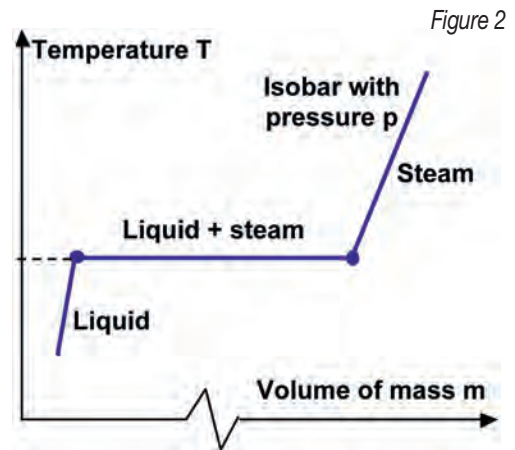
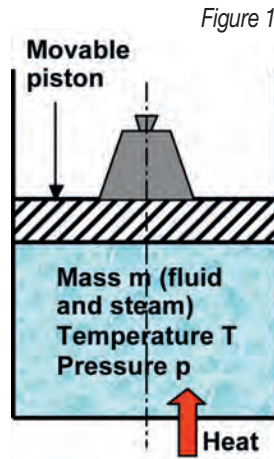


Measuring temperature via pressure

QUESTION: I read in an article about autoclaves that it is possible to measure the temperature by measuring the pressure. Why can we do this? Are there other applications where it is possible to measure temperature in the same way?

Roland G

ANSWER: The ability to measure temperature via pressure is based on the thermodynamic relationships that apply to vaporization and condensation. As an example, let us study what happens with a specific mass of water that is enclosed in a space subject to constant pressure (Figure 1). Heat is added; the temperature of the liquid increases, at which its volume increases somewhat, but the pressure always remains constant (Figure 2). At a specific temperature (the evaporation temperature or "boiling point"), the liquid begins to vaporize, which involves a large increase in the volume of the mixture of liquid and gas. This mixture is called wet steam. Vaporization is a process that requires a lot of heat. During vaporization the temperature remains constant and according to the laws of thermodynamics there is then a fixed relationship between pressure and temperature. After all the liquid has vaporized the result is saturated water vapour. If we add more heat, the temperature of the steam rises and the steam becomes overheated. The pressure remains constant during this entire sequence of events from liquid to overheated steam. If we remove heat, the process occurs in reverse: the steam condenses and becomes a liquid.



During vaporization or condensation there is a mixture of liquid and vapour. During these processes, both the temperature and the pressure are each constant and thermodynamically related to each other. It is therefore possible to determine the temperature within this range by measuring the pressure. For example, at a pressure of 0.1 MPa the evaporation temperature is 100 °C; at 0.2 MPa it is 120 °C and at 0.4 MPa it is 144 °C. (0.1 MPa = 1 bar = 105 Pascal or N/m²). However, it is impossible to use this method with only liquid or only steam.

Applications

The range of applications for this measurement technique is relatively narrow. In autoclaves that use wet steam of a specified pressure, it

is possible to measure the temperature via the pressure. Autoclaves are used in such industries as food and pharmaceuticals. When steam condenses onto an object, a very powerful heat transfer occurs. Another application is condensers used in steam technology. One household application is the pressure cooker, which is a saucepan that is equipped with a tightly sealed lid and that can withstand internal pressures higher than normal air pressure. The food inside therefore cooks at a temperature above 100 °C, which shortens the cooking time required.

If you have comments or questions, contact Professor Dan Loyd at the Institute of Technology at Linköping University: dan.loyd@liu.se

Questions should be of general interest and be about temperature measurement techniques and/or heat transfer.

QUESTIONS?
ANSWERS!