

In conventional tubular reactors heat is thus delivered to the reaction zone through the reactor walls.

Other than tubular furnaces solutions for pyrolysis equipment are known. Those include rotary reactors with complicated rotor blade arrangement. Costs for building and maintaining such equipment are higher than the profits that could be ever obtained by means thereof.

Traditional process for producing low-molecular weight hydrocarbons by thermal degradation thus encounters the following problems: 1. poor performance factor for tubular furnace reactors; 2. loss of valuable feedstock material; 3. long reaction times; 4. high secondary reactions rates; 4. high energy consumption; 5. non-optimum (less than possible) product yield and selectivity.

SUMMARY OF THE INVENTION

Embodiments of the invention alleviate above mentioned problems by implementing a novel method of thermal, thermo-chemical or catalytic thermo-chemical processing of feedstock, such as thermal cracking of hydrocarbon-containing compounds.

Embodiments of the present invention provide a rotary machine type reactor suitable for the pyrolysis of hydrocarbon-containing feedstock.

According to a first aspect of the present invention, there is provided a shock wave reactor for thermal cracking of hydrocarbon-containing feedstock, including: a casing wherein a duct is formed with at least one inlet and at least one outlet; a rotor the periphery of which contains an axial-flow blade cascade; wherein the casing substantially encloses the periphery of the rotor and a number of stationary vane cascades inside the duct, wherein the cascades are configured to direct feedstock containing process stream to repeatedly pass said cascades in accordance with helical trajectory while propagating within the duct between the inlet and outlet and to generate stationary shock-waves to heat the feedstock, and wherein the reactor comprises a number of catalytic surfaces.

According to a second aspect of the present invention, there is provided the use of the above reactors in executing at least one procedure selected from the group consisting of: processing hydrocarbon feedstock containing medium and light weight hydrocarbon fractions; processing gaseous, oxygen-containing, fatty acid-based feedstock material; processing gaseous, fatty-acid based feedstock material, which material is preprocessed pine oil; processing gaseous cellulose-derived, and in particular, lignocellulose-derived feedstock material; and fast pyrolysis process comprising converting biomass-derived feedstock material into oil.

According to a third aspect of the present invention, there is provided a reactor assembly, including at least one of the above reactors and at least one further element selected from the group consisting of: a drive engine, a heat recovery unit, a quenching unit, a pyrolysis furnace, a pyrolysis furnace with external heating, a pre-heating apparatus or an air filter.

According to a fourth aspect of the present invention, there is provided a pyrolysis plant including at least two of the above reactors, functionally connected in series or in parallel.

According to a fifth aspect of the present invention, there is provided a method for thermal, thermo-chemical or catalytic thermo-chemical processing of feedstock matter including: obtaining a shock wave reactor having a casing wherein a duct is formed with at least one inlet and at least one outlet, and a rotor, the periphery of which contains an axial-flow blade cascade, wherein the casing substantially encloses the periphery of the rotor and a number of stationary vane cascades inside the duct, and wherein the reactor comprises a number of catalytic surfaces; elevating the rotation speed of the rotor to reach a predetermined process speed or speed range; feeding the feedstock containing process stream into the inlet port, whereupon both stationary cascades and the rotor cascade begin directing the feedstock containing process stream to repeatedly pass through said cascades in accordance with helical trajectory while propagating within the duct between the inlet and outlet ports, and sequentially generating stationary shock-waves to heat the feedstock stream within the reactor, causing thermal degradation or pyrolysis thereof, and directing the pyrolyzed product stream through the outlet port to a predetermined post-processing unit.

According to a sixth aspect of the present invention, there is provided a method for importing energy for fast endothermic- or fast exothermic catalytic reaction produced from mechanical energy of rotating blade cascades, said method including: obtaining a shock wave reactor comprising a number of catalytic surfaces and passing a preheated, feedstock containing gaseous phase into the reactor to carry out endothermic gaseous phase reactions, wherein the heat is provided by impulses, generated by shock waves resulting from mechanical energy derived from rotation of internal rotor blades.

In one embodiment, the helical-path reactor comprises a rotor with a shaft and a disk provided with blades forming an axial-flow rotor blade cascade, a stationary directing ring-shaped rim optionally provided with at least two stationary vane cascades adjoining the axial-flow rotor cascade, and a casing. The outer surface of the directing rim arranged within the casing substantially defines the duct with the inner surface of the casing to remain there between.

Alternatively, at least some of the stationary vane cascades could be formed on the duct wall-defining inner surface of the casing, for example. Cross-section of the duct in the meridian plane forms a ring-shaped profile.

The duct may comprise several dividing partitions arranged in such a way to create several operational chambers. Operational chambers are preferably of equal size; however, other technical implementations are possible whether appropriate.

The reactor comprises at least one inlet port for feedstock stream and at least one outlet port for product stream. The inlet port is preferably arranged after each dividing partition in the direction of rotation of the rotor and the outlet port is preferably arranged before the dividing partition. The inlet and outlet ports may be integrated within the duct.

derived feedstock material; and fast pyrolysis process comprising converting biomass-derived feedstock material into oil.

29. A reactor assembly, comprising at least one reactor according to any of claims 1-27 and at least one further element selected from the group consisting of: a drive engine, a heat recovery unit, a quenching unit, a pyrolysis furnace, a pyrolysis furnace with external heating, a pre-heating apparatus or an air filter.

30. A pyrolysis plant comprising at least two reactors according to any of claims 1-27, functionally connected in series or in parallel.

31. A method for thermal, thermo-chemical or catalytic thermo-chemical processing of hydrocarbon-containing feedstock matter comprising:

- a. obtaining a shock wave reactor having
a casing wherein a duct is formed with at least one inlet and at least one outlet,
and
a rotor, the periphery of which contains an axial-flow blade cascade,
wherein the casing substantially encloses the periphery of the rotor and a
number of stationary vane cascades inside the duct, and
wherein the reactor comprises a number of catalytic surfaces;
- b. elevating the rotation speed of the rotor to reach a predetermined process speed or speed range;
- c. feeding the feedstock containing process stream into the inlet port, whereupon both stationary cascades and the rotor cascade begin directing the feedstock containing process stream to repeatedly pass through said cascades in accordance with helical trajectory while propagating within the duct between the inlet and outlet ports, and sequentially generating stationary shock-waves to heat the feedstock stream within the reactor, causing thermal degradation or pyrolysis thereof, and
- d. directing the pyrolyzed product stream through the outlet port to a predetermined post-processing unit.

32. The method of claim 31, wherein the method is applied for thermal cracking of hydrocarbon-containing feedstock.

33. The method of claim 31 or 32, wherein the duct has a substantially ring- shaped meridian section.

34. The method of any of claims 31-33, wherein the feedstock comprises medium or light weight hydrocarbon fractions.

35. A method for importing energy for fast endothermic- or fast exothermic catalytic reaction produced from mechanical energy of rotating blade cascades, said method comprising:

- a. obtaining a shock wave reactor comprising a number of catalytic surfaces and
- b. passing a preheated, feedstock containing gaseous phase into the reactor to carry out endothermic gaseous phase reactions,

wherein the heat is provided by impulses, generated by shock waves resulting from mechanical energy derived from rotation of internal rotor blades.

36. The method of claim 35, wherein the feedstock comprises medium or light weight hydrocarbon fractions.

37. The method of claim 35 or 36, wherein the feedstock is cellulose-derived or, in particular, lignocellulose-derived preprocessed biomass, supplied into the reactor in substantially gaseous form.