

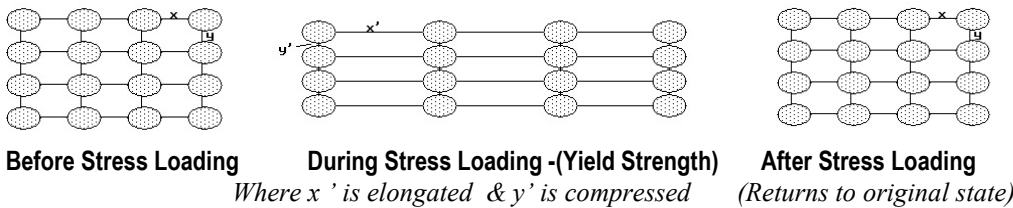
The Effect of the COLDfire Thermal Cycling Process on Young's Modulus of Elasticity

Young's modulus of elasticity is used to measure the strength of a material and as a measurement in engineering of the capacity of metal and other materials to withstand stress and strain. Stress is defined as the internal force exerted by one part of an elastic body upon the adjoining part. Strain relates to the deformation or change in dimensional size or form occasioned by the stress forces.

When a body is subjected to pull, it is said to be under tension, or tensional stress. When it is being pushed, i.e., is supporting a weight, it is under compression, or compressive stress. Shear, or shearing stress, results when a force tends to weaken or break a body in a 'cross sectional' form. Torsion, or torsional stress then occurs when the external forces tend to twist a body around an axis.

Materials are considered to be elastic in relation to an applied stress only if the strain changes in size or shape disappear after the force is removed. This 'elastic limit' is the maximum stress a material can sustain and still return to its original form (fig. 1). It is this 'theoretical' failure where a body remains distorted after the force is removed to which the measurement of Young's Modulus is applied. The point at which the permanent distortion begins is generally referred to as *Yield Strength*. The strength of the material being tested up to the point of physical failure or destruction is referred to as *Tensile Strength*.

Fig. 1 Material return to original state after stress loading



By application of the patented COLDfire process to metals and other materials a transformation of the molecular crystal grain structure of the material takes place. This alteration of grain structure and composition results in materials, once treated, that have wear factor increases of two to three times that of the original material. Exhaustive scientific testing of several materials ranging from Aluminium to Tungsten Carbide and even Cobalt, has revealed that while Young's Modulus remains the measurement of Yield strength, the application of the COLDfire process is proven to facilitate an *elongation of the modulus*, extending the materials treated well beyond previously attainable Yield Strength limitations.

As can be seen in the extensive independent test results (Table 1), there has been an average increase in Yield and Tensile Strength with an additional elongation gain of 22% following the COLDfire treatment. It also shows clearly the increase or 'elongation' of Young's modulus of elasticity after the treatment of the material by the COLDfire thermal process.

This increase in elasticity of course does not relate directly to an increase in strength of the material. Given the regulated working parameters of components being treated, such as gears, automotive parts or cutting blades. The contained, programmed and stress limited application patterns of force and energy used in production allows a dramatic extension of the 'operational wear window' leading to a component life extension of typically to two or three times, dependant on application.

TECHNOLOGY FOCUS INFORMATION

Table 1. Yield & Tensile Strength comparison of Untreated & Treated Material by the COLDFire process.
Untreated Sample material

Sample	Size (in.)	Yield Load (lbs)	Tensile Load(lbs)	Yield (psi)	Tensile (psi)	Elongation %
1	0.4934 x 0.2270	4,280	4,765	38,200	42,500	Broke prior to mmt
2	0.4885 x 0.2408	4,400	4,859	37,400	41,300	11
3	0.5691 x 0.2290	4,460	5,143	34,200	39,500	10
4	0.4970 x 0.1724	3,300	3,695	38,500	43,100	10
5	0.4929 x 0.1289	2,450	2,705	38,600	42,600	9
			Average	37,380	41,800	10

Treated Sample material

Sample	Size (in.)	Yield Load (lbs)	Tensile Load(lbs)	Yield (psi)	Tensile (psi)	Elongation %
1	0.4951 x 0.2451	4,600	5,106	37,900	42,100	13
2	0.4989 x 0.2324	4,410	4,833	38,000	42,100	13
3	0.5011 x 0.2278	4,330	4,857	37,900	42,500	12
4	0.5016 x 0.1458	2,740	3,080	37,500	42,100	10
5	0.5012 x 0.1647	3,170	3,507	38,400	42,500	13
			Average	37,940	42,260	12.2

Test Method: ASTM E-8 Yield & Tensile Test **Material:** Aluminium
 Test conducted by Constellation Technology Corporation, Analytical Services Laboratory. Test report: A00638

If we extend the study to examine the actual failure of a component as opposed to the ‘theoretical’ failure state measured by Young’s modulus. That the failure of tensile strength either represented by breakage or wear factors that make a component no longer of use. The same dramatic increase in the serviceable life of components after treatment is seen.

As a general guide Table 2 provides a breakdown of metallurgical research into the parameters of Young’s Modulus measurements in metals commonly used in production. By referring the increase in the performance of the sample test results (Table 1) using aluminium (the lowest on the scale of the commonly used metals), the gains experienced by use of the COLDFire Thermal Process in Table 1 can then be applied to the known properties of the metals reflected in Table 2.

Table 2. Young’s Modulus for typical Metals

Tungsten Carbide (WC)	450 - 650
Tungsten (W)	406
Chromium (Cr)	289
Beryllium (Be)	200 - 289
Nickel (Ni)	214
Iron (Fe)	196
Low Alloy Steels	200 - 207
Stainless Steels	190 - 200
Cast Irons	170 - 190
Copper (Cu)	124
Titanium (Ti)	116
Brasses and Bronzes	103 - 124
Aluminum (Al)	69

Source: Dept of Materials Science & Engineering, Cornell University

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