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(54) **Title:** METHOD AND SYSTEM FOR PURIFICATION OF OIL

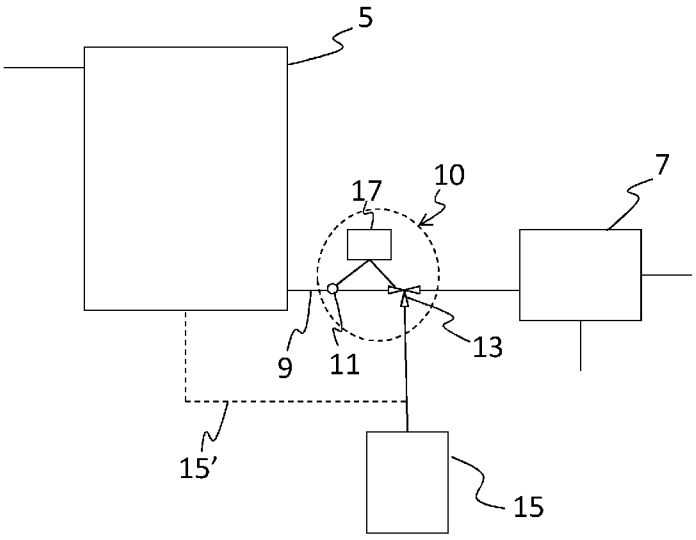

Fig. 1

(57) **Abstract:** A method and a system for purification of oil, wherein the method comprises the steps of: -adding to a contaminated oil provided in a preparation tank a chemical booster for boosting capturing of impurities and/or a separation of phases in the contaminated oil; -waiting for allowing different phases to be separated; -pumping content out from the preparation tank through a fluid connection; -sensing at least one property of the content in the fluid connection; -controlling a valve provided in the fluid connection to transfer the content to a next step in the purification process or to another destination in dependence of the sensed at least one property.

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Method and system for purification of oil

TECHNICAL FIELD OF THE INVENTION

The present invention relates to a method and a system for purification of oil.

BACKGROUND OF THE INVENTION

Purification of oils, such as for example slop oil, waste oil and industrial oil is important for the possibility to reuse oils and therefore an important factor for the environmental future and the limited nature resources of oils. Purification of slop oil is problematic in many ways. Slop oil can comprise oil, water, particles and emulsion phase. The particles can stabilize the emulsion phase and complicate a purification process. Purification of industrial emulsions comprising water and oil, such as for example cutting fluids is also an important environmental issue.

SUMMARY

An object of the present invention is to improve efficiency in purification of oils.

This is achieved by a method for purification of oil comprising the steps of:

- adding to a contaminated oil provided in a preparation tank a chemical booster for boosting capturing of impurities and/or a separation of phases in the contaminated oil;
- waiting for allowing different phases to be separated;
- pumping content out from the preparation tank through a fluid connection;
- sensing at least one property of the content in the fluid connection;
- controlling a valve provided in the fluid connection to transfer the content to a next step in the purification process or to another destination in dependence of the sensed at least one property.

This is also achieved by a system for purification of oil, said system comprising:

- at least one preparation tank in which a contaminated oil and a chemical booster for boosting capturing of impurities and/or separation of phases in the contaminated oil is provided;
- at least one centrifugal separator;
- a fluid connection allowing transfer of content out from the preparation tank; and
- at least one redirection arrangement provided in the fluid connection, said redirection arrangement comprising a valve which is arranged to direct the content from the preparation tank to either the centrifugal separator, possibly via another tank, or to another destination, said redirection arrangement further comprising at least one sensor and a control system connected to the at least one sensor and to the valve, wherein said control system is arranged for controlling said valve to transfer said content to the centrifugal separator or to the other destination in dependence of an output from the at least one sensor.

Hereby content on its way from a preparation tank to a next step in the purification process can be automatically redirected to another destination if a sensor indicates that the content is not suitable for the next purification step. This could for example be if a phase of water is transferred out from the preparation tank. In that case it would be better to redirect the water phase to another destination and not provide it into for example a centrifugal separator.

In one embodiment of the invention the method further comprises controlling said valve to only transfer the content to the next step of the purification process if the sensed property corresponds to an oil content above a predefined threshold.

Hereby content comprising a low percentage of oil can be redirected to another destination possibly for further purification by other means.

In one embodiment of the invention the method further comprises controlling said valve to not transfer the content to the next step of the purification process if the

sensed property indicates that the content is water. Hereby water can be redirected to another destination.

In one embodiment of the invention the step of sensing comprises sensing dielectric properties of the content. A sensor detecting dielectric properties is robust also in harsh environments.

Further embodiments are described in the detailed description and in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows schematically a part of an oil purification system according to one embodiment of the invention.

Figure 2 shows schematically a part of an oil purification system according to one embodiment of the invention.

Figure 3 shows schematically a part of an oil purification system according to one embodiment of the invention.

Figure 4 is a flow chart of a method according to one embodiment of the invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Figure 1 shows schematically a part of an oil purification system according to one embodiment of the invention. The system comprises a preparation tank 5 in which a contaminated oil is provided. A chemical booster is provided to the contaminated oil in the preparation tank 5. The chemical booster is provided for boosting the capturing of impurities in the contaminated oil and/or for boosting a separation of phases in the contaminated oil. The chemical booster can be a liquid separation aid having a larger density than the oil thus forming a heavy phase together with the contaminating particles in the oil. Such a chemical booster could be used for purification of industrial

oils which are not containing water. Another type of chemical booster which can be used for slop oils containing both water, oil, solid impurities and an emulsion phase (of water and oil), is an emulsion breaker, also called demulsifier, for breaking an emulsion phase of oil and water. A demulsifier can destabilize emulsions and facilitate separation of water and solids and/or salts from the oil. Another alternative chemical booster that can be used in this invention is a water cleaning product which will improve the separation of oil contaminants from water. Such a chemical booster may be suitable for the purification of industrial emulsions, such as cutting fluids. In one embodiment of the invention the preparation tank 5 can be warmed up by heaters provided to the tank. This could be for example steam coils provided inside the tank or heating elements provided to the outside of the tank. By warming the contaminated oil together with the booster the separation of phases and/or the capturing of impurities can be more efficient.

The oil purification system comprises further a centrifugal separator 7. This can be a centrifugal separator which is adapted for separating out water and/or sludge from oil which is useful for the purification of slop oils. The centrifugal separator can also be a decanter centrifuge adapted for separating particles and sludge from oil and water. Such a centrifuge can be used in a step of purification before the use of another centrifugal separator when slop oils are purified. Another type of centrifugal separator which can be used in this invention is adapted for separating oil and sludge from water which is useful in the purification of industrial emulsions, such as cutting fluids and oil contaminated water. In a process and system for purification of lubrication oils and/or industrial oils according to the invention a centrifugal separator 7 designed for separating impurities from the oil is used.

The oil purification system comprises further a fluid connection 9 allowing transfer of content out from the preparation tank 5. According to the invention a redirection arrangement 10 is provided in the fluid connection 9. The redirection arrangement comprises at least one sensor 11 provided in the fluid connection 9 and a valve 13 arranged in the fluid connection 9 to direct the content from the preparation tank 5 to either the centrifugal separator 7 or to another destination. The other destination could

be another part of the system such as for example a storage tank 15 or back to the preparation tank 5, shown as an alternative with a dotted line 15' in Figure 1. The content in the storage tank 15 can of course be further transferred for further purification. A pump (not shown) is also provided somewhere in the fluid connection 9 for pumping the content from the preparation tank 5. Furthermore according to the invention the redirection arrangement 10 comprises a control system 17 connected to the at least one sensor 11 and to the valve 13. The control system 17 is arranged for controlling the valve 13 to transfer the content coming through the fluid connection 9 from the preparation tank 5 either to the centrifugal separator 7 or to the other destination (for example the storage tank 15 or back to the preparation tank 5) in dependence of an output from the at least one sensor 11. In one embodiment of the invention two sensors 11 are provided in the redirection arrangement where one of the sensors is set to detect oil and the other is set to detect water.

The at least one sensor 11 is arranged to sense a property of the content passing the sensor in the fluid connection 9. The property sensed can be for example dielectric properties of the content. Such a sensor can be based on capacitive or microwave measurement technology or based on impedance spectroscopy. An advantage with this type of sensor is that it is a very stable type of sensor which is not affected by the environment. For example if impurities from the oil will be attached to the sensor the output from the sensor will not be affected as would be the case with many other types of sensors. This is especially useful when purifying slop oils because of the many impurities that can be present in slop oil. When slop oils are purified different phases comprising for example oil or water may be built up already in the preparation tank. According to the invention a phase of for example water can be redirected to for example a storage tank 15 by the redirection arrangement 10 instead of entering the centrifugal separator. For slop oil purification a sensor setup which can differentiate between oil and water can suitably be used. One possibility is to use at least one sensor measuring dielectric properties as described above. Possibly two such sensors can be combined where one of the sensors is tuned for giving a response for lower dielectric values than the other. Hereby the tuning can be set such that one of the sensors give a response when water is present and the other gives a response when oil is present.

When none of them gives a response air is present. The possibility to also detect air in the system is suitable and can be used for controlling of flows in the system. When water is detected the valve should in that case be controlled to transfer the content to the other destination, possibly the storage tank 15. When oil is detected or alternatively depending on sensor settings, when water is not detected the valve should be controlled to transfer the content to the centrifugal separator 7.

In purification systems which are arranged for purification of industrial oils or industrial emulsions where there are not as much impurities as in slop oils other types of sensors can be used instead. One example of a sensor which can be used is a sensor measuring density differences for example via a vibrating fork or Coriolis measurements. The control system 17 can be arranged to control said valve 13 to only transfer the content to the centrifugal separator 7 if the detected property corresponds to an oil content above a predefined threshold. Hereby impurities, water and sludge and oil containing more than a certain degree of impurities can be transferred to the other destination, possibly the storage tank 15, and not to the centrifugal separator 7. The content in the storage tank 15 could be transferred to another part of the system for further purification.

Figure 2 shows schematically a part of an oil purification system according to one embodiment of the invention. In this embodiment it is shown that a redirection arrangement 10 according to the invention can be provided also in other positions of an oil purification system. Here it is shown that if a receiving tank 21 is provided before the preparation tank 5 a redirection arrangement 10 according to the invention can be provided also between the receiving tank 21 and the preparation tank 5. Hereby for example water separated from oil in the receiving tank can be redirected to a storage tank 15 even before it is treated with a chemical booster in the preparation tank 5. Furthermore it is shown in this embodiment that a redirection arrangement 10 can be provided also after the centrifugal separator 7. For example the redirection arrangement 10 can be provided to the outlet from the centrifugal separator where water is coming out if the centrifugal separator is separating oil and water. If the sensor 11 of the redirection arrangement 10 detects oil in this outlet from the

centrifugal separator the flow could for example be directed back to the preparation tank 5 instead of to a water tank 22. The redirection arrangement 10 could also possibly be connected to a warning system or to an automatic stop function or to a control system. If oil is detected an alarm could be provided or the operation of the centrifugal separator could be automatically stopped or a flow in to the centrifugal separator could be reduced.

Figure 3 shows schematically a part of an oil purification system according to one embodiment of the invention. In this embodiment it is shown that a redirection arrangement 10 according to the invention can be provided in more than one position of a purification system, for example if there are more than one centrifugal separators used. In a purification system where slop oils are purified the first centrifugal separator may be a decanter centrifuge 31 for separating sludge and particles. An oil phase retrieved from the decanter centrifuge can be transferred to a mediate tank 33. From the mediate tank 33 the oil can be further transferred through a fluid connection 37 to a second centrifugal separator 35. In the fluid connection 37 a redirection arrangement 10 according to the invention can be provided. A redirection arrangement 10 can also be provided between a preparation tank 5 and the decanter centrifuge 31 as described in relation to Figure 1. Possibly the oil in the mediate tank 33 can be treated with a chemical booster and possibly the mediate tank can be warmed up for increasing separation effectivity in the same way as described for the preparation tank 5 in relation to Figure 1.

Figure 4 is a flow chart of a method according to one embodiment of the invention. The method steps are described below:

S1: Adding to a contaminated oil provided in a preparation tank 5 a chemical booster for boosting capturing of impurities and/or a separation of phases in the contaminated oil.

S3: Waiting for allowing different phases to be separated.

S5: Pumping content out from the preparation tank 5 through a fluid connection 9.

S7: Sensing a property of the content in the fluid connection 9.

S9: Controlling a valve 13 provided in the fluid connection 9 to transfer the content to a next step in the purification process or to another destination in dependence of the sensed property. The next step of the purification process can be a centrifugal separator. The other destination can be for example a storage tank or back to the preparation tank.

In one embodiment of the invention the step of controlling comprises controlling said valve 13 to only transfer the content to the next step of the purification process if the sensed property corresponds to an oil content above a predefined threshold.

In one embodiment of the invention the step of controlling comprises controlling said valve to not transfer the content to the next step of the purification process if the sensed property indicates that the content is water.

In one embodiment of the invention the step of sensing comprises sensing dielectric differences in the content or measuring density differences.

In one embodiment of the invention a step of warming the content in the preparation tank before it is pumped out is provided.

The system for purification of oil according to the invention further comprises a control system which is configured for controlling the system for purification of oil to perform the method according to the invention as described above. The control system is connected to pumps, valves and sensors in the purification system in order for controlling the flows in the system. The invention further comprises a computer program product comprising instructions which, when executed in a processor in the control system in the system for purification of oil of the invention, cause the control system to perform the method as described above.

CLAIMS

1. A method for purification of oil comprising the steps of:
   - adding to a contaminated oil provided in a preparation tank a chemical booster for boosting capturing of impurities and/or a separation of phases in the contaminated oil;
   - waiting for allowing different phases to be separated;
   - pumping content out from the preparation tank through a fluid connection;
   - sensing at least one property of the content in the fluid connection;
   - controlling a valve provided in the fluid connection to transfer the content to a next step in the purification process or to another destination in dependence of the sensed at least one property.

2. A method according to claim 1, further comprising controlling said valve to only transfer the content to the next step of the purification process if the sensed at least one property corresponds to an oil content above a predefined threshold.

3. A method according to claim 1 or 2, further comprising controlling said valve to not transfer the content to the next step of the purification process if the sensed at least one property indicates that the content is water.

4. A method according to any one of the claims 1-3, wherein the step of sensing comprises sensing dielectric properties of the content or measuring density differences of the content.

5. A method according to any one of the claims 1-4, wherein a step of warming the content in the preparation tank is provided before the content is pumped out.

6. A system for purification of oil, said system comprising:
   - at least one preparation tank in which a contaminated oil and a chemical booster for boosting capturing of impurities and/or separation of phases in the contaminated oil is provided;
   - at least one centrifugal separator;
   - a fluid connection allowing transfer of content out from the preparation tank; and
   - at least one redirection arrangement provided in the fluid connection, said redirection arrangement comprising a valve which is arranged to direct the content from the preparation tank to either the centrifugal separator, possibly via another tank, or to another destination, said redirection arrangement further comprising at least one sensor and a control system connected to the at least one sensor and to the valve, wherein said control system is arranged for controlling said valve to transfer said content to the centrifugal separator or to the other destination in dependence of an output from the at least one sensor.

7. A system according to claim 6, wherein the control system is arranged to control said valve to only transfer the content to the centrifugal separator if the output from the at least one sensor corresponds to an oil content above a predefined threshold.

8. A system according to any one of the claims 6 or 7, wherein the control system is arranged to control said valve to not transfer the content to the centrifugal separator if the output from the at least one sensor indicates that the content is water.

9. A system according to any one of the claims 6-8, wherein the sensor measures dielectric properties of the content passing in the fluid connection.

10. A computer program product comprising instructions which, when executed in a processor in a control system in a system for purification of oil according to any one of the claims 6-9, cause the control system to perform the method according to any one of the claims 1-5.

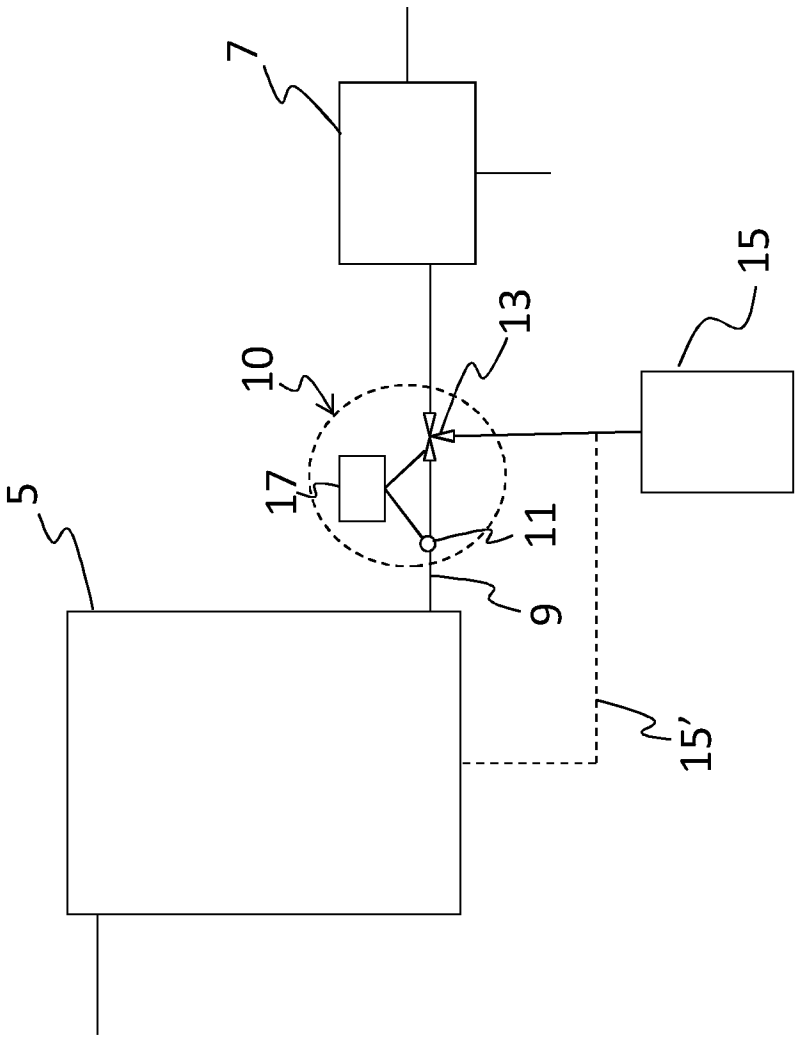

Fig. 1

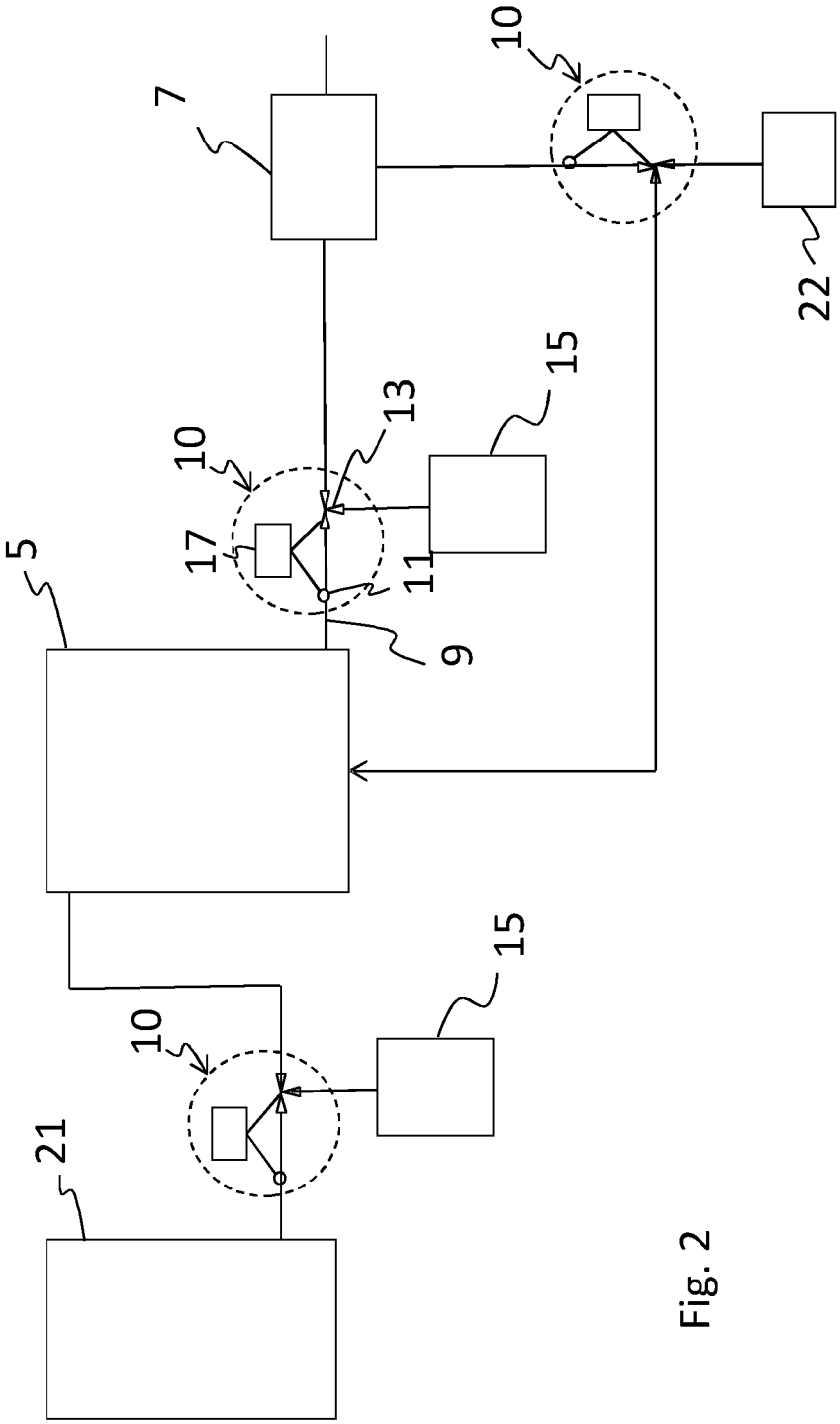

Fig. 2

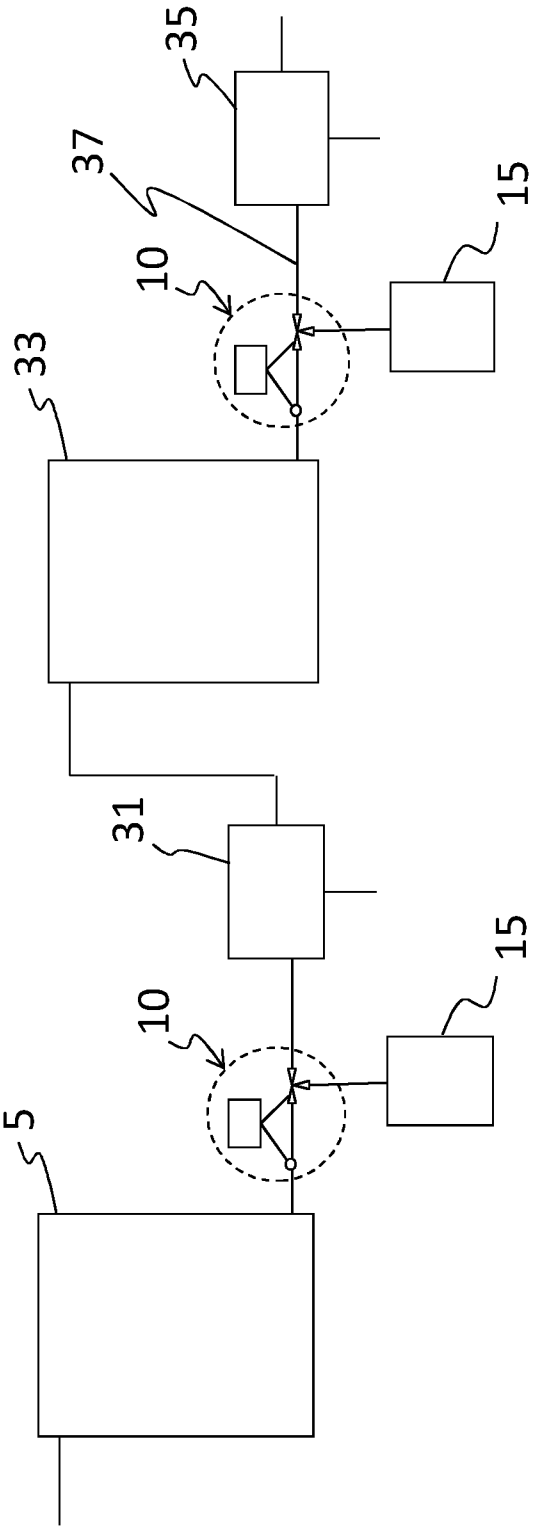

Fig. 3

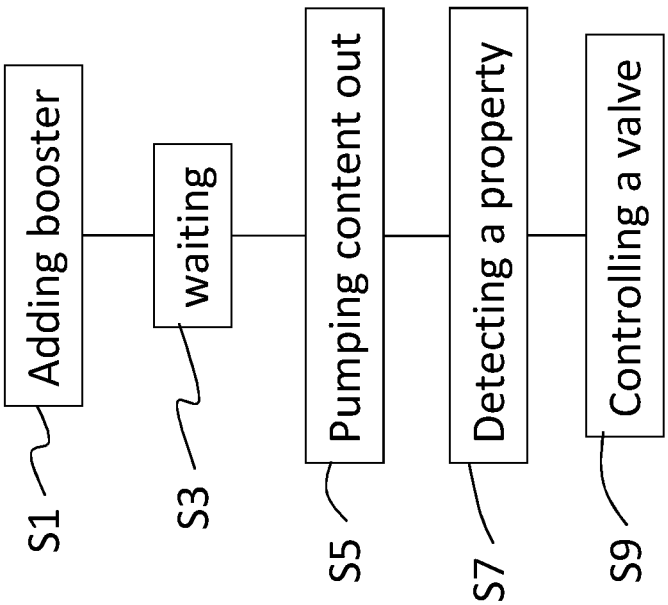
Adding booster
waiting
Pumping content out
Detecting a property
Controlling a valve
S1
S3
S5
S7
S9

Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2017/050453

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: B01D, C10G

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

SE, DK, FI, NO classes as above

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

EPO-Internal, PAJ, WPI data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 103127746 B (CHINA PETROLEUM & CHEMICAL ET AL), 5 June 2013 (2013-06-05); Abstracts retrieved from: WPI/EPODOC database; figures 1-2	1-10
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A	WO 0071640 A1 (ABB RESEARCH LTD ET AL), 30 November 2000 (2000-11-30); figure 1	1-10
	--	
A	CA 2597344 A1 (GOLTER LEE B), 10 February 2008 (2008-02-10); figure 5	1-10
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☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29-06-2017	30-06-2017

Name and mailing address of the ISA/SE	Authorized officer
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Continuation of: second sheet

International Patent Classification (IPC)

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C10G 33/08 (2006.01)

CN	103127746	B	05/06/2013	NONE			
WO	0071640	A1	30/11/2000	AU	4283900	A	12/12/2000
				DE	19923901	A1	30/11/2000
CA	2597344	A1	10/02/2008	NONE			