

ENERGY HANDLING SYSTEM

Technical field of the invention

The present invention relates to the field of energy handling. More particularly, the present invention relates to systems, methods and applications for handling energy, such as for example storing, converting or transmitting energy, whereby the energy handling is performed with high efficiency and low losses.

Background of the invention

The consumption of energy as well as the demand for producing energy in an environmental friendly manner has been increasing over the last decades and - amongst others due to global warming – it is expected to further increase over the following years. It therefore is of utmost importance that energy handling is performed in an efficient manner and/or at low cost.

Energy handling may comprise one or more of a number of actions such as expansion and/or compression of a material, such as a fluid, introducing a phase transition in a material, storing of a material, converting energy from one form to another form, such as for example converting thermal energy into mechanical energy or vice versa, transmitting energy, etc.

Although a number of energy handling, storing and conversion systems have been explored over the last tens of years, there is still a quest for efficient energy handling systems.

Summary of the invention

It is an object of the present invention to provide a good system and method for handling energy, e.g. storing, transmitting or converting energy. It is an advantage of embodiments of the present invention that efficient systems and methods for handling energy are provided.

The above objective is accomplished by a method and apparatus according to the present invention.

In one aspect, the present invention relates to an energy handling system for converting, storing or transmitting energy. The energy handling system comprises a heat exchange unit for exchanging heat between a first substance and a second substance. The heat exchange unit comprises a first inner compartment and a second outer compartment. The first inner compartment and the second outer compartment are positioned adjacent each other and are being separated by a heat exchange surface. The heat exchange unit also comprises a balloon being mounted in the first inner compartment so as to form in the first inner

compartment a hermetically sealed volume between the outer surface of the balloon and the heat exchange surface. The hermetically sealed volume is being filled with the first substance and the balloon is being configured for being filled with a balloon fluid. The second outer compartment is being filled with the second substance.

5 The area of the heat exchange surface that is in contact with the first substance and the second substance remains substantially the same during the heat exchange process. It is an advantage of embodiments of the present invention that the energy handling system is based on a unit, which may be referred to as a HBVI-unit (Hydraulic Balloon Vessel Interface), which is a unit providing substantially the same heat exchange surface area during the heat
10 exchange process. This unique characteristic results in the fact that the energy conversion system can be performed with a high efficiency, i.e. with high yield. It is for example an advantage of systems according to embodiments of the present invention that little or no losses occur due to friction, since the HBVI unit does not substantially suffer from surfaces that are in contact with each other. Furthermore, since there is no friction, also wear of the balloon
15 can be reduced and/or avoided. The first inner compartment also may be referred to as the vessel. Where in embodiments of the present invention reference is made to the surface area of the heat exchange surface being substantially the same during the heat exchange process, this means that at least during 90% (for example during 95% or during 98%) of the time of heat exchange in the system, the surface area of the heat exchange surface that is in contact with
20 the first substance and the second substance varies less than 10% (for example varies less than 5%, for example less than 2%).

 According to some embodiments of the present invention, the system may furthermore comprise a controller for controlling one of the volume of the balloon fluid in the balloon or the second substance in the second outer compartment, for inducing a heat
25 exchange at the heat exchange surface.

 The controller may be programmed for controlling the heat exchange process to occur under substantially isentropic, isobaric, isothermic and/or polytropic conditions, during at least 50% of the heat exchange process, advantageously during at least 60% of the heat exchange process or at least 75% of the heat exchange process or at least 90% of the heat exchange
30 process. It is an advantage of at least some embodiments of the present invention that the conditions under which the heat exchange process can occur can be fully controlled, so that a substantially isothermic process, a substantially isentropic process, a substantially isobaric process, a polytropic process or a combination thereof can be selected and fully controlled.

The controller may be programmed for controlling the energy exchange process to occur under substantially the same temperature, i.e. isothermic. In one particular example operation at a substantially constant temperature of the fluid between the balloon and the vessel can for example be obtained, which may advantageously result in especially efficient energy conversion, e.g. heat exchange.

According to some embodiments, the balloon may be fixed at two positions in the first inner compartment to form the hermetically sealed volume but to further not touch the walls of the first inner compartment during the heat exchange process. It is an advantage of embodiments of the present invention that energy storage and/or energy conversion can be performed with low losses. It is for example an advantage that the system is not based on a moving piston, since the latter results in friction losses and no constant area of the energy exchange surface.

It is an advantage of embodiments of the present invention that by the use of a balloon in a vessel unit as configured as indicated in compressor applications described herein, the amount of dead space in the system is close to zero, resulting in an efficient energy conversion wherein nearly the full volume of the system is used for energy conversion.

The balloon may be pre-shaped so that the shape of the balloon, when the balloon is filled, fills a large part of the volume of the first inner compartment without touching the first inner compartment except at the two fixation points.

The balloon may be fixed in a pre-tensioned manner. It is an advantage of embodiments of the present invention that by fixing the balloon in a pre-tensioned manner, it is assured that no or less contact is present between the balloon and the vessel, also upon filling the balloon with the balloon fluid, thus allowing the area of the heat exchange surface to be and remain substantially constant during the heat exchange process.

According to at least some embodiments, the heat exchange process may be controlled for occurring at a pressure in the range 1 to 700 bar, e.g. in the range 200 to 700 bar, e.g. in the range 200 to 400 bar. It is an advantage of embodiments of the present invention that the pressure at which the heat exchange process is controlled may be selected so that an especially efficient system is obtained. It is an advantage of embodiments of the present invention that the pressure at which the heat exchange process is controlled may be selected so that the system can be kept compact in size, which typically results in a cost reduction.

The heat exchange process may be controlled for occurring with a maximum volume exchange of the balloon in the range 1.5 to 2.5 times, e.g. in the range 1.75 to 2.25 times. The

balloon may be made of a material allowing extension towards at least 250% of its volume, e.g. at least 300% of its volume, e.g. at least 350% of its volume, e.g. at least 400% of its volume, without breaking.

5 The second outer compartment may be isolated from the outer world by an isolation tube. The isolation tube may be an isolation tube providing an additional cavity around the second outer compartment, whereby the additional cavity may be under vacuum or for example filled with an isolation fluid.

10 In order to have a better heat handling, e.g. turbulence may be organised in one or more of the compartments, e.g. using an Archimedes screw. The latter results in mingling of the heat.

The heat exchange surface may be made of a pressure resistant material. The heat exchange surface may be made of any type of material such as for example a metal like aluminum or steel, a composite such as for example carbon-based composites, or alike. Selection of the material may depend on the temperature at which processing will be performed. Embodiments of the present invention are not limited by the materials that is selected, provided they are resistant to the pressures and the temperatures used for performing the heat exchange process.

20 The balloon fluid may be oil. The first substance may in some embodiments be a liquid, e.g. water.

The first substance may in some embodiments be a supercritical gas.

25 The second substance may be a liquid. The second substance may be a cold liquid or may be a warm liquid. In some embodiments, the second substance may be a gas. The heat exchange unit may be substantially cylindrically shaped and the first inner compartment and the second outer compartment may be configured as substantially concentric compartments. The compartments may be substantially cylindrically shaped. Alternatively, the compartment also may have any other suitable shape, such as for example droplet shaped.

The system may comprise a pumping unit for controlling the volume of the balloon fluid in the balloon.

30 In some embodiments, the heat exchange unit may be configured for allowing the system to operate as a compressor.

In some embodiments, the heat exchange unit may be configured for allowing the system to operate as an expander.

According to embodiments of the present invention, in the energy handling system, the heat exchange unit may be a first heat exchange unit, the balloon may be a first balloon

- and the balloon fluid may be a first balloon fluid, and the energy handling system further may comprise at least a first auxiliary balloon fluid reservoir and at least a first hydraulic pumping/motor unit for selectively controlling flow of the first balloon fluid to and/or from the first auxiliary balloon fluid reservoir from and/or to the first balloon. The controller may be
- 5 configured for controlling the thermodynamic process in the at least first HBVI by controlling at least the first hydraulic pumping/motor unit so as to induce different cycles of expansion and/or compression in the at least first heat exchange unit, the system thus providing subsequent cycles of expansion and/or compression, so as to control energy handling, such as converting, storing or transmitting energy.
- 10 The energy handling system furthermore may comprise at least a second heat exchange unit comprising a second vessel with a second balloon suspended therein, the second balloon defining a first sub-volume therein and a compartment in the second vessel outside the second balloon,
- 15 a second auxiliary balloon fluid reservoir, and a second hydraulic pumping/motor unit for selectively controlling flow of the second auxiliary balloon fluid to and from the second auxiliary fluid balloon reservoir, and
- 20 the first heat exchange unit and the at least a second heat exchange unit may be configured so that the first heat exchange unit is fluidically connected to the second heat exchange unit and allows flow of a fluid therebetween under control of the first hydraulic pumping/motor unit and the second hydraulic pumping/motor unit.
- The system may be configured for inducing different thermodynamic conditions at the same time in the first heat exchange unit and the second heat exchange unit for the fluid providing the fluidic connection, referred to as Kilianic conditions.
- The energy handling system may comprise a further number of heat exchange units
- 25 selectively linked to each other, configured and controlled to induce continuous operation of the energy handling system.
- The energy handling system may be configured as one or a combination of some of a compressor, or
- an expander, or
- 30 a heat pump for domestic use and wherein the controller is configured for operating in a temperature range between 0°C and 85°C, or
- a heat pump for industrial use wherein the controller is configured for operating in a temperature range between 40°C and 200°C, or

a heat engine, or
a system for separating fluid components out of a fluid, or
a liquification system, or
an energy stock piling system.

- 5 Where in the present invention reference is made to a heat exchange unit, reference may be made to a HBVI unit.

In one aspect, the present invention also relates to a method of handling energy, the method comprising inducing an energy exchange process using an energy handling system as described in the first aspect.

- 10 In one aspect, the present invention also relates to a method of producing mechanical energy, the method comprising controlling at least a first hydraulic pumping/motor unit for operating a system as described above as a heat engine.

- In one aspect, the present invention also relates to a method of producing heat, the method comprising controlling at least a first hydraulic pumping/motor unit for operating a
15 system as described above as a heat pump. The method may comprise distributing the produced heat to a plurality of different houses.

- In yet another aspect, the present invention relates to an energy handling system for converting, storing or transmitting energy, the energy handling system comprising
at least a first HBVI unit comprising a vessel with a balloon suspended therein, the balloon
20 defining a first sub-volume therein and a compartment in the vessel outside the balloon,
at least a first auxiliary fluid reservoir, and
at least a first hydraulic pumping/motor unit for selectively controlling flow of the first auxiliary fluid to and/or from the first auxiliary fluid reservoir;
the energy handling system further comprising a controller configured for controlling the
25 thermodynamic process in the at least first HBVI by controlling at least the first hydraulic pumping/motor unit so as to induce different cycles of expansion and/or compression in the at least first heat exchange unit, the system thus providing subsequent cycles of expansion and/or compression, so as to control energy handling, such as converting, storing or transmitting energy.

- 30 It is an advantage of embodiments of the present invention that an efficient and cost effective energy handling system can be obtained based on one or more HBVI units.
The controller may be configured for controlling at least the first hydraulic pumping/motor unit so as to operate the system as a heat pump. It is an advantage of embodiments of the

present invention that a heat pump can be obtained based on one or more HBVI units, resulting in efficient heat pump systems.

The controller may be configured for controlling at least the first hydraulic pumping/motor unit so as to perform said converting, storing or transmitting at least partly under isentropic, polytropic or isothermal conditions.

According to some embodiments, the energy handling system furthermore may comprise at least a second HBVI unit comprising a vessel with a balloon suspended therein, the balloon defining a first sub-volume therein and a compartment in the vessel outside the balloon, a second auxiliary fluid reservoir, and

10 a second hydraulic pumping/motor unit for selectively controlling flow of the second auxiliary fluid to and from the second auxiliary fluid reservoir;

and the at least a first HBVI unit and the at least a second HBVI unit may further be configured so that the compartment of the vessel of the first HBVI unit is fluidically connected to the compartment of the vessel of the second HBVI unit and allows flow of a third fluid between the compartments of the HBVI's under control of the first hydraulic pumping/motor unit and the second hydraulic pumping/motor unit,

15 According to some embodiments, the controller may be configured for controlling the first hydraulic pumping/motor unit and the second hydraulic pumping/motor unit so as to perform said converting, storing or transmitting at least partly under kilianic conditions.

20 Kilianic conditions or a kilianic process may be defined as a set of conditions or a process wherein steps are performed under different thermodynamic conditions in different HBVI's on a fluid present in the fluidic connection between at least two interconnected HBVI units.

According to some embodiments, the controller may be configured for repeatedly performing the following steps – thus referred to as a kilianic process - :

- 25 - compressing of the third fluid in the compartment of the first HBVI unit thus inducing energy exchange, such as for example heating of the third fluid and increasing the pressure to a first predetermined pressure in compartment of the first HBVI unit
- displacing the third fluid from the compartment of the first HBVI unit to the compartment of the second HBVI unit by driving the first hydraulic pumping/motor unit as a pumping unit and driving the second hydraulic pumping/motor unit as a motor unit
- 30 - allowing the third fluid to expand in the compartment of the second HBVI unit till the third fluid reaches a second predetermined temperature and to a second predetermined pressure, and

- displacing the third fluid from the compartment of the second HBVI unit to the compartment of the first HBVI unit by driving the second hydraulic pumping/motor unit as a pumping unit and driving the first hydraulic pumping/motor unit as a motor unit.

5 It is an advantage of embodiments of the present invention that by accurately controlling the first and second hydraulic pumping/motor units, the processes occurring in the HBVI units can be tuned for obtaining selected operation of the HBVI units.

Said compressing may comprise compressing of the third fluid in the compartment of the first HBVI unit thus heating the third fluid to a first predetermined temperature, by driving the first hydraulic pumping/motor unit as a pumping unit and blocking the second hydraulic
10 pumping/motor unit, and further compressing the third fluid in the compartment of the first HBVI unit thus increasing the pressure to a first predetermined pressure in compartment of the first HBVI unit by driving the first hydraulic pumping/motor unit as a pumping unit and blocking the second hydraulic pumping/motor unit.

15 It is an advantage of embodiments of the present invention that particular temperature and pressure conditions can be maintained in the HBVI's used in the system for inducing an efficient process.

Allowing the third fluid to expand may comprise allowing the third fluid to expand in the compartment of the second HBVI unit till the third fluid reaches a second predetermined
20 temperature and a by driving the second hydraulic pumping/motor unit as motor unit and blocking the first hydraulic pumping/motor unit, allowing the third fluid to further expand in the compartment of the second HBVI unit to a second predetermined pressure by driving the second hydraulic pumping/motor unit as motor unit and blocking the first hydraulic pumping/motor unit.

25 Allowing the third fluid to further expand may comprise allowing the third fluid to further expand isothermally.

The energy handling system may be configured as a heat pump for domestic use and wherein the controller is configured for operating in a temperature range between a lower limit and a higher limit. The lower limit may for example be between -10°C and +10°C, e.g. between -
30 30°C and + 20°C or even between -30°C and +35°C. The upper limit may for example be between 40°C and 90°C , e.g. between 50°C and 85°C. Operating in this temperature range means that both the temperature at which heat is captured (source temperature) and the temperature at which heat is delivered falls within this range.

The energy handling system may be configured as a heat pump for industrial use wherein the controller is configured for operating in a temperature range between 40°C and 250°C, e.g. between 40°C and 200°C.

5 The at least first and second hydraulic pumping/motor unit may be closed loop hydraulic systems.

The heat pump further may comprise a third to eighth HBVI, coupled to the first HBVI and the second HBVI and controlled so as to perform similar actions as in the first and second HBVI in a delayed manner, the resulting generated heat being a substantially continuous heat flow.

10 The controller may be configured for controlling the first hydraulic pumping/motor unit and the second hydraulic pumping/motor unit so as to operate the system as a heat engine.

The controller may be configured for repetitively performing :

compressing of the third fluid in the compartment of the second HBVI unit thereby increasing the pressure to a first predetermined pressure in compartment of the second HBVI unit using the second hydraulic pumping/motor unit,

15 displacing the third fluid from the compartment of the second HBVI unit to the compartment of the first HBVI unit by driving the second hydraulic pumping/motor unit as a pumping unit and driving the first hydraulic pumping/motor unit as a motor unit

allowing the third fluid to expand in the compartment of the first HBVI unit till the third fluid reaches a second predetermined pressure,

20 displacing the third fluid from the compartment of the first HBVI unit to the compartment of the second HBVI unit by driving the first hydraulic pumping/motor unit as a pumping unit and driving the second hydraulic pumping/motor unit as a motor unit.

It is an advantage of embodiments of the present invention that by accurately controlling the first and second hydraulic pumping/motor units, the processes occurring in the HBVI units

25 can be tuned for obtaining selected operation of the HBVI units.

The system may be configured for inducing different thermodynamic conditions at the same time for the fluid in the first heat exchange unit and the second heat exchange unit, referred to as Kilianic conditions.

30 At least part of the process may be performed under isentropic, polytropic or isothermic or kilianic conditions. According to embodiments of the present invention, particular temperature and pressure conditions can be maintained in the HBVI's used in the system for inducing an efficient process.

In some embodiments, said expanding may be isothermic expanding.

The energy handling system may be configured as one or a combination of some of

- a compressor, or
an expander, or
a heat pump for domestic use and wherein the controller is configured for operating in a temperature range between 0°C and 85°C, or
- 5 a heat pump for industrial use wherein the controller is configured for operating in a temperature range between 40°C and 200°C, or
a heat engine, or
a system for separating fluid components out of a fluid,
a liquification system, or
- 10 an energy stock piling system.
- The energy handling system may comprise a further number of heat exchange units selectively linked to each other, configured and controlled to induce continuous operation of the energy handling system.
- In one aspect, the present invention also relates to energy produced using a system as
- 15 described above. The energy may be heat. The energy may be any of mechanical or chemical energy.
- In another aspect, the present invention also relates to a method of producing mechanical energy, the method comprising controlling at least a first hydraulic pumping/motor unit for operating a system as described above as a heat engine.
- 20 In still another aspect, the present invention also relates to a method of producing heat, the method comprising controlling at least a first hydraulic pumping/motor unit for operating a system as described above as a heat pump.
- The method may comprise distributing the produced heat to a plurality of different houses.
- Although there has been constant improvement, change and evolution of devices in
- 25 this field, the present concepts are believed to represent substantial new and novel improvements, including departures from prior practices, resulting in the provision of more efficient – including more cost efficient -, stable and reliable devices of this nature.
- The above and other characteristics, features and advantages of the present invention will become apparent from the following detailed description, taken in conjunction with the
- 30 accompanying drawings, which illustrate, by way of example, the principles of the invention. This description is given for the sake of example only, without limiting the scope of the invention. The reference figures quoted below refer to the attached drawings.

Brief description of the drawings

FIG. 1 is a schematic representation of an energy handling system in accordance with embodiments of the present invention.

FIG. 2 is an example of a hydraulic balloon – vessel interface system as can be used in
5 an energy handling system according to embodiments of the present invention.

FIG. 3 illustrates cross-sectional views of different hydraulic balloon-vessel interface systems, according to embodiments of the present invention.

FIG. 4 illustrates different ways for connecting the balloon in the vessel in a pre-tensed manner, according to embodiments of the present invention.

10 FIG. 5 illustrates conditions under which an energy handling system according to embodiments of the present invention can be operated, thus resulting in a polytropic process (lefthand side), an isobaric process (central image) and an isothermic process (righthand side).

FIG. 6 illustrates a schematic overview of an energy handling system based on a single HBVI in accordance with embodiments of the present invention.

15 FIG. 7 illustrates a schematic overview of an energy handling system based on two HBVIs in accordance with embodiments of the present invention.

FIG. 8 illustrates a schematic overview of an energy handling system based on four HBVIs in accordance with embodiments of the present invention.

20 FIG. 9 illustrates a schematic overview of an energy handling system based on eight HBVIs in accordance with embodiments of the present invention.

FIG. 10 illustrates how a fluid/fluid interface as can be used in embodiments of the present invention.

FIG. 11 illustrates how a system using HBVI's can be used for acting as a compressor, according to embodiments of the present invention.

25 FIG. 12 illustrates how a system using HBVI's can be used for acting as an expander, according to embodiments of the present invention.

FIG. 13 illustrates a combined compressor/expander according to an embodiment of the present invention.

30 FIG. 14 illustrates a liquification system according to an embodiment of the present invention.

FIG. 15 illustrates a vaporisation system according to an embodiment of the present invention.

FIG. 16 illustrates an energy handling system according to an embodiment of the present invention.

In the different figures, the same reference signs refer to the same or analogous elements.

Description of illustrative embodiments

The present invention will be described with respect to particular embodiments and
5 with reference to certain drawings, but the invention is not limited thereto but only by the claims. The drawings described are only schematic and are non-limiting. In the drawings, the size of some of the elements may be exaggerated and not drawn on scale for illustrative purposes. The dimensions and the relative dimensions do not correspond to actual reductions to practice of the invention.

10 Furthermore, the terms first, second, third and the like in the description and in the claims, are used for distinguishing between similar elements and not necessarily for describing a sequence, either temporally, spatially, in ranking or in any other manner. It is to be understood that the terms so used are interchangeable under appropriate circumstances and that the embodiments of the invention described herein are capable of operation in other
15 sequences than described or illustrated herein.

Moreover, the terms top, bottom, over, under and the like in the description and the claims are used for descriptive purposes and not necessarily for describing relative positions. It is to be understood that the terms so used are interchangeable under appropriate circumstances and that the embodiments of the invention described herein are capable of
20 operation in other orientations than described or illustrated herein.

It is to be noticed that the term "comprising", used in the claims, should not be interpreted as being restricted to the means listed thereafter; it does not exclude other elements or steps. It is thus to be interpreted as specifying the presence of the stated features, integers, steps or components as referred to, but does not preclude the presence or addition
25 of one or more other features, integers, steps or components, or groups thereof. The term "comprising" therefore covers the situation where only the stated features are present and the situation where these features and one or more other features are present. The word "comprising" according to the invention therefore also includes as one embodiment that no further components are present. Thus, the scope of the expression "a device comprising means
30 A and B" should not be interpreted as being limited to devices consisting only of components A and B. It means that with respect to the present invention, the only relevant components of the device are A and B.

Similarly, it is to be noticed that the term “coupled”, also used in the claims, should not be interpreted as being restricted to direct connections only. The terms “coupled” and “connected”, along with their derivatives, may be used. It should be understood that these terms are not intended as synonyms for each other. Thus, the scope of the expression “a device
5 A coupled to a device B” should not be limited to devices or systems wherein an output of device A is directly connected to an input of device B. It means that there exists a path between an output of A and an input of B which may be a path including other devices or means. “Coupled” may mean that two or more elements are either in direct physical or electrical contact, or that two or more elements are not in direct contact with each other but yet still co-
10 operate or interact with each other.

Reference throughout this specification to “one embodiment” or “an embodiment” means that a particular feature, structure or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, appearances of the phrases “in one embodiment” or “in an embodiment” in various places
15 throughout this specification are not necessarily all referring to the same embodiment, but may. Furthermore, the particular features, structures or characteristics may be combined in any suitable manner, as would be apparent to one of ordinary skill in the art from this disclosure, in one or more embodiments.

Similarly it should be appreciated that in the description of exemplary embodiments
20 of the invention, various features of the invention are sometimes grouped together in a single embodiment, figure, or description thereof for the purpose of streamlining the disclosure and aiding in the understanding of one or more of the various inventive aspects. This method of disclosure, however, is not to be interpreted as reflecting an intention that the claimed invention requires more features than are expressly recited in each claim. Rather, as the
25 following claims reflect, inventive aspects lie in less than all features of a single foregoing disclosed embodiment. Thus, the claims following the detailed description are hereby expressly incorporated into this detailed description, with each claim standing on its own as a separate embodiment of this invention.

Furthermore, while some embodiments described herein include some but not other
30 features included in other embodiments, combinations of features of different embodiments are meant to be within the scope of the invention, and form different embodiments, as would be understood by those in the art. For example, in the following claims, any of the claimed embodiments can be used in any combination.

Furthermore, some of the embodiments are described herein as a method or combination of elements of a method that can be implemented by a processor of a computer system or by other means of carrying out the function. Thus, a processor with the necessary instructions for carrying out such a method or element of a method forms a means for carrying
5 out the method or element of a method. Furthermore, an element described herein of an apparatus embodiment is an example of a means for carrying out the function performed by the element for the purpose of carrying out the invention.

In the description provided herein, numerous specific details are set forth. However, it is understood that embodiments of the invention may be practiced without these specific
10 details. In other instances, well-known methods, structures and techniques have not been shown in detail in order not to obscure an understanding of this description.

The invention will now be described by a detailed description of several embodiments of the invention. It is clear that other embodiments of the invention can be configured according to the knowledge of persons skilled in the art without departing from the technical
15 teaching of the invention, the invention being limited only by the terms of the appended claims.

In a first aspect, the present invention relates to an energy handling system. Such an energy handling system may be a system adapted for converting energy, storing energy, transmitting energy, ... The energy handling system according to embodiments of the present
20 invention comprises at least one heat exchange unit for exchanging heat between a first substance and a second substance. It is to be noted that the energy handling system may comprise more than one heat exchange unit. The energy handling system may be based on performing expansion or compression of a fluid or may perform a plurality of such actions, resulting in the possibility for converting between different types of energy, such as for
25 example thermal energy, electric energy, mechanical energy, etc.... According to embodiments of the present invention, the heat exchange unit comprises a first inner compartment and a second outer compartment. The first inner compartment and the second outer compartment are positioned adjacent each other and are being separated by a heat exchange surface. The heat exchange unit also comprises a balloon being mounted in the first inner compartment so
30 as to form in the first inner compartment a hermetically sealed volume between the outer surface of the balloon and the heat exchange surface. The hermetically sealed volume is being filled with the first substance and the balloon is being configured for being filled with a balloon fluid. The second outer compartment is being filled with the second substance. According to embodiments of the present invention, the area of the heat exchange surface that is in contact

with the first substance and the second substance remains substantially the same during the heat exchange process.

By way of illustration, embodiments not being limited thereto, an exemplary embodiment of the present invention will further be discussed with reference to
5 FIG. 1 and FIG. 2.

FIG. 1 illustrates a schematic representation of an exemplary energy handling system 1. The energy handling system 1 is based on one or more heat exchange units 100, which may be referred to as a HBVI-unit (Hydraulic Balloon Vessel Interface). The one or more energy exchange units 100, e.g. heat exchange units, may be used for performing compression and/or
10 expansion of a fluid, used in the energy handling action. Since in the energy exchange units 100 typically heat will be exchanged, in the following examples and description reference also may be made to heat exchange units but it is to be noted that the invention is not limited to heat exchange and other types of energy also could be envisaged. The one or more heat exchange units 100 may be controlled by a controller 2. Such a controller may comprise any suitable
15 processor. In some embodiments, such a controller may be configured for controlling fluids in the one or more heat exchange units, for inducing energy exchange, e.g. a heat exchange at the heat exchange surface of the heat exchange units 100. The controller 2 may be programmed for controlling the energy exchange process to occur under substantially isentropic, isobaric, isothermic and/or polytropic conditions, during at least 50% of the energy
20 exchange process, advantageously during at least 60% of the energy exchange process or at least 75% of the energy exchange process or at least 90% of the energy exchange process. It is an advantage of at least some embodiments of the present invention that the conditions under which the energy exchange process can occur can be fully controlled, so that a substantially isothermic process, a substantially isentropic process, a substantially isobaric process, a
25 polytropic process or a combination thereof can be selected and fully controlled. In one embodiment, the controller 2 may be programmed for controlling the energy exchange process to occur under substantially the same temperature. In one particular example operation at a substantially constant temperature can for example be obtained, which may advantageously result in especially efficient energy exchange. For controlling the fluids in the at least one
30 energy exchange unit 100, the energy handling system 1 may comprise one or more pumping systems 3. It is to be noted that in systems according to embodiments of the present invention, particular temperature and pressure conditions can be maintained in the HBVI's used in the system for inducing an efficient process.

FIG. 2 illustrates an energy exchange unit as can be used in embodiments of the present invention. The energy exchange unit 100 allows for exchanging heat between a first substance 110 and a second substance 120. The first substance may in some embodiments be a liquid, e.g. water. The first substance may in some embodiments be a supercritical gas. Furthermore, additional interface liquids may be used to avoid any kind of contamination. The latter will further be described in FIG. 10. The heat exchange unit 100 comprises a first inner compartment 130 and a second outer compartment 140. The first inner compartment 130 and the second outer compartment 140 are positioned adjacent each other and are separated by a heat exchange surface 150. The heat exchange surface 150, corresponding with the outer surface of the first inner compartment 130, is defined by the outer surface of a vessel. Since high pressures may be induced in the first inner compartment 130, the outer surface of the first inner compartment 130, i.e. the heat exchange surface 150, typically may be made of a pressure resistant material. Such a material may be any type of material such as for example a metal like aluminum, iron or steel, a composite such as for example carbon-based composites, a metal composite, or alike. Selection of the material may also depend on the temperature at which processing will be performed. Embodiments of the present invention are not limited by the materials that is selected, provided they are resistant to the pressures and the temperatures used for performing the heat exchange process.

The vessel may be substantially cylindrically shaped and the first inner compartment and the second outer compartment may be configured as substantially concentric compartments. The compartments may be substantially cylindrically shaped. Alternatively, the compartment also may have any other suitable shape, such as for example droplet shaped. The second outer compartment may be formed conformally with the first inner compartment. In some embodiments, the compartments also may have other shapes. FIG. 3 illustrates by way of illustration and embodiments not being limited thereto, two examples of cross-sections for the vessels that can be used, a first one for a cylindrically shaped vessel and a second one for an alternatively shaped vessel, having a larger heat exchange surface area.

According to the exemplary embodiment shown in FIG. 2, a balloon 160 is being mounted in the first inner compartment 130 so as to form in the first inner compartment 130 a hermetically sealed volume 170 between the outer surface of the balloon 160 and the heat exchange surface 150. The balloon 160 may be made of any suitable material such as rubber materials suited for the temperature ranges and the fluids that are applied. The material may be selected as function of the temperature that will be used in the system. Advantageously, the balloon 160 is fixed at two positions in the first inner compartment 130 to form the

hermetically sealed volume 170 but to further not touch the walls (or touch them as little as possible) of the first inner compartment 130 during the heat exchange process. The balloon 160 may be fixed in a pre-tensioned manner. By way of example, embodiments not being limited thereto, four different ways of connecting the balloon to the vessel are illustrated. In example A of FIG. 4, the balloon is connected to the vessel via a ring shaped fixation means. In example B of FIG. 4, a connection with a larger fixation area between the balloon and the vessel is shown. In examples C and D of FIG. 4, a connection to the wider portion of the vessel is obtained. In the examples C and D of FIG. 4, a connection element that fits at one side to the vessel shape is used. The connection element is provided with an introduction tube, allowing the balloon fluid to be introduced from outside the vessel into the balloon.

The balloon 160 typically may be filled with a balloon fluid 180. The balloon fluid 180 may be oil, although embodiments are not limited thereto. The balloon fluid 180 may be pumped towards the balloon or away from the balloon 160 in the energy handling system. The balloon is configured such with respect to the inner compartment that it forms the hermetically sealed volume 170 that is filled with the first substance 110. In some embodiments, the balloon may be pre-shaped so that, when enlarging due to pumping with balloon fluid, it enlarges with a similar shape as the heat exchange surface. The balloon also may be pre-shaped so as to compensate for gravity forces working on the balloon and the balloon fluid. The heat exchange process may be controlled for occurring with a maximum volume exchange of the balloon 160 in the range 1.5 to 2.5 times, e.g. in the range 1.75 to 2.25 times.

The second outer compartment 140 is, in embodiments according to the present invention, being filled with the second substance 130. The second substance may be a liquid. The second substance 140 may be a cold liquid or may be a warm liquid. In some embodiments, the second substance may be a gas. The second outer compartment 140 may in some embodiments be isolated from the outer world by an isolation tube 190. The isolation tube may be an isolation tube providing an additional cavity around the second outer compartment, whereby the additional cavity may be under vacuum or for example filled with an isolation fluid.

According to embodiments of the present invention, the area of the heat exchange surface 150 that is in contact with the first substance 110 and a second substance 140 remains substantially the same during the energy exchange process. By providing substantially the same heat exchange surface area during the energy exchange process, the energy conversion system can be performed with a high efficiency, i.e. with high yield. Where reference is made to the surface area of the heat exchange surface being substantially the same during the energy exchange process, this means that at least during 90% (for example during 95% or during 98%)

of the time of energy exchange in the system, the surface area of the heat exchange surface that is in contact with the first substance and the second substance varies less than 10% (for example varies less than 5%, for example less than 2%).

As indicated above, the energy handling system may be equipped with a controller and the heat exchange unit may be controlled to induce a heat exchange process at the heat exchange surface. The heat exchange process may be controlled to occur at a pressure in the range 200 to 700 bar, e.g. in the range 200 to 400 bar. Further as indicated above, the heat exchange process may be controlled to operate substantially isothermic process, a substantially isentropic process, a substantially isobaric process, a polytropic process or a combination thereof. By way of illustration, embodiments not being limited thereto, an example of such processes is shown in FIG. 5. In the example shown on the left hand side of FIG. 5, a polytropic process is shown. In the central portion of FIG. 5, an isobaric process is shown, where the pressure can be kept substantially constant. Furthermore, on the righthand side of FIG. 5, an isothermal process is shown, where the temperature can be kept constant. As indicated above, it is an advantage of embodiments of the present invention that particular temperature and pressure conditions can be maintained in the HBVI's used in the system for inducing an efficient process.

In one aspect, the present invention relates to an energy handling system for converting, storing or transmitting energy comprising at least one hydraulic balloon-vessel interface (HBVI) unit as described in the first aspect, one example thereof shown in FIG.2., embodiments of the aspect not being limited thereto. The energy handling system further comprises at least a first auxiliary fluid reservoir containing first auxiliary fluid, and at least a first hydraulic pumping/motor unit for selectively controlling flow of the first auxiliary fluid between the first auxiliary fluid reservoir and the balloon of the first HBVI unit. The energy handling system further also comprises a controller for controlling at least the first hydraulic pumping/motor unit so as to repetitively induce expansion and/or compression in the at least first HBVI unit. The system thus may provide for different cycles of expansion and/or compression, so as to control energy handling, such as converting, storing or transmitting energy. Aside from particular applications for energy handling, the system also may be used for evaluating thermodynamic properties of fluids or to explore the characteristics of new types of fluids. Such different cycles may in some embodiments occur in a single HBVI unit, whereby for example the different cycles may occur as subsequent cycles, or may in other embodiments occur in multiple HBVI units that are coupled to each other as cycles that occur subsequently

or that at least partly occur simultaneously. It is an advantage of embodiments of the present invention that an efficient energy handling system can be obtained based on one or more HBVI units. In some embodiments, the first auxiliary fluid may correspond directly with the balloon fluid as referred to in the first aspect. In other embodiments, wherein for example small leakages of the balloon fluid would result in unwanted, e.g. dangerous, situations, the first auxiliary fluid may also be used for controlling a further auxiliary fluid used as balloon fluid in the second HBVI, thus referred to as liquid/liquid interface or fluid/fluid interface.

According to embodiments of the present invention, the controller may be implemented as a microcontroller, such as for example a chip-controller, as a dedicated processor, in a general purpose processor driven via a particular computer program product, etc.

It is to be noted that, whereas systems with a single HBVI unit can be used, also systems with multiple HBVI units can be implemented. The latter may for example, when controlled appropriately, result in a substantially continuous operation of the system, for example continuous operation as a heat engine or as a heat pump. The latter will be illustrated further below in the present description.

By way of illustration, embodiments of the present invention not being limited thereto, a number of examples will further be described below.

A first example is illustrated in FIG. 6, showing an energy handling system 1 operating based on a single HBVI unit 610. The HBVI unit 610 typically may be connected to a heat exchange element 612 via a circulation pump 614. In some embodiments, the outer compartment of the HBVI unit 610 may operate itself as the heat exchange element. The HBVI unit 610 further is connected to a hydraulic pump/motor system 620 fluidically connecting the inner portion of the balloon of the HBVI unit 610 with a fluid reservoir 630. By controlling the pump/motor system 610 using a controller 640, the filling of the balloon of the HBVI unit 610 can be controlled. The latter allows for inducing expansion or compression of the fluid in the space defined between the vessel of the HBVI unit 610 and the balloon of the HBVI unit 610. By controlling the expansion or compression of the fluid in the space defined between the vessel and the balloon using the controller 640, the way the expansion or compression occurs can be controlled. The process may be controlled such that at least part of the energy exchange process occurs substantially isothermic, substantially isentropic, substantially isobaric, polytropic or as a combination thereof. The hydraulic pump/motor system 620 typically may be connected to an electrical motor/generator system 650. Such a motor/generator system

650 may be an electrical asynchronous motor/generator system or DC motor/generator. Depending on how the controller 640 is used for controlling the hydraulic pump/motor system 620, different actions can be induced in the system and the system can for example be used as a heat pump or as a heat engine. It is to be noted that further components such as for example
5 filters, valves such as overpressure valves, safety valves, sensors or measuring devices such as e.g. temperature sensors, pressure sensors, flow measuring devices, power measuring devices, etc., ... may be implemented in the system where appropriate, as will be understood by the person skilled in the art.

10 A second example is shown in FIG. 7, showing an energy handling system 1 operating based on two HBVI units 710a, 710b. The HBVI unit 710a, 710b each typically may be connected to a heat exchange element 712a, 712b via a circulation pump 714a, 714b. In some embodiments, the outer compartment of the HBVI units 710a, 710b may operate itself as heat exchange element. The HBVI units 710a, 710b further each are connected to a hydraulic
15 pump/motor systems 720a, 720b fluidically connecting the inner portion of the balloon of the respective HBVI units 710a, 710b with a fluid reservoir 730a, 730b. By controlling the pump/motor system 720a, 720b using a controller 740, the filling of the balloon of the respective HBVI unit 710a, 710b can be controlled. The latter allows for inducing expansion or compression of the fluid in the space defined between the vessel and the balloon of the
20 respective HBVI units 710a, 710b. By controlling the expansion or compression of the fluid in the space defined between the vessel and the balloon using the controller 740, the way the expansion or compression occurs can be controlled. The process may be controlled such that at least part of the energy exchange process occurs substantially isothermic, substantially isentropic, substantially isobaric, polytropic or as a combination thereof. According to some
25 embodiments, the process may also be controlled such that kilianic conditions are used, i.e. conditions as described above in this description. The latter can be obtained since two or more HBVI units are coupled to each other. The hydraulic pump/motor systems 720a, 720b typically may be connected to an electrical motor/generator system 750. The electrical motor/generator system 750 may be connected to both the hydraulic pump/motor systems
30 720a, 720b. Such motor/generator systems 750 may be an electrical asynchronous motor/generator system. Depending on how the controller 740 is used for controlling the hydraulic pump/motor systems 720a, 720b, different actions can be induced in the system such as compression and expansion. According to the different actions that are induced in the system, the system can for example be used as a heat pump or as a heat engine. The system

may be provided with an additional pumping system 722 connected to a leak tank 732. The latter can be used to cope with leakage shortages in the fluid reservoirs 730a, 730b, caused by lubricating leakage of the pumping systems 720a, 720b. It is to be noted that also optional valves 780a between HBVI's or optional valves 790a, 790b towards the leakage tanks may be implemented in the system.

In a further example as shown in FIG. 8, a system 1 as described in the second example is shown, but rather than using fluid reservoirs 730a, 730b, the HBVI units 710a, 710b are fluidically connected with further HBVI units 710c, 710d via pump/motor systems 720a, 720b.

More particularly, the . These are arranged similarly as HBVI units 710a, 710b. The HBVI unit 710c, 710d each typically may be connected to a heat exchange element 712c, 712d via a circulation pump (not shown explicitly). By controlling the pump/motor system 720a, 720b using a controller 740, the filling of the balloon of the respective HBVI unit 710a in fluidic communication with the balloon of the HBVI unit 710d and the filling of the balloon of the HBVI unit 710b in fluidic communication with the balloon of the HBVI unit 710c can be controlled. In the drawing and for one application envisaged, it is also indicated per HBVI unit if it provides an interface with the environment at high temperature (H) or an interface with the environment at low temperature (C). The environmental temperatures of the HBVI's are such that each of the pump/motor systems 720a, 720b can operate at one environmental temperature. The latter allows for inducing expansion or compression of the fluid in the space defined between the vessel and the balloon of the HBVI units 710a, 710b, 710c and 710d. By controlling the expansion or compression of the fluid in the space defined between the vessel and the balloon using the controller 740, the way the expansion or compression occurs can be controlled. The process may be controlled such that at least part of the energy exchange process occurs substantially isothermic, substantially isentropic, substantially isobaric, polytropic or as a combination thereof. It is an advantage of embodiments of the present invention that particular temperature and pressure conditions can be maintained in the HBVI's used in the system for inducing an efficient process. According to some embodiments, the process may also be controlled such that kilianic conditions are used, i.e. conditions as described above in this description. The latter can be obtained since two or more HBVI units are coupled to each other. Similar as in FIG. 7, also optional additional valves 780a, 780b are indicated between different HBVI's. Further features of the system may for example be as described in the second example. Such features may include, but are not limited to, filters, valves such as overpressure valves, safety valves, sensors or measuring devices such as e.g.

temperature sensors, pressure sensors, flow measuring devices, power measuring devices, etc., ... and may be implemented in the system where appropriate, as will be understood by the person skilled in the art.

5 In a fourth example, a system 1 is shown based on eight HBVI units, illustrated in FIG. 9. In this system, HBVI units are also interconnected two by two, so as to allow for improved operation and so as to avoid the need for liquid tanks (the balloons of the HBVI operate as liquid tanks or may act as additional HBVI's).

Although not shown, the pump/motor systems again are under control of a controller
10 allowing to induce expansion or compression in the HBVI units, thus allowing to control the energy exchange process. Again such processes may be controlled to occur substantially isothermic, substantially isentropic, substantially isobaric, polytropic or as a combination thereof. Again, since HBVI units are coupled, also processing under Kilianic conditions can be envisaged. Also, in these embodiments, optional features such as valves, a leakage tank, etc.
15 can be added as would be understood by the skilled person. It is to be noted that the embodiment of a system wherein eight HBVI units are combined, a substantially continuous process of energy handling can be obtained through inducing subsequent cycles in the different HBVI units and combining these.

In FIG. 9, which illustrates a system 1 that allows for substantially continuous energy
20 production – e.g. heat in case of a heat pump or e.g. mechanical energy in case of a heat engine –, it is also indicated per HBVI unit if it provides an interface with the environment at high temperature (H) or an interface with the environment at low temperature (C). In the continuous energy conversion system shown in FIG. 9, HBVI units 710a, 710b, 710h as well as energy exchange elements 712a, 712b, 712h are shown. Other elements such as valves,
25 hydraulic pump/motor systems and an electrical motor/generator system are also shown. Other standard and optional components may be present as understood by the person skilled in the art.

The above examples schematically illustrate the use of one or more HBVI units. It is to
30 be understood that the number of HBVI units can be further increased, as required for the application in energy handling.

Further by way of illustration, FIG. 10 shows how a fluid/fluid interface can be introduced to avoid possible dangerous situations whereby a first fluid leaks into a second fluid,

whereby the first fluid and the second fluid are reactive with each other. The latter could for example occur when reactive fluids are only separated by the wall formed by the balloon. Embodiments of the present invention implementing an additional fluid/fluid interface, e.g. a liquid/liquid interface, can overcome such issues by introducing a further fluid/fluid interface, thus separating fluids that may reactively interact with each other by a further fluid. In FIG. 10, the use of three fluids 1101, 1103, 1105 is shown, whereby the fluids 1101, 1103 that may reactively interact with each other are not only separated by a single balloon wall, but by two balloon walls and the intermediate, further fluid 1105. Such an interface may be implemented in systems 1 based on HBVI units.

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Further by way of illustration, FIG. 11 shows how a system 1 that can be operated as a compressor, thus illustrating one of the applications of systems of the present invention. In the system 1 of FIG. 11, which is a schematic representation of a compressor based on two HBVI units, a first and second HBVI unit 1210a, 1210b are shown being interconnected with a pumping system 1220a. The space between the vessel wall and the balloon of each HBVI unit 1210a, 1210b is controllably connected to an inlet controlled by a valve 1216a, 1216b. When one space in one HBVI unit 1210a is filled with a fluid e.g. air, via the inlet, the valve 1216a is closed and the fluid can be compressed by filling of the balloon with balloon fluid, using the pump system 1220. The compressed fluid then may be transferred to a high pressure vessel 1290, by controlling valve 1218a. Once the compressed fluid is transferred from HBVI unit 1210a, a similar process may be performed in the second HBVI unit 1210b, using the pumping system 1220 and similar components valve 1216b and valve 1218b, thus allowing to bring compressed fluid from the second HBVI unit 1210b towards the high pressure vessel 1290.

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Also by way of illustration, FIG. 12 shows how a system 1 that can be operated as an expander, thus illustrating one of the applications of systems of the present invention. In the system of FIG. 12, which is a schematic representation of an expander based on two HBVI units, a first and second HBVI unit 1310a, 1310b are shown being interconnected with a pumping/motor system 1320a. The space between the vessel wall and the balloon of each HBVI unit 1310a, 1310b is controllably connected to a high pressure vessel 1390 controlled by a valve 1316a, 1316b. An amount of fluid is provided in one HBVI unit 1310a and allowed to expand. The expansion may be used for controlling the balloon fluid in the balloon of the HBVI unit, which may be used for operating the pumping/motor system 1320a. Further valves 1318a 1318b provide the connection between the HBVI units and the outer world. Once the

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compressed fluid is expanded, a similar process may be performed in the second HBVI unit 1310b, using the pumping system 1320a and the valves.

FIG. 13 shows a combination of an expander and compressor in a single embodiment. The functionality of the compressor and the expander are combined in one system. Similar components as shown in FIG. 12 are indicated. Rather than having an outlet to the outside world, in this embodiment, both a high pressure vessel 1390 as a low pressure vessel 1492 are indicated. The system can for example be used as a closed system (e.g. usable with gasses with specific characteristics). Such a system may be used in energy stock piling applications, such as systems using compression when energy is in excess and expansion when energy is in shortage.

FIG. 14 shows a liquification system 1 for separating a fluid obtained under high pressure in its components. The system can for example be used in an energy stock piling system. In the system, a plurality of HBVI systems are configured in cascade wherein at each stage the thermodynamical conditions are chosen so as to be able to split one or more components of the fluid off. The latter system thus allows for separating a fluid in its components.

FIG. 15 illustrates a vaporiser system 1 by combining different functionalities of subsystems comprising HBVI units. The vaporiser of the example uses a system based on 4 HBVI units for bringing a fluid at high temperature in the vaporiser. A liquid is heated in the vaporiser to vaporise the liquid by bringing it into contact with the heat of the fluid at high temperature. The vapour is thereafter allowed to expand in the expander.

Further by way of illustration, FIG. 16 illustrates a system 1 for energy handling, combining the functionality of a compressor, providing a high pressure fluid source, a liquification system, allowing to split the high pressure fluid in its components, a vaporiser, for vaporising at least one of these components and an expander for expanding the vaporised component. By combining different functionalities obtainable with systems comprising HBVI units, efficient energy handling can be obtained. Also this system typically may be used for energy stock piling.

Whereas some applications are illustrated above, it will be clear that these are only a number of applications and that other applications for energy handling also can be envisaged.

In one aspect, the present invention also relates to a method of handling energy, the method comprising inducing an energy exchange process using an energy handling system as described in the first aspect. According to embodiments of the present invention, the energy exchange process may be performed in a substantially isothermic process, a substantially
5 isentropic process, a substantially isobaric process, a polytropic process or a combination thereof. The process advantageously can be performed in such a manner that the heat exchange surface between the first and second substance in contact with these substances remains substantially equal during substantially the full energy exchange process.

10 It is to be understood that although preferred embodiments, specific constructions and configurations, as well as materials, have been discussed herein for devices according to the present invention, various changes or modifications in form and detail may be made without departing from the scope of this invention. Steps may be added or deleted to methods described within the scope of the present invention.

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CLAIMS

1. An energy handling system (1) for converting, storing or transmitting energy, the energy handling system (1) comprising
a heat exchange unit (100, 610, 710a, 1210a, 1310a) for exchanging heat between a first
5 substance (110) and a second substance (120), the heat exchange unit (100) comprising a
first inner compartment (130) and a second outer compartment (140), the first inner
compartment (130) and the second outer compartment (140) being positioned adjacent
each other and being separated by a heat exchange surface (150),
a balloon (160) being mounted in the first inner compartment (130) so as to form in the
10 first inner compartment (130) a hermetically sealed volume (170) between the outer
surface of the balloon (160) and the heat exchange surface (150), the hermetically sealed
volume (170) being filled with the first substance (110), the balloon (160) being configured
for being filled with a balloon fluid (180)
the second outer compartment (140) being filled with the second substance (130),
15 characterised in that
the area of the heat exchange surface (150) that is in contact with the first substance (110)
and a second substance (120) remains substantially the same during the heat exchange
process.
2. An energy handling system (1) according to claim 1, wherein the system furthermore
20 comprises a controller (2, 640, 740) for controlling one of the volume of the balloon fluid
(180) in the balloon (160) or the second substance (120) in the second outer compartment
(140), for inducing a heat exchange at the heat exchange surface (150).
3. An energy handling system (1) according to claim 2, wherein the controller is programmed
for controlling the heat exchange process to occur under substantially isentropic, isobaric,
25 isothermic and/or polytropic conditions, during at least 50% of the heat exchange process,
advantageously during at least 60% of the heat exchange process or at least 75% of the
heat exchange process or at least 90% of the heat exchange process.
4. An energy handling system (1) according to any of claims 1 to 2, wherein the controller is
programmed for controlling the heat exchange process to occur under substantially the
30 same temperature.
5. An energy handling system (1) according to any of the previous claims, wherein the balloon
(160) is fixed at two positions in the first inner compartment (130) to form the hermetically
sealed volume (170) but to further not touch the walls of the first inner compartment (130)
during the heat exchange process.

6. An energy handling system (1) according to the previous claim, wherein the balloon (160) is fixed in a pre-tensioned manner.
7. An energy handling system (1) according to any of the previous claims, wherein the heat exchange process is controlled for occurring at a pressure in the range 200 to 700 bar, e.g. in the range 200 to 400 bar.
8. An energy handling system (1) according to any of the previous claims, wherein the heat exchange process is controlled for occurring with a maximum volume exchange of the balloon (160) in the range 1.5 to 2.5 times, e.g. in the range 1.75 to 2.25 times.
9. An energy handling system (1) according to any of the previous claims, wherein the second outer compartment (140) is isolated from the outer world by an isolation tube (190).
10. An energy handling system (1) according to any of the previous claims, wherein the heat exchange surface (150) is made of a pressure resistant material.
11. An energy handling system (1) according to any of the previous claims, wherein the balloon fluid (180) is oil and wherein the first substance (110) is a liquid, e.g. water.
12. An energy handling system (1) according to any of the previous claims, wherein the first substance (110) is a supercritical gas.
13. An energy handling system (1) according to any of the previous claims, the heat exchange unit being a first heat exchange unit (710a, 1210a, 1310a), the balloon (160) being a first balloon and the balloon fluid (180) being a first balloon fluid, the energy handling system (1) further comprising at least a first auxiliary balloon fluid reservoir (630, 730, 732), and at least a first hydraulic pumping/motor unit (620, 720a, 1220a, 1320) for selectively controlling flow of the first balloon fluid to and/or from the first auxiliary balloon fluid reservoir (630, 730a) from and/or to the first balloon ; the controller (2, 640, 740) being configured for controlling the thermodynamic process in the at least first HBVI (100, 610, 710a, 1210a, 1310a) by controlling at least the first hydraulic pumping/motor unit (620, 720a, 1220a, 1320) so as to induce different cycles of expansion and/or compression in the at least first heat exchange unit (100, 610, 710a, 1210a, 1310a), the system (1) thus providing subsequent cycles of expansion and/or compression, so as to control energy handling, such as converting, storing or transmitting energy.
14. The energy handling system (1) according to claim 13, wherein the energy handling system (1) furthermore comprises

- at least a second heat exchange unit (710b, 1210b, 1310b) comprising a second vessel with a second balloon suspended therein, the second balloon defining a first sub-volume therein and a compartment in the second vessel outside the second balloon,
 - 5 - a second auxiliary balloon fluid reservoir (730b), and
 - a second hydraulic pumping/motor unit (720b, 1220b, 1320b) for selectively controlling flow of the second auxiliary balloon fluid to and from the second auxiliary fluid balloon reservoir (730b), and
- wherein the first heat exchange unit (710a, 1210a, 1310a) and the at least a second heat
- 10 exchange unit (710b, 1210b, 1310b) are configured so that the first heat exchange unit (710a, 1210a, 1310a) is fluidically connected to the second heat exchange unit (710b, 1210b, 1310b) and allows flow of a fluid therebetween under control of the first hydraulic pumping/motor unit (720a, 1220a, 1320a) and the second hydraulic pumping/motor unit (720b, 1220b, 1320b).
- 15 15. The energy handling system (1) according to claim 14, wherein the system is configured for inducing different thermodynamic conditions at the same time in the first heat exchange unit and the second heat exchange unit for the fluid providing the fluidic connection, referred to as Kilianic conditions.
- 20 16. The energy handling system (1) according to any of the previous claims, the energy handling system (1) comprising a further number of heat exchange units selectively linked to each other, configured and controlled to induce continuous operation of the energy handling system (1).
- 25 17. The energy handling system (1) according to any of the previous claims, wherein the energy handling system (1) is configured as one of
- a compressor, or
 - an expander, or
 - a heat pump for domestic use and wherein the controller (2, 640, 740) is configured for operating in a temperature range between 0°C and 85°C, or
 - a heat pump for industrial use wherein the controller (2, 640, 740) is configured for
 - 30 operating in a temperature range between 40°C and 200°C, or
 - a heat engine, or
 - system for separating fluid components out of a fluid,
 - a liquification system, or
 - an energy stock piling system.

18. A method of producing mechanical energy, the method comprising controlling at least a first hydraulic pumping/motor unit for operating a system according to any of claims 1 to 16 as a heat engine.
19. A method of producing heat, the method comprising controlling at least a first hydraulic
5 pumping/motor unit (720a, 1220a, 1320a) for operating a system according to any of claims 1 to 16 as a heat pump.
20. The method according to claim 19, the method comprising distributing the produced heat to a plurality of different houses.