ammonia as an energy carrier is that liquid ammonia is easier to transport and to store, relative to natural gas or hydrogen gas.

[0005] Green and blue ammonia can be produced at remote locations where feedstock cost is low or abundant. Green and blue ammonia are produced at remote locations where feedstock cost is low (*e.g.,* natural gas for blue ammonia) or abundant (*e.g.,* wind, solar, hydropower for green ammonia) “Green ammonia” is defined herein as ammonia made by a process that is 100% renewable and carbon free. “Blue ammonia” is defined herein as ammonia produced by a low carbon method, *e.g.,* natural gas stream reforming with carbon capture and underground storage.

[0006] It would be desirable to find a productive way of dissociating ammonia (NH_3) into relatively high purity hydrogen (H_2) and nitrogen (N_2), particularly so that the hydrogen can be used as a clean product and/or fuel source.

SUMMARY

[0007] Described herein are examples of an ammonia dissociation process and system that can substantially obviate one or more of the problems due to limitations and disadvantages of the related art.

[0008] Additional features and advantages of the examples will be set forth in the description which follows, and in part will be apparent from the description, or may be learned by practice of the described process and/or system. The objectives and other advantages will be realized and attained by the process and/or system particularly pointed out in the written description and claims hereof as well as the appended drawings.

[0009] In an aspect, provided is a process for dissociating ammonia into hydrogen and nitrogen that may include preheating a liquid ammonia feed in a first preheater to produce a preheated liquid ammonia stream while recovering heat from a dissociated hydrogen/nitrogen stream; vaporizing the preheated liquid ammonia feed to produce a vaporized ammonia stream; dissociating at least a

water to produce a hydrogen-nitrogen gas mixture and an aqueous ammonia solution; and feeding the aqueous ammonia solution to the ammonia distillation unit for recovery of unreacted ammonia and of the wash water.

[0023] In examples, disclosed is a process for dissociating ammonia into hydrogen and nitrogen that may include dissociating ammonia from a vaporized ammonia stream in isothermal conditions to produce a reactor effluent without temperature change across the reactor, while recovering heat from a dissociated hydrogen/nitrogen stream, and feeding the reactor effluent to a radiant tube reactor to dissociate ammonia present in the reactor effluent to output the dissociated hydrogen/nitrogen stream.

[0024] In another aspect, disclosed is a system for dissociation of ammonia into hydrogen and nitrogen that may include an ammonia dissociation furnace that may include a convection section and a radiant section. The system may include a preheater heat exchanger arranged to receive a liquid ammonia feed and a dissociated hydrogen/nitrogen stream, the preheater heat exchanger configured to transfer heat from the dissociated hydrogen/nitrogen stream to the liquid ammonia feed and produce a preheated ammonia stream. The system may include a vaporizer downstream of the preheater and configured to vaporize the preheated ammonia stream to produce a vaporized ammonia stream. The system may include a first reactor and configured to receive the vaporized ammonia stream, the first reactor including an adiabatic reactor or an isothermal unit. The system may include a radiant tube reactor located in the radiant section and downstream from the first reactor and configured to receive a reactor effluent from the first reactor and to output the dissociated hydrogen/nitrogen stream. The system may include a low-carbon fuel feed to the ammonia dissociation furnace from a pressure swing adsorption, an ammonia scrubber, the vaporizer, or a combination thereof.

[0025] In examples, the first reactor may include an adiabatic reactor comprising an inlet condition temperature ranging from about 500°C to about 750°C, and an outlet condition temperature ranging from about 300 to about 550°C; or an isothermal unit comprising an inlet condition temperature ranging

from about 300°C to about 650°C, and an outlet condition temperature ranging from about 300 to about 600°C.

[0026] The system may include a steam generation section that may include one or more coils in the convection section of the ammonia dissociation furnace configured to recover heat from the ammonia dissociation furnace and utilize the heat in the steam within the process.

[0027] In another aspect, disclosed is a system for dissociation of ammonia into hydrogen and nitrogen that may include an ammonia dissociation furnace that may include a convection section and a radiant reactor section. In examples the system may include an ammonia distillation reboiler section located in the convection section of the ammonia dissociation furnace, the ammonia distillation reboiler section thermally coupled to an ammonia distillation unit and including one or more coils configured to recover heat from the convection section of the ammonia dissociation furnace. The system may include an adiabatic reactor comprising one or more catalysts to dissociate ammonia and a reactor effluent. The system may include one or more radiant tubes located in the radiant reactor section of the ammonia dissociation furnace configured to receive the reactor effluent from the adiabatic reactor and output a dissociated hydrogen/nitrogen stream.

[0028] In examples, the system may include a heat exchanger functionally connected to a steam drum and arranged to produce steam by recovering heat from the dissociated hydrogen/nitrogen stream.

[0029] In examples, the system may include a gas turbine exhaust feed to one or more burners located in the ammonia dissociation furnace.

[0030] In examples, the system may include an ammonia scrubber coupled to the ammonia distillation reboiler section, the ammonia scrubber arranged to receive the dissociated hydrogen/nitrogen stream and configured to remove unreacted ammonia from the dissociated hydrogen/nitrogen stream with wash water to produce a hydrogen-nitrogen gas mixture and an aqueous ammonia solution, wherein the aqueous ammonia solution is directed to the ammonia distillation unit for recovery of an unreacted ammonia and of the wash water.

[0031] In another aspect, disclosed is a system for dissociation of ammonia into hydrogen and nitrogen that may include an isothermal unit and configured to receive a vaporized ammonia stream and to recover heat from a dissociated hydrogen/nitrogen stream, and a radiant tube reactor downstream the isothermal unit configured to receive a reactor effluent from the isothermal unit and to output the dissociated hydrogen/nitrogen stream.

[0032] In examples, the isothermal unit may include a reactor cum heat exchanger with an ammonia containing stream inlet condition temperature ranging from about 300°C to about 650°C, and an outlet condition temperature ranging from about 300 to about 600°C.

[0033] In examples, the radiant tube reactor may include one or more radiant tubes located in a radiant reactor section of an ammonia dissociation furnace comprising a convection section.

[0034] In examples, one or more of the above discussed systems may include an ammonia scrubber for receiving the dissociated hydrogen/nitrogen stream, the ammonia scrubber configured to remove unreacted ammonia from the dissociated hydrogen/nitrogen stream with wash water to produce a hydrogen-nitrogen gas mixture.

[0035] In examples, one or more of the above discussed systems may include a pressure swing adsorption unit configured to receive the hydrogen-nitrogen gas mixture from the ammonia scrubber, the pressure swing adsorption unit configured to purify the hydrogen-nitrogen gas mixture to give a hydrogen product stream having a hydrogen concentration ranging from 75 mol% to 99.99999 mol%.

[0036] In examples, the pressure swing adsorption unit may include a flue gas effluent directed to the ammonia dissociation furnace to be used as fuel.

[0036a] In another aspect, there is provided a process for dissociating ammonia into hydrogen and nitrogen, comprising:

feeding a vaporized ammonia stream to an adiabatic reactor comprising one or more catalysts to dissociate ammonia;

feeding an effluent reactor stream of the adiabatic reactor to one or more radiant tubes located in a radiant reactor section of an ammonia dissociation furnace to produce a dissociated hydrogen/nitrogen stream, wherein the ammonia dissociation furnace comprises a convection section; and

transferring heat from the convection section of the ammonia dissociation furnace to an ammonia distillation unit.

[0036b] In another aspect, there is provided a process for dissociating ammonia into hydrogen and nitrogen, comprising:

dissociating ammonia from a vaporized ammonia stream in isothermal conditions to produce a reactor effluent while recovering heat from a dissociated hydrogen/nitrogen stream; and

feeding the reactor effluent to a radiant tube reactor to dissociate ammonia present in the reactor effluent to output the dissociated hydrogen/nitrogen stream.

[0037] As further illustrated in the examples described in the description that follows, any two or more of the above recited process steps and/or system features may be combined.