

"METHOD OF CONNECTING COPPER
AND ALUMINUM PIPES"

The present invention relates to a method of connecting a copper pipe and an aluminum pipe, which is used, for example, for connecting a copper pipe to an aluminum refrigerant pipe of a cooling unit of a refrigerator.

Refrigeration cycle piping in a refrigerator is constructed by pipes made of materials such as copper, aluminum and iron. Such pipes are connected by methods suitable to each material to be used. In conventional methods of connecting a copper pipe with an aluminum pipe (refrigerant pipe of a cooling unit), a short copper pipe and an aluminum pipe are connected in a joint by flash welding, butt welding or explosion pressure welding. However, such a joint is expensive. Furthermore, when an aluminum pipe of the joint is connected to the aluminum pipe of the cooling unit, TIG welding, which is a highly complicated procedure, must be performed. In order to solve this problem, a method has been proposed for soldering together a copper pipe and an aluminum pipe which are connected with each other. According to this method, solder is applied to an outer surface portion of an end of a copper pipe which is connected into an inner surface portion of an enlarged end of an aluminum pipe to which solder has also been applied. Ultrasonic vibration is applied to

the copper pipe to melt the solder and thereby connect the two pipes. As was mentioned, in this method, solder is applied to both pipes. Therefore, in order to connect the two pipes, the inner diameter of the end of the aluminum pipe must be far greater than the outer diameter of the end of the copper pipe. Thus, a clearance between the copper and aluminum pipes is increased, resulting in poor welding strength and requiring a large amount of solder. In addition, since the solder may not seal the entire welding portion, refrigerant leakage can result.

The present invention has been made in consideration of this and has as its object to provide a method of connecting, with solder, a copper pipe and an aluminum pipe which are connected to each other, wherein the welding strength between the two pipes is high, the amount of solder used is small, and the solder is introduced along the entire welding portion between the two pipes so as to prevent leakage of a refrigerant.

According to the present invention, there is provided a method of connecting a copper pipe and an aluminum pipe, comprising the steps of:

preparing a copper pipe having an outer surface portion at one end portion thereof, which is coated with solder, and an aluminum pipe having an inner surface

portion at one end portion thereof, which is coated with solder;

positioning the copper and aluminum pipes so that the said end portions face each other and are coaxial;

5 relatively moving the copper and aluminum pipes so that their ends abut under a predetermined force;

heating and melting the solder applied to the said one end portions of the copper and aluminum pipes while the copper and aluminum pipes abut each other;

10 applying ultrasonic oscillation to the copper and aluminum pipes while the solder is melted and while said one end portion of the copper pipe is inserted into said one end portion of the aluminum pipe under a force greater than said predetermined force; and

15 cooling the solder while the copper pipe is inserted into the aluminum pipe, thereby connecting the copper and aluminum pipes.

With this method, the pipes may be securely welded, welding strength is improved, and the amount of

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solder used is decreased. Furthermore, solder fills the entire welding portion between the two pipes. A copper pipe of higher strength is fitted inside an aluminum pipe. Therefore, even if two pipes must be welded tightly, the inner diameter of neither pipe will be decreased.

This invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a side view showing a copper pipe and an aluminum pipe which are connected by a method according to an embodiment of the present invention;

Fig. 2 is an enlarged sectional view of one end portion of each of the copper and aluminum pipes;

Fig. 3 is a schematic sectional view of a solder plating apparatus for explaining a step of applying solder to a copper pipe;

Fig. 4 is a sectional view schematically showing a solder plating apparatus for applying solder to an aluminum pipe; and

Figs. 5 to 9 are sectional views showing in sequential order the steps of the method according to the present invention.

The preferred embodiment of the present invention will now be described with reference to the accompanying drawings.

Figs. 1 and 2 show a copper pipe 1 and an aluminum

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pipe 2 (refrigerant pipe of a cooling unit), both of which are of cylindrical shape and are to be connected. A distal end of the copper pipe 1 is tapered so as to have a smaller diameter toward its distal end opening.

5 The diameter of the distal end of the aluminum pipe is enlarged so as to form an enlarged-diameter portion 2a. The extreme end of the portion 2a is tapered so as to have a large diameter. An inner diameter A of the enlarged-diameter portion 2a, except for the tapered
10 portion, is equal to or slightly smaller than an outer diameter B of the copper pipe 1. According to this embodiment, the diameter A is set to be smaller than the diameter B by about 0.05 to 0.1 mm. This difference corresponds to an estimated thickness (about 0.05 to
15 0.1 mm) of an eroded layer of the aluminum pipe 2, which is removed upon ultrasonic solder welding. A length C of the enlarged-diameter portion 2a is slightly shorter than a fitting length D (Fig. 9) of the pipes 1 and 2.

Figs. 3 and 4 show an ultrasonic solder plating
20 apparatus for applying solder on the copper pipe 1 and the aluminum pipe 2. An oscillating plate 6 is connected to an ultrasonic oscillator 5 and is dipped in molten solder 7 in a solder bath tank 4 with a heater 3. The copper pipe 1 and the aluminum pipe 2 which are
25 dipped in the solder 7 are connected to blow pipes 10 and 11, which are respectively connected to an air compressor 20 through solenoid valves 8 and 9. The blow

pipe 10 connected to the copper pipe 1 is also connected to the air compressor 20 through a pressure reducing valve 12. The blow pipe 11 connected to the aluminum pipe 2 is exposed to air through a small hole 11a formed in the pipe wall. The solder 7 is an aluminum solder consisting of, for example, 95% of Zn and 5% of Al. The heating temperature of the solder 7 is set such that the copper pipe 1 side is kept at about 415°C, and the aluminum pipe 2 side is kept at about 440°C.

Fig. 5 shows a part of a pipe connecting apparatus. A pressure jig 14 for holding the copper pipe 1 concentrically with the aluminum pipe 2 is arranged above a holder 13 holding the pipe 2 to be vertically movable. An ultrasonic oscillator 15 is mounted on the pressure jig 14. Two sets of gas burners 16 and 17 are each arranged in two steps between the holder 13 and the pressure jig 14. The gas burners 16 and 17 are for heating the copper and aluminum pipes 1 and 2, respectively.

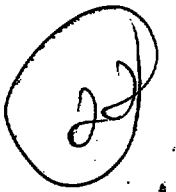
Procedures for connecting the copper pipe 1 and the aluminum pipe 2 will be described below.

First, solder is applied to ends of the two pipes 1 and 2. For this purpose, the pipes 1 and 2 are connected to the blow pipes 10 and 11. The solenoid valves 8 and 9 are closed and ends of the pipes 1 and 2 are dipped in the melted solder 7 while the ultrasonic oscillator 7 is driven, as shown in Figs. 3 and 4.

Since low pressure compressed air is supplied from the air compressor 20 into the copper pipe 1 through the valve 12 and the blow pipe 10, the internal pressure of the copper pipe 1 is increased and the melted solder 7 will not enter the pipe 1. Meanwhile, the air inside the aluminum pipe 2 is released through the small hole 11a of the blow pipe 11. Therefore, the melted solder 7 is introduced inside the aluminum pipe 2. As a result, the solder 7 coats only the outer surface portion at the end portion of the copper pipe 1, and the inner and outer surface portions at the end of the aluminum pipe 2. Ultrasonic oscillation (about 18 kHz) is applied to the solder 7 by the oscillator 6. Thus, cavitation occurs and an indefinite number of vacuum nuclei are formed in the melted solder 7. The instantaneous force generated when such nuclei disappear serves to remove surface contamination or oxide films on the copper pipe 1 and the aluminum pipe 2, thereby forming uniformly thin solder layers on the two pipes 1 and 2. The ultrasonic oscillation increases the flowability of the solder 7 and improves the wetting and plating ability of the pipes. After the plating, the pipes 1 and 2 are drained and the valves 8 and 9 are opened. Then, the compressed air is blown through the copper pipe 1 and the aluminum pipe 2 via the blow pipes 10 and 11. This blows away "dripping" excess solder from the lower ends of the pipes 1 and 2 and prevents formation of solder

lumps dripping from the pipes 1 and 2. In order to coat the copper pipe 1 with a sufficient amount of solder 7, the copper pipe 1 is dipped in the solder 7 again (the dipping depth in the second dipping operation is set to be slightly less than that in the first dipping operation). The aluminum pipe 2 is air-blown again in order to form a more uniform layer on the inner surface of the pipe 2.

In the manner described above, thin solder layers 18 and 19 are formed on the ends of the copper pipe 1 and the aluminum pipe 2, respectively. The pipes 1 and 2 are held by the pressure jig 14 and the holder 13 so as to be vertically opposed to each other, as shown in Fig. 5. The pressure jig 14 is moved downward so as to abut the lower end of the pipe 1 against the upper end of the pipe 2 under a low pressure. In this state, the ends of the pipes 1 and 2 are heated by the gas burners 16 and 17 so as to melt the solder layers 18 and 19, respectively, as shown in Fig. 7. If the pressure acting on the copper pipe 1 in this step is excessively great, the copper pipe 1 is inserted into the aluminum pipe 2 when the solder layers 18 and 19 are melted. In this case, a good coupling cannot be obtained. Therefore, the pressure acting on the pipe 1 is kept very low. When the solder layers 18 and 19 are melted, the ultrasonic oscillator 15 is driven. At the same time, the pressure jig 14 is used to strongly urge the



copper pipe 1 downward so as to fit the end of the
copper pipe 1 inside the end of the aluminum pipe 2, as
shown in Fig. 8. The amount of downward movement of the
copper pipe 1 in this step is set to be slightly larger
5 than the length C of the enlarged-diameter portion 2a of
the aluminum pipe 2. Then, the copper pipe 1 having a
higher strength than that of the aluminum pipe 2 is used
to expand the lower portion of the enlarged-diameter
portion 2a of the aluminum pipe 2. When the diameter of
10 the aluminum pipe 2 is enlarged by the copper pipe 1 in
this manner, the two pipes 1 and 2 are in tight contact
with each other. Furthermore, since the inner diameter
of the enlarged-diameter portion 2a of the aluminum pipe
2 is set to be slightly smaller than the outer diameter
15 of the copper pipe 1, erosion of the aluminum pipe 2
during solder plating will not increase the clearance
between the pipes 1 and 2. Thus, the ultrasonic
oscillation applied on the copper pipe 1 from the
ultrasonic vibrator 5 is effectively transmitted to the
20 aluminum pipe 2. The ultrasonic oscillation improves
the wetting and plating ability of the solder layers 18
and 19 with the melted solder 7, and allows complete
filling of the clearance between the pipes 1 and 2 with
the solder 7. Thereafter, application of ultrasonic
25 oscillation and heating by the gas burners 16 and 17 are
stopped. The solder solidifies by natural cooling. In
this manner, the copper pipe 1 and the aluminum pipe 2

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are welded together.

As has been described above, according to the present invention, solder coated on end portions of a copper pipe and an aluminum pipe, respectively, is melted by heating. Ultrasonic oscillation is applied to the copper and aluminum pipes while the end portions of these pipes are fitted with each other. Therefore, the pipes can be securely welded with a high welding strength. Since only a small clearance is kept between the two pipes, the amount of solder used is small. The solder can also be introduced uniformly in the entire fitting portion between the two pipes, so leakage of any fluid flowing through these pipes in an application site will be prevented. Since a copper pipe having a higher strength is inserted into an aluminum pipe, the inner diameter of neither pipe will be decreased. The flow of a fluid through these pipes will not be prevented.

In the embodiment described above, an aluminum pipe is exemplified by one used as a refrigerant pipe of a cooling unit in a refrigerator. However, any aluminum pipe for other applications may be used. The aluminum pipe is not limited to a cylindrical pipe but may be a pipe with an elliptical or rectangular section. One end of a copper pipe and an aluminum pipe need not be enlarged in diameter nor tapered. Solder for connecting the two pipes may include any components or have any composition as long as it is capable of soldering

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aluminum and copper. Various techniques known in this art may be used for applying solder to each pipe.

CLAIMS

1. A method of connecting a copper pipe and an aluminum pipe, comprising the steps of:

5 preparing a copper pipe having an outer surface portion at one end portion thereof, which is coated with solder, and an aluminum pipe having an inner surface portion at one end portion thereof, which is coated with solder;

10 positioning the copper and aluminum pipes so that the said end portions face each other and are coaxial; relatively moving the copper and aluminum pipes so that their ends abut under a predetermined force;

heating and melting the solder applied to the said one end portions of the copper and aluminum pipes while the copper and aluminum pipes abut each other;

15 applying ultrasonic oscillation to the copper and aluminum pipes while the solder is melted and while said one end portion of the copper pipe is inserted into said one end portion of the aluminum pipe under a force greater than said predetermined force; and

20 cooling the solder while the copper pipe is inserted into the aluminum pipe, thereby connecting the copper and aluminum pipes.



2. A method according to claim 1, wherein the solder is coated on said one end portion of each of the copper and aluminum pipes in thin layers.

3. A method according to claim 1 or 2, wherein said one
5 end portion of the copper pipe has an outer diameter which is not smaller than the inner diameter of said one end portion of the aluminum pipe.

4. A method according to any of claims 1 to 3, wherein
10 said one end portion of the aluminum pipe has a diameter larger than that at the other end thereof.

5. A method according to any of claims 1 to 4, wherein
a distal end of said one end portion of the copper pipe has a tapered portion having a smaller diameter toward the opening thereof, and a distal end of said one end
15 portion of the aluminum pipe has a tapered portion having a larger diameter toward the opening thereof.

6. A method according to any of claims 1 to 5, wherein
said one end portion of the copper pipe is inserted into
20 said end portion of the aluminum pipe for a distance longer than the length of said one end portion of the aluminum pipe.

7. A method of connecting copper and aluminum pipes, substantially as hereinbefore described with reference to the accompanying drawings.

25 8. A copper pipe and an aluminum pipe which are connected by a method according to any of claims 1 to 7.

