Coking.com Best Practices Seminar

Recent Advances in Delayed Coker Heater Technologies to Extend Run Lengths and Reduce Tube Metal Temperatures

April 24, 2002

Presented by

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Petro-Chem Development Co., Inc. offers the refining, petrochemical, offshore and onshore production industries, a unique and extensive line of heat transfer equipment and services. Petro-Chem is the only company of its kind with such a wide range of products and with markets throughout the world.

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Table of Contents

I. Two coking mechanisms dominate the internal fouling rates in delayed coker heaters

- Bulk cracking
- Film cracking

A. Bulk cracking

Normal or conventional coker heater analysis is based on bulk cracking models

- Minimize the bulk fluid time above 800°F

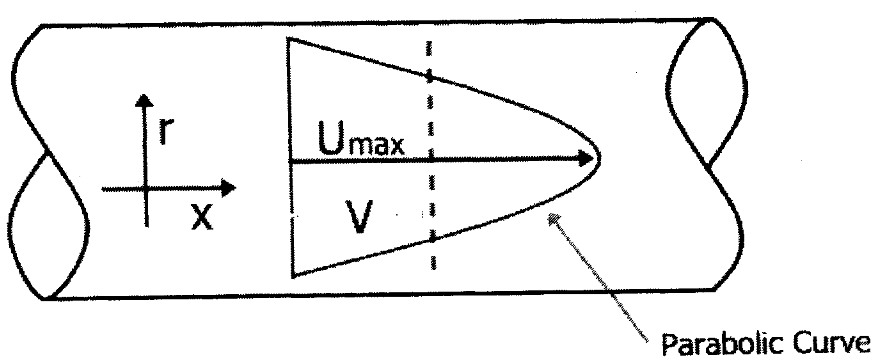
B. Film cracking - TRANSACTIONS OF THE ASME

"There is another type of decomposition produced in heaters, "Film Cracking", which is independent of mass decomposition and which occurs when the film is overheated because of higher heat inputs to the tubes than the charge can absorb. Film cracking can occur below temperatures of mass decomposition and may become serious where evaporation in the heater (two phase flow) forms a viscous emulsion of vapors and liquid with liquid as the outer phase. Film cracking, occurring when the charge is above the temperature of initial decomposition, may cause heavy coke deposits in the tubes and premature shutdown of the heater. A well designed heater not only must produce the desired time-temperature effects (bulk cracking analysis) but do this with linear and mass velocities and vaporization in the tube which will produce a sufficiently turbulent flow to tear up the film so that even if it is overheated temporarily or locally it is quickly quenched in the main flow."

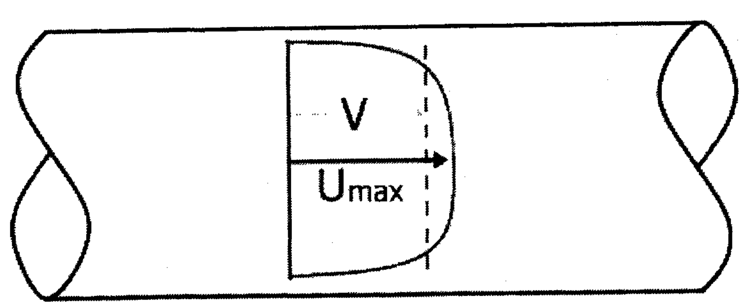
II. Film cracking

- The primary cause of elevated rates of tube side fouling
- Primary design variables influencing film cracking:
  - ✓ Flowing conditions at the tube wall
  - ✓ Peak radiant flux rate
  - ✓ Asphaltenes
  - ✓ Pressure
  - ✓ Bulk fluid and film temperature
  - ✓ Cracked heavy gas oil (CHGO) recycle rates and composition
  - ✓ Inside heat transfer rate

A. Flowing conditions at the tube wall



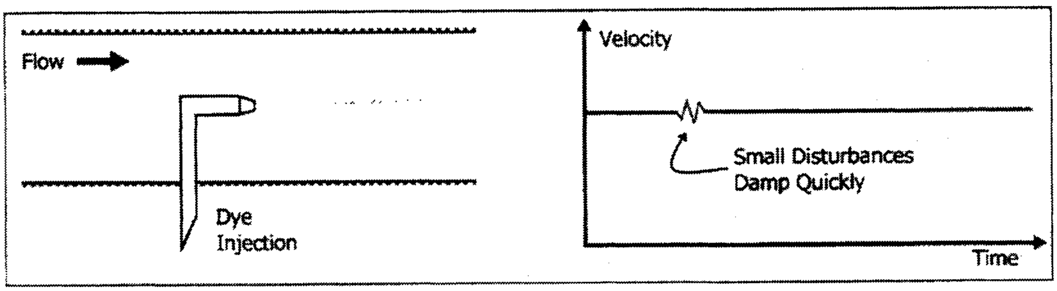
Pipe Flow Velocity - Laminar



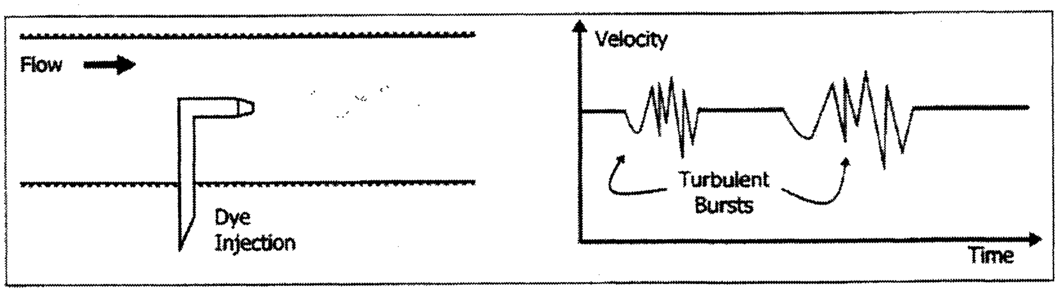
Pipe Flow Velocity - Turbulent

II. Film cracking (continued)

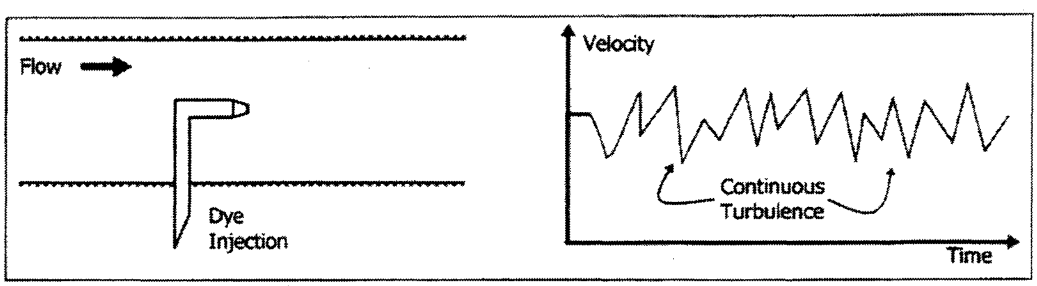
A. Flowing conditions at the tube wall (continued)



Dye Streak Visualization and Velocity Measurements – Laminar Flow



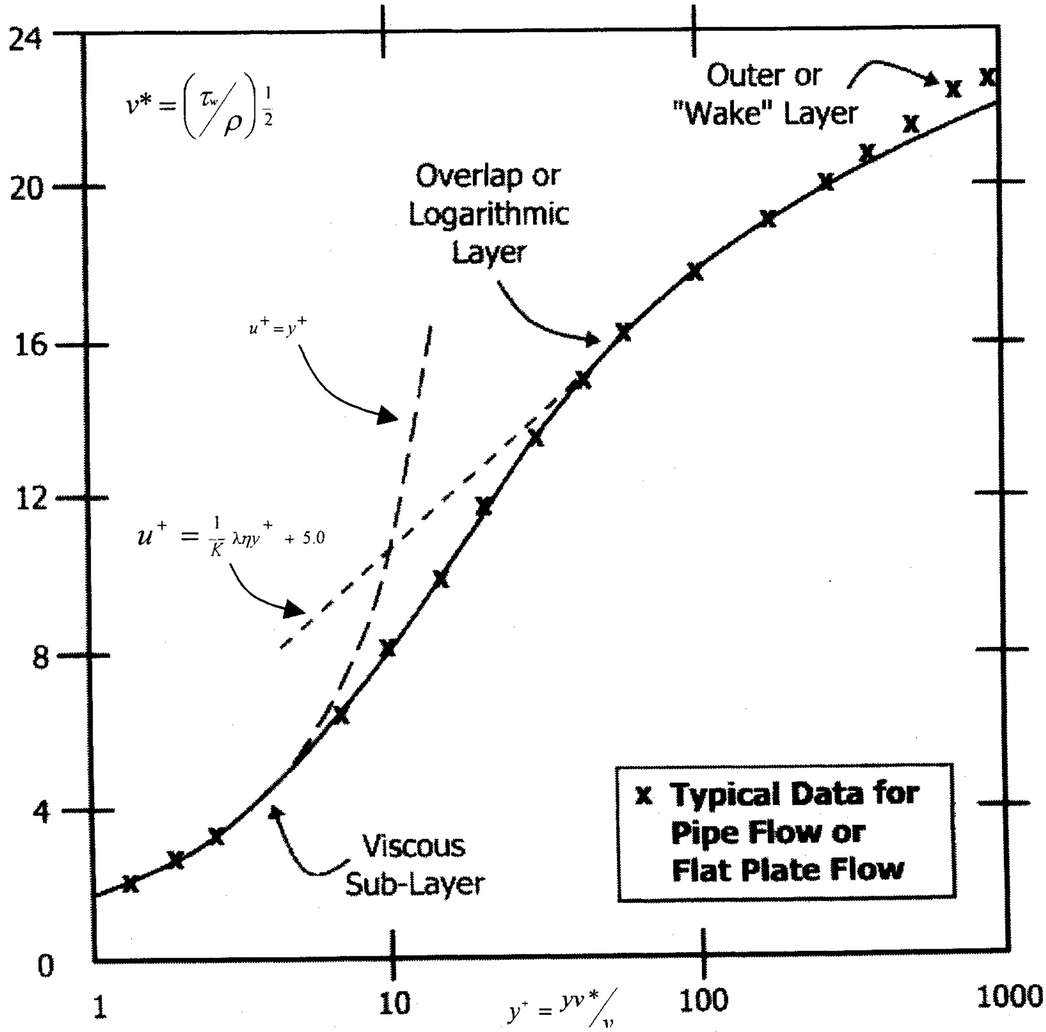
Dye Streak Visualization and Velocity Measurements – Transition Flow



Dye Streak Visualization and Velocity Measurements – Turbulent Flow

II. Film cracking (continued)

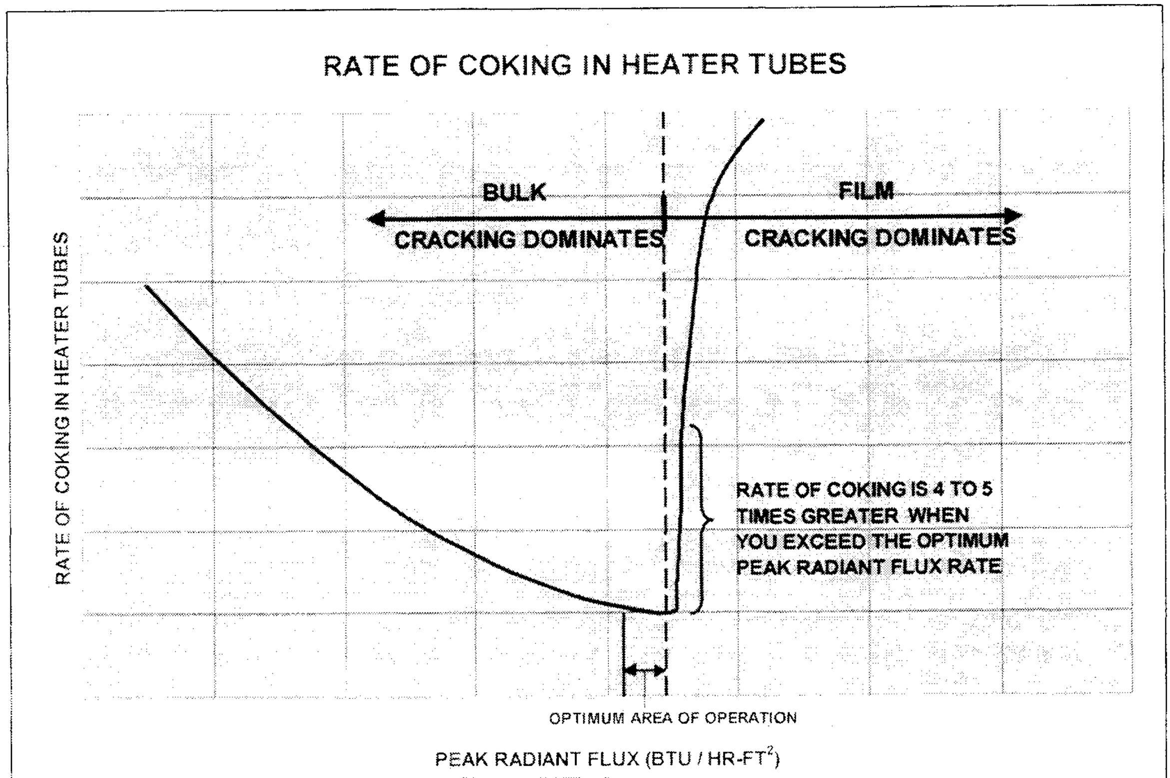
A. Flowing conditions at the tube wall (continued)



The Law-of-the-Wall for Turbulent Mean Flow Past a Smooth,

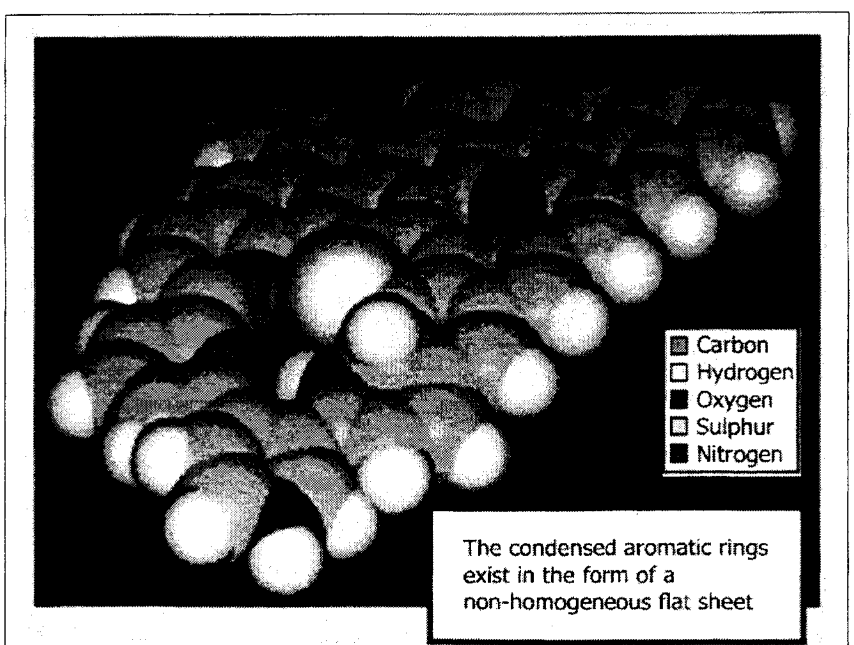
II. Film cracking (continued)

B. What is the allowable peak radiant flux rate for the film condition?



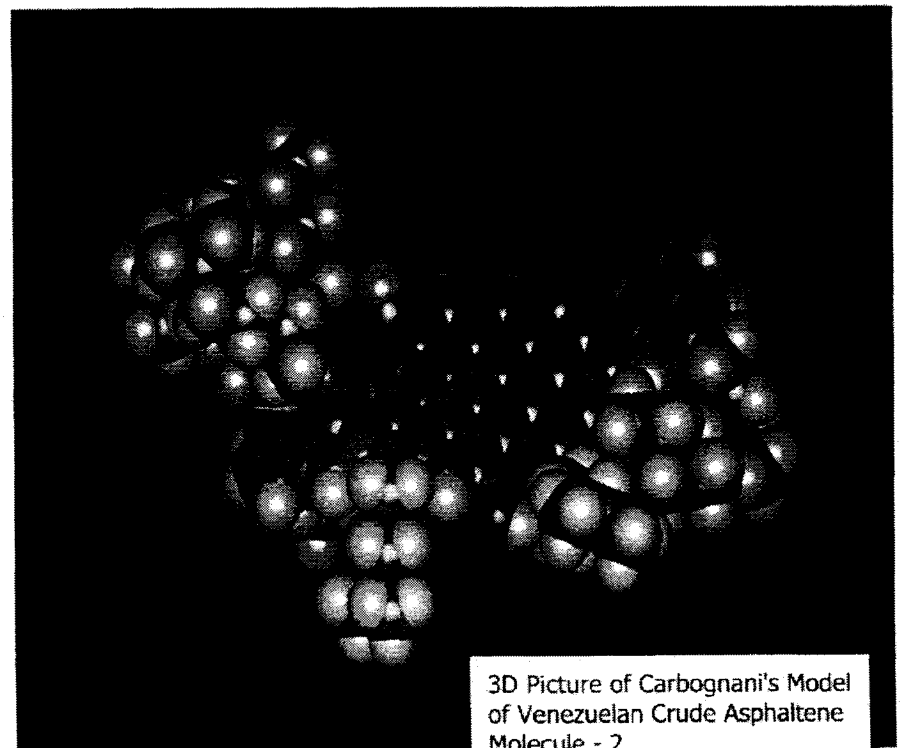
DON'T FALL OFF THE CLIFF ! ! !

C. Asphaltenes

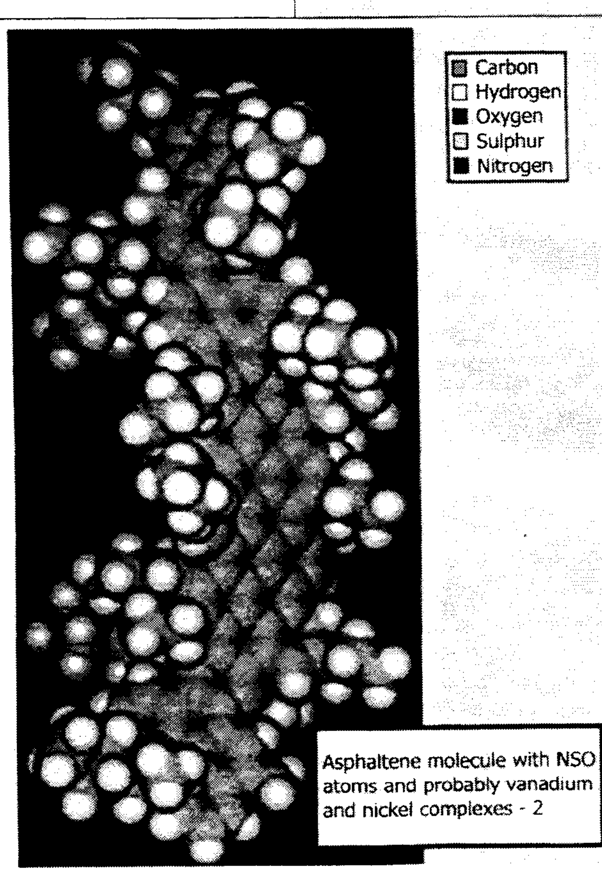


II. Film cracking (continued)

C. Asphaltenes (continued)



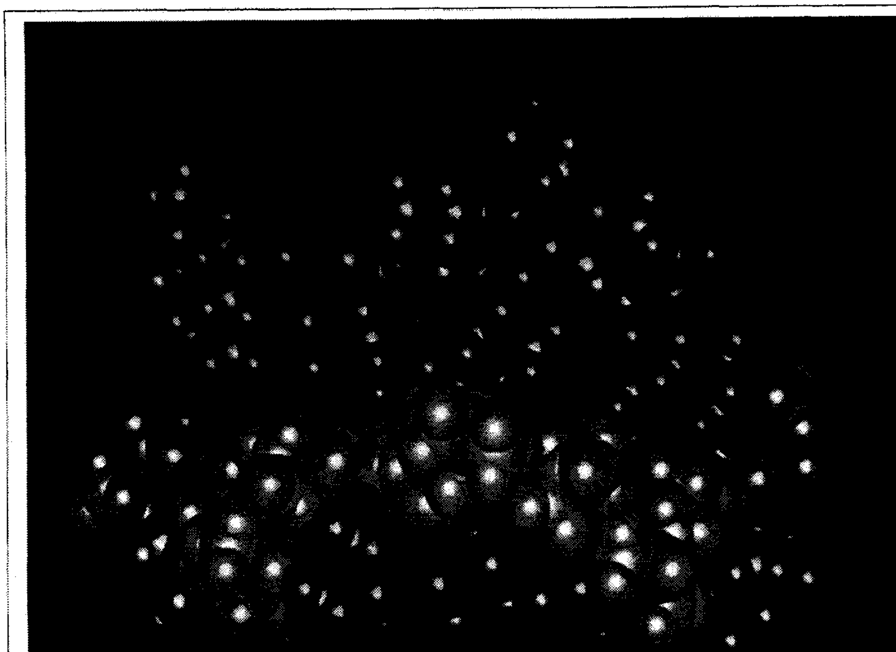
3D Picture of Carbognani's Model of Venezuelan Crude Asphaltene Molecule - 2
(Courtesy of Prof. J. Murgich)



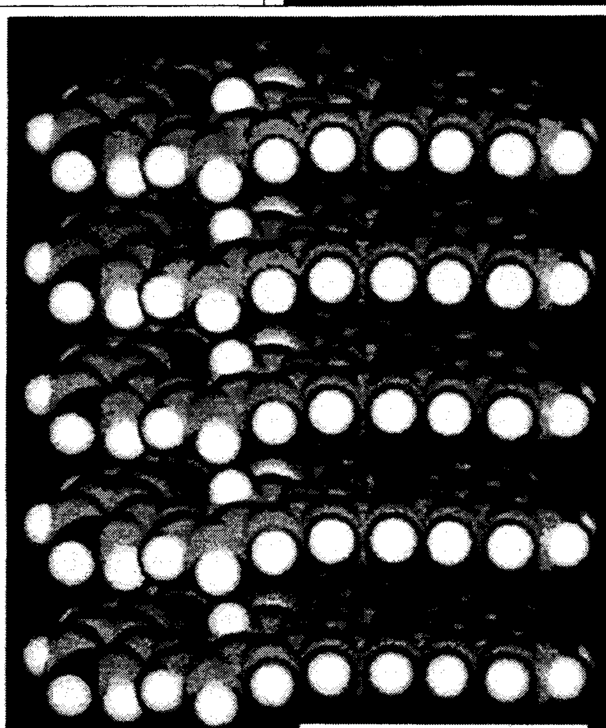
Asphaltene molecule with NSO atoms and probably vanadium and nickel complexes - 2

II. Film cracking (continued)

C. Asphaltenes (continued)



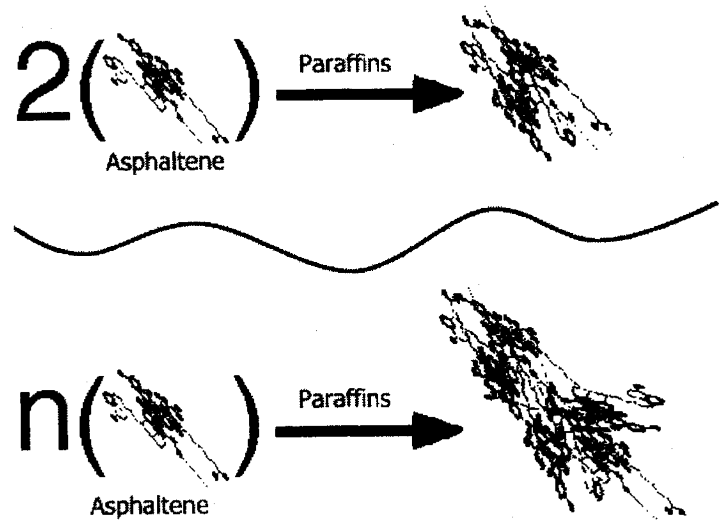
Flocculation/Aggregation of Venezuelan Crude Asphaltene Molecules - 2
(Courtesy of Prof. J. Murgich)



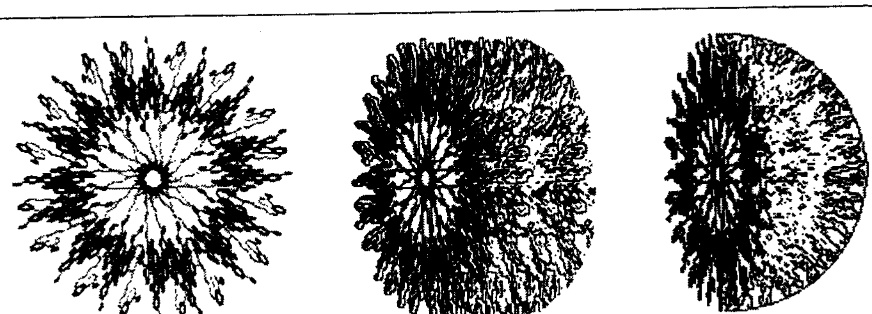
Asphaltene molecule - compact stack of thin sheets

II. Film cracking (continued)

C. Asphaltenes (continued)



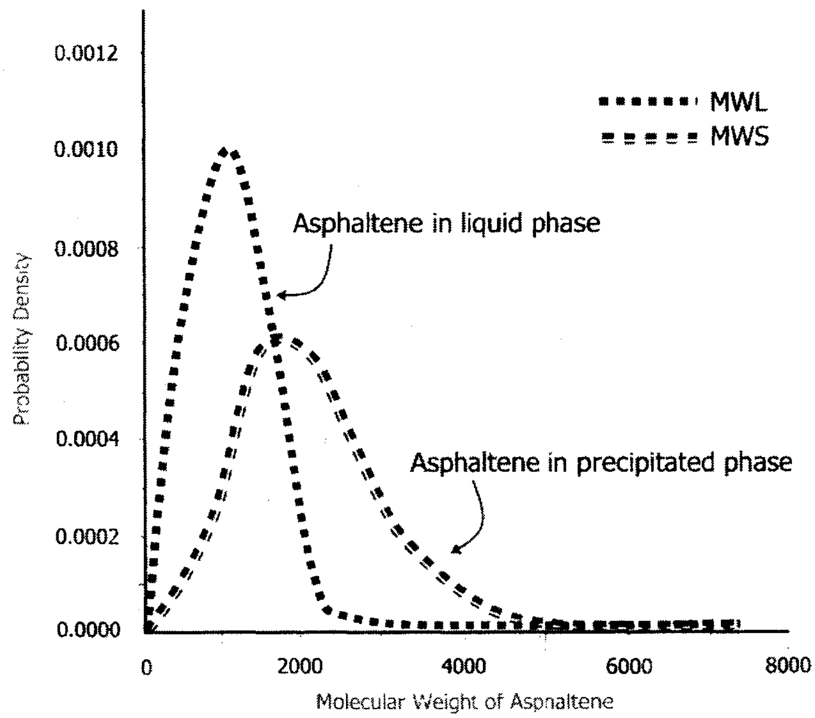
Various stages of asphaltene flocculation due to excess amounts of paraffins in the solution



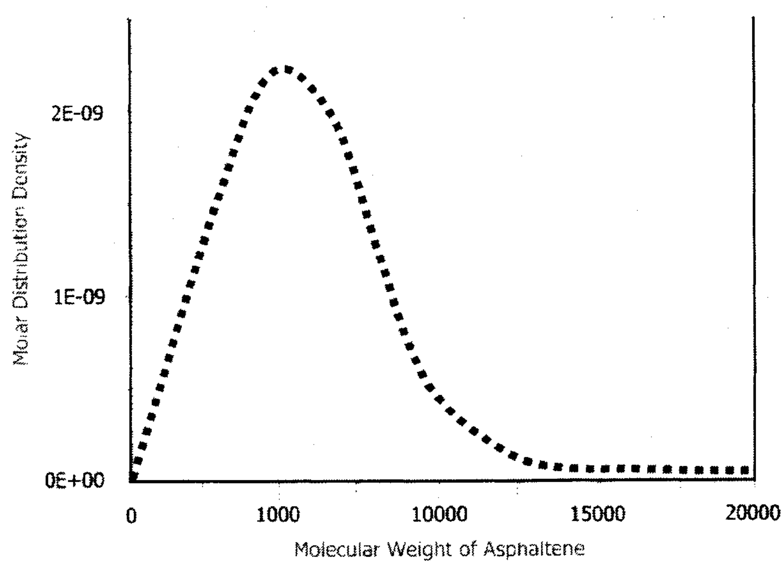
Various shapes of asphaltene micelles formed in the presence of large amounts of polar or aromatic solvents

II. Film cracking (continued)

C. Asphaltenes (continued)



Molecular size distribution of asphaltene of a California crude in solution and after precipitation by the addition of n-C5



Molecular weight distribution of asphaltene in the live crude oil A.

II. Film cracking (continued)

D. Pressure

E. Bulk fluid and film temperature

F. Cracked heavy gas oil (CHGO) recycle rates and composition

G. Inside heat transfer rate

H. Peak radiant flux rate

III. Conditions that influence Asphaltene destabilization and the formation of dry sludge on the heater tube wall

A. Higher Asphaltene concentration increases fouling rates

B. Higher pressures in the coil increase fouling rates

C. Higher bulk and film temperatures increase fouling rates

D. Lower CHGO recycle rates increase fouling rates

E. CHGO composition can increase fouling rates

F. Low inside heat transfer rates can increase fouling rates (low mass velocities in heater coil)

G. Higher peak radiant flux rates increase fouling rates

H. More velocity steam does not help and can actually increase fouling rates

I. Anti-foulants – <u>do not</u> reduce the fouling rates in delayed coker heaters

> Fouling rates are increased when the previous adverse conditions cause an overheating of the fluid film and form a dry sludge on the heater tube wall which is not mixed back into the bulk fluid.

IV. Results from case studies

V. *Petro-Chem Film Cooling Technologies* ™

A. Providing new "knobs" for operators to turn to:

1. Control the film
2. Control the flux

B. Producing **RESULTS**:

1. Increase capacity
2. Increase run lengths
3. Reduction in fouling rates
4. Reduction in tube metal temperatures
5. Increased tube life

C. Recent patents

1. Upflow Double Fired	Control the **film** and **flux**
2. Double Row, Double Fired	Control the **flux**
3. Feed Preheater and Controls	Control the **flux**
4. Circumferential Injection through Special Return Bends of CLGO/CHGO or Any Other Beneficial Fluid into the Fluid Film	Control the **film**
5. Adjustable Louvers	Control the **flux**
6. Insitu Flux Probe	Control the **flux**

See "Appendix Three: Petro-Chem Patents" for patent summaries

Appendix One: Information Inquiry Form

Information Inquiry

Petro-Chem Development Co., Inc.

Interest: (state your firm's needed technology or problem)

Name:

Firm:

Address:

Email:

Telephone:

Fax:

Please give your inquiry to Bill Gibson at the end of the presentation or mail it to:

Ms. Cindy Gildersleeve
Petro-Chem Development Co., Inc.
8310 East 73rd Street South
Tulsa, OK 74133

or email us at:

CGilders@Petro-ChemTulsa.com

Appendix Two: Partial List of delayed coker heater studies and revamps:

Sun Oil .... Tulsa, OK
Marathon Oil .... Robinson, IL
Marathon Oil .... Robinson, IL
Chevron.. Salt Lake City, UT
Citgo .... Lemont, IL
Marathon Oil .... Robinson, IL
Chevron.. Pascagoula, MS
Texaco .... Anacortes, WA
Tosco .... Rodeo, CA
Citgo .... Lemont, IL
Texaco .... Wilmington, CA
Chevron.. El Segundo, CA
Koch Refining... Pine Bend, MN
Clark Refining .... Hartford, IL
Koch Refining (Transfer Line Study) .... Pine Bend, MN
Citgo .... Lemont, IL
Koch Refining (21 Unit) .... Pine Bend, MN
BP Amoco .... Texas City, TX
Citgo Petroleum .... Lemont, IL
Clark Oil .... Hartford, IL
Clark Refining .... Hartford, IL
Citgo .... Lake Charles, LA
Shell Oil... Deer Park, TX
Koch Refining... Corpus Christi, TX

Appendix Three: Recent Petro-Chem Patents

Petro-Chem Film Cooling Technologies ™

1. Upflow Double Fired

2. Double Row, Double Fired

3. Feed Preheater and Controls

4. Circumferential Injection through Special Return Bends of CLGO/CHGO or Any Other Beneficial Fluid into the Fluid Film

5. Adjustable Louvers

6. Insitu Flux Probe

Please review the included patent summaries.

US006241855B1

(12) **United States Patent**
Gibson et al.

(10) **Patent No.: US 6,241,855 B1**
(45) **Date of Patent: *Jun. 5, 2001**

(54) **UPFLOW DELAYED COKER CHARGER HEATER AND PROCESS**

(75) Inventors: **William C. Gibson**, Tulsa; **Robert L. Gibson**, Broken Arrow; **James T. Eischen**, Tulsa, all of OK (US)

(73) Assignee: **Petro-Chem Development Co. Inc.**, New York, NY (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **09/379,775**

(22) Filed: **Aug. 24, 1999**

(51) Int. Cl.[7] **C10B 17/00**; C10B 1/04; F22B 21/24

(52) U.S. Cl. **202/124**; 202/127; 196/117; 122/174; 122/235.14; 122/236; 122/356

(58) Field of Search 208/132, 131, 208/50; 122/355, 511, 208, 235.4, 236, 174, 356; 202/124, 127; 196/117

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,002,149 * 1/1977 Yamamoto et al. 122/356
5,078,857 1/1992 Melton 208/132
5,284,438 * 2/1994 McGill et al. 431/9
5,656,150 * 8/1997 Reed et al. .... 208/48 R
6,095,097 * 8/2000 Gibson et al. 122/367.1

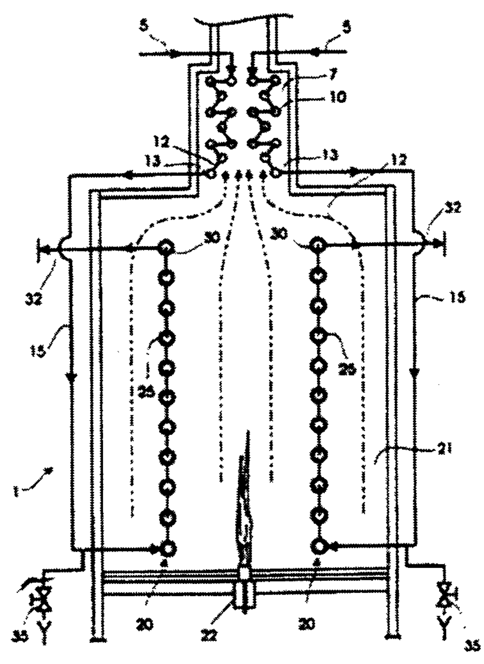
* cited by examiner

Primary Examiner—Bekir L. Yildirim
(74) *Attorney, Agent, or Firm*—Head, Johnson and Kachigian

(57) **ABSTRACT**

An improved process and article of manufacture to effectuate pressure reduction in a delayed coker charge heater's radiant heat section outlet and feedstock process coil, by upflowing coker feedstock through a single or double row, single or double fired, feedstock process coil. The innovative upflowing of coker feedstock as disclosed by the present invention allows BFW/Steam injection and vaporizing hydrocarbons to rise in the same flow direction as the coker feedstock, resulting in an enhanced mixing of fluid film and coker feedstock. Such enhanced mixing, in turn, increases heat transfer rates to the feedstock. As coker charge heater burners are commonly located in the bottom of the heater, the lower portion of the heater is typically the location of highest processing temperatures and tube side fouling. Upflowing the process coil places migrates the hottest processing section to a cooler location in the heater, and thus, contributes to conditions which reduce coking/fouling rates within the feedstock process coil, increase feedstock process coil tube life, reduce tube skin temperatures, and increase run time between decoking the interior portion of the feedstock process coil.

10 Claims, 5 Drawing Sheets



US006264798B1

(12) **United States Patent**
Gibson et al.

(10) **Patent No.:** **US 6,264,798 B1**
(45) **Date of Patent:** **Jul. 24, 2001**

(54) **DELAYED COKER CHARGE HEATER AND PROCESS**

(75) Inventors: **William C. Gibson**, Tulsa; **Robert L. Gibson**, Broken Arrow; **James T. Eischen**, Tulsa, all of OK (US)

(73) Assignee: **Petro-Chem Development Co. Inc.**, New York, NY (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/357,544**

(22) Filed: **Jul. 20, 1999**

(51) **Int. Cl.**[7] **C10B 17/00; C10B 1/04; F22B 21/24**

(52) **U.S. Cl.** **202/124; 202/127; 196/117; 122/174; 122/235.14; 122/236; 122/356**

(58) **Field of Search** 208/132, 131, 208/50; 122/355, 511, 208, 235.14, 236, 174, 356; 202/124, 127; 196/117

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,002,149 * 1/1977 Yamamoto et al. 122/356
5,078,857 1/1992 Melton 208/132
5,284,438 * 2/1994 McGill et al. 431/9
5,656,150 * 8/1997 Reed et al. .... 208/48 R
6,095,097 * 8/2000 Gibson et al. 122/367.1

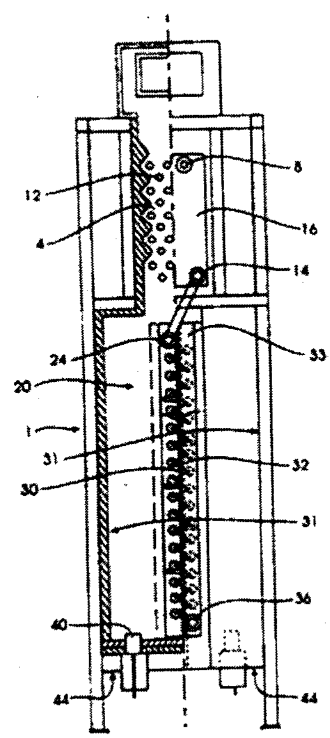
* cited by examiner

Primary Examiner—Bekir L. Yildirim
(74) *Attorney, Agent, or Firm*—Head, Johnson & Kachigian

(57) **ABSTRACT**

An improved process and article of manufacture to advance heater performance and reduce the cost of delayed coker charge heaters. Such improved performance is realized by routing delayed coker feedstock through a double row, double fired, heating conduit thus creating a channel to contain previously heated flue gas and resulting in the introduction of downflow, backside convective heat transfer to the interior portion of the heating conduit. When replacing the present art's single row coker tubes with the double row heating conduit afforded by the instant invention, the backside convective heat transfer introduced to the interior portion of the heating conduit eliminates the necessity of double firing the present art's single row coker heater tubes to achieve similar results.

13 Claims, 4 Drawing Sheets



US006245218B1

(12) **United States Patent**
Gibson et al.

(10) **Patent No.:** **US 6,245,218 B1**
(45) **Date of Patent:** **Jun. 12, 2001**

(54) **SYSTEM AND METHOD TO EFFECTUATE AND CONTROL COKER CHARGE HEATER PROCESS FLUID TEMPERATURE**

(75) Inventors: **William C. Gibson**, Tulsa; **Robert L. Gibson**, Broken Arrow, both of OK (US)

(73) Assignee: **Petro-Chem Development Co. Inc.**, New York, NY (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/387,056**

(22) Filed: **Aug. 31, 1999**

(51) **Int. Cl.**[7] **C10G 9/20**
(52) **U.S. Cl.** **208/131**; 202/153; 202/159
(58) **Field of Search** 208/50, 131, 132; 202/153, 159

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,661,241 * 4/1987 Dabkowski et al. 208/131
4,983,272 * 1/1991 Stavropoulos 208/50

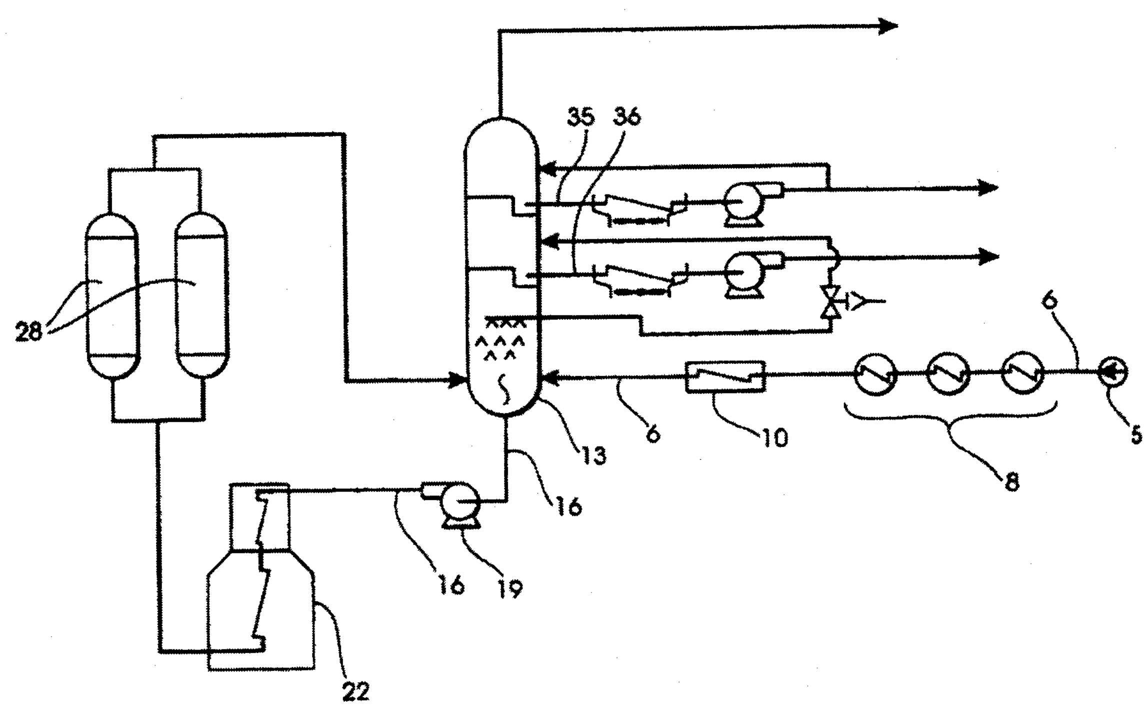
* cited by examiner

Primary Examiner—Bekir L. Yildirim
(74) *Attorney, Agent, or Firm*—Head, Johnson & Kachigian

(57) **ABSTRACT**

A system and method to improve the efficiency of delayed coker charge heating by effecting and controlling the temperature of a coker process fluid, prior to its introduction to a coker charge heater. In its preferred embodiment, the instant invention strategically positions and controls a pre-heater to automatically stabilize and minimize delayed coker charge heater firing rates. Said pre-heater's set point is derived by a feed forward control system that allows for the detection of process fluid temperature within a combination tower bottom, and communicates that temperature value to a pre-heater. Based upon the temperature value communicated to the pre-heater, the pre-heater intensifies, maintains, or decreases its firing to effect an operationally consistent combination tower bottoms temperature. By maintaining nearly constant combination tower bottoms temperature, a delayed coker charge heater derives enhanced operational efficiency and increases its life expectancy. Such benefits result from a nearly constant coker charge heater process fluid inlet temperature and optimized coker firing rates.

6 Claims, 6 Drawing Sheets



US006270656B1

(12) **United States Patent**
Gibson et al.

(10) **Patent No.:** **US 6,270,656 B1**
(45) **Date of Patent:** **Aug. 7, 2001**

(54) **REDUCTION OF COKER FURNACE TUBE FOULING IN A DELAYED COKING PROCESS**

(75) Inventors: **William C. Gibson**, Tulsa; **Robert L. Gibson**, Broken Arrow, both of OK (US)

(73) Assignee: **Petro-Chem Development Co., Inc.**, New York, NY (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/370,165**

(22) Filed: **Aug. 9, 1999**

(51) **Int. Cl.**[7] **C10G 9/16**

(52) **U.S. Cl.** .... **208/131; 208/48 R; 208/48 AA; 208/50**

(58) **Field of Search** .... 208/131, 132, 208/50, 48 R, 48 AA; 201/28, 29, 30

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,878,088 * 4/1975 Nahas et al. 208/50
4,455,219 * 6/1984 Janssen et al. 208/131
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4,549,934 * 10/1985 Graf et al. 196/98
4,661,241 * 4/1987 Dabkowski et al. 208/131
4,720,338 * 1/1988 Newman et al. 208/131
4,797,197 * 1/1989 Mallari 208/131
5,645,712 * 7/1997 Roth 208/131
5,824,194 * 10/1998 Kruse 201/29

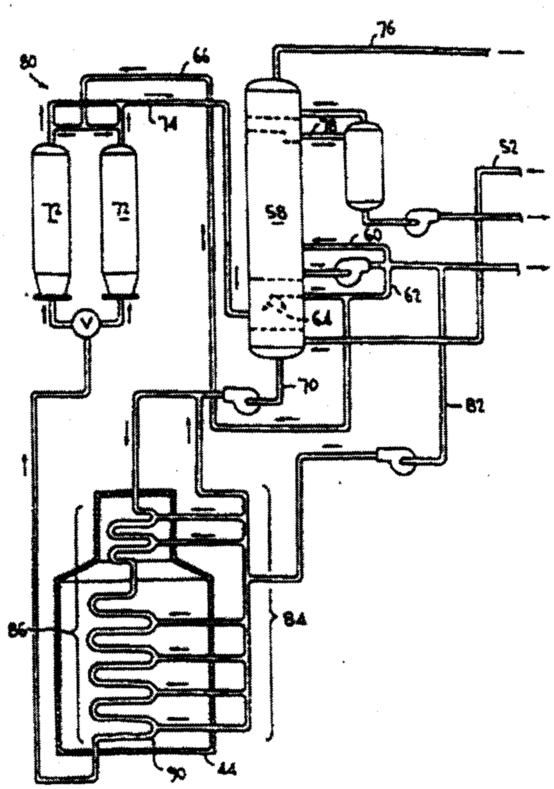
* cited by examiner

Primary Examiner—Bekir L. Yildirim
(74) *Attorney, Agent, or Firm*—Breiner & Breiner

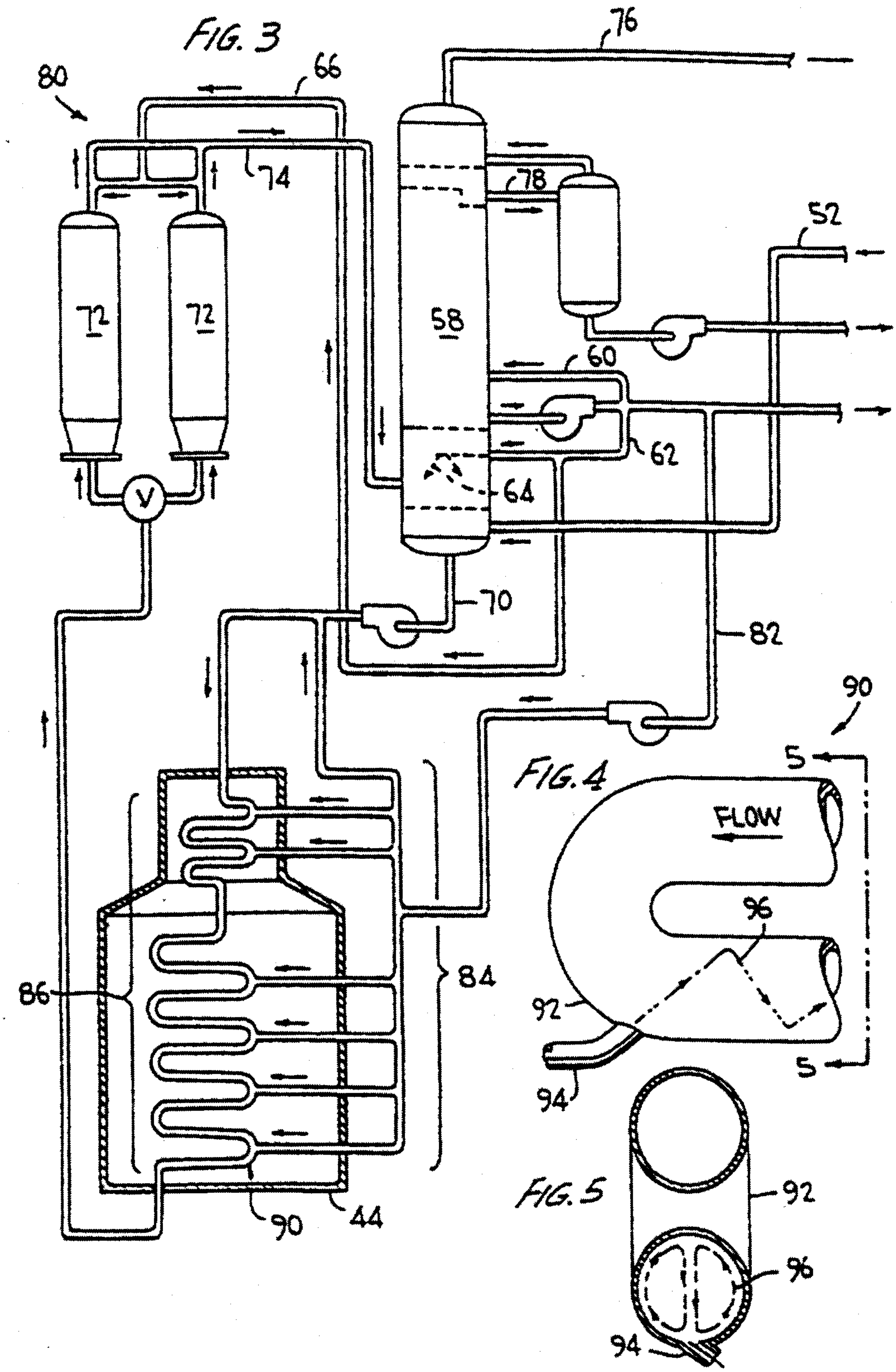
(57) **ABSTRACT**

In a delayed coking process, furnace tube fouling is minimized by including a measured amount of full boiling range heavy gas oil as an additive in the furnace feed, preferably by forced recycle from a heavy gas oil stream. An additive is preferably supplied directly to individual furnace tubes by multiple circumferential injection upstream of each tube receiving the additive.

3 Claims, 2 Drawing Sheets



U.S. Patent Aug. 7, 2001 Sheet 2 of 2 US 6,270,656 B1



US006095097A

United States Patent [19]

Gibson et al.

[11] Patent Number: 6,095,097

[45] Date of Patent: Aug. 1, 2000

[54] ADJUSTABLE LOUVER SYSTEM FOR RADIANT HEAT TRANSFER CONTROL IN A DIRECT-FIRED HEATER

[75] Inventors: William C. Gibson; James T. Eischen, both of Tulsa, Okla.

[73] Assignee: Petro-Chem Development Co., Inc., Tulsa, Okla.

[21] Appl. No.: 09/378,850

[22] Filed: Aug. 23, 1999

[51] Int. Cl.[7] F22B 23/06; F22B 37/10

[52] U.S. Cl. 122/367.1; 165/96; 165/DIG. 132

[58] Field of Search .... 122/44.2, 155.2, 122/503, 367.1, 367.2, 367.3; 432/175; 110/261, 262, 263, 264, 265; 165/96, DIG. 132, 904

[56] References Cited

U.S. PATENT DOCUMENTS

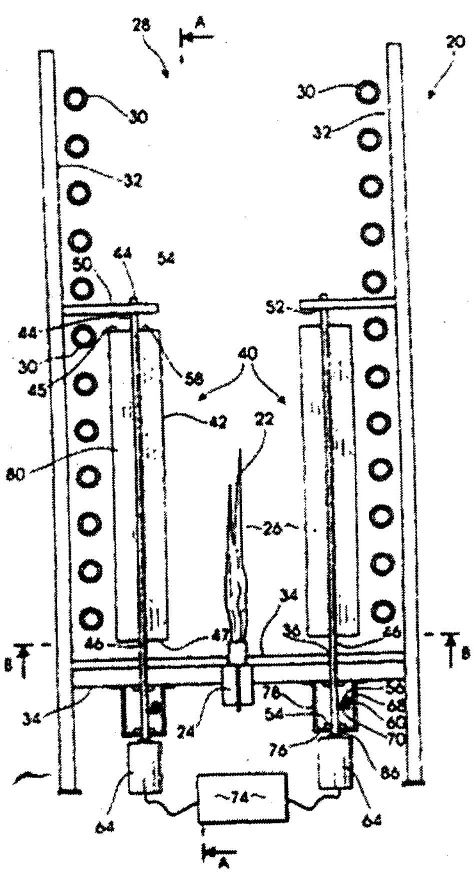
4,617,870 10/1986 Hirano et al 110/323
5,365,888 11/1994 Aronov 122/367.1

Primary Examiner—Denise L. Ferensic
Assistant Examiner—Jiping Lu
Attorney, Agent, or Firm—Head, Johnson & Kachigian

[57] ABSTRACT

An adjustable louver system for controlling the direct thermal radiation reaching fluid tubes in a direct-fired heater. An angular position of louver blades of the louver system is adjusted by rotating first and second axles attached to the louver blades. The louver blades may be positioned manually or by an electric or pneumatic motor. A hand crank or knob located outside the heater manually turns the louver blades. The motor, which is also located outside the heater, is controllable by a temperature actuator. In some embodiments, the louver blades have pivot pins which fit into slots of a connecting plate. Rotation of one of the louver blade causes the connecting plate to rotate all of the louver blades simultaneously. In some embodiments, the louver blades are vertically positioned and the louver axles fit into holes in upper and lower guide plates. In other embodiments, the louvers are horizontally disposed and the louver axles fit into openings in the heater walls.

16 Claims, 6 Drawing Sheets



US006325535B1

(12) **United States Patent**
Gibson et al.

(10) **Patent No.:** **US 6,325,535 B1**
(45) **Date of Patent:** **Dec. 4, 2001**

(54) **IN-SITU RADIANT HEAT FLUX PROBE COOLED BY SUCTION OF AMBIENT AIR**

(75) Inventors: **William C. Gibson; Mike Duffield; James T. Eischen, all of Tulsa; Robert L. Gibson, Broken Arrow, all of OK (US)**

(73) Assignee: **Petro-Chem Development Co., Inc., New York, NY (US)**

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/379,044**

(22) Filed: **Aug. 23, 1999**

(51) **Int. Cl.**[7] **G01K 17/00**
(52) **U.S. Cl.** **374/29; 374/141; 374/179; 122/504.2**
(58) **Field of Search** **374/179, 29, 141; 136/230, 233; 122/504.2**

(56) **References Cited**

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(57) **ABSTRACT**

A probe for determining the heat flux in a direct-fired heater. The direct-fired heater is under a vacuum pressure. This vacuum pressure induces a small quantity of ambient air through a ceramic insulating tube and eventually into the heater. The induced air cools an absorber head and receptacle, causing heat to flow from a target to a base. The target is an outer surface of the absorber head exposed to radiant heat inside the direct-fired heater. The base is that portion of the absorber head and receptacle which has a surface exposed to cooling air within the ceramic tube. The vacuum pressure inside the heater causes ambient air to be induced into a second end of the ceramic tube. Air passages at a first end of the ceramic tube cause the induced air to flow past the base and into the heater. A thermocouple is fitted into a cylindrical slot inside the receptacle. First and second thermocouple wires extend from the thermocouple to a weatherhead, which has electrical contacts which connect to the first and second thermocouple wires and to instrumentation, such as a digital meter or other input, output device such as a microprocessor or computer for monitor and control of heat flux. After measuring the thermocouple temperature in the receptacle, one can then determine the heat flux through the target by experimental correlations.

7 Claims, 3 Drawing Sheets