

**TITLE****Temperature Control of Near-Infrared Analyzer****5 Background of the Invention**

The invention relates to thermal management in instrumentation and more particularly it relates to temperature control of a near-infrared analyzer.

Thermal management in instrument packaging has always
10 been an important design consideration. Internal temperature control of near-infrared (NIR) analyzers is essential for measurement precision. More particularly, NIR spectrophotometers can be affected by temperature variations as little as 2 to 4 degrees C, which cause
15 shifting of optimal wavelengths, and the addition of error in the measurement.

The typical process spectrophotometer is controlled within a band of temperature by utilization of an on-off type control strategy. In the "on" state, a condenser or
20 other device is turned on to remove heat build-up from within the spectrophotometer enclosure. The condenser or other device remains "on" until a low temperature limit is reached and then the condenser is turned "off." The temperature in the spectrophotometer enclosure rises from
25 the heat generated by the electronics and/or the external environment until a second temperature limit is reached, which causes the condenser or other device to be turned "on" again. This on/off temperature control approach commonly allows the internal temperature to cycle 2-4 C
30 degrees.

Summary of the Invention

A preferred temperature control strategy was devised to remove heat from the analyzer and control the optical
35 bench temperature continuously at aim. A temperature sensor is fastened to the optical bench in an analyzer to serve as a measurement input device for a control strategy which is truly aim-seeking. The control strategy employs a heat pipe heat exchanger to remove heat from the

analyzer enclosure. A heat pipe utilizes a fluid (such as an alcohol) to remove heat by evaporation of the fluid at an internal air circulation heat exchanger and then recondensing the fluid at an external air circulation heat exchanger. Heat pipes are particularly useful in that internal cabinet air, not outside air, is circulated through the critical optical components, thereby eliminating the need for additional filtering of the cooling air.

10 A PID temperature controller achieves the desired temperature setpoint by manipulation of heat exchanger fan speeds. The heat removal rate can be very precisely controlled. In practice, both heat exchanger fans could be controlled together; however, to achieve optimal
15 internal temperature uniformity, the internal heat exchanger fan is maintained at full speed and just the external fan is controlled to adjust heat removal rate. Optical bench temperature control is maintained to plus or minus 0.1 degree C vs. a typical temperature control range
20 of plus or minus 2 degrees C.

More particularly, the invention includes an apparatus and a process for controlling the temperature of an analyzer cabinet wherein heat is generated within the cabinet. The apparatus comprises a heat exchanger having
25 internal and external chambers surrounding heat pipe coils attached to the analyzer cabinet. The internal side chamber is in communication with the cabinet via an inlet and an outlet; a continuously operating constant speed fan located in the inlet is provided for circulating air past
30 the coils and through said cabinet. The external chamber is in communication with fresh outside ambient air and a variable speed fan circulates outside ambient air through the external chamber. A temperature sensor located in the cabinet produces signals corresponding to the temperature
35 at the sensor location. The variable speed fan is responsive to the signals produced by the sensor.

The other embodiment of this invention is an improved process for controlling the internal cabinet temperature of a near-infrared analyzer, and therefore, the accuracy

of the analyzer. This improvement comprises continuously measuring the temperature of the critical optical components in the cabinet, and, in response, continuously circulating temperature-controlled air by these critical optical components to maintain the components at a relatively constant temperature. By use of this process, the temperature of the temperature-sensitive critical optical components can be maintained to plus or minus 0.1 degree C.

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Brief Description of the Drawing

The Figure is a schematic illustration of an analyzer and associated internal and external heat exchangers.

Detailed Description of the Preferred Embodiment

Referring to the Figure analyzer cabinet 10 contains critical optical systems 12, in addition to electrical components (not shown). "Critical optical systems" or "critical optical components" are meant to include photodetectors, gratings, grating mounts, etc., which are temperature sensitive and are normally housed inside the analyzer cabinet in what is called an "optical bench." Temperature sensor 14 is attached to the critical optical systems and outputs a temperature signal to temperature controller 15. Also, attached to analyzer cabinet 10 is a heat pipe heat exchanger 16, having an internal side 16a, an external side 16b, and heat pipe coils 18. The heat pipe coils extend from the internal side to the external side so that heat may be transferred from the internal side to the external side. In addition, the internal side has an internal inlet 20 for removing air from the analyzer cabinet, and an internal outlet 22 for providing temperature-controlled air to the critical optical systems. A continuously operating internal fan 24 is mounted in the internal outlet 22 to provide movement of air through the internal side of the heat pipe heat exchanger. The external side 16b of the heat pipe heat exchanger has an external inlet 28 for providing fresh outside ambient air to the heat-pipe heat exchanger, and

an external outlet 30 for removing this air from the external side. A speed-controlled fan 32 is mounted in the external outlet 30 to provide movement of air through the external side of the heat pipe heat exchanger 16. The speed controlled fan 32 is electrically connected to the temperature controller 15, and the speed of the fan increases or decreases based on the output signal from the temperature sensor 14, thus providing more or less cooling to the heat pipe coils 18 in heat exchanger 16.

10 In one example of a preferred construction, a Noren Model CC600F heat pipe heat exchanger containing interior and exterior fans (supplied by Noren Products, Inc., Menlo Park, CA) was attached to the enclosure of a Guided Wave 300P Near-Infrared Analyzer (supplied by UOP Guided Wave, 15 El Dorado Hills, CA). A Minco foil-type 100 ohm Resistance Temperature Detector, or RTD, was attached to critical optical components in the analyzer and inputted signals to a ECS Model 6415 PID temperature controller having a 10 amp control output. This output was in turn 20 connected to the external fan of the heat pipe heat exchanger for control of the external fan speed.

What is claimed is:

1. An apparatus for controlling the temperature of an analyzer cabinet wherein heat is generated within said cabinet, said apparatus comprising: a heat exchanger
5 having internal and external chambers surrounding heat pipe coils, said heat exchanger attached to said analyzer cabinet; said internal side chamber being in communication with said cabinet by means of an inlet and an outlet; a
10 continuously operating constant speed fan located in said inlet for circulating air past said coils and through said cabinet; said external chamber being in communication with fresh outside ambient air; and a variable speed fan circulating outside ambient air through said external chamber; a temperature sensor located in said cabinet;
15 said sensor producing signals corresponding to the temperature at the sensor location; and said variable speed fan being responsive to said signals.

2. The apparatus of Claim 1, wherein the temperature
20 sensor is located on critical optical components within said analyzer cabinet.

3. The apparatus of Claim 2, wherein the critical optical components are of the group consisting of a
25 photodetector, a grating, and a grating mount.

4. In the process for controlling the internal cabinet temperature of a near-infrared analyzer having critical optical components, the improvement comprising:
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- a) continuously measuring the temperature of the Critical optical components in cabinet; and,
- b) continuously circulating temperature-controlled air past the critical optical
35 components to maintain the components at a relatively constant temperature.





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REPLACED

5. The process of Claim 4, wherein the critical optical components are of the group consisting of a photodetector, a grating, and a grating mount.

- 5 6. The process of Claim 4, wherein the temperature of the critical optical components is maintained to plus or minus 0.1 degrees C.

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This Sheet Has Been Replaced



TITLE

Temperature Control of Near-Infrared Analyzer

5 Background of the Invention

The invention relates to thermal management in instrumentation and more particularly it relates to temperature control of a near-infrared analyzer.

Thermal management in instrument packaging has always
10 been an important design consideration. Internal temperature control of near-infrared (NIR) analyzers is essential for measurement precision. More particularly, NIR spectrophotometers can be affected by temperature variations as little as 2 to 4 degrees C, which cause
15 shifting of optimal wavelengths, and the addition of error in the measurement.

The typical process spectrophotometer is controlled within a band of temperature by utilization of an on-off type control strategy. In the "on" state, a condenser or
20 other device is turned on to remove heat build-up from within the spectrophotometer enclosure as is described in U.S. Patent No. 4,328,676. The condenser or other device remains "on" until a low temperature limit is reached and then the condenser is turned "off." The temperature in
25 the spectrophotometer enclosure rises from the heat generated by the electronics and/or the external environment until a second temperature limit is reached, which causes the condenser or other device to be turned "on" again. This on/off temperature control approach
30 commonly allows the internal temperature to cycle 2-4 C degrees.

Summary of the Invention

A preferred temperature control strategy was devised
35 to remove heat from the analyzer and control the optical bench temperature continuously at aim. A temperature sensor is fastened to the optical bench in an analyzer to serve as a measurement input device for a control strategy which is truly aim-seeking. The control strategy employs
40 a heat pipe heat exchanger to remove heat from the



What is claimed is:

1. An apparatus for controlling the temperature of an analyzer cabinet (10) in which heat is generated by operational components (12) located in said cabinet (10), said apparatus comprising:

a heat exchanger (16) having heat pipe coils (18), an internal chamber (16a) and an external chamber (16b), said chambers (16a, 16b) surrounding said heat pipe coils (18),

said heat exchanger (16) being attached to said cabinet (10) in such a way that said internal chamber (16a) is in communication with said cabinet (10) by means of an outlet (20) from said cabinet (10) and an inlet (22) to said cabinet (10),

a continuously operating constant speed fan (24) being located in said inlet (22) for circulating air through said cabinet (10) and past said heat pipe coils (18),

said external chamber (16b) being in communication with fresh outside ambient air,

a variable speed fan (32) circulating said outside ambient air through said external chamber (16b) to cool said heat pipe coils (18),

a temperature sensor (14) located in said cabinet producing signals corresponding to the temperature at the sensor location,

said variable speed fan (32) being responsive to said signals.

2. The apparatus of Claim 1, wherein the temperature sensor is located on critical components within said analyzer cabinet.

3. The apparatus of Claim 2, wherein the critical optical components are of the group consisting of a photodetector, a grating, and a grating mount.



4. An improved process for controlling the temperature of a near-infrared analyzer critical optical components housed within a cabinet (10) having attached a heat exchanger (16) having heat pipe coils (18), an internal chamber (16a) and external chamber (16b) said chambers (16a, 16b) surrounding said heat pipe coils (18) wherein said internal chamber (16a) communicates with the cabinet (10) via an inlet (22) to said cabinet (10) and an outlet (20) from said cabinet and the external chamber (16b) communicates with fresh, outside air via an inlet (30) and outlet (28) having a variable speed fan (32), characterized in that the temperature of the critical optical components is controlled at an aim point of plus or minus 0.1°C by:

- a) continuously measuring the temperature of the critical optical components in cabinet (10) by means of a temperature sensor (14) fastened to the critical components;
- b) continuously circulating air by means of the constant speed fan (24) past the critical optical components to maintain the components at a relatively constant temperature; and,
- c) controlling the speed of the variable speed external fan (32) from signals generated by the temperature sensor (14).

5. The process of Claim 4, wherein the critical optical components are of the group consisting of a photodetector, a grating, and a grating mount.

6. The process of Claim 4, wherein the temperature of the critical optical components is maintained to plus or minus 0.1 degrees C.



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② IPER + Annexes

(54) Title: TEMPERATURE CONTROL OF NEAR-INFRARED ANALYZER

(57) Abstract

A preferred temperature control strategy was devised to remove heat from the analyzer and control the optical bench temperature continuously at aim. A foil-type RTD temperature detector is fastened to the optical bench to serve as a measurement input device for a PID control strategy, which is truly aim-seeking. The control strategy employs a heat pipe technology to remove heat from the analyzer enclosure. A heat pipe utilizes a fluid (such as an alcohol) to remove heat by evaporation of the fluid at an internal air circulation heat exchanger and then recondensing the fluid at an external air circulation heat exchanger. The PID temperature controller achieves the desired temperature setpoint by manipulation of heat exchanger fan speeds. The heat removal rate can be very precisely controlled. In practice, both heat exchanger fans could be controlled together; however, to achieve optimal internal temperature uniformity, the internal heat exchanger fan is maintained at full speed and just the external fan is controlled to adjust heat removal rate. Optical bench temperature control is maintained to plus or minus 0.1 degree C vs. a typical temperature control band of plus or minus 2 degrees C.

