

UNIT FOR INJECTING A COKE-DEPOSITION INHIBITOR SOLUTION
INTO TUBULAR FURNACES FOR HYDROCARBON PYROLYSIS

Field of the invention

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The present invention relates to the petrochemical industry and is intended for use in plants for ethylene and propylene production by thermal cracking (pyrolysis) of hydrocarbon feedstock.

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Background of the invention

At present the world wide production of ethylene and propylene is based on the pyrolysis of hydrocarbon feedstocks in the presence of steam in furnaces with tubular coils. As feedstock ethane, propane-butane mixes, as well as naphtha and gas oil fractions are used. Usually a pyrolysis furnace has two sections: convection and radiant. Passing through the coil of the convection section feedstock is evaporated, mixed with steam and preheated to 550-650°C. In the subsequent radiant section this mixture is heated up to 750-950°C and cracked, thus forming ethylene, propylene, butylene and several by-products. The main problem of this process is formation and build-up of coke deposits on the coil walls of the radiant section. In most furnaces these coke deposits are removed by burning-out with steam and oxygen.

In some of the tubular pyrolysis furnaces coke deposition is prevented by introduction of an inhibitor into the process stream which includes, for example, alkaline-metal compounds. In most cases an inhibitor in the form of an aqueous solution or suspension of such compounds is injected into the hot feedstock flow via an

injection unit inserted close to the boundary between convection and radiant sections of the coil. In operation wall burn outs/perforation happen frequently in the zone of inhibitor solution injection. These burn outs are
5 caused by the impingement of droplets of inhibitor solution on the hot metallic walls close to the point of injection which produce multiple cycle temperature changes causing thermal metal fatigue and resultant furnace break down.

10 European Patent EP 0617112 A2 discloses injection unit for introducing a liquid coke inhibitor solution into tubular reactor for hydrocarbon pyrolysis incorporating a straight run of a coil with inlet pipe for supplying a feedstock, an inhibitor atomizer, a tube
15 for supplying an inhibitor to the atomizer and surrounding it an additional tube positioned coaxially. In this unit the latter tube surrounding the atomizer serves as a shroud protecting the coil walls from impingement by liquid inhibitor solution. This additional
20 tube in itself is not protected from droplets of inhibitor solution.

European Patent EP 0606898 B1 discloses a unit for introducing coke inhibitor solution into a tubular furnace for hydrocarbon pyrolysis which includes a
25 straight run of a coil with inlet pipe for supplying a feedstock, an injection nozzle for inhibitor atomizing and a tube for supplying an inhibitor to injection nozzle which is positioned in parallel to the flow of gaseous feed stream and can be moved along an axial direction. In
30 the operating position the nozzle is moved into the gaseous stream extending a distance of about 1-3 times the diameter of the coil straight run.

US Patent № 5435904 discloses the unit for

introducing a coke inhibitor solution into a tubular furnace for hydrocarbon pyrolysis which includes a straight run of a coil with inlet pipe for supplying a feedstock, an inhibitor atomizer, a tube for supplying an inhibitor to atomizer and surrounding it an additional tube positioned coaxially. To disperse a liquid via this unit a compressed gas is used which is supplied to the atomizer through an annular passageway between the inner and additional tubes.

10 US Patent № 4708787 discloses the unit to disperse a liquid throughout a gaseous stream. This unit includes a straight run of pipe equipped with inlet conduit together with an insert in the form of a Venturi tube for supplying a gas, a liquid atomizer and a tube for
15 supplying a liquid to the atomizer which are coaxially positioned within the pipe straight run, and that the atomizer is concentrically located within the throat of the Venturi tube.

US Patent № 3812029 discloses the unit for injection
20 of a liquid with susceptibility to coke formation into a vessel preheated to a high temperature. This unit includes an inner tube for supplying an injected liquid and surrounding it shroud in which water is introduced. The said inner tube and shroud end in a common nozzle
25 where the injected liquid and water are mixed prior to their introduction into the heated vessel.

USSR Inventor's Certificate № 1661189 A1 discloses a unit for purging the inner surface of a cylindrical branch pipe by air stream. This unit includes a tube for
30 supplying compressed air, positioned concentrically with the branch pipe, together with an annular nozzle fixed on the said tube forms the air stream in the shape of a hollow cone.

USSR Inventor's Certificate № 633892 discloses a unit for introduction of a coke deposition inhibitor into a tubular furnace for hydrocarbon pyrolysis. This unit includes inner and outer tubes positioned concentrically.

- 5 Preheated hydrocarbon feedstock flows through the inner tube. A gaseous coke inhibitor is introduced into the feed flow through a passageway between the inner and outer tubes.

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Summary of the invention

The invention resolves the problem of elimination of coil burn outs in the zone of inhibitor solution injection.

- 15 To solve this problem a unit for injecting a coke-deposition inhibitor solution into a tubular furnace for hydrocarbon pyrolysis, including a straight run of a coil with inlet pipe for supplying a feedstock, an inhibitor atomizer, a tube for supplying an inhibitor to atomizer
20 and surrounding it an additional tube positioned coaxially, is provided with a vortex gate for reducing a turbulence downstream from point of injection. The vortex gate is concentrically located within a straight run of a coil in the zone of inhibitor solution injection.

- 25 The vortex gate is an aerodynamic grid which divides the flow into individual streams aligned in parallel to the axis of the coil. Within a specific distance related to the diameter of the coil in a straight run downstream from the vortex gate flow turbulence decreases with a
30 corresponding reduction in radial drift rate of additions.

The radial drift rate of the inhibitor solution droplets from the flow stream core to the wall layer of

the coil decreases and evaporation of the droplets is completed before they reach the wall. This prevents the risk of coil wall burn out.

The preferred atomizer is the swirler. The advantage of the swirler is the axially symmetrical form of the atomized liquid cone which minimizes feed stock flow disturbance at the outlet of the vortex gate.

This preferred configuration of the invention also has the following features:

- 10 - The vortex gate consists of radial plates and cylindrical rings;
- The radial plates are attached symmetrically to the additional tube;
- The cylindrical rings are attached to the radial plates coaxially with the additional tube and form an inner passage which expands in stages in the direction of flow of feedstock;
- 15 - The vortex gate includes 3-5 cylindrical rings whose width increases in the direction of flow progressively from 0.25 to 0.9 times the inner diameter of the coil in the straight run;
- 20 - The distance from upstream edge of the plate to the nearest point of connection of an inlet branch pipe for supplying feedstock is not less
- 25 - than twice the inner diameter of the coil in its straight run.

Brief description of the drawings

30 The invention is further illustrated in the attached drawings. In Fig.1 the general view of the injection unit is shown and in Fig.2 the sectional view of vortex gate

is shown.

Description of the preferred embodiment

5 The injection unit comprises the straight run of a coil 1 with the flange 2, the inlet branch pipes 3, 4 and the insert assembly including the back flange 5, the inhibitor supply tube 6, the additional tube 7, the swirler 8 and the vortex gate formed by the radial plates 9 and cylindrical rings 10, 11, 12, 13. The insert
10 assembly is centred within the straight run of the coil 1 by the flange 2 and by projections of the radial plates 9. The cylindrical rings 10, 11, 12, 13 are attached to the radial plates 9 coaxially with the additional tube 7
15 and form inner passage which expands in stages in the direction of flow.

 The injection unit operates in the following way. Through the pipe branches 3 and 4 the feedstock flow coming from the convection section of the furnace (not
20 shown in drawings) enters into the straight run of the coil 1 of the furnace radiant section. The aqueous solution of coke-deposition inhibitor is delivered under pressure from an outside source (not shown in drawings) to the swirler 8 through the inhibitor supply tube 6 and
25 is injected into the feedstock flow. The cylindrical rings 10, 11, 12, 13 and the radial plates 9 form together the vortex gate which divides the feedstock flow into individual streams aligned in parallel to axis of the straight run of the coil.

30 As a result of the influence of the vortex gate on the feedstock flow its turbulence decreases downstream during a distance equivalent to 5-10 times the diameter of the coil in the straight run. In this zone the rate of

radial drift of additives also decreases. In consequence of this the rate of inhibitor solution droplets transfer from the core of feedstock flow to the wall decreases, and thus evaporation of droplets is completed before they reach the wall. Inhibitor particles formed after evaporation of the solution droplets do not cause damage to the coil walls on contact therewith.

The vortex gate includes four cylindrical rings, 10, 11, 12 and 13. Their width increases in ratio to the inner diameter of the coil in the straight run from 0.25 for ring 10 up 0.9 for ring 13. The widths of the rings have been developed from experimental data. The number of the rings has been chosen on the basis that the effectiveness of a vortex gate having less than 3 rings sharply decreases but vortex gate using more than 5 rings under the operating conditions of the injectors is undesirable because of restrictions generated in the flow cross section of the coil.

Preferably, the distance from the upstream edge of plate 9 to the closest point of junction of the feed stock supply line 4, is not less than twice the inner diameter of the coil. The effectiveness of the injection unit at that distance increases due to the additional decrease in flow turbulence intensity at the point of inhibitor injection.

Commercial applicability

The present invention can be applied in tubular furnaces for hydrocarbon pyrolysis where coking is prevented by injecting an inhibitor solution into the hot process stream.

When fabricating the units based on this invention

it is necessary to use materials which are capable of lengthy operation (tens of thousands of hours) when exposed to temperatures in the range 600 to 650°C without development of thermal brittleness. Steels of stable austenite structure incapable of structural changes under long exposure to heat must mainly be used, for example steels of 18-8 or 18-12 type stabilized by titanium or niobium.

Twelve units based on this invention were fabricated. These injection units were tested under operating conditions in 6 commercial pyrolysis furnaces, and the results were excellent. During more than two years not a single case furnace coil break-down in the region of unit location has occurred.



CLAIMS

That which is claimed is:

1. A unit for injecting a coke-deposition inhibitor
5 solution into tubular furnaces for hydrocarbon pyrolysis
including a straight run of a coil with inlet pipe for
supplying a feedstock, an inhibitor atomizer, a tube for
supplying an inhibitor to atomizer and surrounding it an
10 additional tube positioned coaxially, wherein for
reduction of turbulence the said injection unit is
provided with a vortex gate concentrically located within
a straight run of a coil in the zone of inhibitor
solution injection.

2. The injection unit of claim 1, wherein the
15 atomizer is swirler.

3. The injection unit of claim 1, wherein the vortex
gate consists of radial plates, which are attached
symmetrically to the additional tube, and of cylindrical
rings, which are attached to the radial plates coaxially
20 with the additional tube and form an inner passage, which
expands in stages in the direction of flow of feedstock.

4. The injection unit of claim 3, wherein the said
vortex gate includes 3-5 cylindrical rings, and the width
of the rings increases progressively in the direction of
25 flow from 0.25 to 0.9 times the inner diameter of the
coil in the straight run, from the first to last ring
accordingly.

5. The injection unit of claim 3, wherein the
distance from upstream edge of the said plate to the
30 closest point of junction of the nearest inlet branch
pipe for supplying a feedstock is not less than twice
the inner diameter of the coil straight run.