Summary of the Invention

[0013] According to a first aspect of the present invention there is provided a steam delivery system for providing industrial steam, the system comprising:

a feedwater control system for providing a flow of feedwater;

a thermal energy storage apparatus in fluid communication with the feedwater control system to heat the feedwater flowing through a conduit of the thermal energy storage apparatus to provide steam; and

a desuperheater in fluid communication with the thermal energy storage apparatus to receive the steam and regulate the steam temperature;

a sparge system in fluid communication with the desuperheater;

such that in use, the steam delivery system provides industrial steam having at least one of a predetermined temperature and a predetermined pressure ; and

the steam delivery system operates in configurations comprising:

an excess-steam configuration, wherein at least a portion of the steam provided by the desuperheater is redirected to the sparge system;

a no-demand configuration, wherein the steam provided by the desuperheater is redirected to the sparge system.

[0014] Advantageously, the present inventors have developed a system and method as described herein for providing industrial steam at a predetermined temperature and/or a predetermined pressure, from a flow of feedwater having a variable temperature and/or a variable pressure and/or a variable flowrate. Furthermore, the system and method can advantageously accommodate a thermal energy storage apparatus operating at variable temperature (for example, the thermal energy storage apparatus may have a standby temperature and an operating temperature) and thereby producing steam of a variable temperature and/or a variable pressure. Yet further still, the system and method can advantageously adapt to a wide range of thermal energy storage apparatus.

Thermal energy storage apparatus

[0015] It will be appreciated by the skilled person that any thermal energy storage apparatus that is capable of transferring heat energy to a flow of feedwater will be suitable in the present invention. An example of the thermal energy storage apparatus is disclosed in PCT/AU2022/050031, which is incorporated by reference herein.

[0016] In preferred embodiments of the invention, the thermal energy storage apparatus comprises:

a sensible heat storage body having a heat exchanger channel and a heating element channel adapted to receive a removable heating element; and

a heat exchanger having an inlet and an outlet, wherein at least a portion of the heat exchanger is disposed along the channel.

kPaG and about 3000 kPaG, or about 3000 kPaG and about 3500 kPaG, or about 3500 kPaG to 4000 kPaG.

[0062] In an embodiment of the invention, the steam provided by the thermal energy storage apparatus has a variable flowrate. In preferred embodiments of the invention, the flowrate is from about 50 kg/h to about 2000 kg/h. For example, the flowrate is between about 50 kg/h and about 100 kg/h, or about 100 kg/h and about 150 kg/h, or about 150 kg/h and about 200 kg/h, or about 200 kg/h and about 250 kg/h, or about 250 kg/h and about 300 kg/h, or about 300 kg/h and about 350 kg/h, or about 350 kg/h and about 400 kg/h, or about 400 kg/h and about 450 kg/h, or about 450 kg/h and about 500 kg/h, or about 500 kg/h and about 550 kg/h, or about 550 kg/h and about 600 kg/h, or about 600 kg/h and about 650 kg/h, or about 650 kg/h and about 700 kg/h, or about 700 kg/h and about 750 kg/h, or about 750 kg/h and about 800 kg/h, or about 800 kg/h and about 850 kg/h, or about 850 kg/h and about 900 kg/h, or about 900 kg/h and about 950 kg/h, or about 950 kg/h and about 1000 kg/h, or about 1000 kg/h and about 1200 kg/h, or about 1200 kg/h and about 1400 kg/h, or about 1400 kg/h and about 1600 kg/h, or about 1600 kg/h and about 1800 kg/h, or about 1800 kg/h and about 2000 kg/h.

Steam storage unit

[0063] In an embodiment of the invention, the steam delivery system further comprises a storage unit in fluid communication with the desuperheater, such that the storage unit stores excess steam. In preferred embodiments of the invention, the stored steam is released to meet variable steam demand.

[0064] As discussed, the steam demand may vary from time to time. Advantageously, the steam storage unit can act as a buffer and provides a faster response than the thermal energy storage apparatus. For example, when the steam demand changes, it may take about 20 to 30 seconds for the thermal energy storage apparatus to respond to this change, while the steam storage unit can accommodate this change with a shorter response time. Furthermore, the peak steam demand may be higher than the maximum steam flowrate. Advantageously, the stored steam can then be released to meet the peak demand.

[0065] In preferred embodiments of the invention, the storage unit is a steam accumulator or a steam drum.

[0066] There is also disclosed a steam delivery system for providing industrial steam, the system comprising:

a feedwater control system for providing a flow of feedwater;

a thermal energy storage apparatus in fluid communication with the feed water control system to heat the feedwater flowing through a conduit of the thermal energy storage apparatus to provide steam;

a desuperheater in fluid communication with the thermal energy storage apparatus to receive the steam and regulate the steam temperature;

a sparge system in fluid communication with the desuperheater;

such that in use,

the steam delivery system provides industrial steam having at least one of a predetermined temperature and a predetermined pressure, and

the steam delivery system operates in configurations comprising:

an excess-steam configuration, wherein at least a portion of the steam provided by the desuperheater is redirected to the sparge system;

a no-demand configuration, wherein all the steam provided by the desuperheater is redirected to the sparge system.

[0067] According to a second aspect of the invention there is provided a method of providing industrial steam, the method comprising the steps of:

a) providing feedwater through a feedwater control system;

b) flowing the feedwater from the feedwater control system to a thermal energy storage apparatus to heat the feedwater to provide steam; and

c) desuperheating the steam to regulate the steam temperature;

d) sparging the steam provided by the desuperheater to a sparge system in configurations comprising:

an excess-steam configuration, wherein at least a portion of the steam provided by the desuperheater is redirected to the sparge system;

a no-demand configuration, wherein the steam provided by the desuperheater is redirected to the sparge system

to thereby provide industrial steam having at least one of a predetermined temperature and a predetermined pressure.

[0068] There is also disclosed a method of providing industrial steam, the method comprising the steps of:

a) providing feedwater through a feedwater control system;

b) flowing the feedwater from the feedwater control system to a thermal energy storage apparatus to heat the feedwater to provide steam; and

c) desuperheating the steam to regulate the steam temperature;

d) sparging the steam provided by the desuperheater to a sparge system in configurations comprising:

an excess-steam configuration, wherein at least a portion of the steam provided by the desuperheater is redirected to the sparge system;