A thermo-magnetic exchanging device includes a heat exchanging element and a magnet unit. The heat exchanging element has at least one channel to convey a heat-carrying fluid. The magnet unit is disposed around the heat exchanging element and provides a magnetic field to the heat exchanging element. The magnitude of the magnetic field is non-uniform. The cross-sectional area of the channel corresponds to the magnetic field so that temperature gradients at different points of the heat exchanging element are substantially the same when the heat-carrying fluid flows through the channel.
THERMO-MAGNETIC EXCHANGING DEVICE

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The inventions relates to a thermo-magnetic exchanging device, and in particular, to a thermo-magnetic exchanging device including a heat exchanging element and a magnet unit generating a magnetic field to the heat exchanging element.

[0003] 2. Description of the Related Art

[0004] Magnetic refrigeration is considered a highly efficient and environmentally friendly cooling technology. Magnetic refrigeration techniques adapt a magneto-caloric effect of magnetocaloric materials (MCM) to realize or utilize refrigeration cycles.

[0005] Please refer to FIG. 1, a conventional thermo-magnetic exchanging device 1 includes a heat exchanging element 10 and a magnet unit 20. The heat exchanging element 10 includes a channel 11 and a plurality of channels 12, wherein the channel 11 is located between the channels 12. In this embodiment, a heat-carrying fluid flows through the channels 11 and 12, wherein the cross-section areas of the channels 11 and 12 are the same, and the distance between the two adjacent channels 11 and 12 are the same. The magnet unit 20 can generate a magnetic field to the heat exchanging element 10. Since the magnetic field is non-uniform, the magnetic field in the channel 11 may exceed that in the channel 12, and the heat exchange efficiency between the heat exchanging element 10 and the heat-carrying fluid in the channel 11 is greater than that between the heat exchanging element 10 and the heat-carrying fluid in the channel 12. Thus, the efficiency of the thermo-magnetic exchanging device 1 is decreased.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The invention can be more fully understood by reading the subsequent detailed description and examples with references made to the accompanying drawings, wherein:

[0012] FIG. 1 is a schematic view of a conventional thermo-magnetic exchanging device;

[0013] FIG. 2 is a schematic view of a thermo-magnetic exchanging device of a first embodiment of the invention;

[0014] FIG. 3 is a perspective view of a heat exchanging element of the first embodiment of the invention;

[0015] FIG. 4 is a cross-sectional view along the line A-A' of FIG. 3;

[0016] FIG. 5 is a schematic view of a thermo-magnetic exchanging device of a second embodiment of the invention; and

[0017] FIG. 6 is an exploded schematic view of a thermo-magnetic exchanging device of a third embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0018] Please refer to FIGS. 2 to 4. FIG. 2 is a schematic view of a thermo-magneto-exchanging device 2 according to a first embodiment of the invention. FIG. 3 is a perspective view of a heat exchanging element 30 according to the first embodiment of the invention. FIG. 4 is a cross-sectional view along the line A-A' of FIG. 3. The thermo-magnetic exchanging device 2 includes a heat exchanging element 30 and two magnet units 40. The heat exchanging element 30 has a tube structure.

[0019] The heat exchanging element 30 is made of a material selected from a group consisting of at least one magnetocaloric material. The magnetocaloric material, for example, and not limited to, may be Mn—Fe—P—As alloy, Mn—Fe—P—Si alloy, Mn—Fe—P—Ge alloy, Mn—As—Sb alloy, Mn—Fe—Co—Ge alloy, Mn—Ge—Sb alloy, Mn—Ge—Si alloy, La—Fe—Co—Si alloy, La—Fe—Si—H alloy, La—Na—Mn—O alloy, La—K—Mn—O alloy, La—Ca—Sr—Mn—O alloy, La—Ca—Pb—Mn—O alloy, La—Ca—Ba—Mn—O alloy, Gd alloy, Gd—Si—Ge, Gd—Yb alloy, Gd—Si—Sb alloy, Gd—Dy—Al—Co alloy, or Ni—Mn—Ga alloy.
The heat exchanging element 30 includes a channel 31 and two channels 32. The number of the channel 31 or the channels 32 is not to be limited. In the embodiment, the channel 31 is located between the channels 32. The channel 31 and the channels 32 are arranged along a first extension direction D1. The first extension direction D1 is parallel to a cross-section S1 of the heat exchanging element 30. The heat exchanging element 30, the channel 31, and the channels 32 are extended along a longitudinal direction D3. The channel 31 and the channels 32 are provided to convey a heat-carrying fluid.

The magnet unit 40 may be a permanent magnet, a superconducting magnet, or a solenoid. Two magnet units 40 are disposed around the heat exchanging element 30. In the embodiment, the heat exchanging element 30 is located between the magnet units 40. The magnet units 40 and the heat exchanging element 30 are arranged along a second extension direction D2, wherein the first extension direction D1, the second extension direction D2, and the longitudinal direction D3 are perpendicular to each other. Each of the magnet units 40 can provide a magnetic field to the heat exchanging element 30, and the magnitude of the magnetic field may be time-varying and non-uniform. Thus, when the magnetic field is applied to the heat exchanging element 30, the heat exchange ability of the heat exchanging element 30 can be changed.

Please refer to FIG. 2, the cross-section S1 of the heat exchanging element 30 has a first cross-section zone Z1 and two second cross-section zones Z2. The channel 31 is located in the first cross-section zone Z1, and the channels 32 are located in the second cross-section zone Z2, respectively. The areas of the first cross-section zone Z1 and the second cross-section zones Z2 are the same, wherein the first cross-section zone Z1 is located between the second cross-section zones Z2. In the embodiment, the first cross-section zone Z1 and the second cross-section zones Z2 are arranged along the first extension direction D1.

The arrangement of the first cross-section zone Z1 and the second cross-section zones Z2 are substantially parallel to the magnet unit 40. The first cross-section zone Z1 is close to the center area of the magnet unit 40. The second cross-section zones Z2 are close to two opposite ends of the channels 40. The magnetic field in the first cross-section zone Z1 exceeds that in each of the second cross-section zones Z2. Namely, the magnitude of the magnetic field applied to the first channel 31 is greater than the magnitude of the magnetic field applied to each of the second channels 32.

In general, a stronger magnetic field can facilitate higher heat exchange ability of the heat exchanging element 30. Since the cross-sectional area of the channels 31 and 32 are designed to correspond to the magnetic field distribution within the heat exchanging element 30, temperature gradients at different points of the cross-section S1 of the heat exchanging element 30 are substantially the same when the heat-carrying fluid flows through the channels 31 and 32.

In the embodiment, the cross-section area of the channel 31 is greater than the cross-sectional area of the channel 32, and the area of the first cross-section zone Z1 and the second cross-section zone Z2 are the same. Since the first cross-section zone Z1 of the heat exchanging element 30 has stronger magnetic field, the cross-section area of the channel 31 is designed to exceed that of the channel 32.

When the heat-carrying fluid flows through the channel 31 and the channels 32, the flowing velocity of the heat-carrying fluid in the channel 31 is higher than that in the channel 32. Since the magnetic field of the second cross-section zones Z2 are lower than that of the first cross-section zone Z1, heat exchange ability of the heat exchanging element 30 in the second cross-section zones Z2 are relatively weak. However, by the slower flowing velocity of the heat-carrying fluid in the channels 32, the heat exchange between the exchanging element 30 in the second cross-section zone Z2 and the heat-carrying fluid in the channels 32 is sufficient. Thus, the temperature gradients in the second cross-section zone Z1 and the second cross-section zone Z2 are substantially the same.

Please refer to FIG. 5, which is a schematic view of a thermo-magnetic exchanging device 2b of a second embodiment of the invention. In the embodiment, the heat exchanging element 30a includes a plurality of channels 31a. The cross-section areas of each of the channels 31a and the channels 32a are the same. However, the number of the channel 31a in the first cross-section zone Z1 exceeds that of the channel 32a in the second cross-section zone Z2. Namely, the total cross-section area of the channels 31a in the first cross-section zone Z1 exceeds that of the channel 32a in the second cross-section zone Z2. Moreover, as shown in FIG. 5, the distance between the two adjacent channels 31a and channel 32a exceeds that between the two adjacent channels 31a and channel 32a. Thus, the total cross-section area of the channels 31a in the first cross-section zone Z1 and the total cross-section area of the channel 32a in the second cross-section zone Z2 can be appropriately designed corresponding to the magnitude of the magnetic field.

Please refer to FIG. 6, which is an exploded schematic view of a thermo-magnetic exchanging device 2b of a third embodiment of the invention. The heat exchanging element 30b includes a heat exchanging portion 33 and a heat exchanging portion 34, and the heat exchanging portion 33 is coupled with the heat exchanging portion 34. Each of the magnet units 40b includes a magnet portion 41 and a magnet portion 42, and the magnet portion 41 is coupled with the magnet portion 42. The channel 31b includes a channel portion 311 and a channel portion 312. Each of the channels 32b includes a channel portion 321 and a channel portion 322. The channel portion 311 is communicated with the channel portion 312, and the channel portion 321 is communicated with the channel portion 322.

In the embodiment, the magnetic field generated by the magnet portion 41 is greater than the magnetic field generated by the magnet portion 42. The cross-section area of the channel portion 311 exceeds that of the channel portion 312, and the cross-section area of the channel portion 321 exceeds that of the channel portion 322. Thus, the total cross-section area of the channels 31b and 32b of the heat exchanging portion 33 exceeds that of the channels 31b and 32b of the heat exchanging portion 34. Namely, the cross-sectional areas of the channels 31b and 32b can be appropriately designed corresponding to the magnitude of the magnetic field. Thus, when the heat-carrying fluid flows through the channels 31b and 32b, temperature gradients at different points of each end of the heat exchanging element 30b are substantially the same.

In conclusion, the temperature gradients at different points of the heat exchanging element are substantially the same when the heat-carrying fluid flows through the channel, and the exchange efficiency of the thermo-magnetic exchanging device is increased.
While the invention has been described by way of example and in terms of preferred embodiment, it is to be understood that the invention is not limited thereto. To the contrary, it is intended to cover various modifications and similar arrangements (as would be apparent to those skilled in the art). Therefore, the scope of the appended claims should be accorded the broadest interpretation so as to encompass all such modifications and similar arrangements.

What is claimed is:

1. A thermo-magnetic exchanging device, comprising:
   a heat exchanging element, having at least one channel to convey a heat-carrying fluid and having two ends; and
   a magnet unit, disposed around the heat exchanging element and providing a magnetic field to the heat exchanging element, wherein the magnitude of the magnetic field is non-uniform, wherein the cross-sectional area of the channel corresponds to the magnetic field so that temperature gradients at different points of each end of the heat exchanging element are substantially the same when the heat-carrying fluid flows through the channel.

2. The thermo-magnetic exchanging device as claimed in claim 1, wherein the heat exchanging element is made of a material selected from a group consisting of at least one magnetocaloric material.

3. The thermo-magnetic exchanging device as claimed in claim 2, wherein the magnetocaloric material is Fe—P—As alloy, Fe—P—Si alloy, Mn—As—Sb alloy, Mn—Ge—Sb alloy, Mn—As—Sb alloy, Mn—Ge—Sb alloy, Mn—As—Sb alloy, Mn—Ge—Sb alloy, Mn—As—Sb alloy, Mn—Ge—Sb alloy, Mn—As—Sb alloy, Mn—Ge—Sb alloy, Mn—As—Sb alloy, Mn—Ge—Sb alloy, or Ni—Sb—Ga alloy.

4. The thermo-magnetic exchanging device as claimed in claim 1, wherein the magnet unit is a permanent magnet, a superconducting magnet, or a solenoid.

5. A thereto-magnetic exchanging device, comprising:
   a heat exchanging element having a first channel and a second channel to convey a heat-carrying fluid, wherein the first channel has a first cross-sectional area and the second channel has a second cross-sectional area, and the first cross-sectional area is greater than the second cross-sectional area; and
   a magnet unit, disposed around the heat exchanging element, providing a magnetic field to the heat exchanging element, wherein the magnitude of the magnetic field applied to the first channel is greater than the magnitude of the magnetic field applied to the second channel.

6. The thermo-magnetic exchanging device as claimed in claim 5, wherein the heat exchanging element is made of a material selected from a group consisting of at least one magnetocaloric material.

7. The thermo-magnetic exchanging device as claimed in claim 6, wherein the magnetocaloric material is Fe—P—As alloy, Fe—P—Si alloy, Fe—P—Ge alloy, Mn—As—Sb alloy, Mn—Ge—Sb alloy, Mn—Ge—Sb alloy, Mn—Ge—Sb alloy, Mn—Ge—Sb alloy, Mn—Ge—Sb alloy, Mn—Ge—Sb alloy, Mn—Ge—Sb alloy, or Ni—Sb—Ga alloy.

8. The thermo-magnetic exchanging device as claimed in claim 5, wherein the magnet unit is a permanent magnet, a superconducting magnet, or a solenoid.

9. A thereto-magnetic exchanging device, comprising:
   a heat exchanging element having a plurality of first channels and at least one second channel to convey a heat-carrying fluid, wherein the distance between the two adjacent first channels is greater than the distance between the two adjacent first channel and second channel; and
   a magnet unit, disposed around the heat exchanging element, providing a magnetic field applied to the heat exchanging element, wherein the magnitude of the magnetic field applied to the first channel is greater than the magnitude of the magnetic field applied to the second channel.

10. The thermo-magnetic exchanging device as claimed in claim 9, wherein the heat exchanging element is made of a material selected from a group consisting of at least one magnetocaloric material.

11. The thermo-magnetic exchanging device as claimed in claim 10, wherein the magnetocaloric material is Fe—P—As alloy, Fe—P—Si alloy, Fe—P—Ge alloy, Mn—As—Sb alloy, Mn—Ge—Sb alloy, Mn—Ge—Sb alloy, Mn—Ge—Sb alloy, Mn—Ge—Sb alloy, or Ni—Sb—Ga alloy.

12. The thermo-magnetic exchanging device as claimed in claim 10, wherein the magnet unit is a permanent magnet, a superconducting magnet, or a solenoid.

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