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The Physical Properties of Thermal Expansion of Solid Matter

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Abstract: Thermal expansion is the tendency of matter to change shape, area, and volume in responses to change in temperature. The main objective is to review the thermal expansion of the solid state and its application. This study reviews the thermal expansion of solid state and its applications. The research revues thermal expansion of phases by collecting deferent information from different reference books and also discussed about the next out comes: Thermal expansion of phases is important for building and to bend different material. In this case expansions dap or join on a hot day consecrate in run way Sections in airport expands and this cause cracking to solve this problem. Leave small gap between sections, in anti – scaling values bimetallic strip when the bi metal strip. Is heated they expands more than invar this makes the strip bends with brass on the out sides of the curve, when the bimetal strips heated it curves and breaks contact then temperature reaches a cot value. Thermal expansion of status measurements of temperatures unites of temperature, expansion of solids, and its application. Based on the literature review about thermal expansion of solids: the factors that affecting thermal expansion of solids original length (direct), temperature (direct), material type. Solids in general have the smallest expansively while gases have the greatest expansively and liquids lie in between. Thermal the expansion of phases is important for building and to bend different material. In this case expansion dap or join, on the day concentrate in run way sections in airport expands and this cause cracking to solve this problem.

Keywords: Thermal Expansion, Thermometer, Solid Matter, Phase Difference, Gas Expansion

1. Introduction

Thermal expansion is the tendency of matter to change in shape, volume, and area in response to a change in temperature. Temperature is a monotonic function of the average molecular kinetic energy of a substance. When a substance is heated, molecules begin to vibrate and move more, usually creating more distance between themselves. Thermal expansion is linked to a change of temperature. The higher the temperature difference, the more the object will expand. Second, it is dependent on the material. It is clearly related to dilatation with may result from altering other parameters such as pressure, magnetic field, etc. and it level, something about the dependence on volume of the energies of various interaction processes in solid in general, solids expands upon heating, i.e. they exhibit positive coefficients of theta) expansively (CTE). However, a minority of solids show the inverse effect, i.e. of contraction upon heating and thus exhibit negative expansion (NTE) [1].

There has been an increasing amount of interest is solids and their potential application. The underlying mechanisms for NTE have been found to be complex. The reason that most solids have positive CTEs is well understood whit; is due primarily to an increase in the inter atomic bond length, which manifests at the macroscopic level as an overall increase in dimension or Volume [2].

Thermal expansion is the tendency of matter to change shape, area and volume in response to change in temperature. Temperature is mono atone function, of the average molecular kinetic energy of a substance. When substance is heated the kinetic energy of its molecule increases [3].

When people ask about the temperature they ate sally asking how hot or cold something is without thermometer. However most people can do in better then hot or cold or perhaps warm or cool in describing a relative temperature, even throw there are other factors that confuse people about

temperature on a basis of the net direction heat low. When we touch an object a property called temperature.

Thermal expansion is generally decreases with increase bound energy which has an effect on the melting point of solids so high melting point are more likely to half lower thermal expansion. Generally liquid expand slightly more thin solids. The thermal expansion of gasses is higher component of that of crystals [1]. At the glass transition temperature, rearrangements that occur in amorphous material lead to character discontinuity allow detection of the glass transition temperature where a super cooled liquid transformers to glass [3].

The coefficient or thermal expansion disease, how the size of an object change which archangel in temperature. Specifically if measures the fractional change in sized per degree change in temperature at constant pressure several type of coefficients half been develop volumetric, area in the liner. Which is used depends on the particular application and which dimensions are considered important. For solids might only be conserved with the change along length or over some area.

The volumetric thermal expansion coefficient is (he tot basic thermal expansion coefficient and the most relevant for fluids. In generally substances. Spaded or contract when the temperatures changes whit expansion occurring in all direction, substances that at the same rate in every direction called isotropic. For isotropic materials the and volumetric thermal expansion ate respectively approximately twice and three times larger than the linear expansion coefficient [4].

1.1. General Objective

The main objective is review the thermal expansion solid and its application.

1.2. Specific Objective

1) To list type of thermal expansion.
2) Explain the thermal expansions of coefficient are solids.
3) To identify the factors affecting thermal expansion.

1.3. Significance of the Project Work

This project thermal expansion of solid and the readers to have insight and give deep understanding of the treatment, waste disposal, cause of increasing solid waste and its contribution to the human health hazardous and environmental related problems. The higher the temperature difference, the more the object will expand.

2. Thermal Expansion of Solid

Thermal expansion depends on: material, size and temperature change [6]. Thermal expansion of state is the increase or decrease of the size (length area or volume) of body due to a change in temperature. Thermal expansion is large for gases, in relatively small, but not negligible for liquids and solids. Thermal expansion of stale is also (he tendency of matter to change its shape area and volume in response to change in temperature most materials expand when they are heated and contract when they are cooled [7].

2.1. Measurement of Temperature

Temperature is a measure of the degree of hotness and coldness of substances while heat is a form energy that transferred from one object to another. Heat is flow energy from hotter region to colder region while temperature indicates the direction of heat flow. Temperature is a basic quantity but heat is a derived physical quantity.

The heat added to a body is the sum of the kinetic energy and potential energy of the particles. That is,

$$\text{Heat} = \sum\text{Kinetic energy} + \sum \text{Potential energy}$$

$$Q = \sum KE + \sum U$$

Both heat and temperature are scalar quantities. Heat is measured in joule (J) and temperature is measured in Kelvin (K).

Heat can flow from one region to another in three different ways.

1) Conduction;
2) Convention;
3) Radiation.

Temperature scales are uses in measuring temperature. These are Celsius scale (°C), Kelvin scale (K) and Fahrenheit scale (°F). To design a temperature scale two fixed reference points have to be used. These points are freezing point of water (ice point of temperature) and boiling point of water (steam point temperature). Absolute zero is the temperature at which a substance has no thermal energy. Temperature measures of hotness and coldness of a substance the higher the temperature. The temperature of a substance is a measurement of the average kinetic of the particle within the substance. If the particle in a substance have a hips average kinetic energy than the object is at a higher temperature that is to say if particles on average moving faster than the object is at a higher temperature [5].

The temperature is measured by thermometer, several scales and unit exists for measuring temperature, the most common being the delicious 4 tile is with units called degree centigrade (°C), the Fahrenheit height scale with unit called degree Fahrenheit and especially in science the Kelvin scale with units denotes k [7-12].

It is impossible to measure the temperature of a boil accurately by touching or using our sense of perception. an instrument used to measure the temperature is called thermometer. There are many kind of thermometer; a thermometer is specified by choosing a particular thermometric substance and a particular thermometric property of matter is a property that varies predictably with an increase or decrease in temperature [8].

It could be the change of pressure in a gas thermometric, a change in electromotive force in thermocouple, or the change in height of a liquid thermometer.. It is assumed that three is a one to-one relation between the measured valves of the property and the temperature.

Fahrenheit scale: using this scale this scale the normal freezing point of water 32°F and the normal baling point of water is 212°F.

Celsius scale: using Celsius scale normal freezing point of water is 0°C and normal boiling of water is 100°C.

Kelvin: the final temperature unit you may come ay toss is called Kelvin. Note if isn't degrees Kelvin scale has not negative numbers. The low text unperturbed is substance can drop down to" degree Kelvin or absolute zero [4].

2.2. Converting Unit Temperature

A device used to measure the temperature of a body is known as thermometer. A thermometer may be calibrated to measure temperature in Fahrenheit, Celsius or Kelvin scale. If the upper fixed point and Lower fixed point of two thermometers A and B are given, then the reading of T_A can be changed to the corresponding reading of T_B by the relation given below;

Let us now develop a relationship between any readings in Celsius Scale and the corresponding Fahrenheit, it is obvious that the ratio of the difference in the respective reading of and the intervals of temperature in Celsius scale with the corresponding lower fixed points the difference in the respective reading of and the intervals of temperature in Fahrenheit scale with the corresponding lower fixed points are the same.

Temperature is measure of the average kinetic energy of the particles, heat is the total thermal energy inside the substance (the total kinetics and potential energies added together) on average, 'the particles are moving faster in the spark, however, there far more particles are moving faster in the spark, however, there are more Partech's 1 the water all with a kinetic energy and potential energy. It is important to notice average kinetic energy in any substance some particles will moving faster than others and so this particles will have more kinetic energy than the other [7-9].

2.3. Thermal Expansion

Thermal expansion is the tendency of matter to change its shape, area and volume in response to change the temperature through heat transfer temperature is monotonic function of the average molecules kinetic energy of substance. When substance heated the kinetic materials which contract with increasing temperature are usual, with in limited in size and only occurs within limited temperature ranges. The degree of expansion divided by the change in temperature is called the materials coefficient of thermal expansion. Solid expand when heated its atoms them salves do not expand. But the volume they take up does. When a solid heated its atoms about their fixed points. The relative increase in the size of solids when heated is her metal railway tracks have small gaps to that when the sun heats them the tracks expand in to these gaps and don't buckle solids also undergo thermal expansion. Railroad tracks and bridges, for example, have expansion joints to allow them to freely expand and contract with temperature changes [1].

2.4. Thermal Expansion of Solid

When a solid heated its particles move further apart causing the solid to expand. The amounts of expansion in a solid depend on:

1) The nature of the solid;
2) The rise of the temperature.

There are three types of expansion of solid. These are

a) linear expansion (one dimension expansion).
b) Area expansion (two dimension expansion).
c) Volume expansion (three dimension expansion).

The basic properties of thermal expansion; thermal expansion is clearly related to temperature change. The grater the temperature change the more a bimetallic strip will bend.

Second, it depends on the material.

The underlying cause of thermal expansion; an increase temperature implies an increase in the kinetic energy of the individual atoms. In a solid, the in a gas the atoms or molecules are closely packed together, but their kinetic energy (1 the form of small, rapid vibration) pushes neighboring atoms or molecules apart from each other. This neighbor – to neighbor pushing results in a slightly greater distance, on average, between neighbor, and adds up to a larger size for the whole body. For most substances under culinary conditions, there is no preferred direction, and an increase in temperature will increase in temperature will increase the solid's size by a certain fraction in each dimension [10].

1) Thermal expansion is the increase, or derivate, of the size (length, area or volume) of a body due to a change in temperature.
2) Thermal expansion is large for gases, and relatively small, but not negligible, for liquids and solids.
3) The change in size or volume of an object with change in temperature.
4) Expansion of solids before and after Appling heat.

When a solid is heated its particles vibrate more rapidly as a result they collide and push each other further apart. When a solid is heated, its molecules gain kinetic energy and vibrate more vigorously. As the vibration become larger, the molecules tiles are pushed farther apart and the solid expands slightly in all directions. Factors that affecting thermal expansion of solids original length (direct), temperature (direct), material type solids in general have the smallest (expensively while gases have the greatest expansively and liquids lie in between. [11, 12].

List four real – life problems due to expansion of material.

1) On a hot day concrete runway sections in airport expands and this cause cracking "To solve this problem we leave small gabs between sections.
2) On a hot day concrete bridges expand. To solve this problem, we leave small gab at one end and support the other end with rollers.
3) Telephone wire contract on cold day lays, Solve this problem, we leave wires slack so that they are free to change length.
4) On a hot day railway lines expand to solve this problem,

gaps are left between sections of railway lines to avoid damage of the rails as the expand in hot weather [15].

We have already seen that when a solid is heated its particles moves further apart and hence the solid expands (increases in size). The ball and ring experiment shown in figure is a good demonstration of the expansion of a solid.

The cold metal ball easily passes through the ring, after heating the metal ball expands and it is no longer able to pass through the ring. How much solid expends on heated will depends on the substance how much its temperature increases [12].

2.5. Linear Expansion of Solid

Linear expansion is the increase in length that a heated body makes along a certain line or direction. When a metal rod is heated it expands and increases in length. This expansion is referred to as liner expansion. The diagram in figure below shows rod of length LC (measured in metal) before and alter heating.

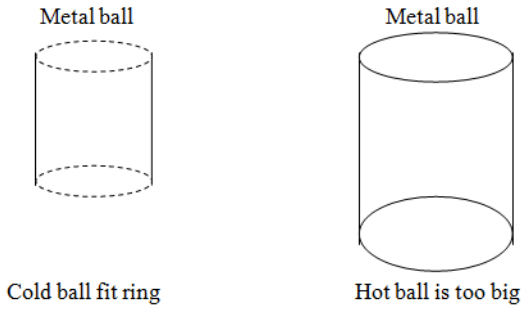

Figure 1. *The hoop and ball experiment.*

According the law of expansion on, the change in length of the rod is directly proportional to both the original length (l_0) and the rise of the temperature (ΔT).

2.6. Linear Expansion of Solid

When a metal rod is hated it expends and increase in length, this expansion is referred to as liner expansion, the diagram in Frig: shows rod of length LC (measured in metal) before and alter heating.

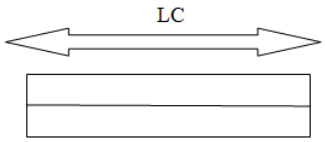

Figure 2. *Before Heating.*

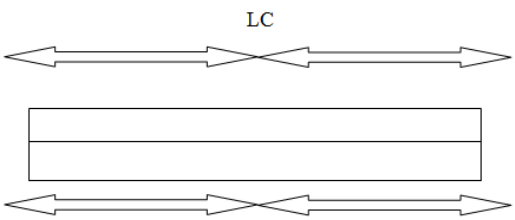

Figure 3. *After Heating.*

The road's temperature has increase in length on heating the increase in L is difference between the difference between the lengths before heating I and the length after heating 1h.

This cloud be written as I=1h-Ic

So for an j increase in temperature T the fractional increase Length = A II Y he fractional increase in length per unit of temperature (K).

It is found by dividing the fractional increase the temperature AT

$$A= 1/1\ T$$

Which is the same as a = L/Lc T

A is also known as the same as the coefficient of linear expansion for the solid. It represents the in length n > based of given substance when its temperature it by 1k. it is measured in per k.

When you talk about the expansion of solid in any dimension under the influence o you're talking about liner expansion. Thanks to physics, you can measure how much a solid will expand based on how much its temperature change [10].

The figure shows an image of this phenomenon.

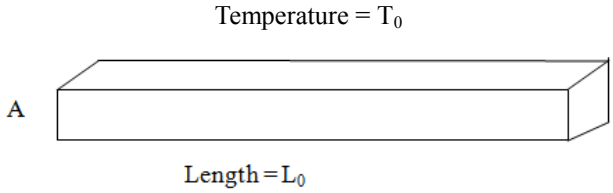

Figure 4. *Image of original temperature.*

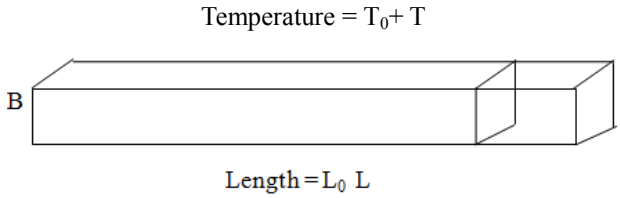

Figure 5. *Image of new temperature extension.*

$$\text{Length} = L_0\ L$$

Linear expansion usually takes place by applying heat y solids. Under thermal expansion a solid object's change in length;

L = is proportional to the change in tempera

T, = you can show this relationship mathematically.

Note: this example us a subscript 0 (Lo, for example), which is common for these kinds of equations.

First Suppose YPU Raise the temperature of an object a small amount:

$$T=T_0+ T$$

where T Represents the final Temperature to represents the original temperature.

And T represents the change in Temperature.

The change of temperature results in an expansion in my

linear dimension of when you; you heat a solid, the expands by a few percent and that percentage is proportional to the change in temperature. In general the change in length of a solid is directly proportional to the original length and to the change in temperature and also depends upon the material from which the solid is made L/Lo (the Fraction by which the solid expands).

Table 1. *The values for the linear expansion coefficient of some solid are shown in table.*

Substance	Linear expansion coefficient (x105/k)
Aluminum	2.3
Copper	1.7
Brass	1.9
Icon	1.1
Concrete	1.2

Table: the linear expansion coefficients of some solids.

This means that an I m iron rod will deepened by $11x10^5$ as for every I k rise temperature. With these valves, we can now calculate the in length of material.

2.7. Surface (Area) Expansion of Solids

When metal plate is heated it expands and increases in size. This expansion is called surface or area expansion. If the metal plate of original (A0) is heated to a temperature of (ΔT) then, the increase or change in area (ΔA) of the plate after heating is given by Where, β (beta) is coefficient of surface expansion and is equal to β =2 α The final area of the plate after heating is given by;

1) $\Delta A = A_F - A0$
2) $A_F = A_0 + \Delta A$
3) $A_F = A_0 + A0\beta\Delta T$
4) $\Delta A = A_0\beta\Delta T$
5) $A_F = A_0 (1+ \beta\Delta T)$

In the example we have looked at in linear expansion. The sample has been long in comparison to its height and width, so that only significant is in length. In practice many objects are not long and thin and we need to develop a strategy to deal with these objects. We will start by looking at the expansion, in two dimensions of a metal plate [12-15].

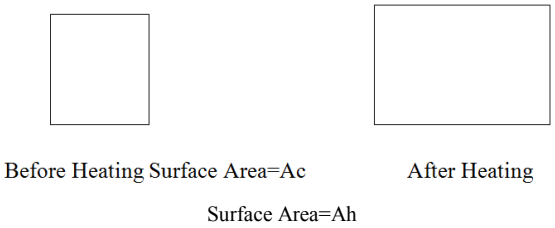

Figure 6. *Dimensional expansion of an object.*

As the plate is heated to causes an increase in temperature T it expand in width and height such that the surface area when heated Ah is longer than the length surface area, AC, so the fractional increase in surface area, B per unit rise in temperature (C^o or K) Is given bay

$$B = A/Ac\ T$$

$$A=B\ Ac\ T$$

2.8. Volume Expansion of Solids

Volume expansion is take place in three dimensions. Volume expansion is the increase in length, width and height of a substance due to heating. We now need consider the expansion of a solid mm (hive dimensions. When the length breadth and height of the substance all increase on hating, many solids are made up of crystals, regular shapes composed of molecules joined to one another as though on springs. A spring that is pulled back, just before it is released, is an example of feudal energy, or energy that an object possesses by virtue of its position. For a crystalline Saul at room temperature, potential energy and spacing between molecules are relatively low temperature increases and solid expand, the space between molecules increases as the potential energy in the solid [1-4].

In fact, the responses of solids to changes in temperature tend to be more dramatic, at least when they are seen in daily life, than are the behaviors of liquids or gases under conditions of thermal expansion. Of course, solids actually respond less change in temperature than fluids do; but 1 h since they are solids; people expect their counters to the din movable. Thus, when the volume of a solid changes as a result of an increase in thermal Knot, the outcome is more noteworthy [11].

In general, objects expand in all directions as temperature increase. In the drawing, the original boundaries of the object are shown with soul lines, and the expanded boundaries with dashed lines. (a) Area increases because both length and width increase. The area of a circular plug also increase (b) if the plug is removed, the hole it leaves becomes larger with increasing temperature, just as if the expanding plug were still mi place (c) volume also increases, because all three dimensions increases.

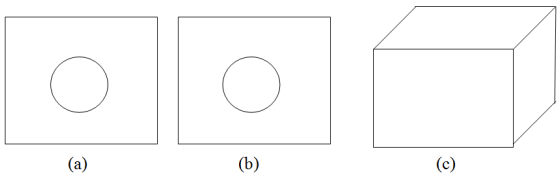

Figure 7. *Thermal Expansion in Three Dimensions.*

As the temperature of the cube increases from T_0 to T_f it expands in all sides and its volume changes from VO to V f hence ΔV = Vf - V0

According to the law of expansion the change in volume of substances depend on the original volume and the rise of temperature. Mathematically

$\Delta V \sim V0\Delta T$
$\Delta V = V0¥\Delta T$
$\Delta V = V0¥\Delta T$
$\gamma = 3\sigma$

Where, (gamma) is called coefficient volume expansion and equal to,

1) $\Delta V = V0\gamma\ \Delta T$

2) $\Delta V = Vf - V0$
3) $Vf - V0 = V0\gamma\,\Delta T$
4) $Vf = V0 + V0\gamma\,\Delta T$

2.9. The Application of Thermal, Expansion of Phase

Thermal expansion widely uses in the following
1) Bimetallic strips.
2) Bimetallic strip as a switch and Thermostat.

Bimetallic strips

Bimetallic strip is a strip made of two different metals bonded together along their length.

For example if iron and brass bonded together, the coefficient of linear expansion of iron expands more than the iron and the strip bend.

Note that the bimetallic strip bends towards the metal which expands less when heated and bends toward the metal which contrast most when cooled.

$$V_f = V_0\,(1+\gamma\,\Delta T)$$

Thermal expansion of phases is important for building and to bend different material. In this case expansions dap or join on a hot day consecrate in run way Sections in airport expands and this cause cracking to solve this problem. Leave small gap between sections, in anti – scaling values bimetallic strip when the bi metal strip. Is heated they expands more than invar this makes the strip bends with brass on the out sides of the curve, when the bimetal strips heated it curves and breaks contact then temperature reaches a cot value. Thus switching of the current to the system under control.

Industrial Application of Thermal Expansion:

The application of phases is important or phase it industry are as flows:

For electric ions. Fish tanks, fire alarms car flashers, expansions of holes or mounting trains tires during flight, frozen pipers burst and turn over lake of water is spring. Thermometer most thermometer contain liquid, or (usually alcohol or mercury) this liquid is concerned to flow in one direction only (along the tuber) due to change in volume that are caused because of temperature change.

3. Summary

The temperature of a substance is the indication the average of the particles. Thermal expansion is the tendency of matter to change in shape, area and volume in response to change in temperature through heat transfer. When the kinetic energy of an opposing molecule increases. Thus the molecules begin moving thought usually maintain “a great average separation. All three state of matter [solid, liquid and give] expand when heated. The atom them salves do not expand but the volume they take ‘the thermal expansion of solid can be explained in terms of the increasing instance particles that occurs on warming. When a solid is heated its atoms vibrate faster about that is points. Solids actually respond less to changes in temperature than fluids do; but since (Iv wig solids, people expect their contours to be immovable. The volume of a solid change as we testily of an increase in thermal energy, the outcome is more change depends on three dimensions are length, width and height of the objects. We can use this to find by how much the volatile of sample expands the ability of the expansion of different state, gases expand more than liquid and also liquid expands more than solids. Generally, when the temperature of the materials thee and (hose materials is expands in different ways. Gas expands more than both solids and liquids for a given rise in temperature.

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