

THERMOPLASTIC FITTING ELECTRIC HEAT WELDING
METHOD AND APPARATUS

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5 The present invention relates to a method and apparatus for electrically heat welding thermoplastic fittings having electric resistance heating elements disposed therein to other plastic members, such as plastic pipe joints.

10 Electric heat weldable fittings formed of thermoplastic material generally include an electric resistance heating coil or element positioned adjacent the inside surfaces of the fitting which are to be welded to one or more other thermoplastic members such as plastic pipe sections. The electric resistance heating element is usually a coil of resistance wire disposed in the thermoplastic material of the fitting and is connected to electric contacts which are attached to an outside surface of the fitting. Examples of such electric heat weldable thermoplastic fittings are described in United States Patents Nos 4,147,926 and 4,349,219.

20 In the welding the fitting to other plastic members positioned adjacent thereto, a source of electric power is connected to the contacts, such as by electric cable, and electric power is supplied to the resistance heating element of the fitting. The heating element heats the fitting and the adjacent thermoplastic members to temperatures which cause the thermoplastic materials to melt whereby they become welded together.

25 The quality of the weld which results is primarily dependent upon the correct quantity of electric power being supplied to the heating element of the fitting. If too little electric power is supplied, too little heating takes place and an inadequate low strength weld results. If too much electric power is supplied, the fitting and plastic members to which the fitting is welded can be deformed and overheated whereby a good weld does not result. Other factors that affect the quality of the weld produced include heating element abnormalities, eg

short-circuits, poor fitting alignment and poor contact between surfaces to be welded.

Various types of control and electric power generating apparatus have been utilized for supplying the electric power to electric heat weldable thermoplastic fittings. Initially, such apparatus was manually controlled by an operator and the quantity of electric power supplied to the heating elements of the fittings was determined by visual observation of the fittings as they were welded. More recently, control apparatus has been developed whereby the operator manually programs the control apparatus to supply a predetermined quantity of electric power to the heating element of the fitting in accordance with the particular size of the fitting. Also, electric heat weldable fittings having heating coils and separate resistors disposed therein have recently been developed. The values of the resistors are chosen in accordance with the size of the fitting and the electric power to be supplied thereto. Electric power control apparatus is utilized with such fittings adapted to sense the values of the resistors and automatically supply a preset quantity of electric power to the heating coil in accordance therewith. Examples of such fittings and control apparatus are described in United States patent No. 4,486,650.

While the fittings including separate resistors and the control apparatus which automatically supply the heating coils of the fittings with predetermined quantities of electric power have generally achieved reasonably good results, there is significant room for improvement.

According to one aspect of the invention there is provided a method of electrically heat welding a thermoplastic fitting having an electric resistance heating element disposed therein whereby a regulated quantity of electric power is supplied to the heating element during

the welding process and the making of a high quality weld is ensured, said method comprising the steps of:-

a) connecting said fitting to a controlled electric power source whereby said resistance heating element of said fitting is supplied with controlled electric power;

b) sensing the initial temperature of said fitting;

c) sensing the initial magnitude of the current flowing through said resistance heating element of said fitting and comparing such magnitude with predetermined current levels for various sizes of fittings thereby to determine the size of said fitting being welded and the total time the controlled electric power should be supplied to said resistance heating element of said fitting to ensure the making of a high quality weld;

d) continuing to sense one or more electrical characteristics of said resistance heating element of said fitting during the time said controlled electric power is supplied thereto and comparing such characteristics at predetermined time intervals with predetermined electrical characteristics for the size of fitting determined in step (c) thereby to determine if the welding process is proceeding abnormally at such time intervals; and

(e) terminating the supply of electric power to said resistance heating element of said fitting when it is determined that said welding process is proceeding abnormally in step (d) or otherwise at the end of the total time required for the making of a high quality weld as determined in accordance with step (c).

According to another aspect of the invention there is provided apparatus for electrically heat welding a thermoplastic fitting having an electric resistance heating element disposed therein connected to a pair of electric contacts attached to said fitting whereby a regulated quantity of electric power is supplied to the heating element during the welding process and the making of a high

quality weld is ensured, said apparatus comprising first electric power generating means for producing controlled electric power; current sensor means for sensing the magnitude of the current flow from said electric power generating means electrically connected thereto; electric cables connected to said electric power generating means and adapted for removable connection to said electric contacts of said fitting for connection to said electric contacts of said fitting for conducting electric power to said electric resistance heating element of said fitting; switch means electrically connected between said electric power generating means and said cable; and a computer operably connected to said current sensor means and said switch means for receiving and comparing the magnitude of the current flowing through said resistance heating element of said fitting with predetermined current levels for various sizes of fittings and thereby determining the size of the fitting being welded and the total time the constant voltage electric power should be supplied to said heating element of said fitting for the making of a high quality weld, and for comparing such magnitude at predetermined time intervals with predetermined current levels for the size of fitting being welded, thereby to determine if the welding process is proceeding abnormally at such time intervals and for operating said switch means to terminate the supply of electric power to said heating element of said fitting, if it is determined that said welding process is proceeding abnormally or otherwise at the end of the total time determined to be required for the making of a high quality weld and temperature sensing means attached to said cable and adapted for connection to at least one of said electric contacts of said fitting and wherein said computer is operably connected to said temperature sensor means for adjusting the total time said electric power is supplied to said heating element in accordance with the initial temperature of said fitting.

Preferably, the method of welding includes the steps of sensing the magnitude of the temperature of said resistance heating element of said fitting over the time period said controlled electric power is supplied thereto and comparing such magnitude at predetermined time intervals with predetermined temperature levels for the size of fitting determined in step (c) thereby to determine if the welding process is proceeding abnormally at such time intervals; and terminating the supply of controlled electric power of said resistance heating element when it is determined that said welding process is proceeding abnormally as a result of such temperature comparisons.

With such a method and apparatus, the thermoplastic fittings do not require separate resistors or other devices for indicating the electric power required. In accordance with the present invention, the entire welding process of each fitting is comparatively monitored to ensure the fitting and other aspects of the process are

not defective and that the proper quantity of electric power is supplied to the fitting.

5 The method and apparatus of the present invention enable the quantity of electric power supplied to the heating element to be automatically determined and accurately controlled and also enable the quality of the fitting to be determined early in the welding process and the application of electric power to the fitting terminated if such fitting is defective.

10 It is also possible for the initial temperature of the fitting to be taken into account and the temperature of the heating element to be comparatively monitored along with the magnitude of the current flowing therethrough during the welding process to ensure a high quality weld.

15 In order that the present invention will be more readily understood, the following description is given merely by way of example, reference being made to the accompanying drawings in which:-

20 Figure 1 is a side view of an electric heat weldable thermoplastic sleeve, having the ends of a pair of pipe sections inserted therein, with one embodiment of electric power and control apparatus of the present invention illustrated schematically in relation thereto;

25 Figure 2 is an enlarged cross-sectional view of portions of the fitting, plastic pipe sections and electric power and control apparatus of Figure 1;

Figure 3 is a partial top view taken along line 3-3 of Figure 2;

30 Figure 4 is an enlarged view of one of the connectors of the electric power and control apparatus of Figure 1;

Figure 5 is a bottom view taken along line 5-5 of Figure 4;

35 Figure 6 is a graph showing the current-time relationships of different fittings; and

Figure 7 is a schematic illustration of the electric power and control apparatus of the present invention connected to a thermoplastic fitting having a resistance heating element disposed therein.

5 Referring now to Figures 1 and 2, an electric heat weldable thermoplastic sleeve 10 is illustrated with the ends of a pair of thermoplastic pipe sections 12 and 14 inserted therein. The sleeve 10 is illustrated with the ends of a pair of thermoplastic pipe sections 12 and 14
10 inserted therein. The sleeve 10 includes a pair of electric contact connectors 16 and 18 attached thereto for receiving complementary, removable electric connectors 20 and 22 attached to the ends of electric cables 24 and 26, respectively. The cables 24 and 26 are connected to an
15 electric power and control apparatus which will be described in detail below.

As best shown in Figure 2, the thermoplastic fitting 10, an electric resistance heating element 28 includes adjacent portions of the interior surface 32
20 thereof which preferably is a coil formed of electric resistance heating wire disposed in a spiral winding within the thermoplastic material forming the sleeve 10. The ends of the heating wire 28 are connected to electric contact pins 34 and 36 in connectors 16 and 18.

25 The connectors 20 and 22 include electric contact sockets 38 and 40, respectively, for engagement with the pins 34 and 36 of the connectors 16 and 18, and these sockets are connected to wires 39 and 40 extending through the cables 24 and 26 respectively. The connector 22 can
30 also include a temperature sensing device 42 such as a thermister, RTD, or thermocouple positioned in heat conducting relationship with the socket contact 40 which is connected to a multiple lead wire 43 also extending through the cable 26. The device 42 senses the temperature of the
35 contact pin 36 when the socket contact 40 is engaged with

the pin 36, to sense an initial temperature which is representative of the outside surface temperature of the entire sleeve 10.

As shown in Figures 2 and 3, the connector 16 of the fitting 10 optionally has moulded around its inner periphery one or more (preferably one to nine) longitudinal code ridges 31, one or more of which can be enlarged so that it also functions as a position guide for the complementary contactor 20. Each size of fitting 10 can include a connector 16 having a particular number and/or arrangement of code ridges 31 to indicate that particular size. For example, the arrangement illustrated in Figure 3 (5 ridges) could indicate a 5-inch (12.7 cm) size fitting. As illustrated in Figures 2, 4 and 5, the complementary connector 20 also optionally includes nine longitudinal recesses 33 which are complementary to the ridges 31 of the connector 16. The connector 20 also includes a code ridge sensing device, such as micro-switch 37, disposed in each of the recesses 33 to detect the present of a code ridge therewithin. The micro-switches 37 are electrically connected to leads 35 of a multiple lead wire 27 which extends through the cable 24.

Referring now to Figure 7, the electric power and control apparatus 30 for the present invention is schematically illustrated connected to the heating element 28 of the sleeve 10 by way of the cables 24 and 26 and the connectors 16, 18, 20 and 22. The apparatus 30 includes a controlled voltage electric power source 45 which is connected by the wires 39 and 41 to the contact sockets 38 and 40 of the connectors 20 and 22. A low voltage electric power source 47 is connected to the wires 39 and 41 by wires 53 and 55, respectively.

A current sensor 46 for sensing the current flowing from the power source 45 to the heating element 28 is electrically connected to the power source 45 by a lead

59 with the output signal therefrom connected by a lead 48 to an electronic computer 50. A resistance sensor 57 for sensing the resistance of the heating element 28 when minimum voltage electric power is applied thereto is electrically connected to the power source 47 by a lead 61 with the output signal therefrom connected to the computer 50 by a lead 63. The temperature sensing device 42, previously described, is connected by the wire 43 attached thereto and extending through the cable 26 to the computer 50, and the microswitches 37 of the connector 20 are connected to the computer 50 by the multiple lead wire 27.

A switch device 52 such as a TRIAC or SCR is provided in the circuit between the heating element 28 and the power source 45 which is operably connected to the computer 50 by a lead 54. A similar switch device 65 is provided in the circuit connecting the power source 47 to the wires 39 and 41 which is connected to the computer 50 by a lead 67. The computer includes a readout module 51 operably connected thereto for visually indicating various modes of operation of the apparatus 30 such as a shut-down due to a defective fitting, etc. Also, the computer 50 is connected to a communication interface 69 by a lead 70 which in turn can be connected to a modem 72, a second computer 74 and a printer 16.

In operation, with the connectors 20 and 22 first connected to the connectors 16 and 18, when the apparatus 30 is turned on, the computer 50 first closes the switch device 65 thereby completing a circuit between the low voltage electric power source 47 and the heating element 28 of the fitting 10 by way of the wires 39, 41, 53 and 55. The low voltage electric power applied to the heating element 28 is at a minimum level sufficient for the resistance sensor 57 to measure the resistance of the element 28 without significantly heating the element. The resistance value so measured is communicated to the

computer 50 by the lead 63 and the computer 50 then opens the switch device 65.

The computer 50 determines the initial temperature of the element 28 which corresponds to the measured resistance value, and the initial outside surface temperature of the fitting 10 is sensed by the computer 50 by means of the temperature sensing device 42 and the wire 43 connected thereto. Also, the computer 50 optionally senses the size of the fitting 10 by means of the code ridges in the connector 16, the micro-switches 37 of the connector 20 activated thereby and the wire 27 connected thereto.

The computer 50 next closes the switch device 52 thereby completing a circuit between the controlled electric power source 45 and the heating element 28 by way of the wires 39 and 41. The computer 50 senses the initial magnitude of the current flowing through the heating element 28 by means of the current sensor 46 and lead 48. The initial temperature of the heating coil 28 and the initial magnitude of the current flowing therethrough are compared by the computer 50 with predetermined current levels for various sizes of fittings at various temperatures in the memory of the computer to determine the size of the fitting being welded. Such size can optionally be compared to the size of fitting indicated by the micro-switches 37, and if the same, the supply of controlled voltage electric power to the element 28 is continued, and the total time such power should be supplied to the element 28 to ensure the making of a high quality weld determined as described below.

Referring to Figure 6, the current-time relationship during the making of a high quality weld for two different sizes of fittings using controlled electric power is illustrated graphically. The top curve 60 represents the welding process for a two-inch sleeve and

the bottom curve 62 represents the welding process for a one-inch (2.51 cm) sleeve. As shown, the current levels are different for the different sizes of sleeve, and each size and type of electrically heat weldable thermoplastic fitting has a current-time relationship which is characteristic of that fitting when a high quality weld is formed using a proper quantity of controlled electric power.

The computer 50 includes such current-time relationship information for a variety of electric heat weldable thermoplastic fittings at various initial temperatures in the memory thereof whereby the computer 50 can make the comparisons described and identify the size of fitting being welded from the initial magnitude of current flowing through the heating element. Upon identification of the fitting, the computer determines the total time the controlled electric power should be supplied to the heating element for the making of a high quality weld. For example, referring to Figure 6, if the initial magnitude of the current flowing through the heating element of a fitting is that designated by the numeral 64, the computer will determine that the fitting is a two-inch (5 cm) sleeve represented by the curve 60. The computer will also then determine from the curve 60 that the total time the controlled electric power should be supplied to the heating element for the making of a high quality weld is the time designated by the numeral 66.

The computer 50 continues to sense the magnitude of the current flowing through the heating element of the fitting being welded over the time the controlled electric power is supplied thereto and compares such magnitude at predetermined time intervals with predetermined current levels for the size of fitting being welded, ie for the two-inch (5 cm) sleeve of Figure 6, the computer would compare the actual current level with the current levels of

the curve 60 at frequent predetermined time intervals. As long as the sensed current levels are substantially the same as the current levels in memory for the size of fitting being welded, the computer continues the welding process to the total required time. If the sensed current levels deviate from the current levels in memory, as for example the deviation shown by the dashed line 68 of Figure 6, the computer 50 determines the welding process is proceeding abnormally and terminates the welding process by turning off the electric power. The operator of the apparatus 30 is informed of the shutdown and the reason therefor by way of the readout 51.

Thus, by the method of the present invention, one or more electrical characteristics, eg resistance, current flow, etc of the heating element of the fitting being welded are continuously sensed or determined, in order to ensure the making of a high quality weld. If such electrical characteristics are abnormal as a result of short-circuits, poor fitting alignment, poor contact between surfaces, etc, the welding process is shut down.

The initial temperature of the outside surface of the fitting 10 and the initial temperature of the heating element 28 of the fitting 10 sensed by the computer 50 as described above can be utilized by the computer 50 to calculate the total time required for the optimum quantity of thermoplastic material making up the fitting being welded and the pipe sections in contact therewith to melt and adjust the previously determined total time if necessary.

As long as the welding process proceeds normally, it is allowed to continue to the end of the required time whereupon the computer 50 terminates the supply of electric power from the power source 47 to the heating element 28 of the fitting 10 being welded by operation of the switch device 52. Upon terminating the supply of electric power

from the source 47, the computer 50 can again cause the resistance of the element 28 to be measured and determines the final temperature thereof in the same manner as described above for measuring the initial temperature of the element 28.

5 In order to facilitate the making of a high quality weld, alternating current is supplied to the heating element of the fitting being welded by the controlled voltage electric power source 45 of the apparatus 30. The frequency of the alternating current is adjusted to that frequency which best causes the fitting being welded to vibrate as a result of the magnetic fields produced by the alternating current flowing through the heating element of the fitting. Such vibration facilitates and promotes the fusing of the softened thermoplastic materials of the fitting and other plastic members being welded thereto.

In order to concentrate the magnetic fields created by the alternating current and amplify the vibration produced thereby, conductive metallic material can be attached to or included in the weldable thermoplastic fittings. For example, as illustrated in Figure 2, iron filings 29 can be suspended in the thermoplastic material forming the fitting 10.

25 During and upon completion of the welding process described above, the computer 50 records in its memory the various temperatures, current magnitudes and other variables sensed and determined during the welding process. For example, the computer 50 can record the initial temperature of the outside surface of the fitting, the initial temperature of the heating element of the fitting, the size of the fitting, the determined time the constant voltage electric power should be supplied to the fitting, the magnitudes of current flowing over the time constant voltage electric power is supplied to the heating element

of the fitting, the final temperature of the heating
element, and the total time the constant voltage electric
power is supplied to the heating element. Such recorded
information can be communicated to a second computer 74 at
5 a remote location by way of the communication interface 69
and a modem 72 connected thereto. The information can be
printed by a printer 76 connected to the computer 74 or
utilized in any other desired way. If the supply of
electric power is terminated as a result of the welding
10 process proceeding abnormally, the nature of the
abnormality will be apparent from the recorded information.



CLAIMS

1. A method of electrically heat welding a thermoplastic fitting having an electric resistance heating element disposed therein whereby a regulated quantity of electric power is supplied to the heating element during the welding process and the making of a high quality weld is ensured, said method comprising the steps of:-

a) connecting said fitting to a controlled electric power source whereby said resistance heating element of said fitting is supplied with controlled electric power;

b) sensing the initial temperature of said fitting;

c) sensing the initial magnitude of the current flowing through said resistance heating element of said fitting and comparing such magnitude with predetermined current levels for various sizes of fittings thereby to determine the size of said fitting being welded and the total time the controlled electric power should be supplied to said resistance heating element of said fitting to ensure the making of a high quality weld;

d) continuing to sense one or more electrical characteristics of said resistance heating element of said fitting during the time said controlled electric power is supplied thereto and comparing such characteristics at predetermined time intervals with predetermined electrical characteristics for the size of fitting determined in step (c) thereby to determine if the welding process is proceeding abnormally at such time intervals; and

(e) terminating the supply of electric power to said resistance heating element of said fitting when it is determined that said welding process is proceeding abnormally in step (d) or otherwise at the end of the total time required for the making of a high quality weld as determined in accordance with step (c).



2. A method according to claim 1 and including the further steps of comparing such temperature levels with predetermined temperature levels for the size of fitting determined in step (c) thereby to determine the adjustment required, if any, in the total time the controlled electric power should be supplied to the resistance heating element level; and changing the total time determined in accordance with step (c) in accordance with said adjustment.

3. A method according to claim 2 and including the further step of sensing the magnitude of the temperature of said resistance heating element of said fitting over the time period said controlled electric power is supplied thereto and comparing such magnitude at predetermined time intervals with predetermined temperature levels for the size of fitting determined in step (c) thereby to determine if the welding process is proceeding abnormally at such time intervals; and terminating the supply of controlled electric power of said resistance heating element when it is determined that said welding process is proceeding abnormally as a result of such temperature comparisons.

4. A method according to claim 1, 2 or 3, wherein the current of said controlled electric power supplied to said resistance heating element of said fitting is alternating current.

5. A method according to claim 4, wherein the frequency of said alternating current is at a level such that said fitting is caused to be vibrated by the magnetic fields produced thereby during said welding process.

6. A method according to any preceding claim, wherein step (d) involves supplying electric power to said heating element at a minimum voltage level for measuring the resistance of said element without significantly



heating said element and the measured resistance of said heating element to determine the initial temperature of said element.

7. A method according to claim 6 and further including the step of recording information relating to said welding process comprising the initial temperature of said heating element, the size of fitting and the time electric power should be supplied thereto, the magnitudes of current flowing over the time electric power is supplied sensed, and the total time constant voltage electric power is supplied to said heating element of said fitting.

8. Apparatus for electrically heat welding a thermoplastic fitting having an electric resistance heating element disposed therein connected to a pair of electric contacts attached to said fitting whereby a regulated quantity of electric power is supplied to the heating element during the welding process and the making of a high quality weld is ensured, said apparatus comprising first electric power generating means for producing controlled electric power; current sensor means for sensing the magnitude of the current flow from said electric power generating means electrically connected thereto; electric cables connected to said electric power generating means and adapted for removable connection to said electric contacts of said fitting for conducting electric power to said electric resistance heating element of said fitting; switch means electrically connected between said electric power generating means and said cable; and a computer operably connected to said current sensor means and said switch means for receiving and comparing the magnitude of the current flowing through said resistance heating element of said fitting with predetermined current levels for various sizes of fittings and thereby determining the size of the fitting being welded and the total time the constant voltage electric power should be supplied to said heating



element of said fitting for the making of a high quality weld, and for comparing such magnitude at predetermined time intervals with predetermined current levels for the size of fitting being welded, thereby to determine if the welding process is proceeding abnormally at such time intervals and for operating said switch means to terminate the supply of electric power to said heating element of said fitting, if it is determined that said welding process is proceeding abnormally or otherwise at the end of the total time determined to be required for the making of a high quality weld and temperature sensing means attached to said cable and adapted for connection to at least one of said electric contacts of said fitting and wherein said computer is operably connected to said temperature sensor means for adjusting the total time said electric power is supplied to said heating element in accordance with the initial temperature of said fitting.

9. Apparatus according to claim 8, wherein said computer is also connected for comparing the temperature of said heating element at predetermined time intervals over the time period said electric power is supplied thereto with predetermined temperature level for the size of fitting being welded thereby to determine if the welding process is proceeding abnormally at such time intervals.

10. Apparatus according to claim 8 or 9, wherein said electric power generating means produces alternating current.



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11. Apparatus according to claim 10 wherein the frequency of said alternating current produced by said electric power generating means is at a level such that when it is supplied to said fitting, the fitting is vibrated by the magnetic fields produced thereby during said welding process.

12. Apparatus according to claim 11 in combination with a thermoplastic fitting having an electric resistance heating element disposed therein connected to a pair of electric contacts attached to said fitting whereby a regulated quantity of electric power is supplied to the heating element during the welding process and the making of a high quality weld is ensured and wherein said fitting includes means attached thereto for concentrating



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the magnetic fields created by said alternating current flowing through the electric resistance heating element thereof and thereby increase vibration of said fitting caused by said alternating current.

13. Apparatus according to claim 12, wherein said means for concentrating said magnetic fields are iron filings for increasing the magnetic permeability of the coil area suspended in the thermoplastic material forming said fitting.

14. Apparatus according to any one of claims 8 to 13 and further comprising second electric power generating means for producing low voltage electric power for measuring the resistance of said element without significantly heating said element and resistance sensor means for sensing the magnitude of the resistance of said heating element electrically connected to said second electric power generating means, said resistance sensor means being operatively connected to said computer.

15. A method of electrically heat welding a thermoplastic fitting substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

16. Apparatus for electrically heat welding a thermoplastic fitting substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.
