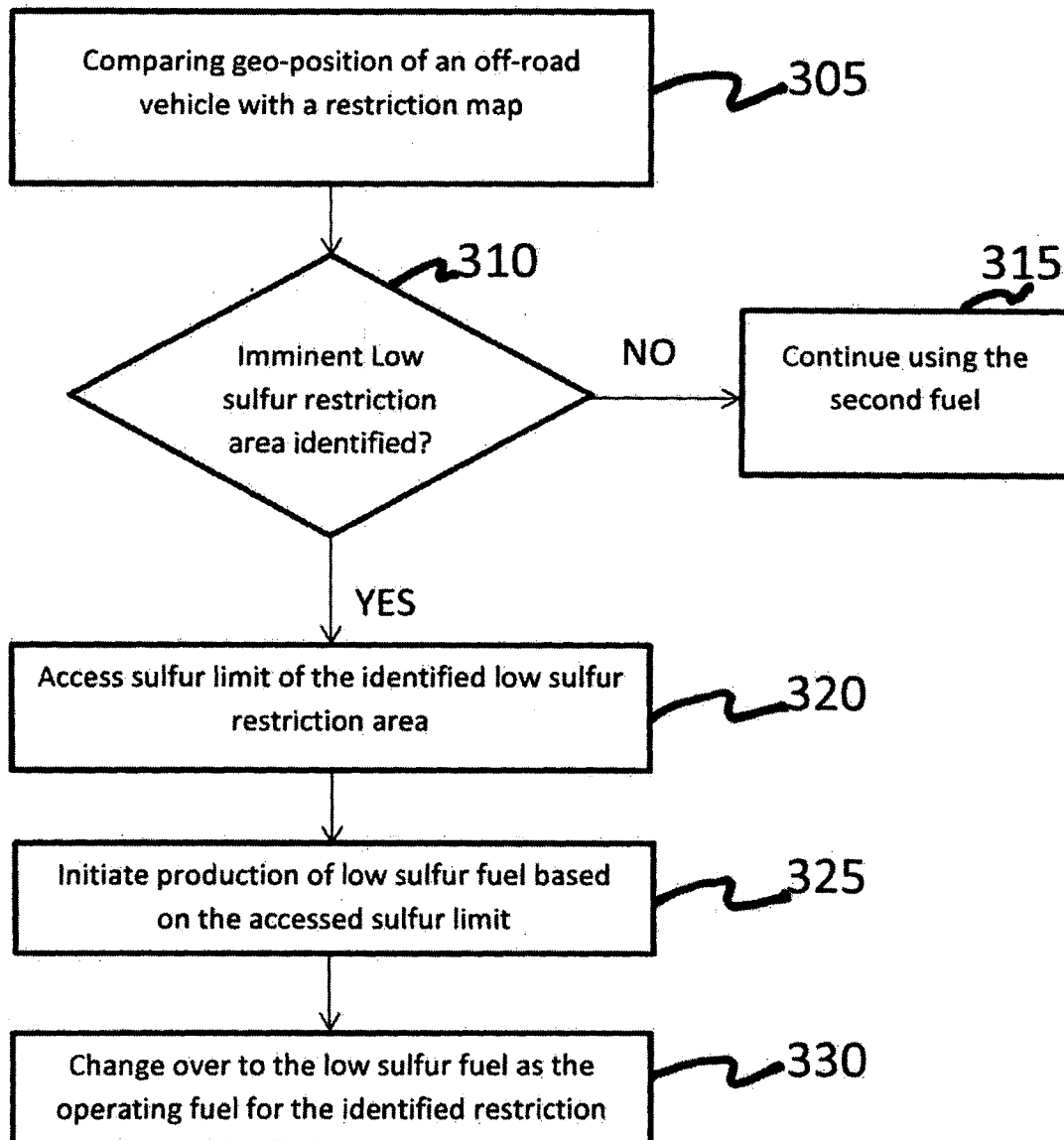


FIGURE 3

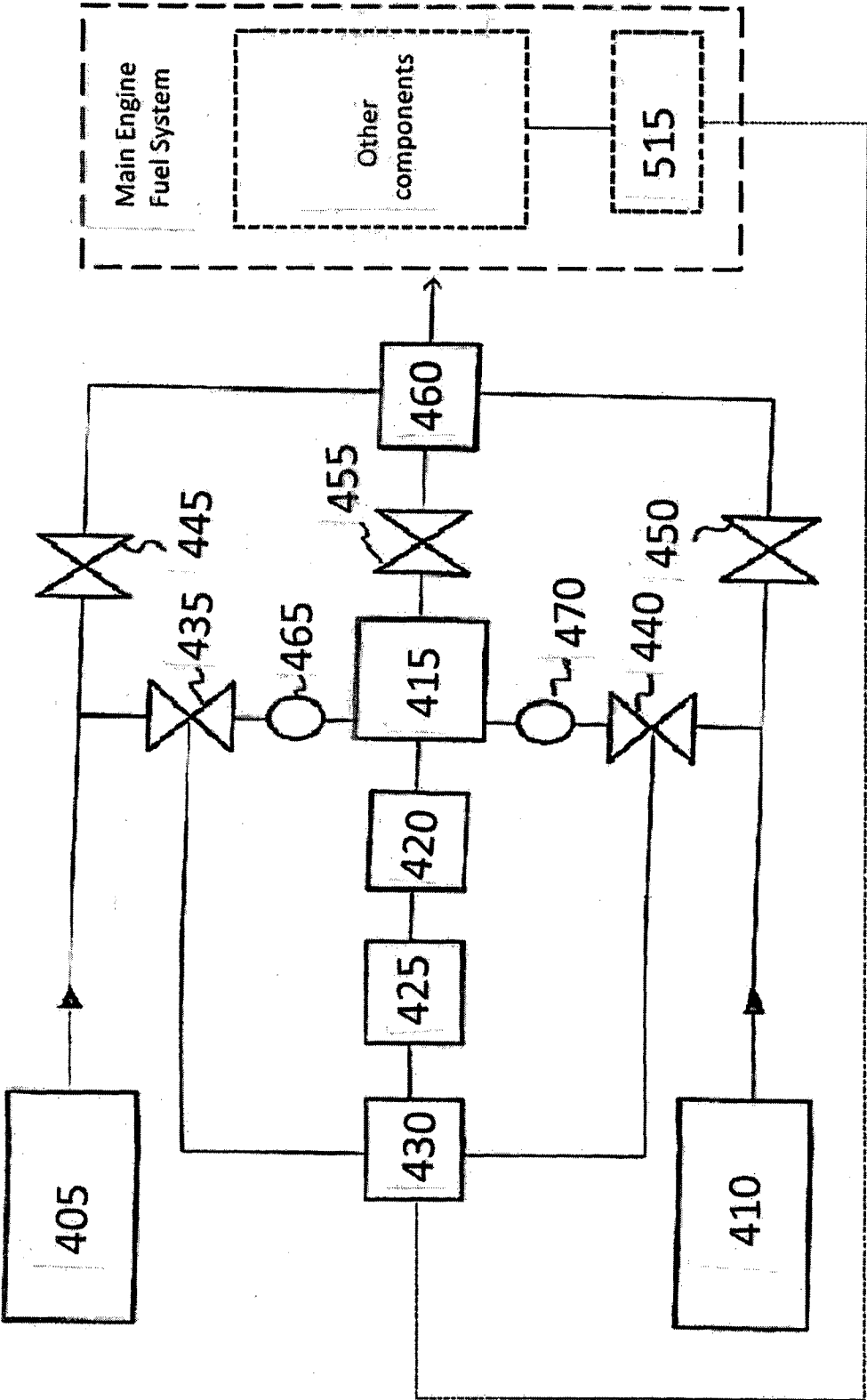


FIGURE 4

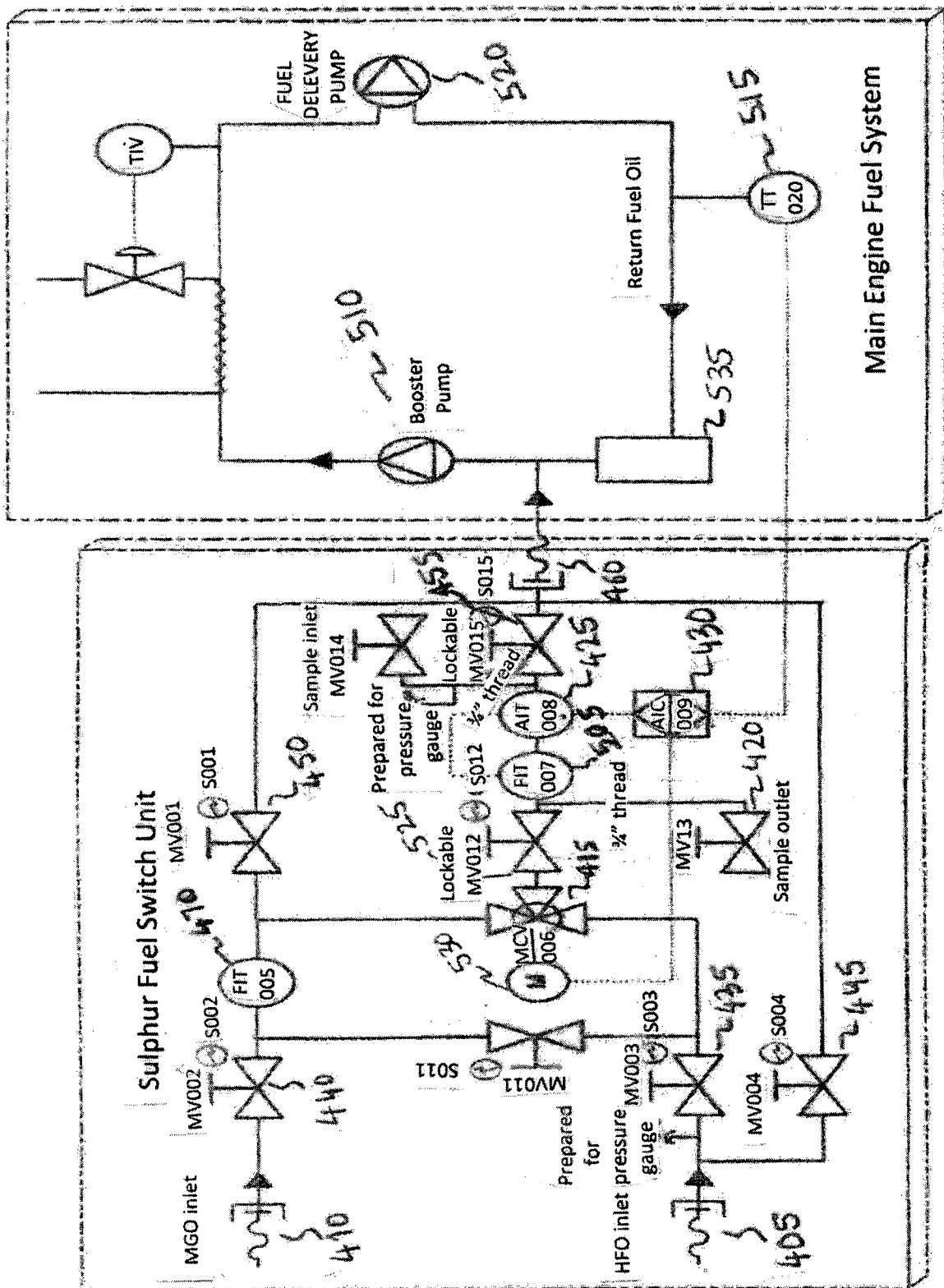


FIGURE 5