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### Heating and cooling device and PVT equipment using the same

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#### Abstract

A heating and cooling device includes a conductive structure, an electric heating pipe and a housing. The housing has a main body and a test space formed in the main body, the electric heating pipe is attached on the main body and used for heating a testing plastic material in the test space, and the housing is covered outside the conductive structure and separated from the main body to form a cooling flow channel. The housing and the main body are separated without contacting each other, so that the dissipation of the heat energy of the electric heating pipe through the housing can be reduced in the heating process, and the function of thermal preservation can be provided. Moreover, the cooling effect can be improved through the larger cooling flow channel during the cooling process. A PVT equipment using the heating and cooling device is further provided.

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## Background/Summary

### RELATED APPLICATION

(1) This application claims the benefit of priority of Taiwan Patent Application No. 111207767 filed on Jul. 19, 2022, the contents of which are incorporated by reference as if fully set forth herein in their entirety.

### BACKGROUND

#### 1. Technical Field

(2) The present disclosure relates to a pressure-volume-temperature (PVT) measurement technology of plastic material, and more particularly, to a heating and cooling device and PVT equipment using the same.

#### 2. Description of Related Art

(3) The PVT measuring instrument is used to measure the rheologic performance of the plastic material to be tested, such as polymer materials, to provide corresponding data. Specifically, the

PVT measuring instrument mainly controls the test parameters of heating, cooling and pressure of the plastic material to be tested, so as to know the rheologic properties of the plastic material to be tested, such as stress, deformation, deformation rate, viscosity, etc. during the testing process.

(4) In the current PVT measuring instrument, there is usually a heating and cooling unit that provides heating and cooling functions respectively during the heating and cooling process of the plastic material to be tested, wherein the heating and cooling unit is usually provided with a groove inside, so that the heating pipe is installed in the groove. Accordingly, the plastic material to be tested is heated via the heating pipe during the heating process, and the cooling effect is provided by guiding the airflow in the groove during the cooling process. However, in the heating and cooling unit of the current PVT measuring instrument, only the groove provided with the heating pipe is used to introduce the airflow, that is, the airflow can only pass through the narrow groove to cool down the plastic material to be tested, so the amount of the introduced airflow is quite limited, which will cause the problem of poor cooling effect (such as cooling too slow); moreover, the current PVT measuring instrument does not have the design to keep the heating and cooling unit warm, so the heating effect is not good due to the leakage of the heat source during the heating process; furthermore, in the current PVT measuring instrument, the stability of the machine of the PVT measuring instrument is not good due to the poor design of struts, such that the machine of the PVT measuring instrument may shake during the pressurization process which may result in an inaccurate measurement. Therefore, there is still much room for improvement in current PVT measuring instruments.

(5) In light of the above, a design should be found to improve the capacity for heating and cooling and stability of the PVT equipment, in particular, by providing a better testing environment for the plastic material to be tested, so as to achieve an effect of effective and rapid cooling, maintaining the temperature of the plastic material to be tested and strengthening the stability of the machine, which will become the technical goal that those persons skilled in the art are striving for.

## SUMMARY

(6) In view of the aforementioned shortcomings of the prior art, the present disclosure provides a heating and cooling device disposed in a pressure-volume-temperature equipment and used to heat and cool a testing plastic material, the heating and cooling device comprises: a conductive structure comprising a main body and a test space formed in the main body for placing the testing plastic material; an electric heating pipe attached on the main body for heating the testing plastic material in the test space through the main body; and a housing disposed outside the conductive structure and separated from the main body to form a cooling flow channel, wherein the housing has an air inlet and an air outlet for cooling airflow to enter and exit the cooling flow channel to cool the testing plastic material.

(7) In one embodiment, the main body further comprises a sensing hole recessed in a direction from an outer sidewall of the main body to the test space for disposing a sensor.

(8) In another embodiment, an outer sidewall of the main body has a groove, and the electric heating pipe is accommodated in the groove and attached on the main body.

(9) In another embodiment, the groove is spiraled around the main body.

(10) In another embodiment, the main body further comprises a cover plate extending radially from two ends of the main body to the housing.

(11) In another embodiment, the air inlet and the air outlet are disposed at opposite ends of the housing respectively.

(12) In yet another embodiment, the main body is penetrated through by the test space.

(13) The present disclosure further provides a pressure-volume-temperature equipment, which comprises: the abovementioned heating and cooling device; and a testing machine comprising a carrier for disposing the heating and cooling device, and a plunger rod located above the carrier and used to enter and exit the test space, wherein a pressure-volume-temperature detection is performed on the testing plastic material in the test space when the plunger rod enters downward into the test

space.

(14) In one embodiment, the carrier comprises a heat insulation structure at a bottom of the carrier, and the heating and cooling device is disposed on the carrier via the heat insulation structure.

(15) In another embodiment, the testing machine further comprises: a pressure plate on which the plunger rod is disposed; a load cell located between the pressure plate and the plunger rod; and a plurality of struts on which the pressure plate is movably disposed, so that the pressure plate is moved up and down relative to the carrier.

(16) In another embodiment, a number of the plurality of struts is four.

(17) In yet another embodiment, the pressure-volume-temperature equipment of the present disclosure further comprises: a servo motor located at a top of the testing machine for driving the pressure plate to move on the plurality of struts; and an optical ruler disposed at a side of the testing machine for measuring a height change of the plunger rod relative to the carrier.

(18) In view of the above, the heating and cooling device heats the test space by the electric heating pipe through the main body of the conductive structure during the heating process, and since the housing and the main body of the present disclosure are separated from each other, a larger cooling flow channel can be formed, so as to achieve the purpose of improving the cooling effect during the cooling process; further, the pressure-volume-temperature equipment of the present disclosure is provided with a heat insulation structure for the installation of the heating and cooling device, so that the heat energy generated in the heating process can be prevented from being dissipated through the carrier, and the thermal preservation function in the heating process can be achieved. And the pressure-volume-temperature equipment uses four struts which can improve the stability of the plunger rod during movement and pressurization.

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## Description

### BRIEF DESCRIPTION OF THE DRAWINGS

(1) FIG. 1 is an exploded perspective view of a heating and cooling device of the present disclosure.

(2) FIG. 2 is a side cross-sectional view of the heating and cooling device of the present disclosure.

(3) FIG. 3 is a perspective view of the structure of a PVT equipment of the present disclosure.

(4) FIG. 4A and FIG. 4B are partial cross-sectional views of the PVT equipment of the present disclosure during the actuation.

### DETAILED DESCRIPTION

(5) Implementations of the present disclosure are described below by embodiments. Other advantages and technical effects of the present disclosure can be readily understood by one of ordinary skill in the art upon reading the disclosure of this specification.

(6) FIG. 1 is an exploded perspective view of a heating and cooling device of the present disclosure, and FIG. 2 is a side cross-sectional view of the heating and cooling device of the present disclosure. As shown in FIG. 1 and FIG. 2, a heating and cooling device 1 of the present disclosure is disposed in a PVT equipment for heating and cooling a testing plastic material with a pressure-volume-temperature (PVT) detection. Specifically, the heating and cooling device 1 of the present disclosure comprises a conductive structure 11, an electric heating pipe 12 attached on the conductive structure 11 and a housing 13 disposed outside the conductive structure 11, wherein the conductive structure 11 is provided for placing the testing plastic material therein, so that the testing plastic material is heated by a heat generated by the electric heating pipe 12 and through the conductive structure 11 during the heating process, and a cooling airflow is introduced from the outside of the housing 13 during the cooling process, so that the cooling airflow can dissipate heat from the testing plastic material in the conductive structure, and then the cooling airflow is discharged. In this way, the heating and cooling device 1 can achieve the purpose of heating and

cooling the testing plastic material, so as to facilitate the pressure-volume-temperature detection of the PVT equipment. The following is a detailed description of the present disclosure.

(7) The conductive structure **11** comprises a main body **111** and a test space **112** formed in the main body **111**. Specifically, the main body **111** is cylindrical, and the test space **112** is formed longitudinally along the axis of the main body **111**. In one embodiment, the test space **112** is formed by longitudinally penetrating through the main body **111**, and a lower part is sealed by other accessories for placing the testing plastic material therein. In another embodiment, the outer sidewall of the main body **111** is recessed inward to form a groove **113**, so that the electric heating pipe **12** can be accommodated in the groove **113** and attached on the main body **111**; and further, the groove **113** may have a spiral shape, that is, the groove **113** can be spiraled around on the main body **111**. In addition, the upper and lower ends of the main body **111** may have cover plates **114** radially extending to the inner sidewall of the housing **13**, so that an airtight space is formed between the housing **13** and the two cover plates **114** when the conductive structure **11** is disposed inside the housing **13**. The airtight space reduces the outflow of hot air during the heating process; and the airtight space is used as a flow channel to introduce/guide the airflow during the cooling process, thereby effectively providing the cooling effect.

(8) In another embodiment, the main body **111** further comprises a sensing hole **115** recessed to a direction from the outer sidewall to the test space for disposing a sensor in the sensing hole **115**. More specifically, as shown in FIG. 1, the sensing hole **115** is adjacent to the test space **112** but not in communication with the test space **112**, and the sensing hole **115** can be used to accommodate, for example, a sensor for sensing temperature, so as to measure the real-time temperature of the test space **112** during the heating process or the cooling process to provide corresponding measurement data.

(9) The electric heating pipe **12** is attached on the main body **111** to heat the testing plastic material in the test space **112** through the main body **111** of the conductive structure **11** during the heating process. In one embodiment, the electric heating pipe **12** can be disposed in the groove **113** and surround on the main body **111**. The electric heating pipe **12** spirally surrounds on the main body **111** along the groove **113** as the groove **113** has a spiral shape, so that the main body **111** conducts heat energy to the test space **112** when being heated to heat the testing plastic material contained in the test space **112**.

(10) The housing **13** is covered outside the conductive structure **11**, wherein the housing **13** and the outer sidewall of the main body **111** are separated with a distance, that is, the inner sidewall of the housing **13** is free from being in contact with the outer sidewall of the main body **111**, so that a cooling flow channel **133** is formed between the housing **13** and the main body **111**; in addition, the housing **13** has an air inlet **131** and an air outlet **132** communicating with the cooling flow channel **133**, so that the cooling airflow is introduced from the air inlet **131** during the cooling process, and the main body **111** is cooled down after the cooling airflow enters the cooling flow channel **133** and flows through the main body **111**, and then a heated airflow flowed through the main body **111** is discharged from the air outlet **132**.

(11) In one embodiment, the air inlet **131** and the air outlet **132** may be disposed at opposite ends of the housing **13**, that is, the air inlet **131** and the air outlet **132** are located at an upper end and a lower end of the housing **13** in a manner of one above the other, so that the airflow flowing through the cooling flow channel **133** effectively cools down the main body **111**.

(12) In addition, as shown in FIG. 1 and FIG. 2, in the present disclosure, the dissipation of the heat energy to outside through the housing **13** may be reduced during the heating process since the main body **111** is free from being in contact with the housing **13**. The large cooling flow channel **133** can make a large amount of cooling airflow flow from the air inlet **131** to the main body **111** during the cooling process, so as to achieve a good cooling effect. In addition, in the present disclosure, the main body **111** can be formed into a structure similar to heat dissipation fins by controlling the extent to which the groove **113** is recessed into the main body **111**, such as deepening a depth D of

the groove **113** (as shown in FIG. 2), so as to increase heat dissipation area to provide better heat dissipation effect.

(13) In one embodiment, the housing **13** is further arranged with a channel **134** relative to the sensing hole **115** of the conductive structure **11**, so that the sensor can be disposed in the sensing hole **115** through the channel **134** of the housing **13** to measure the temperature change of the test space **112**.

(14) In one embodiment, the testing plastic material of the present disclosure is a plastic such as a thermoplastic.

(15) FIG. 3 is a perspective view of the structure of the PVT equipment of the present disclosure, and FIG. 4A and FIG. 4B are partial cross-sectional views of the PVT equipment of the present disclosure during the actuation. As shown in FIG. 3, FIG. 4A and FIG. 4B, a PVT equipment **3** of the present disclosure comprises a heating and cooling device **31** for heating or cooling a testing plastic material **9**, and a testing machine **32** for disposing the heating and cooling device **31** to measure the pressure-volume-temperature (PVT) of the testing plastic material **9**. The PVT equipment **3** of the present disclosure is detailed as below.

(16) The heating and cooling device **31** is used to accommodate the testing plastic material **9**, so as to heat and melt the testing plastic material **9** during the heating process, and provide a cooling effect during the cooling process. In one embodiment, the present disclosure utilizes the heating and cooling device **31** described above (as shown in FIG. 1 and FIG. 2) to provide the function of heating or cooling the testing plastic material **9**. The detailed description of the heating and cooling device **31** is as stated above, and will not be described herein.

(17) The testing machine **32** comprises a carrier **321** (e.g., a carrying base) for disposing the heating and cooling device **31**, and a plunger rod **322** located above the carrier **321** and used to enter and exit a test space **312** of the heating and cooling device **31**. As shown in FIG. 4A, in one embodiment, the carrier **321** comprises a heat insulation structure **323** disposed on a bottom thereof for blocking thermal conduction, so that the heating and cooling device **31** is disposed on the carrier **321** via the heat insulation structure **323**.

(18) Specifically, the testing machine **32** further comprises a base **324**, a plurality of struts **325** fixed on the base **324**, a testing platform **326** located above the base **324** and fixed on each of the struts **325** for disposing the carrier **321**, a pressure plate **327** located above the testing platform **326** and movably provided on the plurality of struts **325** and for the plunger rod **322** to be provided below, and a load cell **328** disposed between the pressure plate **327** and the plunger rod **322**, wherein the load cell **328** is used for sensing pressure.

(19) In addition, the PVT equipment of the present disclosure further comprises a servo motor **33** located at a top of the testing machine **32** and an optical ruler **34** disposed on a side of the testing machine **32** for measuring a height of the plunger rod **322** relative to the carrier **321**, wherein the pressure plate **327** is disposed on the plurality of struts **325** in a manner of moving up and down relative to the carrier **321**. Accordingly, the testing machine **32** uses the servo motor **33** to drive the pressure plate **327** to move on the plurality of struts **325** via a screw rod **35**, and uses the optical ruler **34** to measure the height of the plunger rod **322** relative to the carrier **321**, and then calculates the volume change from the height change. It should be noted that the setting of the optical ruler **34** is not limited in the above way, as long as the height change between the plunger rod **322** and the carrier **321** can be measured.

(20) In one embodiment, the testing machine **32** of the present disclosure may have four struts **325**, so as to provide a better stability during the movement of the pressure plate **327** and the plunger rod **322**.

(21) As shown in FIG. 4A, a lower pushing post **3211** (e.g., a lower holding post) is disposed on the carrier **321** from bottom to top to penetrate into the test space **312** before the testing plastic material **9** is tested, and the lower pushing post **3211** is fixed with a screw **3212** (e.g., a pushing/holding screw) under the lower pushing post **3211** to seal the bottom of the test space **312**, so that the test

space **312** can be filled with the testing plastic material **9**. Before the testing plastic material **9** is placed, the heating and cooling device **31** is preheated via an electric heating pipe, that is, a heating process is performed. After the test space **312** is heated to the initial temperature through the main body, the testing plastic material **9** is put into the test space **312**, such that the testing plastic material **9** is heated to melt.

(22) Next, as shown in FIG. **4B**, when the test space **312** is filled with the testing plastic material **9**, the testing machine **32** uses the servo motor **33** to drive the pressure plate **327** to descend, so that the plunger rod **322** is inserted downward into the test space **312** and the testing plastic material **9** is pressurized, and the test space **312** is sealed up and down by the lower pushing post **3211** and the plunger rod **322** to form a sealed space, thereby generating the required pressure; further, when cooling is required, an external cooling airflow is introduced through the air inlet of the housing to form a circulating airflow in the cooling flow channel, so that the airflow will flow through the main body to cool down the main body, and the heated airflow flowing through the main body will be discharged from the air outlet, so as to provide the cooling function, wherein a good cooling effect can be provided since the cooling flow channel designed in the present disclosure is large. When the test time ends, the testing machine drives the pressure plate **327** by the servo motor **33**, so that the pressure plate **327** and the plunger rod **322** fixed thereon return to the starting position again (as shown in FIG. **4A**), and the test ends.

(23) During the test, the present disclosure measures the relative position or height between the plunger rod **322** and the carrier **321** via the optical ruler **34** to obtain the height change, and calculates the volume change value of the testing plastic material during the test by the height change. In addition, the PVT equipment of the present disclosure is further disposed with, for example, a temperature sensor **36** (as shown in FIG. **4A**) in the sensing hole of the main body, so as to measure the temperature change during the test.

(24) In addition, the test of the present disclosure is based on the standard ISO17744, and the volume change of the testing plastic material (e.g., using the optical ruler to measure the change in the height of the plunger rod as mentioned above) is observed and measured by changing the temperature (e.g., using a heating and cooling device to provide heating or cooling functions) or changing the pressure (using a servo motor to drive the plunger rod to pressurize the testing plastic material). Lastly, the temperature value, pressure value obtained during the test and the volume change value of the testing plastic material measured/calculated by the optical ruler are sent back to the remote computer or stored in the local database, so that the data detection related to the pressure-volume-temperature (PVT) of the testing plastic material is completed.

(25) In view of the above, the heating and cooling device of the present disclosure used for PVT equipment forms a larger cooling flow channel instead of a narrow airflow channel by separating the housing and the main body of the conductive structure, and because of most of the area of the main body of the present disclosure is exposed in the cooling flow channel and is free from being in contact with the housing, a larger heat dissipation area can be provided and the heat energy of the electric heating pipe can be prevented from dissipating through the housing during the heating process. Accordingly, the present disclosure can provide a function of thermal preservation to the test space and the testing plastic material during the heating process, and can effectively improve the heat dissipation effect during the cooling process; further, the PVT equipment of the present disclosure has a heat insulation structure for the heating and cooling device, which can prevent the heat energy from being dissipated from the carrier to the environment, thereby achieving the purpose of thermal insulation and preservation; in addition, the testing machine of the present disclosure uses four struts, which can improve the stability of the movement when the pressure plate and the plunger rod are moved during the test.

(26) The above embodiments are provided for illustrating the principles of the present disclosure and its technical effect, and should not be construed as to limit the present disclosure in any way. The above embodiments can be modified by one of ordinary skill in the art without departing from

the spirit and scope of the present disclosure. Therefore, the scope claimed of the present disclosure should be defined by the following claims.

## Claims

1. A heating and cooling device disposed in a pressure-volume-temperature equipment and used to heat and cool a testing plastic material, the heating and cooling device comprising: a conductive structure comprising a main body and a test space formed in the main body for placing the testing plastic material; an electric heating pipe attached on the main body for heating the testing plastic material in the test space through the main body; and a housing disposed outside the conductive structure and separated from the main body to form a cooling flow channel, wherein the housing has an air inlet and an air outlet for cooling airflow to enter and exit the cooling flow channel to cool the testing plastic material.
  2. The heating and cooling device of claim 1, wherein the main body further comprises a sensing hole recessed in a direction from an outer sidewall of the main body to the test space for disposing a sensor.
  3. The heating and cooling device of claim 1, wherein an outer sidewall of the main body has a groove, and the electric heating pipe is accommodated in the groove and attached on the main body.
  4. The heating and cooling device of claim 3, wherein the groove is spiraled around the main body.
  5. The heating and cooling device of claim 1, wherein the main body further comprises a cover plate extending radially from two ends of the main body to the housing.
  6. The heating and cooling device of claim 1, wherein the air inlet and the air outlet are disposed at opposite ends of the housing respectively.
  7. The heating and cooling device of claim 1, wherein the main body is penetrated through by the test space.
  8. A pressure-volume-temperature equipment, comprising: the heating and cooling device of claim 1; and a testing machine comprising a carrier for disposing the heating and cooling device, and a plunger rod located above the carrier and used to enter and exit the test space, wherein a pressure-volume-temperature detection is performed on the testing plastic material in the test space when the plunger rod enters downward into the test space.
  9. The pressure-volume-temperature equipment of claim 8, wherein the carrier comprises a heat insulation structure at a bottom of the carrier, and the heating and cooling device is disposed on the carrier via the heat insulation structure.
  10. The pressure-volume-temperature equipment of claim 8, wherein the testing machine further comprises: a pressure plate on which the plunger rod is disposed; a load cell located between the pressure plate and the plunger rod; and a plurality of struts on which the pressure plate is movably disposed, so that the pressure plate is moved relative to the carrier.
  11. The pressure-volume-temperature equipment of claim 10, further comprising: a servo motor located at a top of the testing machine for driving the pressure plate to move on the plurality of struts; and an optical ruler disposed at a side of the testing machine for measuring a height change of the plunger rod relative to the carrier.
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