(54) Title: TEMPERATURE SENSOR APPARATUS

(57) Abstract: An apparatus for temperature sensing is disclosed that includes a sensor tube and a cable assembly connected to and extending from said sensor tube wherein said cable assembly communicates electrically with the sensor tube for temperature sensing operations thereof. An O-ring component can be selected based on an inner diameter of said sensor tube and an outer diameter of said cable assembly, wherein said O-ring component is crimped in order to seal and protect said sensor tube from de-alignment and misplacement and located co-axial to said sensor tube and said cable assembly, thereby providing an enhanced mechanical strength and prevention against leakage or ingress of moisture from or to said sensor tube.
TEMPERATURE SENSOR APPARATUS

TECHNICAL FIELD

[0001] Embodiments are generally related to sensor devices and. Embodiments are also related to temperature sensors. Embodiments are additionally related to temperature sensors utilized in harsh and corrosive environments, such as automotive applications.

BACKGROUND

[0002] Temperature sensors are utilized in a variety of applications. For example, temperature sensors that are used in conjunction with ovens typically comprise a metallic tube in which a temperature sensitive element is disposed inside one end with conductive wires extending within the tube from the temperature sensitive element to an opening at the other end of the tube. The metallic tube is inserted through a wall of the oven to permit the temperature sensitive element to be placed in thermal communication with the internal cavity of the oven. The temperature sensitive element is typically a resistive temperature detector, or RTD. The temperature sensor can be also based on a thermistor or thermocouple configuration, a metal oxide semiconductor, or any other type of temperature sensing element.

[0003] One area where temperature sensors find particular usefulness is in the area of exhaust gas environments. Various applications require measurement of temperature of gas or mixture of gases at elevated temperatures. One such application involves automotive or combustion applications in which a need exists for measuring the exhaust gas temperature for emission control using Selective catalytic reduction (SCR) and Exhaust Gas Recirculation (EGR) based emission after treatment systems. The sensor should function in a harsh and corrosive automotive exhaust gas environment containing, for example, soot particles, SO\(_x\), moisture, diesel, NH\(_3\), NO\(_x\), HC, CO, CO\(_2\) etc.

[0004] Exhaust gas temperature (EGT) can be utilized to measure the performance, for example, of an automotive engine. The exhaust gas temperature also provides an indication of the rate of deterioration of automotive engine components. Thus, since the
exhaust gas temperature is an indicator of engine status, it may be used to measure and control operational and functional characteristics of the engine.

[0005] Accurate measurement of the exhaust gas temperature level is important. To accurately measure exhaust gas temperatures, it is necessary to minimize degradation of the EGT measurement system. Thus it is desirable that the EGT measurement system compensate for engine to engine variations and combustor exit temperature profiles. In addition, the measurement system should compensate for shifts in engine profiles that may occur with progressive deterioration of the engine components.

[0006] The penetration of a particular sensor can be determined by the temperature profile of the exhaust gases. The exhaust gas temperature profile is determined by the number, type and arrangement of the combustion nozzles in the combustor. The exhaust gas temperature profile for a particular engine may be determined by using a large number of thermocouple elements arranged in a number of sensors around the exhaust passage and at various penetration depths. Once the exhaust gas temperature profile is defined for a particular type of engine, it may be used to calculate the number and arrangement of EGT sensors necessary to monitor the exhaust gas temperature during normal engine operation.

[0007] As indicated above, a variety of temperature sensing elements can be utilized in the context of an exhaust gas temperature sensor. Resistance Temperature detectors (RTD) elements can be used in temperature measuring equipment. The RTD Element has a ceramic substrate with a platinum or nickel or similar metal thin/thick film resistor with an over coating of a protective layer like glass or ceramic or any other material glazing, which is thermally a good conductor. Wire wound RTD elements are also available. Materials such as, for example, platinum or nickel have a positive coefficient of temperature and the resistance increases linearly with increase in temperature.

[0008] Thermistors are also utilized in temperature measuring equipment. Thermistors are essentially semiconductor devices, which behave as thermal resistors having high negative or positive temperature co-efficient of resistance. Thermistors are made of sintered metal oxide ceramics like oxides of iron, magnesium, nickel, cobalt

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and copper in the form of beads or discs or rods. The variation in temperature is non linear, resistance decreases with increase in temperature in case of negative temperature co-efficient (NTC) of resistance thermistor and resistance increases with increase in temperature in case of positive temperature co-efficient (PTC) of resistance thermistor.

[0009] Thermocouples are the most commonly utilized temperature sensing devices and operate based on the principle of the so-called See-Beck effect, i.e., when two dissimilar metal or ceramic or metal oxide semiconductor junctions are maintained at different temperature an EMF is induced at the junction, which is proportional to temperature difference. Generally Platinum with copper, Constantan, Nickel, Rhodium, Iron, Gold, ZrO₂, Al₂O₃, CeO₂ and so forth can be utilized. The sensing element can be suitably packaged and placed in a gas flow path and the temperature is measured by using a suitable electronic circuit by transduction of resistance or voltage.

[0010] Temperature sensors can be configured to include a housing formed from a material, such as, for example, stainless steel, inconel, brass, and so forth. A connecting cable may typically connect to sensor at an interface junction. The junction or interface of the cable and metal tube is generally crimped to hold the cable mechanically. In harsh environments, however, such as automotive applications, there exists a high demand for water and dust proof sealing and often the crimping of such sensors fails to withstand the ingress of water and moisture and corrosive gases and liquids, while being susceptible to leakage. There thus exists a continuing need for temperature sensors that are water proof and leak proof, while also suitable for harsh and long exposure to corrosive environments, such as, for example, an automobile exhaust gas environment.
BRIEF SUMMARY

[0011] The following summary is provided to facilitate an understanding of some of the innovative features unique to the embodiments and is not intended to be a full description. A full appreciation of the various aspects of the embodiments disclosed can be gained by taking the entire specification, claims, drawings, and abstract as a whole.

[0012] It is, therefore, one aspect of the present invention to provide for an improved temperature sensor.

[0013] It is yet another aspect of the present invention to provide for an improved exhaust gas temperature sensor.

[0014] The aforementioned aspects of the invention and other objectives and advantages can now be achieved as described herein. An apparatus for temperature sensing is disclosed that includes a sensor tube and a cable assembly connected to and extending from said sensor tube wherein said cable assembly communicates electrically with the sensor tube for temperature sensing operations thereof. An O-ring component can be selected based on an inner diameter of said sensor tube and an outer diameter of said cable assembly, wherein said o-ring component is crimped in order to seal and protect said sensor tube from de-alignment and misplacement and located co-axial to said sensor tube and said cable assembly, thereby providing an enhanced mechanical strength and prevention against leakage or ingress of moisture from or to said sensor tube.
BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The accompanying figures, in which like reference numerals refer to identical or functionally-similar elements throughout the separate views and which are incorporated in and form a part of the specification, further illustrate the embodiments and, together with the detailed description, serve to explain the principles of the disclosed embodiments.

[0016] FIG. 1 illustrates a temperature sensing apparatus, which can be implemented in accordance with a preferred embodiment;

[0017] FIG. 2 illustrates a detailed view of a section of the apparatus depicted in FIG. 1, in accordance with a preferred embodiment;

[0018] FIG. 3 illustrates a detailed view of the temperature sensing apparatus depicted in FIGS. 1-2, in accordance with a preferred embodiment;

[0019] FIG. 4 illustrates an external view of the temperature sensing apparatus depicted in FIGS. 1-3, in accordance with a preferred embodiment; and

[0020] FIG. 5 illustrates another view of the temperature sensing apparatus depicted in FIGS. 1-4, in accordance with a preferred embodiment.
[0021] The particular values and configurations discussed in these non-limiting examples can be varied and are cited merely to illustrate at least one embodiment and are not intended to limit the scope of the invention.

[0022] FIG. 1 illustrates a temperature sensing apparatus 100, which can be implemented in accordance with a preferred embodiment. The illustration depicted in FIG. 1 is based on a CS2-CS2 sectional view. The apparatus 100 generally includes a sensor tube 102 that includes a tip 104 that can be formed from a potting compound, such as, for example, SiC. A collar fitting 106 can be integrated with or connected to the sensor tube 102 of apparatus 100 and can be further associated with a fixing nut 108 located about sensor tube 102. The collar fitting 106 is generally integrated with a collar component 107. The apparatus 100 further incorporates an extension tube 112 that is associated with or integrated with sensor tube 102, depending upon design considerations. Note that the extension tube 112 can be formed from a nickel-based superalloy, such as, for example, Inconel®, which is a trademark of the Special Metal Corporation.

[0023] In general, Inconel® is a family of nickel-based superalloys. Inconel alloy 600 is 72% nickel, 16% chromium, and 8% iron. Other forms of Inconel® exist, each with slightly different additions (e.g. Inconel® alloy 750 has a small percentage of titanium and aluminum added for hardenability). Inconel® is highly oxidation and corrosion resistant, even at very high temperatures, and retains a high mechanical strength under these conditions as well. Thus, it is often used in extreme conditions, such as aircraft engine parts, turbocharger turbine wheels, chemical processing and pressure vessels. Other versions of Inconel® resist acid and other aggressive conditions such as Ni-20Cr-16MO-4W Inconel® alloy 686.

[0024] The extension tube 112 can thus form a part of the sensor tube 102 or may form a separate component connected to and associated with the sensor tube 102. The extension tube 112 can be formed from a material, such as, for example, ceramic. The walls 110 of the extension tube 112 can thus be formed from a material such as ceramic. A seal compound 116 can also be provided adjacent a component 115, which
in turn is surrounded by a jacket or sleeve 114 that can be formed from a material such as, for example, fiber glass. An O-ring component 117 can also be provided as a part of apparatus 100, which covers a portion of a jacket or sleeve 118 that functions as an insulated sleeve with a metal braiding (e.g., see crimped locations 203, 205 in FIG. 2).

[0025] The insulated sleeve 118 can be formed from a material, such as, for example, a fluorinated polymer. One example of such a fluorinated polymer is Teflon®. Note that Teflon® is a registered trademark of the "E.I. Du Pont de Nemours & Company Corporation" of Wilmington, Delaware. The insulated sleeve 118 can also be from silicon rubber or a fluoroelastomer, depending upon design consideration. A section 121 of the apparatus 100 is generally indicated in FIG. 1 by dashed lines.

[0026] A cable assembly 120 can also be connected to and extend from the sensor tube 102 via the extension tube 112. The cable assembly 120 can thus communicate electrically with the temperature sensor component (not shown) maintained by the sensor tube 102. The O-ring component 117 can be selected based on an inner diameter of said sensor tube 102 and an outer diameter of the cable assembly 120. The O-ring component 117 is generally crimped in order to seal and protect said sensor tube 102 from de-alignment and misplacement and located co-axial to said sensor tube 102 and the cable assembly 120, thereby providing an enhanced mechanical strength and prevention against leakage or ingress of moisture from or to said sensor tube 102 and resulting temperature sensing apparatus 100.

[0027] FIG. 2 illustrates a detailed view of the section 121 of apparatus 100 depicted in FIG. 1, in accordance with a preferred embodiment. Note that in FIGS. 1-5, identical or similar parts or elements are generally indicated by identical reference numerals. FIG. 2 presents a detailed CS2-CS2 sectional view of the apparatus 100 depicted in FIG. 1. As shown in FIG. 2, the cable assembly is generally surrounded by the insulated sleeve 118, which in turn is located in place within the tube 112. Note that the tube 112 includes an end portion 201 thereof that is flared. The O-ring component 117 is also depicted in section 121 depicted in FIG. 2, wherein the O-ring component 117 is also embedded within the bounds of the tube 112. Note that a circular double crimp can also be implemented at crimped locations 203, 205 depicted in FIG. 2. Note that the crimp dimensions should preferably be maintained as close as possible to the
required dimensions of the O-ring component 117.

[0028] FIG. 3 illustrates a detailed view of the temperature sensing apparatus 100 depicted in FIGS. 1-2, in accordance with a preferred embodiment. Again, identical or similar parts or elements are generally depicted in FIGS. 1-5. Thus, FIG. 3 shows components in addition to those depicted in FIGS. 1-2. For example, a ceramic tube 314 is depicted in FIG. 3 in addition to two wires 302, 304, which are located within the extension tube 112. Note that the two wires 302, 304 can be formed from a material such as Inconel®, depending of course on design consideration and goals. The ceramic tube 314 is located generally within sensor tube 102. Contact terminals 306 are also provided as a part of the apparatus 100 and can communicate electrically with the wires 302, 304. Primary wires 308 and 310 are also indicated in FIG. 3 and form a part of the cable assembly 120.

[0029] FIG. 4 illustrates an external view of the temperature sensing apparatus 100 depicted in FIGS. 1-3, in accordance with a preferred embodiment. FIG. 5 illustrates another view of the temperature sensing apparatus 100 depicted in FIGS. 1-4, in accordance with a preferred embodiment. Note that FIG. 4 illustrates a view along CS2, while FIG. 5 represents a view along CS1. As indicated in FIG. 4, a rear tube crimped connector 402 can be provided along with a heat shrink sleeve 406. A tab housing 408 is also depicted in FIGS. 4-5.

[0030] It will be appreciated that variations of the above-disclosed and other features and functions, or alternatives thereof, may be desirably combined into many other different systems or applications. Also that various presently unforeseen or unanticipated alternatives, modifications, variations or improvements therein may be subsequently made by those skilled in the art which are also intended to be encompassed by the following claims.
What is claimed is:

1. An apparatus for temperature sensing, comprising:
   a sensor tube;
   a cable assembly connected to and extending from said sensor tube wherein
   said cable assembly communicates electrically with said sensor tube for sensing
   operations thereof; and
   an O-ring component selected based on an inner diameter of said sensor tube
   and an outer diameter of said cable assembly, wherein said o-ring component is
   crimped in order to seal and protect said sensor tube from de-alignment and
   misplacement and located co-axial to said sensor tube and said cable assembly,
   thereby providing an enhanced mechanical strength and prevention against leakage or
   ingress of moisture from or to said sensor tube.

2. The apparatus of claim 1 wherein said cable assembly comprises an insulated
   sleeve with a metal braiding thereof, wherein said insulated sleeve comprises a
   fluorinated polymer.

3. The apparatus of claim 1 wherein said cable assembly comprises an insulated
   sleeve with a metal braiding thereof, wherein said insulated sleeve comprises silicon
   rubber.

4. The apparatus of claim 1 wherein said cable assembly comprises an insulated
   sleeve with a metal braiding thereof, wherein said insulated sleeve comprises a
   fluroestalstomer.

5. The apparatus of claim 1 wherein said O-ring component comprises silicon
   rubber.

6. The apparatus of claim 1 further comprising an extension tube connected to said
   sensor tube.
7. An apparatus for temperature sensing, comprising:
   - a sensor tube;
   - a cable assembly connected to and extending from said sensor tube wherein said cable assembly communicates electrically with said sensor tube for sensing operations thereof;
   - an O-ring component selected based on an inner diameter of said sensor tube and an outer diameter of said cable assembly, wherein said o-ring component is crimped in order to seal and protect said sensor tube from de-alignment and misplacement and located co-axial to said sensor tube and said cable assembly, thereby providing an enhanced mechanical strength and prevention against leakage or ingress of moisture from or to said sensor tube; and
   - an extension tube connected to said sensor tube.

8. The apparatus of claim 7 wherein said cable assembly comprises an insulated sleeve with a metal braiding thereof, wherein said insulated sleeve comprises a fluorinated polymer or a silicon rubber material.

9. An apparatus for temperature sensing, comprising:
   - a sensor tube;
   - a cable assembly connected to and extending from said sensor tube wherein said cable assembly communicates electrically with said sensor tube for sensing operations thereof; and
   - an O-ring component selected based on an inner diameter of said sensor tube and an outer diameter of said cable assembly, wherein said o-ring component is crimped in order to seal and protect said sensor tube from de-alignment and misplacement and located co-axial to said sensor tube and said cable assembly, thereby providing an enhanced mechanical strength and prevention against leakage or ingress of moisture from or to said sensor tube, wherein said cable assembly comprises an insulated sleeve with a metal braiding thereof and said insulated sleeve comprises a fluorinated polymer.

10. The apparatus of claim 10 wherein said cable assembly comprises an insulated sleeve with a metal braiding thereof, wherein said insulated sleeve comprises silicon rubber or a fluroestalstomer.
A. CLASSIFICATION OF SUBJECT MATTER

According to International Patent Classification (IPC) or to both national classification and IPC:

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols):

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched:

Electronic data base consulted during the international search (name of data base and, where practical, search terms used):

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X Further documents are listed in the continuation of Box C. X See patent family annex.

* Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
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