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(71) Applicant: COMBUSTION ENGINEERING, INC.
1000 Prospect Hill Road
Windsor Connecticut 06095(US)

(72) Inventor: Smith, Donald Arthur
Route 9A
Haddam Connecticut 06438(US)

(72) Inventor: LaFlesh, Richard Charles
250 East Street North
Suffield Connecticut 06078(US)

(74) Representative: Gross, Gernot K.
Kleiberweg 5
D-6200 Wiesbaden(DE)

(54) **Apparatus for heating and mixing high viscosity fluids.**

(57) An apparatus for heating a highly viscous slurry including an axially elongated hollow housing (1) through which the slurry to be heated flows and a heat exchanger (4) through which a heating fluid is passed disposed within the housing so that slurry flowing axially therethrough must pass over the heat exchanger, characterized in that the heat exchanger comprises an elongated, bulb-shaped chamber 4 mounted on a rotating shaft (6) disposed coaxially within and extending through the housing. The heating fluid enters the chamber (4) through an inlet passage extending through the neck (10) of the shaft (6) and leaves the chamber (4) through an outlet passage also extending through the neck (10) of the shaft (6). A plurality of pins (25) may be mounted to extend radially outward from the external surface of the chamber (4) to continuously stir the slurry and enhance heat exchange.

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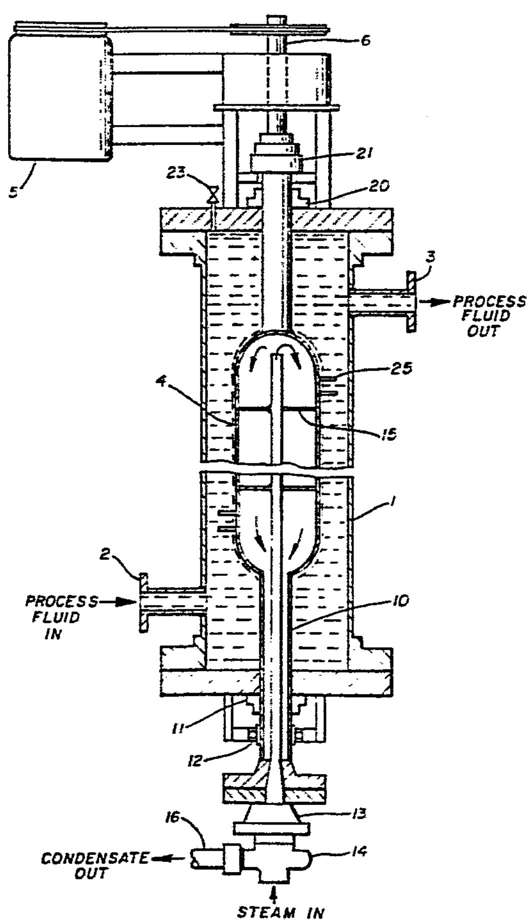

6
21
23
20
5
3
PROCESS FLUID OUT
25
4
15
1
2
PROCESS FLUID IN
10
11
12
13
16
14
CONDENSATE OUT
STEAM IN

# APPARATUS FOR HEATING AND MIXING HIGH VISCOSITY FLUIDS

## TECHNICAL FIELD

The present invention relates to elevating the temperature of highly viscous fluids by a movable heating element. The invention further relates to elevating the temperature of a highly viscous slurry of a hydrocarbon fluid in which an amount of water stabilizes the suspension of particles of solid carbonaceous material at a high pressure by rotating a heating element within the slurry to break up laminar flow of the slurry over the heating element.

## BACKGROUND ART

In the present stage of prior art development, fuels are being developed in the form of slurries of fluid hydrocarbons in which solid carbonaceous material is dispersed. In short, coal, or petroleum coke, is being dispersed in oil, the coal, or petroleum coke, being so finely dispersed that the resulting slurry can be atomized from burners at pressures in the order of 500 psi.

The fuel slurry, as a highly viscous fluid, must be brought to pre-burner temperature quickly. The fluid must arrive at the burner within a fairly high pressure range. The conventional concept of passing this fluid material through a tube-shell heat exchanger must be discarded, as the coefficient of heat exchange and pressure drop through such heating device has been found unsatisfactory. An arrrangement is sought which will elevate the coefficient of heat transfer, yet preclude the penalty of excessive pressure drop in the flow stream.

To elevate the coefficient of heat transfer between the heating element and the fluid being heated, movement of the heating element must be provided to break up laminar flow within the fluid. Further, the surface of the heating element must be given a configuration which will not only agitate the fluid, but extend, or expand, the effective heat transfer surface of the heating element. One of the overall specifications for this new configuration is obviating accumulation of solid deposits on all surfaces coming in contact with the fluid being heated, and the introduction of excessive pressure drop in the flow stream of the fluid.

DISCLOSURE OF THE INVENTION

The present invention contemplates the provision of a casing through which a fluid to be heated is passed. Mounted within the casing is a heated chamber over whose outer surface the fluid being heated passes. The heating chamber within the casing is moved to reduce laminar flow of the fluid passing over its outer surface in elevation of the coefficient of heat exchange between the surface and the fluid. Surface extenders are mounted on the external surface of the heating chamber with the result that movement of the heating element will cause the extenders to increase the reduction of laminar flow while expanding the effective heating transfer surface of the chamber.

Other objects, advantages and features of this invention will become apparent to one skilled in the art upon consideration of the written specification, appended claims, and attached drawings.

BRIEF DESIGNATION OF THE DRAWING

The drawing is a sectioned elevation of the heater for a highly viscous fluid in which the present invention is embodied.

BEST MODE FOR CARRYING OUT THE INVENTION

Overview

The basic objective of the structure in which the invention is embodied is to elevate the temperature of a fluid, or fluid-like material which will be referred to as the process fluid. The process fluid requiring heating by the present embodiment is at a high pressure, i.e. a range including 500 psi.

In reducing the invention to practice, the process fluid being heated is a highly viscous slurry of finely dispersed coal, or petroleum coke, suspended in a hydrocarbon liquid. With the coal, or petroleum coke, homogenized with the oil, the resulting slurry is atomized in a burner developing the products of combustion in a furnace. Atomizing the slurry, with the type of burner available, requires a pressure ranging from 100 to 500 psi.

As the slurry being heated passes through the inventive embodiment, build-up on the heating surfaces has to be obviated. Solid build-up on the heating surfaces would generate prohibitive pressure drops in the flow stream of the slurry. Finally, a degree of agitation of the slurry is required to elevate the coefficient of heat transfer between the heating surface and the slurry.

From one viewpoint, the embodiment of the invention centers about a hollow casing through which the highly viscous slurry is passed. The heating element within the casing is given the form of a chamber whose surface sports pins mounted on the external surface of the elongated chamber. The elongated chamber, radially disposed within the casing, is rotated about the axis common with the axis of the casing to break up the laminar flow of the slurry passing over its surface. The chamber is heated by steam introduced from a source outside the casing. The steam condenses as it gives up its heat to the slurry, the condensed water being continuously withdrawn from the chamber. All the objectives are met with this embodiment, leaving only the mechanical complications of the seals necessary to contain the fluids and introduce a rotating mechanism for the chamber as a heating element.

## The Basic Structure

The drawing discloses a casing 1 which is in the form of a hollow cylinder. The broken midsection indicates greater length than otherwise implied within the limitations of the drawing figure. The first actual reduction to practice has a length in the order of 14 feet, and an inside diameter of about 16 inches. The process fluid is provided an entry 2 near the lower end of casing 1. The heated process fluid leaves the casing 1 via upper exit 3.

Although the actual reduction to practice flows the process fluid up through casing 1, it is to be understood that this direction of flow is not a limitation of the invention. In the actual reduction to practice, the process fluid was first flowed downward over the heating element. However, it presently appears advisable to flow the process fluid into entry 2 and out of exit 3, as disclosed in the drawing.

Within casing 1, an elongated, cylindrical, bulb-shaped chamber 4 presents its outside surface to the process fluid flowed into, and through, casing 1. A motor 5 is mounted externally, and on the upper portion of, casing 1. A power train links motor 5 to shaft 6, shaft 6 extending down through the upper closure of casing 1 to connect to the upper end of chamber 4. Thus, with chamber 4 properly supported for rotation within casing 1, motor 5 imparts the speed of rotation desired for chamber 4 as the external surface of chamber 4 transfers its heat to the process fluid flowing through casing 1.

Once the concept of a cylindrical flow casing, and an internally supported chamber rotated by a power means is accepted, design of their sizes establishes the acceptable pressure drop in the flow stream of the process fluid heated by this arrangement. The quantity of the process stream, the internal diameter of casing 1, the external diameter of chamber 4, and the speed of rotation imparted by motor 5, are adjusted under sound engineering principles to deliver the process fluid at the acceptable pressure and heated to the required temperature. Further, this sizing establishes the rate of flow of the process fluid through casing 1 which will militate against the precipitation of any solid material from the flow stream and its collection on the surfaces within casing 1 which will increase the pressure drop.

Seals

Under the broad concepts of the invention, the embodiment has several moving parts requiring effective bearings and seals. As a beginning, chamber 4 is extended by a neck 10 through the lower end of casing 1. As the chamber 4 and its neck 10 are rotated, the seal between the neck and casing end must be provided at 11. Concomitantly, a bearing 12 is provided outboard of the seal 11 between the end of the casing 1 and the neck 10.

Steam, as a convenient heating medium, is flowed into the interior of chamber, or drum, 4. Specifically, the steam is connected to the lower end of supply tube 13 through a steam joint 14. This supply tube 13 is fixed to steam drum 4 and neck

10. Spider structure 15 is disclosed within steam drum 4, extending from the steam tube 13 to the interior wall of steam drum 4. Therefore, drum, neck, and tube rotate as a unit in steam joint 14. While this rotation is taking place, the steam flowed into steam drum 4 is giving up its heat to the internal wall of the drum 4, condensing and is withdrawn from the lower end of neck 10 at 16.

Shifting attention to the upper portion of casing 1, shaft 6, linked to motor 5, is extended vertically down through the upper wall closure of casing 1 to connect to the upper end of drum 4 and impart the desired rotation to the drum 4. The sealing problem is somewhat simpler on the upper end of casing 1. A seal is provided at 20 and a bearing is provided at 21 between casing 1 and shaft 6. With seals and bearings provided as indicated, the process fluid, even at its high pressure, is contained within casing 1, entering through 2 and exiting through 3.

Operation

Although the overall operation of the embodiment of the invention has been covered piecemeal while describing its configuration and arrangement, a review is in order. The highly viscous, high pressure slurry, or process fluid, is preferably passed upward through the casing 1 from inlet 2 to outlet 3. The rate of flow is designed to be high enough to prevent settling of the solid material from the slurry into accumulation on the parts within the casing. Of course, the rate of flow must also be compatible with the heating surface contacted and the temperature rise required.

In start-up of the system, it has been found highly desirable to purge casing 1 of any vapor. To facilitate this purging, vent valve 23 is installed through the upper closure of casing 1. At this high point of vertical casing 1, valve 23 can be opened at the proper time to withdraw any vapor collecting in the upper part of casing 1 and insure that the process fluid has packed the entire volume of casing 1.

Steam drum 4 rotates within the fluid-packed casing 1 as the slurry flows over its outside surface. This movement of the external heating surface of the drum resists any tendency to form laminar flow by the slurry as it is heated. To further enhance the introduction of turbulence in the slurry, and thereby elevate the heat transfer coefficient, pins 25 are carried on the surface of drum 4. These pins not only extend, or expand, the effective heat transfer surface of the drum, but further promote the mechanical agitation of the slurry as the drum is rotated. Some degree of continued mixing is brought about, but more importantly, reduction of laminar flow is insured by this structure.

The seals between the moving parts of the steam drum, drum neck, casing, and motor shaft, can be regarded as conventional. Various specific and effective forms are available. With the heated, cooling, and heating fluids contained within their respective volumes by proper seals, the end result is that the slurry discharged from outlet 3 is presumably made available for atomization in a downstream burner, not shown.

From the foregoing, it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth, together with other advantages which are obvious and inherent to the apparatus.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the invention.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted in an illustrative and not in a limiting sense.

CLAIMS

1. An apparatus for heating a highly viscous slurry including an enclosed axially elongated hollow cylindrical housing having an inlet opening at one end for receiving the slurry to be heated and an outlet opening at the axially opposite end for discharging the heated slurry therefrom, and a heat exchanger through which a heating fluid is passed disposed within the housing so that the slurry passing axially through the housing must pass over said heat exchanger characterized in that said heat exchanger comprises:

a.) an elongated chamber mounted on a rotating shaft disposed coaxially within and extending through the housing;

b.) an inlet passage extending through said shaft and opening into said elongated chamber for passing the heating fluid into said elongated chamber; and

c.) an outlet passage extending through said shaft and opening into said elongated chamber for passing the heating fluid from said elongated chamber.

2. An apparatus for heating a highly viscous slurry as recited in Claim 1 further characterized by said elongated chamber having a plurality of surface extenders protruding radially outward from the external surface thereof to enhance heat exchange between the heating fluid and the slurry and to continuously stir the slurry as it passes through the housing.

3. An apparatus for heating a highly viscous slurry as recited in Claim 2 further characterized in that said surface extenders comprise pin-like protrusions mounted to the external surface of said elongated chamber.

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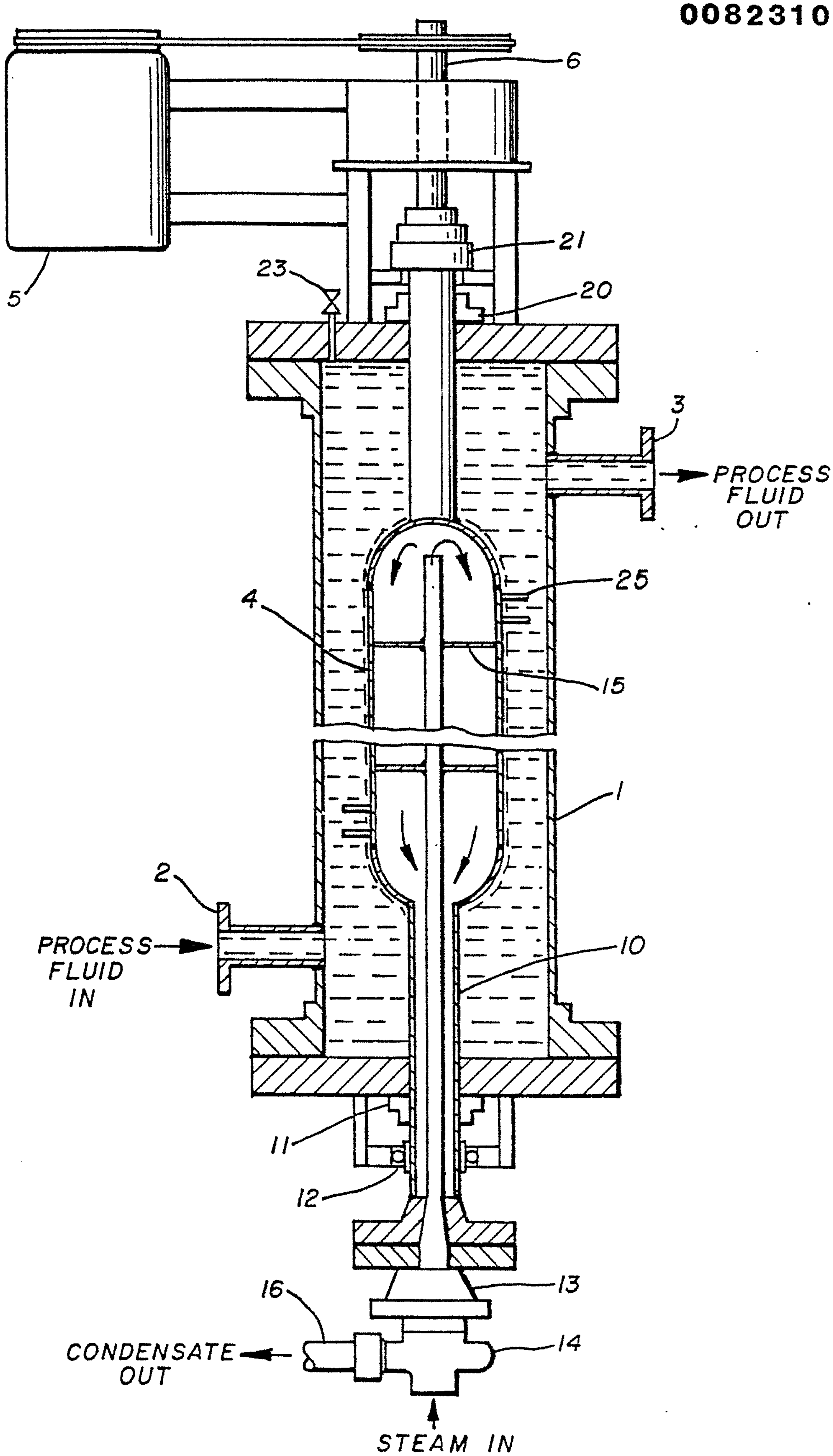

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