Micro Temperature Controller

Field of Invention

The invention relates to a temperature controller suitable for mounting on an injection tool and a method of use thereof. The invention also relates to a temperature controller for providing a reference temperature signal of a temperature control process in an injection tool and a method of use thereof.

Background

In the injection molding process, it is necessary to maintain accurate control of the temperature of plastics material in the injection molding machine and various machine components such as the nozzle and hot runners. This is to ensure that the plastics material used in the injection molding process remain at the right temperature and consistency during the injection molding process.

The inaccurate control of the temperature of the plastics material in the injection tool may compromise the quality of the molded product and/or result in wastage of excess plastics material. For example, inconsistency in the temperature of the molten plastics material may give rise to aesthetic problems such as weld-lines, short shots, incorrect dimensions, warping or poor finishing in the molded product. In some cases, inconsistency in the temperature of certain plastics material, for example Polyacetal, may result in the decomposition of the plastics material and result in dangerous explosions.

In the prior art, the temperature of the plastics material in the injection tool are controlled using commercially available external temperature controllers that are located away from the injection tool. These external temperature controllers are connected to temperature sensing devices such as thermocouples and temperature control devices such as heaters sited within the injection tool via signal cables.

In the operation of the external temperature controller, it was found that the external temperature controller may not accurately reflect the actual temperature of the molten plastics material in the injection tool. In some tests conducted by connecting two external temperature controllers of the same make to the same injection tool, it was found that the two external temperature controllers often provide different temperature readings despite similar settings. Further, a change in the location of the external temperature controller affecting the length or position of the signal cables may result in a different reading for the same temperature of the molten plastics material in the injection tool.

The above problems are exacerbated where there is a need to heat and maintain the temperature of several zones in a large injection tool. In the prior art, several external temperature controllers are employed. However, the inaccuracies and inconsistency between the readings of these external temperature controllers make it very difficult to maintain accurate and consistent control over the temperature of the plastics material.

In order to overcome the abovementioned problems, it is necessary to perform calibration on the external temperature controller before operation. However, calibration is not a satisfactory solution as changes to the location of the external temperature controller or other environmental conditions during the course of operation may also result in signal losses or variation which will lead to inaccuracies in the temperature control. In order to ensure very accurate temperature controls, it may be necessary to perform recalibration of the external temperature controller at regular intervals.

Summary

The invention is defined in the independent claims. Some optional features of the invention are defined in the dependent claims.

A temperature controller having the features of the independent claims offer several technical advantages over the temperature controllers in the prior art. One such advantage is that the use of an opto-coupler 28 and a solid-state switching device 34 in circuit 100, replacing commonly-used relay and transformer circuits found in other control circuits of the prior art enables the control circuit 100 to use lower power consumption components in place of the higher power components that are used in other control circuits of the prior art. This enables the temperature controller to be substantially smaller than the external temperature controllers of the prior art and facilitates mounting of the temperature controller directly on an injection tool.

Further, by mounting the temperature controller directly on the injection tool, the problem of inaccuracies and slow response time arising from signal losses along long signal cables connecting the prior art external temperature controllers and the injection molding machine is obviated.

Description of Drawings

The invention will now be described, by way of example only, and with reference to the accompanying drawings in which:

Fig. 1 is a control circuit diagram of an improved tool controller.

Fig. 2 is a reference temperature selection circuit of an improved tool controller.

Fig 3 is a circuit diagram of an improved tool controller incorporating two control circuits and a reference temperature selection circuit,

Detailed Description

Referring first to figure 1, numeral 100 generally designates a control circuit of the temperature controller.

Circuit 100 includes a comparator for comparing a reference temperature signal with a sensed temperature signal from the injection tool. Circuit 100 also includes an opto-coupler coupled to the output of the comparator; and a solid-state switching device for switching a power supply to a heater of the injection tool. The solid state switching device receives an activation signal from the opto-coupler which in turn, is responsive to a change of state of an output of the comparator

Comparator 12 compares between a first input 14 representing a sensed temperature value from a temperature sensing device such as a thermocouple located within the injection tool (not shown) and a second input 16 representing a pre-determined reference temperature. In one disclosed technique, the reference temperature is pre-determined utilising a reference temperature selection circuit that will be described in greater detail below. The output 18 of the comparator 12 is connected to a DC power source through a resistive-capacitive (R-C) circuit and to the opto-coupler. In the example of Figure 1, the output 18 of the comparator is connected in series to the R-C circuit comprising capacitor 20 and resistor 22 connected in parallel which, in turn, is connected in series to a DC power source 36. The output of the comparator 12 is further connected in series to an optional light emitting diode 24 for providing a visual reference to a user and to the input 26 of an opto-coupler 28 for isolating the circuit and converting the DC input to an amplified AC output 30. The AC output 30 of the opto-coupler is further connected in series to the gate input 32 of a solid-state switching device 34 for switching a power supply (not shown) to a heater of the injection tool (also not shown). In the example of figure 1, solid-state switching device 34 is a Triac, but it will be appreciated that other types of solid-state switching devices may also be provided, and these may be selected for operation dependent upon the nature of the heater power supply.

The comparator 12 performs a check between the sensed temperature value provided to the first input 14 and the reference temperature value provided to the second input 16. When the plastics material in the injection tool have not been heated up, the temperature sensing device (not shown) provides a sensed temperature value to the first input 14 that is lower than

the reference temperature value provided to the second input 16. The output 18 of the comparator 12 is switched from a closed circuit shorted to ground to an open circuit by operation of a built-in transistor (not shown) in the comparator 12. The current from the DC power source 36 flows through the parallel resistive capacitive circuit comprising capacitor 20 and resistor 22 into the opto-coupler 28. When current flows into the opto-coupler 28, an LED (not shown) at the input side of the opto-coupler is energised, activating a galvanic separated optically triggered triac (not shown) at the output side of the opto-coupler 28, the optically triggered triac (not shown) at the output side of the opto-coupler 28 which provides an activation signal to the solid state switching device 34. In the example of Figure 1, opto-coupler 28 switches an AC power supply and provides an AC output 30 which in turns switches triac 34 to supply electrical power to a heater (not shown). The solid state switching device receives an activation signal from the opto-coupler which in turn, is responsive to a change of state of an output of the comparator.That is, the DC power source powers the opto-coupler when the output of the comparator changes state, for the opto-coupler to provide the activation signal to the solid-state switching device.

When the plastics material in the injection tool has reached or goes beyond the desired temperature, the temperature sensing device provides a sensed temperature value to the first input 14 that is equal to or higher than the reference temperature value provided to the second input 16 and the output 18 of the comparator 12 is switched from an open circuit to a closed circuit shorted to ground by operation of a built-in transistor (not shown) in the comparator 12. The current from the DC power source 36 stops flowing into the opto-coupler 28 and is shunted to ground instead. Opto-coupler 28 is de-energised and the activation signal to the triac 34 is removed. When the power supply signal next commutates to zero, triac 34 switches to a non-conducting state and accordingly the power supplied to the heater (not shown) in the injection tool (not shown) is cut off.

It has been found that the temperature controller is more accurate and had a faster response time over the external temperature controllers of the prior art. This was found to be because the external temperature controllers which had to be located at a location remote from the injection tool due to its large size required the use of long signal cables interfacing the external temperature controller to the injection tool . The signal losses along these long signal cables resulted in the external temperature controller of the prior art having lesser sensitivity and a slower response time. For example, a reading from the temperature sensing device in a injection tool of an injection molding machine indicating a minor drop or increase in the temperature of the molten plastics therein which may be crucial to the quality of the molded product may be diminished in the course of transmission and may not be received by the external temperature controller. As the improved temperature controller is mounted directly onto the tool of the injection molding machine, the above problem of inaccuracies and slow

response time arising from signal losses along long signal cables connecting the prior art external temperature controllers of an injection tool is obviated.

As shown in figure 2, numeral 200 generically designates a temperature controller for providing a reference temperature signal of a temperature control process in an injection tool. The temperature controller has a reference temperature selection circuit for a user to select between first and second reference temperatures.

Circuit 200 includes a DC power source 62 is connected to inputs of a first trimmer 64 for a user to select the first reference temperature and a second trimmer 66 for the user to select the second reference temperature. Circuit 200 includes a first selection switch for 68 for switching between the first and second trimmers. In the example of Figure 2, the first and second trimmers 64, 66 are variable resistors, each of a predetermined range of values arranged in parallel. Outputs of trimmers 64, 66 are connected to the first selection switch 68 for selecting between a closed circuit for first trimmer 64 and an open circuit for second trimmer 66, or a closed circuit for second trimmer 66 and an open circuit for first trimmer 64. Operation of selection switch 68 allows a user to select between the first and second trimmers 64, 66. Trimmer 64 has a range of values selected to correspond to an operating condition of the injection tool. Trimmer 66 has a range of values selected to correspond to a standby condition of the injection tool. So, dependent upon a user operation of selector switch 68, the user may select between a first reference temperature signal corresponding to an operating condition of the injection tool or a second reference temperature corresponding to a standby condition of the injection tool. In the example of Figure 2, the first reference temperature signal relates to an operating temperature of a plastics material in the injection tool and the second reference temperature signal corresponds to a standby temperature of the plastics material. The different reference temperature signals are provided dependent upon the respective resistive values of the trimmers 64, 66.

The first selection switch 68 is connected to a (second) selector switch 70 for selective connection to at least first resistor 72 and a second resistor 74, the first resistor 72 having a resistive value different from a resistive value of the second resistor 74. Selector switch 70 allows a user to adjust one of the first and second reference temperature signals (provided via selection of one of trimmers 64, 66 with operation of selector switch 68) based on the plastics material for use in the injection tool. So, if the injection tool is for operation with two different types of plastics material, the values of resistors 72 and 74 are selected so that the reference temperature signal output corresponds with a value – e.g. desired temperature for either operating or standby condition of the plastics material in question.

In the example of Figure 2, three further resistors 76, 78, 80 are provided connected to second selection switch 70 Thus, in total, five resistors 72, 74, 76, 78 and 80 each of

predetermined value (for five different plastics materials for use in the injection tool) are arranged in parallel to each other for selecting between any one of a closed circuit for resistor 72 and open circuits for resistors 74, 76, 78 and 80, a closed circuit for resistor 74 and open circuits for resistors 72, 76, 78 and 80, a closed circuit for resistor 76 and open circuits for resistors 72, 74, 78 and 80, a closed circuit for resistor 78 and open circuits for resistors 72, 74, 76 and 80, or a closed circuit for resistor 80 and open circuits for resistors, 72, 74, 76 and 78. An output of circuit 200 provides a reference temperature signal for a temperature control process. For example, the output may be connected to the second input 16 of the comparator 12 of figure 1. The reference temperature signal is dependent upon a user selection of an operating or standby condition for the plastics material, and the type of plastics material being used.

The predetermined range of values of trimmers 64 and 66 are selected to provide an adjustable value representing a running or operating temperature and a value representing a waiting or standby temperature when connected in series to any one of resistors 72, 74, 76, 78 or 80. The running or operating temperature is a pre-determined optimal temperature for the selected plastics material for injection molding production and the waiting or standby temperature is a pre-determined safe temperature to maintain the plastics material without degradation. This is particularly important when working with sensitive materials such as Polyacetal, as instability in the temperature of Polyacetal may result in dangerous explosions.

In the operation of circuit 200, a user selects between any one of resistors 72, 74, 76, 78 and 80 by operation of the second selection switch 70 to select the desired reference temperature of selected plastics materials. The user then selects between a running or operating temperature and a waiting or standby temperature by operation of the first selection switch 68 that switches between a first trimmer 64 and a second trimmer 66.

The combined values of either one of trimmers 64 or 66, and any one of resistors 72, 74, 76, 78 or 80 will provide the second input 16 of the comparator 12 of either one or both of the control circuit 100 with a value representing either one of a running or operating temperature or a waiting or standby temperature of a selected plastics material.

Any required variation or fine tuning of the reference temperature can be adjusted by adjusting the value of either one of trimmers 64 or 66 as may be appropriate. The values of the trimmers 64 or 66 may be measured using a multi-meter and compared against a reference temperature chart (not shown) with pre-calculated values for easy conversion of the multi-meter readings into temperature values.

Where there is a need to heat and maintain the temperature of several zones in a large injection tool, a second or further control circuit 100 may be connected to the reference

temperature selection circuit 200 for controlling the temperature of multiple zones. A tool controller for controlling the temperature of multiple zones having a common reference temperature signal is more accurate. In the prior art, where there is a need to control the temperature of multiple zones, multiple external temperature controllers are employed, Each of these external temperature controllers are then set to control and maintain the temperature of each individual zone. It has been found that due to the tolerance differences in the components of each of these external temperature controllers, it is impossible to maintain each of these zones at the same temperature. This problem may be alleviated when both control circuits obtain their reference temperature from the same reference temperature selection circuit.

As shown in figure 3, numeral 300 generically designates a temperature controller for controlling the temperature of multiple zones incorporating two control circuits 100 and a reference temperature selection circuit 200.

Further control circuits 100 may be added to the temperature controller 300 if more zones of temperature control are desired.

The temperature controller is mounted on the tool of an injection molding machine and connected to the temperature sensing devices such as thermocouples and temperature control devices such as heaters. In order to facilitate the mounting of the temperature controller onto the tool of an injection molding machine, the temperature controller is preferably provided in a housing having thermal-insulating properties.

It is to be understood that the foregoing description of the invention is intended to be purely illustrative of the principles of the invention, rather than exhaustive thereof, and that changes and variations will be apparent to those skilled in the art, and that the present invention is not intended to be limited other than as expressly set forth in the following claims.

Claims

1. A temperature controller for mounting on an injection tool , the temperature controller having a temperature control circuit comprising:

a comparator for comparing a reference temperature signal with a sensed temperature signal from the injection tool ;

an opto-coupler coupled to the output of the comparator; and

a solid-state switching device for switching a power supply to a heater of the injection tool, the solid-state switching device being arranged to receive an activation signal from the opto-coupler responsive to a change of state of an output of the comparator.

2. The temperature controller as claimed in claim 1, wherein the output of the comparator is connected to a DC power source through a resistive-capacitive circuit and to the opto-coupler.

3. The temperature controller as claimed in claim 2, arranged for the DC power source to power the opto-coupler when the output of the comparator changes state, for the opto-coupler to provide the activation signal to the solid-state switching device.

4. The temperature controller as claimed in any one of claims 1 to 3, wherein the solid-state switching device is a triac.

5. The temperature controller as claimed in any preceding claim, further comprising a reference temperature selection circuit for providing the reference temperatures signal, the reference temperature selection circuit being arranged for a user to select between first and second reference temperatures.

6. A temperature controller for providing a reference temperature signal of a temperature control process in an injection tool, the temperature controller having a reference temperature selection circuit arranged for a user to select between first and second reference temperatures.

7. The temperature controller of any one of claims 5 to 6, wherein the temperature controller is arranged for a user to select the first reference temperature corresponding to an operating condition of the injection tool and the second reference temperature corresponding to a standby condition of the injection tool.

8. The temperature controller of any one of claims 5 to 7, wherein the temperature controller is arranged for a user to select the first reference temperature corresponding to an operating temperature of a plastics material in the injection tool and the second reference temperature corresponding to a standby temperature of the plastics material in the injection tool.

9. The temperature controller of any one of claims 5 to 8, wherein the temperature controller has a selector switch for selective connection to a first resistor and a second resistor, the first resistor having a resistive value different from a resistive value of the second resistor, the selector switching being for a user to adjust one of the first and second reference temperatures based on the plastics material for use in the injection tool.

10. The temperature controller as claimed in any one of claims 5 to 9 wherein the temperature selection circuit comprises a first trimmer for the user to select the first reference temperature; and a second trimmer for the user to select the second reference temperature and a first selection switch for switching between the first trimmer and the second trimmer.

11. The temperature controller as claimed in any one of claims 9 to 10, wherein the temperature selection circuit comprises a second selector switch for adjusting between the plural resistance values, and the temperature controller circuit is arranged to provide an adjusted reference temperature in dependence of conditions of the first and second selector switches.

12. The temperature controller as claimed in any one of claims 5 to 11 wherein the temperature controller further includes a second temperature control circuit as defined in claim 1 for controlling the temperature of a second temperature zone of the injection tool, the comparator of the temperature control circuit and the comparator of the second temperature control circuit each receiving a common reference temperature signal.

13. The temperature controller as claimed in any one of claims 1 to 12 wherein the temperature controller is provided in an insulated material housing.

14. A method of controlling temperature in an injection tool, the method comprising:

comparing a reference temperature signal with a sensed temperature signal from the injection tool

controlling a solid-state switching device to switch a power supply to a heater of the injection tool, the solid-state switching device to switch a power supply to a heater of the injection tool, the solid-state switching device receiving an activation signal from the opto-coupler responsive to a change of state of an output of the comparator

15. A method of providing a reference temperature signal in a temperature control process for an injection tool, the method comprising a user selection between first and second reference temperatures in a reference temperature selection circuit of a temperature controller.