**Title:** ATOMIZATION OF HYDROCARBON FEEDSTOCK

**Abstract:** The present disclosure relates to an assembly implementing the process disclosed for atomizing a hydrocarbon feedstock. The method includes receiving the hydrocarbon feedstock (2) and a diluted mixed steam (3) from a first inlet (5) and a second inlet (6), respectively, by an inner conduit (1), where the flow of the hydrocarbon feedstock (2) is in a motion opposing the diluted mixed steam (3); mixing the hydrocarbon feedstock (2) with the diluted mixed steam (3) in the inner conduit (1) to produce an emulsion (4). The method further includes impacting the emulsion (4) against an impingement section (11) to form an emulsion film on at least a portion of the impingement section (11) by shearing mechanism. The method further includes transmitting streams of atomizing steam (17) through a plurality of jet tubes (18) onto the emulsion film for atomization to generate a plurality of droplets of the hydrocarbon feedstock (2).

Declarations under Rule 4.17:
— of inventorship (Rule 4.17(v))

Published:
— with international search report (Art. 21(3))
ATOMIZATION OF HYDROCARBON FEEDSTOCK

TECHNICAL FIELD

[0001] The present disclosure generally relates to an atomizer, and particularly but not exclusively, to an atomizer for atomization of a hydrocarbon feedstock for fluid catalytic cracking process.

BACKGROUND

[0002] Fluid Catalytic Cracking (FCC) process is a widely used process to convert heavy hydrocarbon feedstock into lighter and more valuable products. The heavy hydrocarbon feedstock includes atmospheric gas oils, vacuum gas oils, topped crudes, residuum, and the like. Typically, the hydrocarbon feedstock of a high boiling point range is pre-heated and is brought into contact with a hot cracking catalyst in a catalytic cracking reactor. Further, the hydrocarbon feedstock is cracked to give products of lower boiling point which are more valuable, such as LPG, gasoline, diesel and light olefins, for example propylene and butylene.

[0003] Typically, the efficiency of the FCC process is governed by many factors, such as, but not limited to, temperature in the catalytic cracking reactor, residence time, activity of the cracking catalyst, surface area of the hydrocarbon feedstock, reactor configuration, to name a few. Among other parameters, the surface area per unit volume of the hydrocarbon feedstock influences the efficiency and yield of the catalytic cracking reaction. Greater the surface area per unit volume better is the possibility for the hot cracking catalyst to come in contact with the hydrocarbon feedstock and faster is the vaporization in the FCC reactor. For this purpose, the heavy hydrocarbon feedstock is atomized in an atomizer, for the FCC process. Typically, the atomization process involves breaking down the hydrocarbon feedstock into a number of droplets to increase the surface area to volume ratio of the hydrocarbon
feedstock. This process generates fine droplets for fast vaporization, thereby enhancing the efficiency of the FCC process.

BRIEF DESCRIPTION OF DRAWINGS

[0004] The detailed description is provided with reference to the accompanying figures. In the figures, the left-most digit(s) of a reference number identifies the figure in which the reference number first appears. The same numbers are used throughout the drawings to reference like features and components.

[0005] FIG. 1 illustrates an assembly for the atomization of a hydrocarbon feedstock, in accordance with an implementation of the present subject matter.

[0006] FIG. 2 illustrates a process for atomization of the hydrocarbon feedstock, in accordance with an implementation of the present subject matter.

DETAILED DESCRIPTION

[0007] The present subject matter relates to an atomizer for atomization of hydrocarbon feedstock. The hydrocarbon feedstock may include fuel oil, asphalt, and the like. In an example, the hydrocarbon feedstock may be obtained from crude oils or petroleum refineries. Although, the description herein provided is with reference to atomization of hydrocarbon feedstock for a Fluid Catalytic Cracking (FCC) process, it may be understood that the atomization can be performed with other liquids as well for varied applications, albeit with a few variations, as may be understood by a person skilled in the art.

[0008] Conventional atomizers are based on internally mixing the steam and liquid feed upstream of a nozzle exit to generate a mixture; and further, transmitting the mixture to the nozzle exit. Although, these
atomizers minimize the requirement of a high feed pressure, the mixture may stratify into two phases while transmitting to the nozzle exit, regardless of how well the two phases are mixed initially, leading to less efficient atomization.

Certain other conventionally used atomizers have the nozzle exit with a very small opening. As a result, the nozzle exit may be easily plugged or choked by various impurities or coking. The downtime and replacement process is very tedious and expensive.

The conventional atomizers fall short in completely and efficiently atomizing a heavy hydrocarbon feedstock which has a high viscosity and a very high surface tension. Inefficient atomization leads to non-uniformity in terms of diameter and velocity of the droplets of the atomized hydrocarbon feedstock. Moreover, it takes considerable time for such hydrocarbon feedstock to vaporize in the FCC reactor. Delayed vaporization of the hydrocarbon feedstock in turn leads to slow and inadequate absorption of heat by the hydrocarbon droplets inside the FCC reactor, thus leading to undesirable thermal cracking and excessive production of byproducts such as coke and gas.

The present subject matter provides an atomizer assembly, herein referred to as an assembly, implementing the disclosed method for atomizing a hydrocarbon feedstock. The hydrocarbon feedstock is atomized into fine droplets by thoroughly mixing the hydrocarbon feedstock with a diluent mixed steam, in opposing motions, to produce an emulsion. In an example, the opposing motion is a cyclonic, and an anti-cyclonic motion. The emulsion is incident against an impingement section, where the emulsion is shattered to generate droplets of the hydrocarbon feedstock. The droplets are further transmitted to a nozzle exit for transmission to the FCC reactor.
The assembly of the present subject matter causes atomization of the hydrocarbon feedstock of varied viscosities and surface tension. Further, the assembly allows for internal mixing of the hydrocarbon feedstock with the diluent mixed steam, thereby minimizing the requirement of the high feed pressure. The use of cyclonic motion for mixing the hydrocarbon feedstock with the diluent mixed steam allows for enhanced mixing and also reduces the surface tension and viscosity of the heavy hydrocarbon feedstock. This enhanced mixing results in generating droplets of the hydrocarbon feedstock of uniform diameter and viscosity at the nozzle exit, thereby enhancing the efficiency of the atomization process.

The following detailed description describes an atomization device for atomizing a hydrocarbon feedstock and its uses in detail. While the aspects of the atomization device can be implemented in any number of different applications and configurations, the atomization device of the present subject matter is described in the context of the following exemplary embodiments.

FIG.1 illustrates an atomizer assembly, herein referred to as assembly 100, in accordance with an embodiment of the present subject matter. The assembly includes an inner conduit 1 for mixing hydrocarbon feedstock 2 and diluent mixed steam 3 to produce an emulsion 4. The hydrocarbon feedstock 2 is received by the inner conduit 1 through a first inlet 5 positioned tangentially to the inner conduit 1. The hydrocarbon feedstock 2 may be obtained from crude oils or from petroleum refineries.

The inner conduit 1 further receives the diluent mixed steam 3 through a second inlet 6 that is positioned tangentially to the inner conduit 1, and opposite to the direction of the first inlet 5. In an example, the diluent and the sweeping steam may be mixed together, herein referring to as the diluent mixed steam 3, prior to feeding into the second...
inlet 6. The diluent includes middle distillates, aromatic rich streams, and surfactants for reducing the viscosity of the hydrocarbon feedstock 2. In an example, the quantity of the diluent mixed steam 3 is dependent on the viscosity of the hydrocarbon feedstock 2. Further, the hydrocarbon feedstock 2 and the diluent mixed steam 3 may be mixed together to form an emulsion 4.

[001 6] In an embodiment, the inner conduit 1 may be so structured to allow the flow of emulsion 4 in a unidirectional manner by a throttling mechanism. In an example, the inner conduit 1 includes a body 7 coupled to the first inlet 5 and the second inlet 6 to receive the hydrocarbon feedstock 2 and the diluent mixed steam 3. In an example, the flow of the hydrocarbon feedstock 2 into the body 7 of the inner conduit 1 is in a motion opposing the diluent mixed steam 3. The motion is a cyclonic motion. Accordingly, the hydrocarbon feedstock 2 may flow into the body 7 of the inner conduit 1 in a cyclonic motion, whereas the diluent mixed steam 3 may flow in an anti-cyclonic motion.

[001 7] Further, the hydrocarbon feedstock 2 and the diluent mixed steam 3 are mixed together in the body 7 of the inner conduit 1 to form an emulsion 4. In an example, the distance between the first inlet 5 and the second inlet 6 is kept minimum to ensure thorough mixing to form an emulsion 4. The use of cyclonic motion for flow of the hydrocarbon feedstock 2 and the diluent mixed steam 3 allows for enhanced mixing and also reduces the surface tension and viscosity of the hydrocarbon feedstock 2. This enhanced mixing results in generating droplets of the hydrocarbon feedstock 2 of uniform diameter and viscosity at a nozzle exit 20, thereby enhancing the efficiency of the atomization process, and also minimizing the requirement of the high feed pressure.

[001 8] The body 7 of the inner conduit 1 further includes first closed end 8 associated with a first cross-sectional area, and a second end 9.
The second end 9 leads to an inwardly tapered to narrow exit 10, where the narrow exit 10 is associated with a second-cross sectional area. Further, the second cross-sectional area is smaller compared to the first cross-sectional area. This smaller cross sectional area at the narrow exit is achieved by inward tapering from the second end 9 in a linear manner. Such structuring allows for the flow of the emulsion 4 from the body 7 towards the narrow exit 10 by a throttling mechanism. The throttling mechanism allows flow of the emulsion 4 with increased velocity for effective atomization.

The assembly 100 further includes an impingement section 11 located axially and contiguous with the inner conduit 1 for atomization. The impingement section 11 includes a serrated wedge shaped guiding edge 12 aligned axially at an exit end of the narrow exit 10 in an inverted manner. The non-perforated serrated wedge shaped guiding edge may be herein referred to as a guiding edge 12. The guiding edge 12 is supported by one or more conical plates 14 on either side extending from a rim of the guiding edge 12. In an example, the preferred number of conical plates 14 is two. Further, each of the one or more conical plates 14 is supported by one or more orifices 13.

In an example, the emulsion 4 is impacted or incident against the guiding edge 12 to cause atomization. The use of the guiding edge 12 in an inverted manner minimizes pressure loss during expansion. In an example, the atomization is achieved by impacting the emulsion 4 against the guiding edge 12 to form an emulsion film on at least a portion of the impingement section 11 by shearing mechanism. In an example, the emulsion film is formed on the conical plates 14 bearing one or more orifices 13.

The assembly 100 further includes an outer conduit 15 arranged concentrically outside the inner conduit 1. The outer conduit 15
further includes a steam inlet 16 for feeding atomizing steam 17 through the steam inlet 16. The outer conduit 15 further includes two or more jet tubes 18 oriented towards the inner conduit 1 at a certain angle from a nozzle exit 20. The jet tubes 18 further include a plurality of jet orifices 19 to allow for passage of atomizing steam 17 from the jet tubes 18 to the conical plates 14. In an example, the angle of the jet tubes 18 is in a range of 30 to 60 degree, preferably between 34 to 45 degrees from the nozzle exit 20. The atomizing steam 17 from the steam inlet 16 is passed through the space between outer walls on the inner conduit 1 and the outer conduit 15 to the orifices 13 on the conical plate 14. The passage of the atomizing steam 17 to the orifices 13 on the conical plate 14 includes passage through the jet orifices 19 disposed on the jet tubes 18, to the orifices 13 disposed on the conical plate 14. The atomizing steam 17 impinges the emulsion film formed on the two or more conical plates 14. This causes partial atomization of the hydrocarbon feedstock 2.

[0022] The assembly 100 further includes a mixing chamber 21 positioned in a contiguous manner beyond the impingement section 11. The mixing chamber 21 receives the partially atomized emulsion 4 containing the hydrocarbon feedstock 2 and diluent mixed steam 3. The mixing chamber 21 is to receive and mix the hydrocarbon feedstock 2, diluent mixed steam 3, and the atomization steam 17 through the orifices 13 thoroughly for a sufficient time, to generate a plurality of droplets of the hydrocarbon feedstock 2. The droplets of hydrocarbon feedstock 2 are further transmitted to the FCC reactor through a plurality of nozzle orifices 22 disposed on the nozzle exit 20 region. The nozzle exit 20 region is disposed axially to the impingement section 11.

[0023] FIG. 2 describes a process for atomizing a hydrocarbon feedstock, in accordance with the implementation of the present subject matter. Accordingly, at block 202, the hydrocarbon feedstock and a diluent mixed steam are received by an inner conduit to produce an
emulsion. In an embodiment, the hydrocarbon feedstock is fed into the inner conduit through the first inlet, and the diluent mixed steam is fed through the second inlet, where the first inlet and the second inlet are coupled to the inner conduit. In an example, the flow of hydrocarbon feedstock is in a motion opposing to that of the diluent mixed steam. The motion is a cyclonic motion. In an example, the hydrocarbon feedstock, flows in a cyclonic motion and the diluent mixed steam, flows in an anti-cyclonic motion.

[0024] At block 204, the hydrocarbon feedstock and the diluent mixed steam are mixed together in the inner conduit to form an emulsion. In an embodiment, the inner conduit may be so structured to allow the flow of emulsion in a unidirectional manner by a throttling mechanism.

[0025] At block 206, the emulsion is impacted against an impingement section to form an emulsion film on at least a portion of the impingement section by shearing mechanism. The impingement section comprising: a serrated wedge shaped guiding edge aligned axially at an exit end of the inner conduit in an inverted manner; and a plurality of conical plates, each bearing a plurality of orifices, disposed on either sides of rim of the guiding edge. In an example, the emulsion is impacted/made incident against the guiding edge to cause atomization. The use of the guiding edge in an inverted manner minimizes pressure loss during expansion. In an example, the emulsion is impacted against the guiding edge to form an emulsion film on at least a portion of the impingement section by shearing mechanism. In an example, the emulsion film is formed on the conical plates bearing one or more orifices.

[0026] At block 208, a stream of atomizing steam is passed through two or more jet tubes onto the emulsion film for atomization. The atomization results in generation of plurality of drops of hydrocarbon feedstock. In an example, the droplets are generated by passing the
atomizing steam to the emulsion film on the orifices disposed on the conical plates. The atomizing steam impinges the emulsion film formed on the two or more conical plates. This causes partial atomization of the hydrocarbon feedstock. Further, the hydrocarbon feedstock, diluent mixed steam, and the atomization steam, are mixed in a mixing chamber for an optimum condition to generate the droplets of the hydrocarbon feedstock.

[0027] The order in which the method 200 is described is not intended to be construed as a limitation, and the steps described can be combined in other ways obvious to a person skilled in the art. Additionally, individual blocks can be added or deleted from the method without departing from the disclosed present subject matter.

[0028] Although the subject matter has been described in considerable detail with reference to certain examples and implementations thereof, other implementations are possible. As such, the scope of the appended claims should not be limited to the description of the preferred examples and implementations contained therein.
I/We claim:

1. An assembly (100) for atomization of a hydrocarbon feedstock, the assembly (100) comprising:
   
an inner conduit (1) to produce an emulsion (4), the inner
   5 conduit (1) comprising:
   
a first inlet (5) for feeding a hydrocarbon feedstock (2);
   
a second inlet (6) for feeding a diluent mixed steam (3), wherein the flow of the diluent mixed steam (3) is in a motion opposing that of the hydrocarbon feedstock (2); and
   
an inner conduit (1) coupled to the first inlet (5) and the second inlet (6) for receiving and mixing the hydrocarbon feedstock (2) with the diluent mixed steam (3) to produce an emulsion (4);
   
an impingement section (11) for atomization of the hydrocarbon feedstock (2), the impingement section (11) comprising:
   
a serrated wedge shaped guiding edge (12) aligned axially at an exit end of the inner conduit (1) in an inverted manner; and
   
a plurality of conical plates (14), each bearing a plurality of orifices (13), disposed on either sides of rim of the guiding edge (12);
   
wherein the impingement section (11) causes atomization of the hydrocarbon feedstock (2) on impact of the emulsion (4) against the guiding edge (12) to disperse a plurality of droplets of the hydrocarbon feedstock (2) from each of the plurality of orifices (13) disposed on the plurality of conical plates (14); and
a nozzle exit (20) aligned axially to the impingement section (11) to transmit the plurality of droplets to a reactor.

2. The assembly (100) as claimed in claim 1, wherein the inner conduit (1) comprises a body (7) structured to allow for unidirectional flow of the emulsion, the body (7) including:
   a first closed end (8); wherein the first closed end (8) is associated with a first cross-sectional area; and
   a second end (9), wherein the second end (9) is inwardly tapering to a narrow exit (10), wherein the narrow exit (10) is associated with a second cross-sectional area, and wherein the second cross-sectional area is smaller to the first cross-sectional area.

3. The assembly (100) as claimed in claim 1, wherein the motion is a cyclonic motion, and an anti-cyclonic motion.

4. The assembly 100 as claimed in claim 1, comprises an outer conduit (15) positioned concentrically above the inner conduit (1), the outer conduit (15) comprising:
   a steam inlet (16) for feeding atomizing steam (17);
   a plurality of jet tubes (18) oriented towards the inner conduit (1), wherein each of the plurality of jet tubes (18) inject streams of atomizing stream (17) to each of the plurality of the conical plates (14); and
   a mixing chamber (21) connected to the outer conduit (15) to receive the hydrocarbon feedstock (2), diluent mixed steam (3), and the atomization steam (17) through each of the plurality of orifices (22) to generate a plurality of droplets of the hydrocarbon feedstock (2).

5. The assembly (100) as claimed in claim 1, wherein the plurality of droplets are generated by impacting of the emulsion (4) against the guiding edge (12) to form an emulsion film on each of the plurality of conical plates (14) by shearing mechanism.
6. The assembly (100) as claimed in claim 4, wherein the jet tubes (18) are placed at an angle of 30 to 60 degrees with respect to the nozzle exit (20).

7. A process for atomizing a hydrocarbon feedstock (2), the process comprising:

- receiving the hydrocarbon feedstock (2) and a diluent mixed steam (3) from a first inlet (5) and a second inlet (6), respectively, by an inner conduit (1), wherein the flow of the hydrocarbon feedstock (2) is in a motion opposing the diluent mixed steam (3);
- mixing the hydrocarbon feedstock (2) with the diluent mixed steam (3) in the inner conduit (1) to produce an emulsion (4);
- impacting the emulsion (4) against an impingement section (11), the impingement section (11) comprising: a serrated wedge shaped guiding edge (12) aligned axially at an exit end of the narrow exit (10) in an inverted manner; and a plurality of conical plates (14), each bearing a plurality of orifices (13), disposed on either sides of rim of the guiding edge (12), to form an emulsion film, wherein the emulsion film is formed on at least a portion of the impingement section (11) by shearing mechanism; and
- transmitting streams of atomizing steam (17) through a plurality of jet tubes (18) onto the emulsion film for atomization to generate a plurality of droplets of the hydrocarbon feedstock (2).

8. The process as claimed in claim 7, wherein the first inlet (5) is in a direction tangential to the inner conduit (1).

9. The process as claimed in claim 7, wherein the motion is a cyclonic motion, and anti-cyclonic motion.

10. The process as claimed in claim 7, wherein the atomizing process comprises mixing the hydrocarbon feedstock (2), diluent mixed steam (3), and the atomization steam (17) in a mixing chamber (21) for an optimum condition to generate the plurality of droplets of the hydrocarbon feedstock (2).
11. The process as claimed in claim 7, wherein the emulsion (4) flows in a unidirectional flow by a throttling mechanism.

12. The process as claimed in claim 7, wherein the emulsion (4) is impacted against the guiding edge (12) of the impingement section (11) to form an emulsion film on each of the plurality of conical plates (14) by shearing mechanism.

13. The process as claimed in claim 7, wherein the plurality of droplets are transmitted to a reactor through a plurality of nozzle orifices (22) disposed on a nozzle exit (20).
RECEIVING A HYDROCARBON FEEDSTOCK AND A DILUENT MIXED STEAM BY AN INNER CONDUIT, WHERE THE FLOW OF HYDROCARBON FEEDSTOCK IS IN A MOTION OPPOSING THE DILUENT MIXED STEAM

MIXING THE HYDROCARBON FEEDSTOCK WITH THE DILUENT MIXED STEAM IN THE INNER CONDUIT TO PRODUCE EMULSION

IMPACTING THE EMULSION AGAINST AN IMPINGEMENT SECTION TO FORM AN EMULSION FILM, WHERE THE EMULSION FILM IS FORMED ON AT LEAST A PORTION OF THE IMPINGEMENT SECTION

TRANSMITTING STREAMS OF ATOMIZING STEAM THROUGH A PLURALITY OF JET TUBES ON TO THE EMULSION FILM FOR ATOMIZATION, TO GENERATE A PLURALITY OF DROPLETS OF THE HYDROCARBON FEEDSTOCK.

Fig. 2
**INTERNATIONAL SEARCH REPORT**

**PCT/IN2016/050171**

**A. CLASSIFICATION OF SUBJECT MATTER**

INV. B01J4/00 B01F5/02 B01F5/04 ClOGll/18

**ADD.**

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)

B01J B01F ClOG

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

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

EPO-Internal , WPI Data

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

<table>
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<th>Category</th>
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<th>Relevant to claim No.</th>
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<td>US 5 948 241 A (OWEN HARTLEY [US]) 7 September 1999 (1999-09-07) claims 1-4 figures 1-7</td>
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Further documents are listed in the continuation of Box C. See patent family annex.

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**Date of the actual completion of the international search**

23 September 2016

**Date of mailing of the international search report**

05/10/2016

Name and mailing address of the ISA/

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**Authorized officer**

Pardo Torre, J
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