US 20250123035A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2025/0123035 A1

JESSEN et al. (43) Pub. Date: Apr. 17, 2025

(54) **A CONDENSER TUBE, A METHOD FOR HEAT TRANSFER AND AN APPARATUS FOR HEAT EXCHANGE**

(71) Applicant: **HYDRO EXTRUDED SOLUTIONS AS**, Oslo (NO)

(72) Inventors: **Ulrik JESSEN**, Vojens (DK); **Bjørn VESTERGAARD**, Aabenraa (DK); **Günter Kurt RYBASCH**, Vojens (DK)

(73) Assignee: **HYDRO EXTRUDED SOLUTIONS AS**, Oslo (NO)

(21) Appl. No.: **18/832,384**

(22) PCT Filed: **Jan. 27, 2023**

(86) PCT No.: **PCT/EP2023/052025**

§ 371 (c)(1),
(2) Date: **Jul. 23, 2024**

(30) **Foreign Application Priority Data**

Jan. 28, 2022 (NO) 20220143

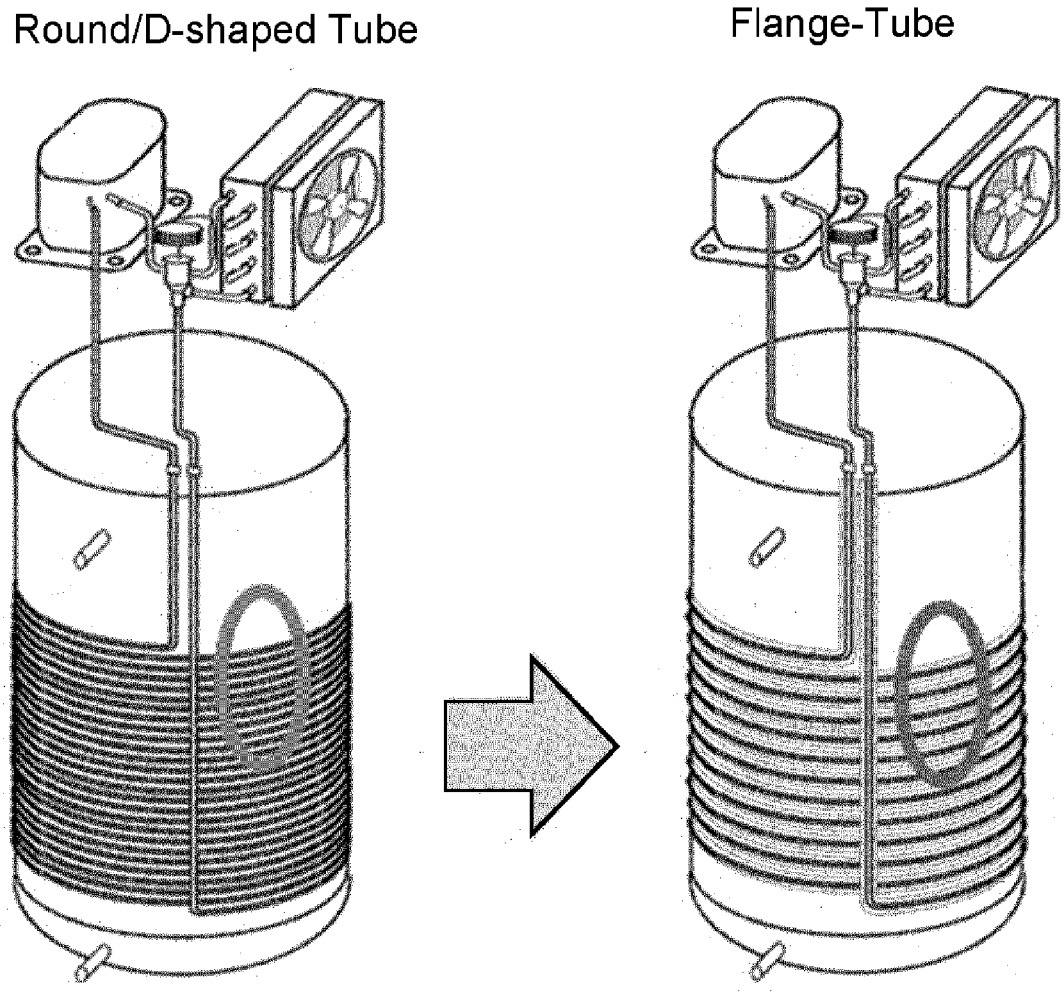
Publication Classification

(51) **Int. Cl.**
F25B 39/04 (2006.01)

(52) **U.S. Cl.**
CPC ***F25B 39/04*** (2013.01)

(57) **ABSTRACT**

A condenser tube profile, a method and an apparatus for heat exchange where a condenser tube profile is applied for heat exchange purposes. The condenser tube profile is made of aluminium or an aluminium alloy in an extrusion process, and a heat transfer medium is transported through one or more channels arranged in the said tube profile. A substantial flat flange is integrated with the tube profile. The tube profile can be winded in a shape of a helix onto the outer surface of an object, and where the flat flange is arranged firmly onto the surface of the object. Also, a method for heat transfer between a heat transfer medium flowing through such condenser tube and a liquid in a tank as well as an apparatus such as a domestic water heater of steel or stainless steel provided with said heat transfer arrangement.



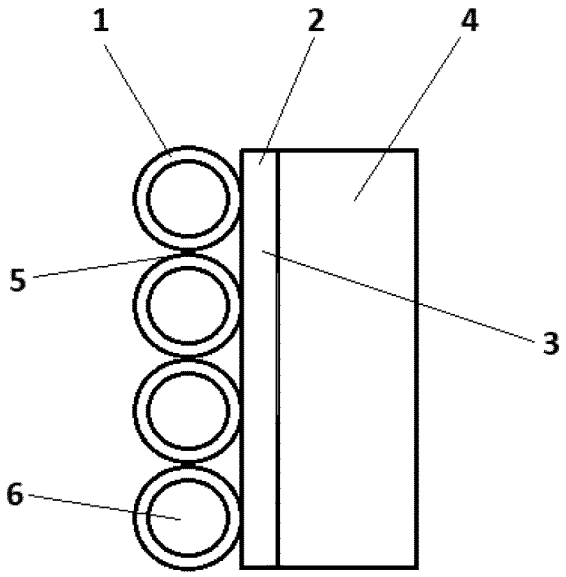


Fig. 1

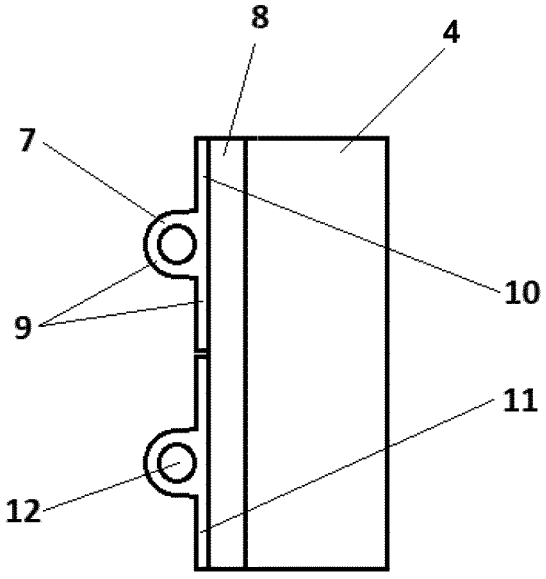


Fig. 2

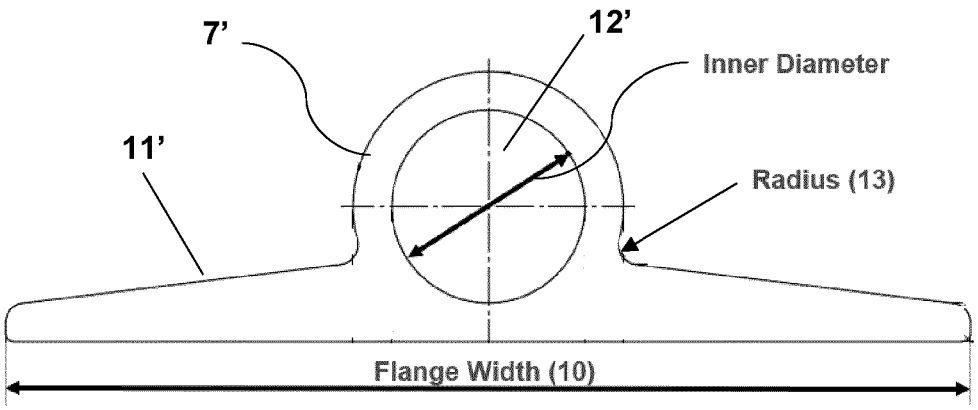


Fig. 3

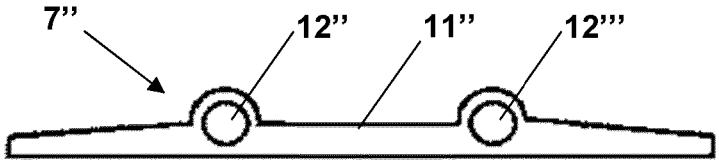


Fig. 4

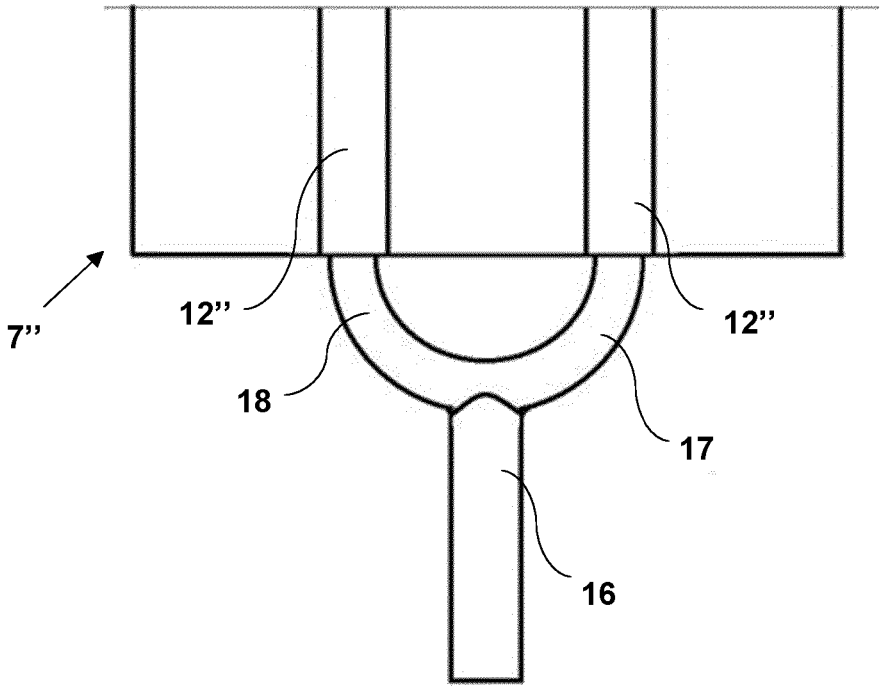

7''
12''
12''
18
17
16

Fig. 5

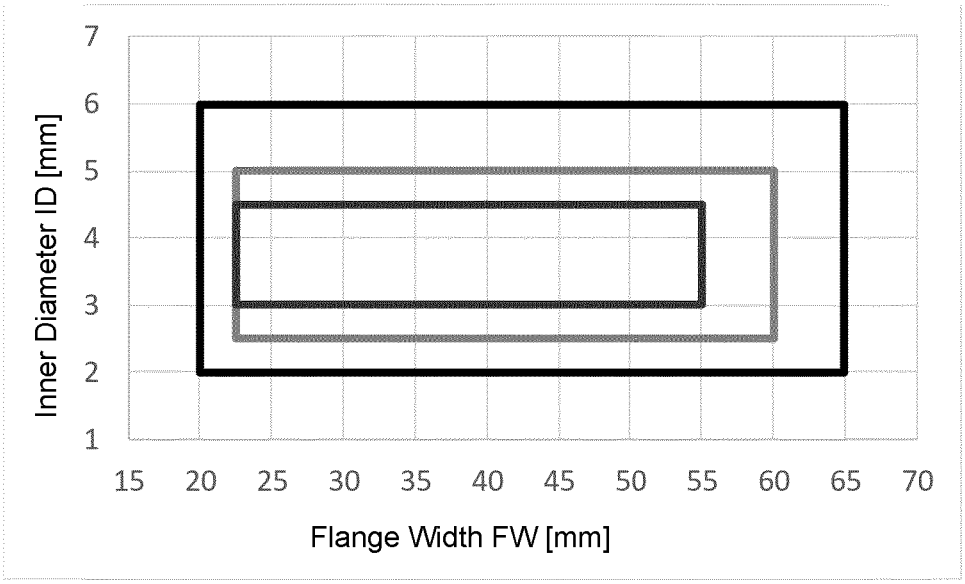

Inner Diameter ID [mm]
7
6
5
4
3
2
1
15
20
25
30
35
40
45
50
55
60
65
70
Flange Width FW [mm]

Fig. 6

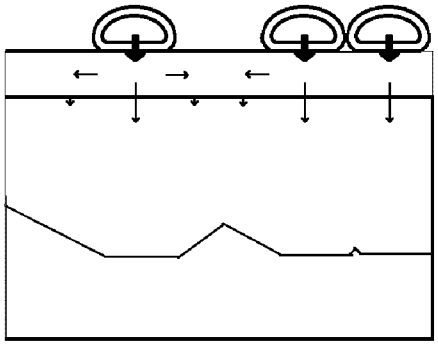


Fig. 7a

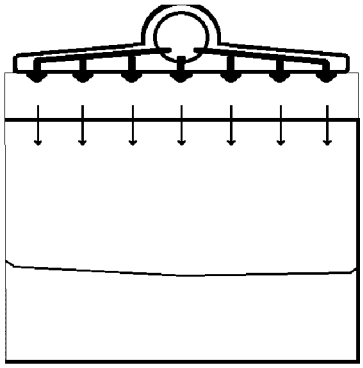


Fig 7b

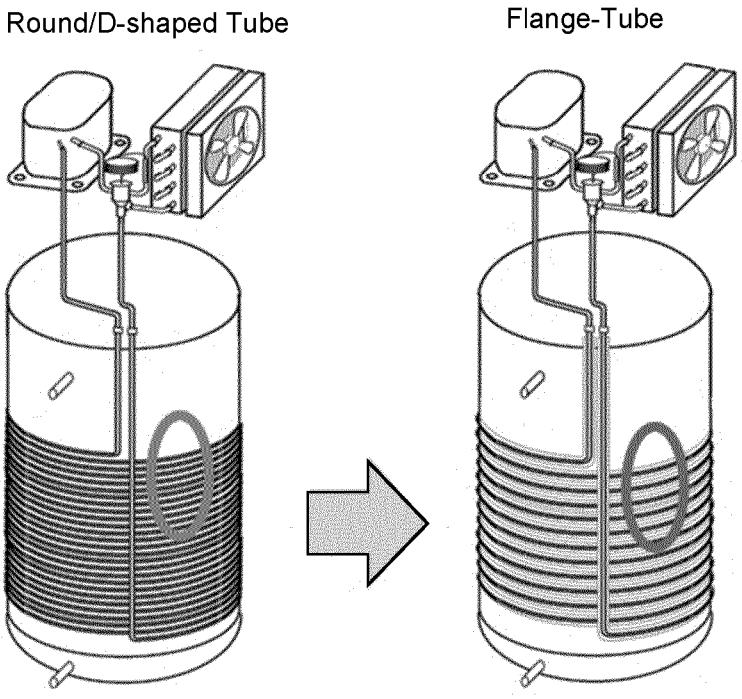


Fig. 8

A CONDENSER TUBE, A METHOD FOR HEAT TRANSFER AND AN APPARATUS FOR HEAT EXCHANGE

TECHNICAL FIELD

[0001] The present invention relates to a condenser tube, a method for heat transfer and an apparatus for heat exchange where a condenser tube is applied for circulation of a heat transfer medium for heat exchange purposes. More specific the present invention relates to a condenser tube profile with one or more channels and of a certain shape, that can be wound in a helix manner outside a container or tank of metal for heat transfer purposes, for instance heating of domestic water.

BACKGROUND ART

[0002] Common technology used today for transferring heat to a liquid contained in a tank made of steel or stainless steel, such as hot water heat pump, is based on round, flattened round or D-shaped aluminium condenser tubes wrapped around the tank. Due to poor heat conductivity in steel and stainless steel the heat is not spread far from the contact point tube-to-tank. To transfer enough heating energy to the liquid (water) in the tank, the condenser tubes are wrapped close to each other and over a greater part of the tank. The length of the round/flattened/D-shaped condenser tube therefore needs to be rather long, often 50-60 meters. Due to this length, the crossflow area of the round/flattened/D-shaped condenser tube therefore needs to be rather large not to introduce high pressure drop in the refrigeration cycle resulting in poor energy efficiency. This solution has been good enough as HFC refrigerant gases have been available without GWP (Global Warming Potential) restrictions/quota regulations until now.

[0003] CN107525311A discloses a high-efficiency cooling condenser pipe for a refrigerator which aims to solve the shortcomings of traditional condensation tubes. The high-efficiency cooling condenser pipe in CN107525311A comprises a heat induction part and a radiation cooling part, wherein the heat conduction part is in contact with the inner wall of a refrigerator body, and the radiation cooling part is connected to the heat conduction part. The preferred shape of the condenser pipe of CN107525311A is the form of omega, welded at the bottom opening.

[0004] There is a need for heat transfer pipes that allow reduced refrigerant charge, both to meet future regulations on refrigerant gases and to provide a more sustainable solution. Furthermore, a reduced charge of refrigerant will enhance the safety of the device. At the same time, it is desired that the energy efficiency (COP) of the heat exchanger is not reduced compared with the current technology, rather it is desired that the energy efficiency is the same or better compared with the best performing current technology.

SUMMARY

[0005] According to a first aspect, the present disclosure provides a condenser tube profile made of aluminium or an aluminium alloy arranged outside an object of a substantially cylindrical shape for heat transfer between a medium transported inside at least one channel of said condenser tube profile, the channel has an inner diameter (ID), and a medium, preferably a liquid, contained in said object, wherein the condenser tube profile is winded onto the outer surface of the said object, wherein the condenser tube profile has a substantially flat flange with a flange width (FW) integrated in parallel with a longitudinal direction of the condenser tube, and the flange is arranged in thermal contact with the outer surface of the said object.

[0006] The at least one channel may have a substantially round shape with the flange integrated in its periphery.

[0007] The flange may be thinner at its outer sides than in the vicinity of the at least one channel and have a slanting surface towards its longitudinal side edges.

[0008] The condenser tube profile may be winded in the shape of a helix with a pitch where one side edge of the flange abuts the other side edge.

[0009] The condenser tube profile is preferably extruded by an extrusion process, and coiled.

[0010] The object may be a tank or container made of steel or stainless steel.

[0011] The condenser tube profile may be provided with two channels.

[0012] The relation, or ratio between the inner diameter (ID) of the channel and the flange width (FW), ID:FW, may be in the interval 2 mm-6 mm: 20 mm-65 mm.

[0013] Alternatively, the relation, or ratio between the inner diameter (ID) of the channel and the flange width (FW), ID:FW, may be in the interval 2.5 mm-5 mm: 22.5 mm-60 mm.

[0014] In a further alternative, the relation, or ratio between the inner diameter (ID) of the channel and the flange width (FW), ID:FW may be in the interval 3 mm-4.5 mm: 22.5 mm-55 mm.

[0015] According to a second aspect, the disclosure provides a method for transferring heat between a heat transfer medium and a medium, preferably a liquid, such as water, contained in a substantially cylindrical tank of steel or stainless steel, where a condenser tube profile made of aluminium or an aluminium alloy conducts the heat transfer medium in one or more channels and is further arranged at the outside of the tank, wherein the condenser tube profile is provided with a substantial flat flange at the periphery of the condenser tube profile and where the sides of the flange are extending parallel to said condenser tube profile in the longitudinal direction thereof, and wherein the flange of the condenser tube is attached in firm contact with the tank and the condenser tube is winded as the shape of a helix.

[0016] The condenser tube profile may be winded in a helix shape with a pitch where the one side of the flange abuts or substantially abuts the other side of the flange.

[0017] The heat transfer medium is preferably a hydrocarbon refrigerant, and the refrigerant system charge is preferably up to 150 g.

[0018] According to a third aspect, the present disclosure concerns the use of a condenser tube profile according to the first aspect, wherein the condenser tube conducts a heat transfer medium in one or more channels and the condenser tube profile is arranged at the outer surface of a cylindrical tank for heating water.

[0019] The heat transfer medium is preferably a hydrocarbon refrigerant, and the refrigerant system charge is preferably up to 150 g.

[0020] According to a fourth aspect, the disclosure provides an apparatus for heating domestic water, comprising a cylindrical tank of steel or stainless steel for water to be heated, where a condenser tube profile made of aluminium

or an aluminium alloy is fixed onto the outer surface of the cylindrical tank for heating the water by a hot medium (refrigerant) flowing through one or more channel(s) of said condenser tube profile, wherein the condenser tube profile is provided with a substantial flat flange at its periphery, the flange having side edges extending in parallel with said condenser tube profile, in the longitudinal direction thereof, wherein the condenser tube profile is winded in the shape of a helix onto the surface of the tank and attached in firm contact with it.

[0021] The condenser tube profile may be winded in a helix shape with a pitch where the one side of the flange abuts or substantially abuts the other side.

[0022] The hot medium (refrigerant) flowing through the one or more channel(s) of said condenser tube profile is preferably a hydrocarbon refrigerant, and the refrigerant system charge is preferably up to 150 g.

[0023] According to the present invention, the condenser tube can be made of aluminium or an aluminium alloy in a single extrusion process, having one or more channels. Further, the extruded tube profile is provided with an integrated flange at its periphery. The flange has a flat face against the tank. The flat face against the tank which will secure a good mechanical and thermal contact between flange condenser tube and tank when the flanged condenser tube is tightly coiled around the tank flat surface. The big contact area between tube flange and tank minimizes the thermal contact resistance between flange tube and tank, hence optimizes the substantially one-dimensional heat transfer from flange tube to liquid inside the tank.

[0024] The cross-sectional shape of the condenser tube profile can be circular with a substantial flat flange and thus may have an omega shape but closed in shape. The substantially round channel shape with the flange integrated in its periphery can sustain internal pressure increase with minimum distortion of its shape and substantially without deformation of the flange, hence maintaining the good thermal contact between flange tube profile and tank. The flange should have sufficient thickness to sustain deformations during coiling and pressurizing. The flange can be thinner at its outer sides than in the vicinity of the channel(s) and thus having a slanting surface towards its longitudinal side edges.

[0025] By winding the condenser tube onto the outer surface of a tank for heating a fluid in a manner with windings of a pitch that brings the long sides of the flange close to each other or even to abut, a very efficient heat transfer can be obtained with a low amount of refrigerating medium necessary in the circulating circuit. One advantageous field of use for the condenser tube is that it can be arranged at the outer surface of a cylindrical tank for heating water for domestic use.

[0026] These and further advantages can be achieved by the invention according to the accompanying claims **1-19**.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] The invention will be further described in detail in the following by means of examples and with reference to the attached drawings **1-8** where:

[0028] FIG. **1** is a cross-section cut of a tank with a condenser tube at its outside and shows a State-of-the-art technology used today based on round, flattened round or D-shaped tubes wrapped around a tank,

[0029] FIG. **2** is a cross-section cut of a tank with a condenser tube profile with one channel and further provided with a flange and being wrapped at the outside the tank, which is an embodiment according to the present invention,

[0030] FIG. **3** shows a condenser tube profile with a flange according to the present invention having one channel,

[0031] FIG. **4** shows a condenser tube profile with a flange according to the present invention and further provided with two channels,

[0032] FIG. **5** discloses means of connecting the flange tube of FIG. **4** to a circuit,

[0033] FIG. **6** discloses a chart showing dimension ranges of various channels and flanges according to the invention,

[0034] FIG. **7***a* indicates the heat transfer in a heater applying a state-of-the-art D-shaped tube and in FIG. **7** *b* there is indicated the heat transfer according to the present flange tube.

[0035] FIG. **8** briefly discloses a sanitary water heater applying round or D-shaped tube (left), and a flange tube according to the present invention (right).

DETAILED DESCRIPTION

[0036] The present disclosure will now be described with reference to the accompanying drawings, in which preferred example embodiments of the disclosure are shown. The disclosure may, however, be embodied in other forms and should not be construed as limited to the herein disclosed embodiments. The disclosed embodiments are provided to fully convey the scope of the disclosure to the skilled person.

[0037] FIG. **1** is a cross-section cut of a tank with a condenser tube at its outside and discloses the state-of-the-art technology used today based on round, flattened round or D-shaped tubes **1** wrapped around a tank **2** made of steel or stainless steel (four windings shown). Due to poor heat conductivity in steel/stainless steel the heat is not distributed far from the contact point **3** tube-to-tank. To transfer enough heating energy to the water **4** in the tank, the tubes are wrapped close to each other **5** and over a greater part of the tank, which is also illustrated in FIG. **8**, left side. The length of the round/D-shaped tube therefore needs to be rather long, often 50-60 meters. The crossflow area **6** of the round/flattened/D-shaped tube therefore needs to be rather large not to introduce high pressure drop in the refrigeration cycle resulting in poor energy efficiency. This results in a certain amount of heat transfer medium in the circuit.

[0038] FIG. **2** discloses two windings of a condenser tube profile **7** provided with a flange **10**, **11** according to the present invention, made of aluminium or an alloy thereof and wrapped around a tank **8** made of steel or stainless steel. The tank may contain a body of water **4**. The good heat conductivity properties of aluminium allow the heat to travel from the channel **12** to the flange **11** with a minimum of restriction between the parts as indicated by arrows **9**.

[0039] As disclosed in FIG. **3**, the flange **11'** of the condenser tube profile **7'** according to the present invention covers a larger area of the tank with full surface contact and therefore minimizes the effect of the poor heat conductivity in steel/stainless steel and in the contact between tank and flange.

[0040] The large width of the flange **11'** associated with the condenser tube profile provided with channel **12'** for a heat transfer medium allows that the number of wraps around the tank can be reduced and therefore the tubular part

can be shortened significantly, for instance down to 18-23 meters, illustrated in the right side of FIG. **8**. This corresponds to 2 to 3 times shorter than commonly used solutions. The condenser tube can be winded in shape of a helix and advantageously with a pitch such that the sides of the flange abuts each other throughout the whole length of the helix to be able to cover as much as possible of the surface of the tank.

[0041] Preferably, the aluminium or aluminium alloy is of an A6xxx, A3xxx or A1xxx type, preferably A3xxx or A1xxx type, with ductility allowing that a condenser tube according to the invention can be formed in a convenient manner into a helix with planar abutment of its flange onto the cylindrical surface of the tank. (In the present disclosure, reference to A1xxx, A3xxx-series and A6xxx-series aluminium alloys refer to the nomenclature of the Aluminum Association which uses a four-digit system for wrought alloy composition families (ref. "International Alloy Designations and Chemical Composition Limits for Wrought Aluminum and Wrought Aluminum Alloys", by The Aluminum Association, Inc). The medium in the tank can be liquid, preferably water.

[0042] The radius (**13**) between the round part and the flange should preferably be placed close to the outer diameter and have a certain size, such as about 0.5 mm (but not limited to this value), to minimize heat transfer distance from refrigerant channel to outer tip of the flange. This design also serves to ease the extrusion process. Furthermore, together with a robust flange thickness, this design minimizes the deformation of the flat tube flange during coiling after the extrusion.

[0043] One technical effect of the significantly shorter tubular part provided by the invention is that it allows a great reduction of the cross-sectional flow area without introducing an overall high pressure drop in the refrigeration cycle.

[0044] The flange condenser tube profile can be made much shorter and with a smaller inner diameter than that of the prior art, and thus enabling a reduction of the inner volume without compromising any functional parameters.

[0045] As a consequence, this (the present condenser tube profile) allows low GWP (Global Warming Potential) gases such as Hydrocarbons to be used up to (and including) 150 gram system charge.

[0046] FIG. **4** shows an alternative design of the condenser tube profile **7"** with a flange **11"** according to the present invention and further provided with two channels **12"**, **12"'**. This design may be provided by one extruded profile and allows that the cross-sectional flow area can be reduced.

[0047] FIG. **5** discloses means of connecting the condenser tube profile **7"** with two channels **12"**, **12"'** of FIG. **4** to a circuit that comprises a yoke formed tube with a main tube **16** having branches **17**, **18**.

[0048] FIG. **6** discloses a chart showing dimension ranges of various channels and flanges according to the invention, indicated by three rectangular areas;

[0049] where the relation, or ratio, between the inner diameter of the channel (ID) and the flange width (FW), (ID):(FW) is in the interval (2 mm-6 mm):(20 mm-65 mm,

[0050] or (ID):(FW) is in the interval (2.5 mm-5 mm):(22.5 mm-60 mm),

[0051] or (ID):(FW) is in the interval (3 mm-4.5 mm):(22.5 mm-55 mm).

[0052] FIG. **7***a* indicates the heat transfer in a heater applying a state-of-the-art D-shaped tube and in FIG. **7** *b* there is indicated the heat transfer according to the present flange tube. The arrows indicate the heat transfer and as can be seen from the illustration in FIG. **7***b* the transfer of heat is very even.

[0053] FIG. **8** briefly discloses a sanitary water heater applying round or D-shaped tube (left), and a flange tube according to the present invention (right). It can be seen that the number of windings of the tube is reduced significantly in the right illustration.

[0054] For instance, simply increasing the flange width brings some advantages. Fewer turns around the tank results in reduced total tube length. This enables reduced refrigerant charge and furthermore, reduced pressure drop in the refrigeration system. On the other side, increasing the flange width leads to longer way for the energy (heat) to travel to reach the tip of the flange, which might lead to slight reduction of total heat transfer into the tank (e.g. the water to be heated).

[0055] Reducing the inner diameter of the tube (channel **12**) brings some advantages like reduced refrigerant charge. On the other side, a possible disadvantage is increased pressure drop in the refrigeration system.

Test

[0056] A Sanitary Hot Water Heat Pump system with 150 g Propane (R290) charge using the present flange-tube profile with inner diameter, ID=ø4.5 mm and flange width, FW=25 mm was tested according to EN 16147. The resulting COP=3.63 was a considerable improvement compared to the COP=3.15 of a traditional system with 900 g R134a (a standard HFC-refrigerant) and round, flattened ø10×1 condenser tube. For reference, the traditional system with round, flattened ø10×1 condenser tube was also tested with 350 g R290 showing COP=3.52.

Conclusions from Test Work:

[0057] Energy Efficiency (COP) using the present flange condenser tube profile can be increased to approx. 3.6-3.8 with system charge 150 g Propane (R290) in a typical Sanitary Hot Water Heat Pump system. Thus, the present flange condenser tube profile reduced the R290 charge to 150 g, which is within safety limits, and improved the COP to approximately same level as high performing common systems using HFC refrigerant gas.

[0058] Energy Efficiency (COP) can be improved further with reduced inner diameter/wider flange (in combination with optimized/lower inner volume evaporator) and operate with max. 150 g Propane.

[0059] Furthermore, according to the present invention there is a possibility to reduce the amount of material used for the manufacturing of the condenser tube compared to the state-of-the-art tubes.

[0060] As an example; a round or D-shaped aluminium tube with ø10×1 mm would require about 77 g/m×55.6 meter=>4.29 kg of aluminium/unit. An aluminium flange condenser tube profile according to the present disclosure with ID=ø5 mm and flange width=25 mm would require about 140 g/m×23 meter=>3.22 kg of aluminium/unit. Therefore, the present aluminium flange condenser tube profile represents a more sustainable solution also with respect to the required material which is significantly less.

[0061] The condenser tube profile can be extruded in its full length, and it can be coiled during production.

1. A condenser tube profile (**7**, **7'**, **7"**) made of aluminium or an aluminium alloy arranged outside an object (**8**) of a substantially cylindrical shape for heat transfer between a medium transported inside at least one channel (**12**) of said condenser tube profile (**7**, **7'**, **7"**), the channel (**12**) has an inner diameter (ID), and a medium, preferably a liquid, contained in said object (**8**), wherein the condenser tube profile (**7**, **7'**, **7"**) is winded onto the outer surface of the said object (**8**),

wherein

a substantially flat flange (**11**) with a flange width (FW) is integrated in parallel with a longitudinal direction of the condenser tube, where the flange is arranged in thermal contact with the outer surface of the said object (**8**).

2. The condenser tube profile according to claim **1**, wherein the at least one channel (**12**) has a substantially round shape with the flange (**11**) integrated in its periphery.

3. The condenser tube profile according to claim **1**, wherein the flange (**11**) is thinner at its outer sides than in the vicinity of the at least one channel (**12**) and has a slanting surface towards its longitudinal side edges.

4. The condenser tube profile according to claim **1**, wherein the condenser tube profile (**7**, **7'**, **7"**) is winded in the shape of a helix with a pitch where one side edge of the flange abuts the other side edge.

5. The condenser tube profile according to claim **1**, wherein the condenser tube profile (**7**, **7'**, **7"**) is made by an extrusion process.

6. The condenser tube profile according to claim **1**, wherein the object (**8**) is a tank or container made of steel or stainless steel.

7. The condenser tube profile according to claim **1**, wherein the condenser tube profile (**7"**) is provided with two channels (**12"**, **12'"**).

8. A The condenser tube profile according to claim **1**, wherein the condenser tube profile (**7**, **7'**, **7"**) is extruded and coiled.

9. The condenser tube profile according to claim **1**, wherein the relation between the inner diameter (ID) of the channel (**12**, **12'**, **12"**, **12'"**) and the flange width (FW), (ID):(FW), is in the interval (2 mm-6 mm):(20 mm-65 mm).

10. The condenser tube profile according to claim **9**, wherein the relation between the inner diameter (ID) of the channel (**12**, **12'**, **12"**, **12'"**) and the flange width (FW), (ID):(FW), is in the interval (2.5 mm-5 mm):(22.5 mm-60 mm).

11. The condenser tube profile according to claim **10**, wherein the relation between the inner diameter (ID) of the channel (**12**, **12'**, **12"**, **12'"**) and the flange width (FW), (ID):(FW) is in the interval (3 mm-4.5 mm):(22.5 mm-55 mm).

12. A method for transferring heat between a heat transfer medium and a medium, preferably a liquid, contained in a substantially cylindrical tank of steel or stainless steel (**8**), where a condenser tube profile (**7**, **7'**, **7"**) made of aluminium or an aluminium alloy conducts the heat transfer medium in one or more channels (**12**) and is further arranged at the outside of the tank,

wherein

the condenser tube profile (**7**, **7'**, **7"**) is provided with a substantial flat flange (**11**) at the periphery of the condenser tube profile (**7**, **7'**, **7"**) and where the sides of the flange are extending parallel to said condenser tube profile (**7**, **7'**, **7"**) in the longitudinal direction thereof, wherein the flange (**11**) of the condenser tube is attached in firm contact with the tank (**2**) and where the condenser tube is winded as the shape of a helix.

13. The method according to claim **12**, wherein the condenser tube profile (**7**, **7'**, **7"**) is winded in a helix shape with a pitch where the one side of the flange abuts or substantially abuts the other side of the flange.

14. The method according to claim **12**, wherein the heat transfer medium is a hydrocarbon refrigerant, and the refrigerant system charge is up to 150 g.

15. Use of a condenser tube profile (**7**, **7'**, **7"**) according to claim **1**, wherein the condenser tube conducts a heat transfer medium in one or more channel(s) (**12**) and the condenser tube profile (**7**, **7'**, **7"**) is arranged at the outer surface of a cylindrical tank (**8**) for heating water.

16. Use of a condenser tube profile (**7**, **7'**, **7"**) according to claim **15**, wherein the heat transfer medium is a hydrocarbon refrigerant, and the refrigerant system charge is up to 150 g.

17. An apparatus for heating domestic water, comprising a cylindrical tank (**8**) of steel or stainless steel for water to be heated, where a condenser tube profile (**7**, **7'**, **7"**) made of aluminium or an aluminium alloy is fixed onto the outer surface of the cylindrical tank (**8**) for heating the water by a hot medium flowing through one or more channel(s) (**12**) of said condenser tube profile (**7**, **7'**, **7"**), wherein

the condenser tube profile (**7**, **7'**, **7"**) is provided with a substantial flat flange (**11**) at its periphery, the flange having side edges extending in parallel with said condenser tube profile, in the longitudinal direction thereof, wherein the condenser tube profile (**7**, **7'**, **7"**) is winded in the shape of a helix onto the surface of the tank (**8**) and attached in firm contact with it.

18. The apparatus according to claim **17**, wherein the condenser tube profile (**7**, **7'**, **7"**) is winded in a helix shape with a pitch where the one side of the flange abuts or substantially abuts the other side.

19. The apparatus according to claim **17**, wherein the hot medium flowing through the one or more channel(s) (**12**) of said condenser tube profile (**7**, **7'**, **7"**) is a hydrocarbon refrigerant, and the refrigerant system charge is up to 150 g.

* * * * *