to fuel a boiler, steam from which is used to drive the compressors of the recovery system. The VOC condensate is the primary fuel for the boiler but this may also be supplemented by heavy fuel oil, and surplus gas - ie what is left over from the VOC condensation and would otherwise be released to atmosphere can also be supplied to the boiler for burning.

Venturi systems offer a way of recovering VOC which is rather different from all the foregoing. One such is described in WO 0208659 (Halse), which concerns a system in which condensed gas is drawn through venturi arrangements through which the oil is also passed, increasing its pressure so that the condensed gas is absorbed. Another venturi system is disclosed in WO 2007086751 (Aasen) in which both oil and gas are fed to an ejector and the gas is swirled for absorption in the oil.

All of the prior art noted above, extending over a period of nearly 90 years, is directed towards extracting VOC from vent gas. It should be noted that extraction of VOC from vent gas does not necessarily extract toxic contaminants at the same time. It should also be noted that until Brievik in 1996 there was no proposal for using extracted VOC to fuel a local boiler, eg on board a tanker or FSO or FPSO. Even then, Breivik required the VOC to be extracted from the vent gas by a process of compression and hydration. And subsequently Ruch required the VOC to be extracted by liquefaction. It may be noted that these proposals – neither of which are known to have been put into practice - were prompted by stringent legislation introduced in Norway to restrict the release of VOC to atmosphere, and were therefore focused principally on preventing atmospheric discharges of VOC rather than on the economic aspects of utilizing VOC. The most recent proposal of this kind comes from Brødreskift, and also demands extraction of VOC from vent gas, with inevitable penalties in cost and complexity. Otherwise recent development has taken a different path with the introduction of absorption systems as proposed by Halse and by Aasen in 2006, neither of which suggests or would readily permit use of the VOC as a boiler fuel.

In all this time nobody has previously perceived that vent gas can be used as a fuel without the added cost and complexity of extracting the VOC.

SUMMARY

It is an object of the present ~~invention~~disclosure to enable vent gas to be used as a fuel, for instance in an onboard boiler generating steam to heat oil and facilitate its loading or unloading, and at the same time to ensure that toxic and otherwise hazardous components of the vent gas are destroyed.

As set forth in our copending patent application GB 1001525.3, in a first

~~aspect~~embodiment the ~~invention~~present disclosure provides a method of treating vent gas from a store of liquid hydrocarbon, which vent gas comprises a mixture of inert gas and VOC, characterised in that said method comprises burning the vent gas undissociated and in gaseous form to provide a source of heat energy.

It will be noted that this method avoids the need for dissociation (which is to say that the components of the vent gas are not separated, and in particular the VOC is not extracted from the inert gas) or liquefaction of the vent gas (and in particular the VOC is not liquefied) and accordingly provides treatment of the vent gas which is cheaper than offered by the prior art.

The vent gas may be burned in a burner together with a support fuel, which may be the liquid hydrocarbon from which the vent gas has arisen, to provide stable combustion. To ensure stability the amount of support fuel may be adjusted automatically according to the Wobbe Index and flow rate of the vent gas.

The vent gas is preferably burned in the presence of combustion air supplied in an amount not less than that required for stoichiometric combustion. Preferably, also, the vent gas is burned so as to produce combustion products which are substantially less damaging to the environment than untreated vent gas: for instance, it is preferred that substantially all methane in the vent gas supplied to the burner is converted to carbon dioxide plus water, that substantially all hydrogen sulphide in the vent gas supplied to the burner is converted to sulphur dioxide plus water, and that all toxic components of the vent gas are rendered harmless by the burner.

The heat energy may be used to produce steam, to heat the liquid hydrocarbon or for other purposes.

The vent gas may be compressed before being burned, and a proportion of the compressed vent gas may be reabsorbed into the liquid hydrocarbon by vapour absorption.

According to a second ~~aspect~~embodiment of the ~~invention~~present disclosure there is provided apparatus for treating vent gas from liquid hydrocarbon, which vent gas comprises a mixture of inert gas and VOC, characterised in that said apparatus comprises a burner operative to burn the vent gas undissociated and in gaseous form together with a support fuel providing stable combustion, a gas conduit for supply of the undissociated vent gas to the burner, a support fuel conduit for supply of the support fuel to the burner and an air conduit arranged to supply combustion air to the burner for combustion of the undissociated vent gas with the support fuel.

The apparatus preferably includes burner control means operative

automatically to adjust the amount of support fuel – which may be the liquid hydrocarbon from which the vent gas has arisen - supplied to the burner according to the Wobbe Index and flow rate of the vent gas.

The apparatus preferably includes a compressor operative to compress the vent gas and may also include a return conduit extending from the compressor to a vapour absorption device whereby a proportion of the compressed vent gas is reabsorbed into the liquid hydrocarbon.

The ~~invention~~present disclosure is particularly but by no means exclusively useful in providing a convenient means for heating oil, to combat its waxiness, and thus in a third ~~aspect~~embodiment the ~~invention~~present disclosure provides a method of heating oil in a tank characterised in that vent gas from the tank, undissociated and in gaseous form, is fed to a burner in a boiler and therein burned with a supply of said oil providing stable combustion, wherein heat energy from the combustion is used to generate steam and the steam is used to heat the oil.

In a fourth ~~aspect~~embodiment the ~~invention~~present disclosure provides apparatus for heating oil in a tank characterised in that said apparatus comprises a boiler fired by means of a burner to generate steam, a gas conduit for supply of undissociated vent gas from the tank to the burner to be burned therein, an oil conduit for supply of oil to the burner to be burned therein and provide stable combustion for the vent gas, an air conduit arranged to supply combustion air to the burner for combustion of the undissociated vent gas with the oil, and a steam conduit extending from the boiler to heat the oil.

In a fifth ~~aspect~~embodiment, the ~~invention~~present disclosure extends to a burner system for the above defined apparatus, which burner system has a manifold extending axially forward to a firing end and comprising a gas passage, a support fuel passage and a combustion air passage, characterised in that said burner system comprises control means operative automatically to adjust the flow of support fuel according to the Wobbe Index and flow rate of the gas.

The support fuel passage may extend substantially along an axial centreline of the manifold, and for support fuel in liquid form the support fuel passage may include a steam atomiser therefor.

The combustion air passage is preferably divided into a primary air passage and a secondary air passage mutually separated. With this arrangement the primary air passage may be circumjacent the support fuel passage and the secondary air passage circumjacent the gas passage. Also, the gas passage may comprise a plurality of gas ducts arranged circumferentially about the axis of the manifold

between the primary air passage and the secondary air passage, and each gas duct may terminate at the firing end in a nozzle inclined to direct the gas forwards and outwards relative to the axis of the manifold.

The secondary air passage is preferably configured and arranged to direct the secondary air forwards and outwards relative to the axis of the manifold. It is also preferred that the combustion air passage terminate at the firing end in an assembly of vanes configured and arranged to swirl the combustion air about the axis of the manifold.

Those skilled in the art of oil handling know that in this art the term 'inert gas' refers to a gas or a mixture of gases, such as flue gas, containing insufficient oxygen to support the combustion of hydrocarbons (see eg *Inert Gas Systems,* International Maritime Organisation, 1990, at paragraph 1.3.1). However the inert gas does not have to be flue gas or the like such as the exhaust from a vessel's engines. In demanding inert gas blanketing, the 1974 International Convention on the Safety of Life at Sea (*SOLAS*) states at Regulation 62 that the inert gas system 'shall be capable of providing on demand a gas or mixture of gases to the cargo tanks so deficient in oxygen that the atmosphere within a tank may be rendered inert, ie incapable of propagating flame.' It follows from this that hydrocarbon gas may itself be used for blanketing provided it is deficient in oxygen.

The use of hydrocarbon gas to form a blanket has two important advantages over the use of flue gas. First, it takes up less VOC from the cargo, which therefore holds its value better. And second, it is less corrosive than flue gas, so the working life of the oil handling facility is prolonged.

The present ~~invention~~disclosure accommodates hydrocarbon gas blanketing.

Thus according to a sixth ~~aspect~~embodiment the ~~invention~~present disclosure provides a method of handling cargoes of liquid hydrocarbon in which:

the liquid hydrocarbon is loaded into a tank and subsequently offloaded from the tank ;

during offloading the tank is backfilled with inert hydrocarbon gas to form a blanket; and

during loading the blanket gas is vented from the tank;

characterised in that said method comprises burning the vented blanket gas undissociated and in gaseous form to provide a source of heat energy.

In an aspect, there is provided a method of handling a cargo of liquid hydrocarbon at sea wherein said cargo is loaded to and offloaded from a store in which it is blanketed with inert blanket gas and wherein the loading of the cargo causes vent gas comprising a mixture of the blanket gas and VOC given off by the liquid hydrocarbon, in varying proportions, to be displaced from the store; characterised in that said method comprises burning the vent gas displaced from the store during loading undissociated and in gaseous form to provide heat for heating the cargo.

The hydrocarbon gas may be extracted from crude oil and the liquid hydrocarbon to be loaded in the tank may be extracted from the crude oil and

separated from the hydrocarbon gas.

The ~~invention~~present disclosure extends to apparatus for treating vent gas from a tank of liquid hydrocarbon, which vent gas comprises a mixture of inert hydrocarbon gas and VOC and is vented from a top of the tank, characterised in that said apparatus comprises:

a supply means operative to supply hydrocarbon gas and liquid hydrocarbon;

a hydrocarbon gas conduit connected to the supply means to receive the hydrocarbon gas;

a liquid hydrocarbon conduit connected between the supply means and the tank for loading the liquid hydrocarbon into the tank;

a blanket gas transfer conduit connected to the top of the tank;

a blanket gas supply conduit connected between the hydrocarbon gas conduit and the blanket gas transfer conduit thereby to supply hydrocarbon gas to the tank to form a blanket over the oil therein;

a burner;

a vent gas supply conduit connected between the blanket gas transfer conduit and the burner to deliver to the burner blanket gas vented during loading of the liquid hydrocarbon; and

a fuel gas supply conduit connected between the hydrocarbon gas conduit and the burner to deliver hydrocarbon gas to the burner as fuel gas;

wherein the burner is configured and arranged to burn the fuel gas during offloading of the liquid hydrocarbon from the tank and to burn the fuel gas and/or the vented blanket gas during loading of the liquid hydrocarbon into the tank.

In another aspect, there is provided an apparatus for handling a cargo of liquid hydrocarbon at sea, which apparatus comprises a store to which the cargo is loaded and from which the cargo is offloaded and in which the cargo is blanketed with inert blanket gas and from which vent gas comprising a mixture of the blanket gas and VOC given off by the liquid hydrocarbon, in varying proportions, is displaced from the store during loading and wherein said apparatus comprises a burner operative to burn the vent gas undissociated and in gaseous form together with a support fuel providing stable combustion, a gas conduit for supply of the undissociated vent gas to the burner, a support fuel conduit for supply of the support fuel to the burner and an air conduit arranged to supply combustion air to the burner for combustion of the undissociated vent gas with the support fuel.

Heat from burning the fuel gas and/or the vented blanket gas may be used (eg through the generation of steam) for a variety of purposes including heating the liquid hydrocarbon in the tank to combat waxiness. And during offloading, the heat may be used to drive a pump for offloading the liquid hydrocarbon.

DETAILED DESCRIPTION

The invention will now be described by way of example only with reference to the accompanying drawings which are purely schematic and not to scale and in which –

Figure 1 shows an oil tanker in side elevation and illustrates the background to the invention;

Figure 2 illustrates a first embodiment of a system for treating vent gas according to the invention;

Figure 3 illustrates a burner control system for use with the system of Figure 2;

Figure 4 is a schematic illustration of a burner for the system, in plan view;