TECHNICAL NEWS

EFFECTS OF ENVIRONMENTAL THERMAL CHANGES IN MACHINES ACCURACIES

Thermal expansion

Thermal expansion is a physical fact which explains the increasing in dimensions of a body caused by increasing the temperature. The amount of such expansion changes depending to the nature of the material and to its aggregation stage, solid, liquid or gas.

Thermal expansion in solids

Temperature increase in a solid body, usually generates an expansion of each one of its linear dimensions (linear thermal expansion). This effect is clearly explained by using a crystal solid, where we can imagine each atom of the solid bound together by means of rigid springs, which represent the electro originated inter-atomic forces binding the complete system. Even in a quite condition, at any temperature, each atom keeps generating very small vibrations around its position in the grid. When the temperature of the solid is increased, such vibrations increase their size and frequency, generating an expansion of the solid in the three linear dimensions of its volume :
length, width and height.
In case of a structures made of various solid elements bound together or made out of castings, forgings or extrusion, when temperature increases , there shall be three thermal expansion results :

- a volumetric thermal expansion
- a surface thermal expansion
- a linear thermal expansion

To count the expansion of a solid body, it is necessary to know the coefficient which measures the variation of each single dimension of the body; knowing such coefficient will allow to count such variation depending to the temperature variation.
The majority of the solids expand in an isotropic way, meaning they have the same percentage variation along the three dimensions in the volume: the linear expansion coefficient is then the same on each dimension, but such volumetric expansion is performed with different timing on each dimension, apart from the solids usually named with symmetric structure : sphere, cube, etc.
Another variable is given by the period of time needed to have such expansion and by the structural geometry of the solid: it is clear that the time needed to expand a foil size mm. 1 x 1000 x 1000 is much shorter than the time needed to expand a cubic solid size mm. 100 x 100 x 100 considering, obviously, an equal thermal conduction of the material and an equal temperature variation.

Consequences

Knowing the linear, surface and volumetric expansion coefficient of the solid materials is much important to foresee the dimensional reactions of structures to temperature variations. Coefficients of materials commonly used are listed on tables : normally, metals are expanding around one hundreds of millimetre per metre each 1 °C of temperature variation. Therefore a bar one meter long will expand mm. 0,0108 following a temperature increase of 1 °C : this is an insignificant variation for certain articles, **but with a fundamental importance if such articles are machine tools, if they have large sizes and if a very high machining accuracy is needed.**

Table

Physic properties of metals (average values)

		Flexion modulus	UTS	Specific weight	Coefficient of expansion	Specific heat	Electric conduction	Thermal conduction	Melting time
		E	Rm	p.sp	c	c.sp	Ω	k	
Unalloyed steel	C40	220000		7,87	0,0108	0,12	0,142	57	1515
Unalloyed steel	C45	220000	680	7,87	0,0108	0,12	0,142	57	
Grey cast iron	G25	120000	125	7,3	0,0107	0,13		53	1176
Spheroidal cast iron	400-15	120000	400	7,3	0,0107	0,13		53	