

DESCRIPTION

TITLE OF THE INVENTION: THERORESPONSIVE SWITCH AND METHOD FOR
MANUFACTURING SAME

5 TECHNICAL FIELD

[0001] The present invention relates to a thermally responsive switch installed as a protective device inside a sealed motor compressor and a method of manufacturing the same.

10 BACKGROUND

[0002]

This type of thermally responsive switch is provided with a sealed container and a thermally responsive plate disposed inside the sealed container. The sealed container is formed of
15 a metal housing and a cover plate. The thermally responsive plate, being curved, is configured to invert its direction of curvature at a predetermined temperature. A conductive terminal pin is inserted through the cover plate and is secured airtight to the cover plate by an electrically insulative filler such as glass.
20 At the tip of the conductive terminal pin located inside the sealed container, a stationary contact is attached directly or indirectly via a supporting element, etc. One end of the thermally responsive plate is connected and secured to the inner surface of the sealed container by way of a supporting element, etc. A
25 movable contact is secured to the other end of the thermally responsive plate. The movable contact as well as the stationary contact serve as a make and break contact.

[0003]

The thermally responsive switch is installed in the sealed housing of the sealed motor compressor and functions as a protector known as a thermal protector for compressor motor applications. When the temperature around the thermally responsive switch becomes abnormally high, or when abnormal current flows through the motor to cause the temperature inside the thermally responsive switch to become abnormally high, the thermally responsive plate is inverted to cause the contacts to be opened and thus, be placed in a non-electrically conductive state. When the temperature falls to a predetermined value or less on the other hand, the thermally responsive plate returns to the original state to close the contacts and thus, be placed in an electrically conductive state.

15 PRIOR ART DOCUMENTS

PATENT DOCUMENT

[0004]

Patent Document 1: JP H10-144189 A

SUMMARY OF THE INVENTION

20 PROBLEMS TO BE OVERCOME BY THE INVENTION

[0005]

It is desirable in a thermally responsive switch to promptly adjust the interior temperature to the exterior temperature or allow the interior temperature to be promptly released to the exterior so that the thermally responsive switch is operated at appropriate temperatures. However, as illustrated in FIGS. 9 and 10 for example, most of the outside surface of the cover plate 104 forming the sealed container 102 in a conventional

thermally responsive switch is covered by a resin 121 serving as an electrically insulative coating. The resin 121 significantly reduces the heat conductivity of the sealed container 102. Thus, development of technologies for improving heat conductivity of the sealed container, serving as the main body of the thermally responsive switch, is desired. The type of electrically insulative resin used in this case is applied so as to cover the cover plate and the conductive terminal pin in order to secure insulation distance between the cover plate and the conductive terminal pin. The so-called internal protector belonging to the technical field of the present invention requires at least 2 mm of insulation distance (creepage distance). However, it is difficult to obtain 2 mm of insulation distance by the filler alone which is used for securing the conductive terminal pin. Thus, the required insulating distance is obtained by providing the above described type of electrically insulative resin.

[0006]

It is one object of the present invention to provide a thermally responsive switch in which heat conductivity of the sealed container can be improved while providing an electrically insulative resin for obtaining insulation distance.

MEANS FOR OVERCOMING THE PROBLEMS

[0007]

A thermally responsive switch of the present invention is primarily characterized by a through hole for securing a conductive terminal pin configured by a cylindrical portion

formed by outwardly projecting a cover plate and only the cylindrical portion, the filler, and the conductive terminal pin being covered by an electrically conductive resin.

[0008]

5 Thus, instead of covering most of the outer surface of the cover plate configuring the sealed container by the resin, only a significantly small portion including the end portion of the cylindrical portion is covered by the resin. As a result, heat conductivity of the sealed container, configuring the main body
10 of the thermally responsive switch, can be significantly improved compared to the conventional technology in which most of the outer surface of the cover plate was covered by the resin. Further, the through hole is configured by the cylindrical portion formed by outwardly projecting the cover plate and
15 thereby allowing the thickness of the filler (glass) to be maintained. As a result, it is possible to maintain the strength of the portion where the conductive terminal pin is mounted while allowing the thickness of most of the cover plate to be reduced. It is thus, possible to significantly improve the heat
20 conductivity of the sealed container. Further, the cylindrical portion projecting from the cover plate increases the surface area, i.e. the area of heat conduction of the entire cover plate, which also contributes in improving the heat conductivity of the sealed container.

25 [0009]

 In the thermally responsive switch of the present invention, the shape of the resin material forming the resin prior to being melted preferably has an inner diameter greater than the outer

diameter of the conductive terminal pin and an outer diameter less than the sum the outer diameter of the cylindrical portion and 2 mm. As a result, it is possible to cause the melted resin material to stay on the end portion of the cylindrical portion by surface tension without spreading any further. Thus, it is possible to reliably cover the conductive terminal pin portion, including the end portion of the cylindrical portion, by the resin and consequently reliably improve the heat conductivity of the sealed container. The outer diameter of the resin material prior to being melted is preferably less than the sum of the outer diameter of the cylindrical portion and 2 mm at the most, and more preferably less than the sum of the outer diameter of the cylindrical portion and 1 mm. Further, the outer diameter of the resin material prior to being melted is preferably greater than the outer diameter of the cylindrical portion subtracted by 2 mm.

[0010]

Further, in the thermally responsive switch of the present invention, the conductive terminal pin is formed of a core material made of copper exhibiting excellent heat conductivity. Thus, heat is also transmitted through the conductive terminal pin to improve heat conductivity even more effectively.

BRIEF DESCRIPTIONS OF THE DRAWINGS

[0011]

[FIG.1] FIG.1 is a vertical cross sectional view of a thermally responsive switch of one embodiment.

[FIG.2] FIG.2 is a transverse cross sectional view of the

thermally responsive switch taken along line II-II of FIG.1.

[FIG.3] FIG.3 is a side view of the thermally responsive switch.

[FIG.4] FIG.4 is a plan view of the thermally responsive switch.

[FIG.5] FIG.5 is an enlarged view of a main portion illustrating
5 the state before a resin material is melted.

[FIG.6] FIG.6 is an external view of a protection unit.

[FIG.7] FIG.7 is a view illustrating one example of installing
the thermal responsive switch to the protection unit (part 1).

[FIG.8] FIG.8 is a view illustrating one example of installing
10 the thermal responsive switch to the protection unit (part 2)

[FIG.9] FIG.9 corresponds to FIG.1 and illustrates a
conventional thermally responsive switch.

[FIG.10] FIG.10 corresponds to FIG.3 and illustrates a
conventional thermally responsive switch.

15

EMBODIMENTS OF THE INVENTION

[0012]

One embodiment applying the present invention to a thermal
protector (protective device) will be described with reference
20 to the drawings.

As illustrated in FIGS.1 to 4, a body of a thermally
responsive switch 1 is configured by a pressure resistant sealed
container 2 which is in turn configured by a metal housing 3 and
a cover plate 4. The housing 3 is formed by draw molding an iron
25 plate using a pressing machine. The two ends of the longer sides
of the housing 3 are molded into a substantially spherical shape
and the mid portion linking the two ends is molded into a shape
of an elongated dome having a semicircular cross section. The

cover plate 4 formed of an iron plate is molded into a shape of an elongated circle and is sealed airtight against the open end of the housing 3 by ring projection welding, etc.

[0013]

5 One end of a thermally responsive plate 6 is connected to the inner side of the sealed container 2 by the intermediary of a support element 5 made of a metal plate. The thermally responsive plate 6 is formed by draw molding a material, which deforms by heat such as a bimetal or a trimetal, into a shape
10 of a shallow dish. The thermally responsive plate 6, being curved, rapidly inverts its direction of curvature when reaching a predetermined temperature. A movable contact 7 is secured to the other end of the thermally responsive plate 6. The portion of the sealed container 2 where the support element 5 is secured
15 is deformed by applying pressure from the outside to control the contact pressure exerted between the movable contact 7 and the stationary contact 8 (later described) and calibrate the temperature where the inverting action of the thermally responsive plate 6 takes place to a predetermined temperature.

20 [0014]

 The cover plate 4 is provided with through holes 4A and 4B. Conductive terminal pins 10A and 10B are insulated and secured airtight to the through holes 4A and 4B, respectively by a known compression-type hermetic sealing method using a filler 9 formed
25 of electrically insulative material such as glass in consideration of thermal expansion coefficient. The conductive terminal pins 10A and 10B are formed of a clad material (composite metal material) in which copper is used as the core material.

A contact support 11 is secured near the tip of the conductive terminal pin 10A located inside the sealed container 2. The stationary contact 8 is secured to the contact support 11 at a location facing the movable contact 7.

5 [0015]

One end of a heater 12 serving as a heat generating element is secured near the tip of the conductive terminal pin 10B located inside the sealed container 2. The other end of the heater 12 is secured to the upper surface (inner surface) of the cover plate
10 4. The heater 12 is disposed along the periphery of the conductive terminal pin 10B so as to be substantially parallel with the thermally responsive plate 6. The heat generated by the heater 12 is transmitted efficiently to the thermally responsive plate 6.

15 [0016]

The heater 12 is provided with a fuse portion 12A (see FIG.2) having a cross sectional area smaller than other portions of the heater 12. While the compressor, being the target of control in this example, is running normally, the fuse portion
20 12A will not melt by the operational current of a later described electric motor 204 (see FIG.8). When the electric motor 204 is locked, the fuse portion 12A will not melt in this case as well since the thermally responsive plate 6 is inverted to open the contacts 7 and 8 in a short period of time. When the thermally
25 responsive switch 1 repeats the opening-closing cycles over a long period of time to exceed the guaranteed count of operations, the movable contact 7 and the stationary contact 8 may weld together and become inseparable. When the rotor of the electric

motor 204 is locked in this state, excessive current is produced to elevate the temperature of the fuse portion 12A which will eventually cause the fuse portion 12A to melt and ensure that the electric path is cutoff. It is thus, possible to ensure that
5 the electric motor 204 is de-energized.

[0017]

A thermally resistant inorganic insulating member 13 such as ceramics, zirconia (zirconium dioxide) is tightly secured in a spaceless manner above the filler 9 securing the conductive
10 terminal pins 10A and 10B. The shape of the thermally resistant inorganic insulating member 13 is determined based on pre-designed properties such as electric strength against creeping discharge and physical strength such as thermal resistivity against sputtering. As a result, it is possible to
15 maintain sufficient insulativity even when sputtered materials produced when the heater 12 is fused is attached to the surface of the thermally resistant inorganic insulating member 13. It is thus, possible to prevent arc produced between the fuse portions from transferring to a location between the conductive
20 terminal pin 10B and the cover plate 4 and to a location between conductive terminal pins 10A and 10B.

[0018]

When current flowing through the electric motor 204 is a normal operational current, which includes a starting current
25 flowing over short period of time, contacts 7 and 8 of the thermally responsive switch 1 stays closed. As a result, electric path formed of the conductive terminal pin 10A-stationary contact support 11-stationary contact 8-movable contact

7-thermally responsive plate 6-thermally responsive plate support 5-housing 3-cover plate 4-heater 12-conductive terminal pin 10B is maintained. Thus, the electric motor 204 stays energized. In contrast, the above described electric path is
5 cutoff as the contacts 7 and 8 are opened by the inversion of the direction in which the thermally responsive plate 6 is curved when: the load of the electric motor 204 is increased and unusually large current flows continuously; the electric motor 204 is locked and significantly large current flows continuously
10 for a few seconds or more; or the temperature of refrigerant inside a pressure resistant airtight container 202 (sealed housing) of the motor compressor 201 later described becomes abnormally high. Thus, the thermally responsive switch 1 is de-energized. Then, when the internal temperature of the
15 thermally responsive switch 1 is reduced, the thermally responsive plate 6 reverses its direction of curvature to close the contacts 7 and 8 and start energization of the electric motor 204.

[0019]

20 The through holes 4A and 4B of the thermally responsive switch 1 are configured by the cylindrical portions 4Aa and 4Bb which are obtained, for example, by burring a portion of the cover plate 4 to project in the shape of a cylinder (a circular cylinder in this example). Only the end portions (tip portions) of the
25 cylindrical portions 4Aa and 4Bb, the filler 9, and a portion (a portion near the filler 9) of the conductive terminal pins 10A and 10B are covered by the electric insulative resin 21 serving as a coating material. Thermoset resin such as an epoxy

resin is used as the resin 21. The resin 21 is required to cover at least the entirety of the surface of the filler 9, in which case, the resin 21 is preferably formed into a spherical surface (creepage surface) having a diameter of at least 3.6 mm ($\phi 3.6$ mm). As a result, it is possible to secure sufficient insulation distance (insulation distance of at least 2 mm or more) between the cover plate 4 and the conductive terminal pins 10A, 10B. Further, the amount of projection and the diametrical dimension of the cylindrical portions 4Aa and 4Bb may be modified as required.

[0020]

Next, a description will be given on a method of manufacturing the thermally responsive switch 1 in which the end portions of the cylindrical portions 4Aa and 4Bb, the filler 9, and portions of the conductive terminal pins 10A and 10B are covered by the resin 21. That is, conductive pins 10A and 10B are inserted into through holes 4A and 4B formed by cylindrical portions 4Aa and 4Bb protruding outward in a cylindrical shape from the cover plate 4 and these conductive pins 10A and 10B are insulated and secured by the filler 9 as illustrated in FIGS.5. Then, the ring shaped resin pellet 21A used as one example of a resin material is disposed on the end portions of the cylindrical portions 4Aa and 4Bb in the above described state. Then, the resin pellet 21A is melted and thereafter solidified to obtain a thermally responsive switch 1 in which the end portions of the cylindrical portions 4Aa and 4Bb, the filler 9, and portions of the conductive terminal pins 10A and 10B are covered by the resin 21.

[0021]

As illustrated in FIG.5, the resin pellet 21A is formed into a ring shape having a predetermined thickness (1mm for example). The inner diameter D1 of the resin pellet 21A is formed
5 so as to be at least larger than the outer diameter D2 of conductive terminal pins 10A and 10B. In this example, the inner diameter D1 of resin pellet is 1.8 mm.

[0022]

Outer diameter D3 of resin pellet 21A is preferably less
10 than dimension D5 which is the sum of outer diameter D4 of the cylindrical portions 4Aa and 4Bb and 2 mm, and more preferably less than dimension D6 which is the sum of the outer diameter of the cylindrical portions 4Aa and 4Bb and 1 mm. In this example,
15 the outer diameter of the cylindrical portions 4Aa and 4Bb is approximately 5 mm and the outer diameter of the resin pellet 21A is 5.5 mm which is less than dimension D5 (7 mm) being a sum of the cylindrical portions 4Aa and 4Bb (5 mm) and 2 mm and which is further less than dimension D6 (6 mm) being a sum of the cylindrical portions 4Aa and 4Bb (5 mm) and 1 mm.

20 [0023]

Outer diameter D3 of resin pellet 21A is preferably greater than the outer diameter of the cylindrical portions 4Aa and 4Bb subtracted by 2 mm, and more preferably greater than the outer diameter of the cylindrical portions 4Aa and 4Bb (the dimension
25 obtained by subtracting 0 mm from the cylindrical portions 4Aa and 4Bb). In this example, the outer diameter of resin pellet 21A is 5.5 mm which is greater than the outer diameter of the cylindrical portions 4Aa and 4Bb (5 mm) subtracted by 2 mm (which

amounts to 3 mm) and which is greater than the outer diameter of the cylindrical portions 4Aa and 4Bb (5 mm).

[0024]

To summarize, the maximum permissible dimension of outer
5 diameter D3 of the resin pellet 21A is the sum of the outer
diameter of the cylindrical portions 4Aa and 4Bb and 2 mm, and
more preferably sum of the outer diameter of cylindrical portions
4Aa and 4Bb and 1 mm. On the other hand, the minimum permissible
dimension of the outer diameter of the resin pellet 21A is the
10 dimension obtained by subtracting 2 mm from the outer diameter
of the cylindrical portions 4Aa and 4Bb, and more preferably
equals the outer diameter of the cylindrical portions 4Aa and
4Bb. In the present embodiment, the outer diameter of the resin
pellet 21A is specified to 5.5 mm within the more preferable range
15 (being greater than the outer diameter of the cylindrical
portions 4Aa and 4Bb and less than the sum of the cylindrical
portions 4Aa and 4Bb and 1 mm).

[0025]

Further, the total amount (total amount per one location)
20 of the resin 21, in other words, the total amount (total amount
per one resin pellet) is preferably designed based on the size
of the openings of through holes 4A and 4B, the diameter of the
cylindrical portions 4Aa and 4Bb, the diameter of conductive
terminal pins 10A and 10B, and properties of the resin material
25 (such as whether the resin material flows easily or does not flow
easily, viscosity, whether the resin material melts easily or
does not melt easily). It is preferable to cover the end portions
of the cylindrical portions 4Aa and 4Bb with the resin 21 without

causing interconnected cells or non-interconnected cells so that the entirety of the filler 9 is not visible from the outside. Thus, the total amount of the resin 21 (total amount of resin pellet 21A) need to be in a sufficient amount to achieve the above
5 described state. The total amount of resin pellet 21A is preferably controlled so as not to unnecessarily interfere (attach) with the conductive terminal pins 10A and 10B and so as not to unnecessarily extend along the conductive terminal pins 10A and 10B when melted.

10 [0026]

Next, a description will be given on one example of how the thermally responsive switch 1, structured as described above, is mounted to a sealed motor compressor as illustrated in FIGS.6 to 8.

15 As illustrated in FIG.6, thermally responsive switch 1 is structured as described above to serve as a protection unit 31 held in a case 32 formed of an electrically insulative synthetic resin, etc. One connection terminal member 33 is insert molded into the case 32. The conductive terminal pin 10A configuring
20 the thermal responsive switch 1 is secured by welding at an end portion 33A of the connection terminal member 33 disposed proximal to the case 32. The other end of the connection terminal member 33 located outside the case 32 serves a tab terminal 33B.
[0027]

25 Further, another connection terminal member 34, being mounted on the case 32, is secured at a predetermined location of the case 32 by snap action. The conductive terminal pin 10B configuring the thermal responsive switch 1 is secured by welding

at an end portion 34A of the connection terminal member 34 disposed proximal to the case 32. The other end of the connection terminal member 34 serves as a receptacle terminal 34B connected to the exterior of the motor compressor 201. The thermally responsive switch 1 is disposed so that the peripheral portion of the housing 3 is covered by the protection wall 32A. However, a clearance is provided between the protection wall 32A and the housing 3. Thus, refrigerant flows in the clearance to exchange heat with the housing 3.

10 [0028]

As illustrated in FIGS. 7 and 8, the protection unit 31 is disposed inside the pressure resistant airtight container 202 of the sealed motor compressor 201. An airtight terminal 203 is mounted to the pressure resistant airtight container 202 of the airtight motor compressor 31. The airtight terminal 203 is provided with multiple terminal pins 203A and the receptacle terminal 34B of the protection unit 31 is connected to either of the terminal pins 203A. The terminal pin 203A has a tab terminal secured thereto by welding. The rotation of the protection unit 31 with respect to the terminal pin 203A is prevented by combining the tab terminal and the receptacle terminal 34B. A main winding 204A (see FIG. 8) of the motor 204 is connected to the connection terminal member 33 of the protection unit 31. The protection unit 31 is disposed in series between a power supply and the motor 204. Thus, supply of power to the motor 204 is thus, cutoff by the operation of the thermally responsive switch 1 when the motor compressor 201 encounters abnormalities.

25 [0029]

In the above described embodiment of the thermally responsive switch 1, the through holes 4A and 4B to which the conductive terminal pins 10A and 10B are secured are configured by cylindrical portions 4Aa and 4Bb formed by outwardly projecting a portion of the cover plate 4. The cylindrical portions 4Aa and 4Bb, the filler 9, and a portion of the conductive terminal pins 10A and 10B are covered by the electrically insulative resin 21. It is thus, possible to significantly improve the heat conductivity of the sealed container 2 configuring the body of the thermally responsive switch 1.

[0030]

The present invention is not limited to the embodiment described above but may be modified or expanded within the spirit of the invention. For example, the resin 21 may also cover the side surfaces of the cylindrical portions 4Aa and 4Bb in addition to the end portions of the cylindrical portions 4Aa and 4Bb.

CLAIMS

What is claimed is:

1. A thermally responsive switch comprising:

5 a sealed container formed of a metal housing and a cover plate secured airtight to an open end of the housing;

 a couple of conductive terminal pins respectively inserted into a couple of through holes provided on the cover plate and respectively secured airtight by an electrically insulative
10 filler;

 a stationary contact secured to one of the conductive terminal pins inside the sealed container;

 a heater having one end connected to the other of the conductive terminal pins inside the sealed container and the
15 other end connected to the cover plate;

 a thermally responsive plate draw molded into a dish-like shape having one end connected to an inner surface of the housing and being configured to invert a direction of curvature thereof at a predetermined temperature; and

20 a movable contact provided on the other end of the thermally responsive plate and configuring a pair of a make and break contact with the stationary contact,

 wherein when the make and break contact is welded, the heater is configured to melts so that an electric path is cutoff,
25 and

 wherein the through holes are configured by cylindrical portions formed by projecting the cover plate outward, only the cylindrical portions, the filler, and the conductive terminal

pins being covered by an electrically insulative resin.

2. The thermally responsive switch according to claim 1,
wherein the resin is a solidified melt of a ring-shaped resin
5 material covering only the cylindrical portions, the filler, and
the conductive terminal pins, and

wherein the resin material prior to being melted has an inner
diameter being greater than an outer diameter of the conductive
terminal pins and an outer diameter being less than a sum of an
10 outer diameter of the cylindrical portions and 2 mm.

3. The thermally responsive switch according to claim 2,
wherein the outer diameter of the resin material prior to being
melted is less than a sum of the outer diameter of the cylindrical
15 portions and 1 mm.

4. The thermally responsive switch according to claims 2
or 3, wherein the outer diameter of the resin material prior to
being melted is greater than the outer diameter of the cylindrical
20 portions subtracted by 2 mm.

5. The thermally responsive switch according to any one of
claims 1 to 4, wherein the conductive terminal pins are formed
of a copper core material.

25

6. A method of manufacturing a thermally responsive switch
provided with a sealed container formed of a metal housing and

a cover plate secured airtight to an open end of the housing;
a couple of conductive terminal pins respectively inserted into
a couple of through holes provided on the cover plate and
respectively secured airtight by an electrically insulative
5 filler; a stationary contact secured to one of the conductive
terminal pins inside the sealed container; a heater having one
end connected to the other of the conductive terminal pins inside
the sealed container and the other end connected to the cover
plate; a thermally responsive plate draw molded into a dish-like
10 shape having one end connected to an inner surface of the housing
and being configured to invert a direction of curvature thereof
at a predetermined temperature; and a movable contact provided
on the other end of the thermally responsive plate and configuring
a pair of a make and break contact with the stationary contact,
15 in which, when the make and break contact is welded, the heater
melts so that an electric path is cutoff, the method comprising:

forming the through holes by cylindrical portions being
formed by projecting the cover plate outward; and

covering only the cylindrical portions, the filler, and the
20 conductive terminal pins with an electrically insulative resin
by solidifying a melt of a ring-shaped resin material at end
portions of the cylindrical portions.

7. The method of manufacturing the thermally responsive
25 switch according to claim 6, wherein the resin material prior
to being melted has an inner diameter being greater than an outer
diameter of the conductive terminal pins and an outer diameter
being less than a sum of an outer diameter of the cylindrical

portions and 2 mm.