Growing Pains - *Mike Brown*

When cutting a piece of metal, changes in temperature will cause dimensional changes that may catch you unaware. Just the act of cutting the metal will increase its temperature and change its dimensions. Changes in the temperature of your workshop will also cause the metal to change dimensions. When you are working on a close-tolerance assembly, it is important to know how to prevent a problem arising from the change.

The amount of the change per degree is called the Coefficient of Expansion (CoE). Note that different metals have a different CoE. For example, aluminium expands at roughly twice the rate of cast iron. Because of differing percentages of alloying metals, different alloys of the same base metal will have different CoE. 6061 aluminium has 99.2% the thermal expansion per degree Fahrenheit as does the alloy 2024.

Here are the approximate CoE values for the metals we typically use:

Metal	Inches/deg F.	Millimetres/deg C.
Aluminium	0.000013	0.0006
Brass	0.000010	0.0005
Bronze	0.000010	0.0005
Cast iron	0.000006	0.0003
Stainless steel	0.000009	0.0004

N.B. Stainless steel varies over an almost 2:l range, so check the alloy's CoE if the work is dimensionally critical. The value shown for SS is approximately correct for the 300 series.

If your workshop undergoes a 50deg F. or 28deg C. Temperature change (summer to winter, perhaps) it is important to note that a 10" or 25.4 cm piece of aluminium will shrink by 0.00622" on 0.16 mm when the temperature changes from 90deg F. to 40deg F. or 32deg C. to 4deg C. That may be enough to take your work out of tolerance. The larger the dimension, the larger the temperature related change in that dimension. Using the CoE, it is possible to make the calculations for dimensional changes due to the temperature and apply them. (Remember, we are talking material, not air temperatures so you can heat or cool the air without affecting the metal quite as quickly.)

Of course our machine tools are also changing dimension with temperature changes. (Interestingly many digital readouts are temperature compensated). Finally your measuring tools are also affected by temperature (this is why many micrometers have plastic panels on the bow to prevent conduction from your hand). This can cause real problems in industry where items measured on the shop floor may well be a different when measured in the metrology lab kept at a constant 68deg F or 20degC.

Fortunately in the home workshop we can normally discount changes in ambient temperature as with the “normal” range of workshop materials, the workpiece, the machine and the tool will have similar CoE’s so that they expand and contract together and the slight differences can usually be ignored. (Be wary of exotic materials though, for example some machinable ceramics have a CoE of virtually zero.)

Things are not easy to ignore when a component heats up due to machining processes. If, for example, you are machining an aluminium piston to fit a previously finished cast iron cylinder, you want to wait until the aluminium has cooled down before you make those all-important final measurements and cuts. That 1" or 25.4 mm diameter aluminium piston may heat up to perhaps 120deg F. or 49deg C. You start at, say, a room temperature and metal temperature of 70deg F. or 21deg C., and you measure the room temperature cylinder so you can machine the piston to a proper clearance. The piston, at the cutting-induced elevated temperature has grown in diameter by 0.00065" or 0.0165 mm. So if you cut it down to the 'correct' diameter while it is hot, when it cools, it will have shrunk and added perhaps 1/2 to 1/3 more piston to cylinder clearance than you desired. OOPs! You could calculate the dimensional compensation but the temperature of the piston changes rapidly because of its small size. It is better to go take a long coffee break and allow the piston to return to near-room temperature. Then you can finish the piston before it heats up again.