whereby a certain, predetermined rotational speed is assigned to a certain mass flow rate provided that feedstock composition is unchanged.

The solution proposed by Bushuev in US 9,494,038 B2 suggests adjusting geometries of the stationary vane cascades in circumferential direction to achieve pressure equalization at the entrance into the rotor blade cascade and at the exit therefrom throughout the entire blade cascade, with the reactor operating under nominal design conditions. Additionally, positions of the stator vane cascades may be adjusted, but only in circumferential direction with regard to the rotor rotation axis. Mentioned arrangement aims at mitigating the undesired large-scale mixing between the adjacent streams. Nevertheless, publication does not address the problem of reducing leakages in off-design operational modes.

In this regard, an update in the field of improving efficiency of rotary reactor apparatuses for chemical processing of hydrocarbon feedstocks, in particular, those of RDR type, is still desired, in view of addressing challenges associated with preventing or at least minimizing flow leakages, in order to optimize operating range and efficiency of the reactor under variable process conditions.

SUMMARY OF THE INVENTION

Embodiments of the present invention solve or to at least alleviate each of the problems arising from the limitations and disadvantages of the related art. Disclosed herein are various embodiments of an apparatus for processing feedstocks in a process fluid, a related arrangement, methods and uses.

According to a first aspect of the present invention, there is provided an apparatus for processing feedstocks in a process fluid, the apparatus including a rotor including a plurality of rotor blades arranged over a circumference of a disk mounted onto a rotor shaft and forming a rotor blade cascade; a plurality of stationary vanes arranged into essentially annular vane cascades adjacently disposed with regard to the rotor blade cascade such, as to form a stator-rotor-stator arrangement, and a casing, in which a duct is formed with at least one inlet and at least one exit, said casing enclosing the rotor blade cascade and the stationary vane cascades inside the duct, wherein position of the rotor blade cascade relative to stationary vane cascades in the stator-rotor-stator arrangement is adjustable in an axial direction along the rotor shaft by a predetermined distance (ΔX).

In an embodiment, position of the rotor blade cascade relative to stationary vane cascades in said stator-rotor-stator arrangement is adjustable through axially displacing the rotor in a longitudinal direction of the rotor shaft.

In an embodiment, said apparatus further comprises at least one thrust bearing element arranged on the rotor shaft, wherein the rotor is rendered axially displaceable through axial displacement of said at least one thrust bearing element on the rotor shaft.

In an embodiment, said at least one thrust bearing element is configured axially displaceable relative to the (reactor) casing.

In an embodiment, the thrust bearing element is accommodated in a separate housing, which is enclosed, at least partly, inside a bearing block, wherein the encased thrust bearing element is configured axially displaceable in a longitudinal direction of the rotor shaft in the related bearing block.

In an embodiment, a coupling arranged between the rotor shaft and a drive shaft is a flexible shaft coupling configured to render the drive shaft and/or the rotor shaft axially displaceable. Said flexible coupling thus enables axial displacement of the drive shaft and/or the rotor shaft.

In an embodiment, in said apparatus, the rotor is rendered axially displaceable through axial displacement of the drive shaft connected to the rotor shaft via the coupling.

In an embodiment, in said apparatus, position of the rotor blade cascade relative to stationary vane cascades in the stator-rotor-stator arrangement is adjustable through axially displacing at least one stationary component, in particular, the (reactor) casing, in a longitudinal direction of the rotor shaft. The drive shaft is preferably fixed, whereby its axial displacement is prevented.

In an embodiment, the coupling arranged between the rotor shaft and a drive shaft is a rigid coupling configured to render the drive shaft and the rotor shaft axially non-displaceable.

In an embodiment, each of the stationary vane cascades are secured on related bearing blocks arranged at both sides of the reactor (gas) casing.

In an embodiment, the apparatus is configured such that adjusting position of the rotor blade cascade relative to stationary vane cascades in the stator-rotor-stator arrangement is accompanied with adjusting at least a rotation speed of the rotor and/or a flow rate of a feedstock-containing process fluid.

In an embodiment, the apparatus further comprises a flow-shaping device arranged inside the (gas) casing in such a way that the duct is formed between the outer casing and the flow-shaping device, said duct has a ring-shaped meridional cross-section. In embodiment, said flow-shaping device is an annular, essentially hollow structure.

In an embodiment, in said apparatus, a vaneless space is formed between an exit from the stator-rotor-stator arrangement and an entrance thereto, said vaneless space being defined by a volume between the (gas) casing and the flow-shaping device.

In an embodiment, the stationary vane cascades are formed with a plurality of stationary nozzle guide vanes that form an annular nozzle guide vane cascade upstream the rotor blades and with a plurality of stationary diffuser vanes that form a diffuser vane cascade downstream the rotor blades.

In an embodiment, the cascades in the stator-rotor-stator arrangement are configured to direct the process fluid to repetitively pass through said cascades and through the vaneless space in accordance with a helical flow path while propagating within the duct between the at least one inlet and at least one exit and to establish conditions for at least one chemical reaction to occur in the process fluid.

In an embodiment, the apparatus further comprises a number of catalytic surfaces.

In some other aspects, use of said apparatus for processing feedstocks in a process fluid according to the embodiments are provided.

According to a second aspect of the present invention, there is provided use of the above apparatus in thermal processing of hydrocarbon-containing feedstock(s).

According to a third aspect of the present invention, there is provided use of the above apparatus for conducting chemical reactions.

According to a fourth aspect of the present invention, there is provided use of the above apparatus for thermal- or thermochemical cracking of hydrocarbon-containing feedstock(s).

According to a fifth aspect of the present invention, there is provided use use of the above apparatus for executing an at least one procedure selected from the group consisting of: processing hydrocarbon feedstock preferably containing medium and light weight hydrocarbon fractions; processing gasified carbohydrate-containing feedstock matter, processing gasified glyceride- and/or fatty acid-containing feedstock matter, and processing gasified cellulosic biomass material.

According to a sixth aspect of the present invention, there is provided an arrangement including at least two of the above apparatuses, at least functionally connected in parallel or in series.

According to a seventh aspect of the present invention, there is provided a method for improving process efficiency and for regulating flow losses during processing of feedstocks in a process fluid, in particular, in off-design conditions, including:

- obtaining an apparatus comprising: a rotor comprising a plurality of rotor blades arranged over a circumference of a disk mounted onto a rotor shaft and forming a rotor blade cascade; a plurality of stationary vanes arranged into annular vane cascades adjacently disposed with regard to the rotor blade cascade such, as to form a stator-rotor-stator arrangement; and a casing, in which a duct is formed with at least one inlet and at least one exit, said casing enclosing the rotor blade cascade and the stationary vane cascades inside the duct; and
- adjusting position of the rotor blade cascade relative to stationary vane cascades in the stator-rotor-stator arrangement in an axial direction along the rotor shaft by a predetermined distance (ΔX).

In embodiment, position of the rotor blade cascade relative to stationary vane cascades in said stator-rotor-stator arrangement is adjusted through axially displacing the rotor in a longitudinal direction of the rotor shaft.

In another embodiment, position of the rotor blade cascade relative to stationary vane cascades in the stator-rotor-stator arrangement is adjusted through axially displacing at least one stationary component, in particular, the casing, in a longitudinal direction of the rotor shaft.

The utility of embodiments of the present invention arises from a variety of reasons depending on each particular embodiment thereof. By providing a rotor displaceable in axial direction (viz., in a longitudinal direction of a rotor shaft), tip-clearance leakage–associated flow losses characteristic to known rotary-type reactors and/or turbomachines can be effectively prevented or at least minimized. In conventional rotary reactors, flow leakages trigger a range of secondary reactions leading to formation of the side products, such as coke, and reduce the yields of the primary (target) products.

Embodiments of the present invention have proved particularly useful in attempts to operate the rotary reactor apparatus designed for conducting (thermo)chemical reactions, such as (steam) cracking of hydrocarbons, in off-design mode, established upon modifying a range of parameters in the reactor (e.g. process temperature, which is often associated with adjusting rotational speed of the rotor, and/or chemical composition of the feedstock). The