Apparatus for measurement of thermal expansion of building and insulating materials

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An apparatus for study of the coefficient of thermal expansion of steel, glass and other building and insulating materials like gypsum, cellular concrete, has been set up. The apparatus is based on Linear Variable Differential Transducer. The measured values have been compared with the standard values and found within ±5 to 10%. The details of apparatus have also been discussed.

Changes in temperature of materials are generally accompanied by dimensional changes. This phenomenon is referred to as thermal expansion. In the absence of changes in the character of atomic bonding and structural modifications, thermal expansion occurs in a continuous and usually monoatomic manner.

Thermal expansion of solids can display discontinuous or irreversible behaviour due to such effects on crystallographic transformations. Recrystallization of structural rearrangements in such materials as glasses, decomposition reactions, densification of porous solids, creep deformation, can contribute to unusual thermal expansion behaviour.

Thermal expansion is one of the thermal properties of materials, the study of which is very essential in engineering design. The thermal shock resistance is a relative measure of degree of resistance of material to sudden temperature changes without cracking and is estimated from the ratio $K_S/aE$ (ref. 3-5), where $K$ is the thermal conductivity; $S$ is the strength, $a$ is the coefficient of thermal expansion and $E$ is the modulus of elasticity.

Thermal expansion is an important property that relates directly to bonding forces between atoms in a solid materials.

The authors have developed method for measuring the thermal expansion of the solids used as building materials and insulations. This method is intended to provide a means of determining the coefficient of linear expansion of the materials which are not distorted or indented by the thrust of the dialatometer on the specimens. The specimens are placed tightly with base of furnace so that expansion must be in the upward direction only, the temperature at which the thermal expansion is measured is fixed by temperature controller device.

Apparatus

The apparatus as shown in Fig. 1 consists of double walled refractory material heat furnaces. The sample is placed in this furnace firmly from the bottom of the furnace so that the expansion of solid should lie in one direction, i.e., upward only. Linear Variable Differential Transducer (LVDT), for measuring the changes in length, is fixed on the mounting fixture so that its position may be adjusted to accommodate specimens of varying length. The accuracy is about 0.001 to 1 mm with least count of 1 micron for any change in length. The measuring device reaction is of the order of 10 psi so that the specimen is not distorted or appreciably indented.

As it is well established that longer the specimen and more sensitive the measuring instrument, the more accurate will be the determination if the temperature is well controlled. After doing certain exercises a 30 cm × 1.5 cm × 1.5 cm size sample is selected for doing the experiment. The cross section of the specimen is rectangular one. Both end of the specimen is reasonably flat and perpendicular and tightly fitted lower end with steel plate.

The materials are generally used in the range of temperature $50 \pm 2^\circ C$ with $40 \pm 5\%$ relative humidity. The temperature of the furnace is controlled by the help of temperature controller device. The expansion of the material is measured with the help of thermal expansion measuring unit as shown in Fig. 1 and Photo 1.

Calculation

Calculation of the coefficient of linear thermal expansion over the temperature range used as follows.
Thermal Expansion & Temperature Measuring Device

\[ \alpha = \frac{\Delta L}{L_0 \Delta T} \] ...

Where, \( \alpha \) = coefficient linear thermal expansion per degree Celsius
\( \Delta L \) = change in length of test specimen due to heating or cooling in cm
\( L_0 \) = Length of test specimen at room temperature in cm
\( \Delta T \) = Temperature difference in °C over which the change in length of the specimen is measured

On the basis of above calculation the thermal expansion of ordinary glass, steel, aluminium, gypsum, cellular concrete, A.C. sheet, ceramic rods, backelite rods have been determined by the above apparatus as shown in Table 1.

Results and Discussion
The results of thermal expansion have been compared with the standard results available in the literature and it is found that the variations are of the order of 5% to 12% which may be due to structural
changes, densification and crystallographic transformation due to different heat treatments etc. The variation with standard results is shown in Fig. 3. The study is also conducted to see the effect of temperature on thermal expansion of aluminium, AC sheet and cellular concrete as shown in Fig. 4. It is observed that after $90^\circ$C the thermal expansion of AC sheet and cellular concrete will not vary with temperature, whereas in case of aluminium, thermal expansion will vary upto $130^\circ$C. The study may be made useful by determining uniform stability of building materials with rise of temperature.

**Conclusion**

From the above study, following conclusions may be drawn. The apparatus is based on linear variable differential transducer which is supposed to be more precise.

From Fig. 2, it is found that the apparatus is suitable for measuring thermal expansion of building and insulating materials as these materials have good agreement with literature values.

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**References**