IMPULSE EXCITATION TECHNIQUE, IET

Submitted by: Tuğçe SEVER

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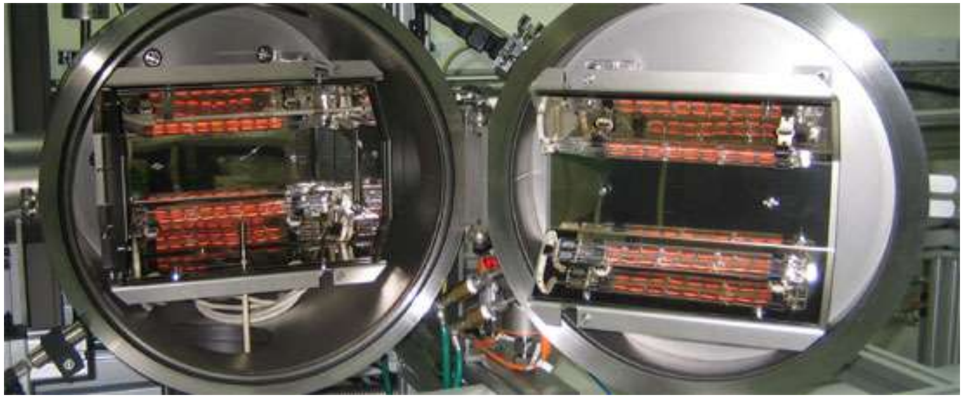
Outline

- What the impulse excitation technique is used for
- The principles of the IET
- High performance IET devices
- The measurement systems of the Grindosonic and RFDA software
- Devices according to temperature
- Application fields
- Advantages of IET
- Disadvantages of IET

Impulse Excitation Technique,

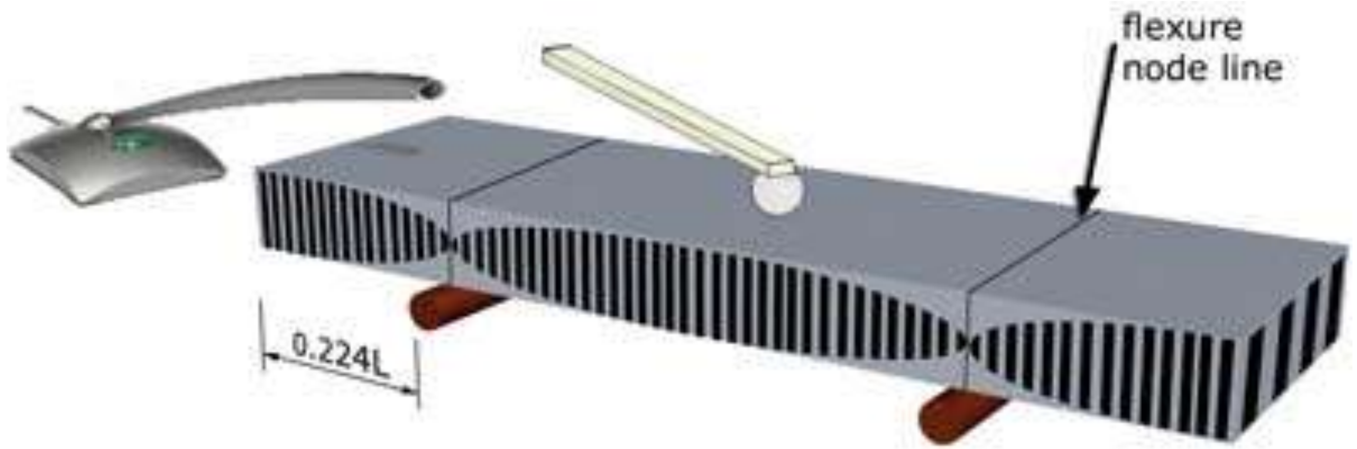
- measure the dynamic elastic properties of materials
- detect defects

Dynamic methods of measuring;



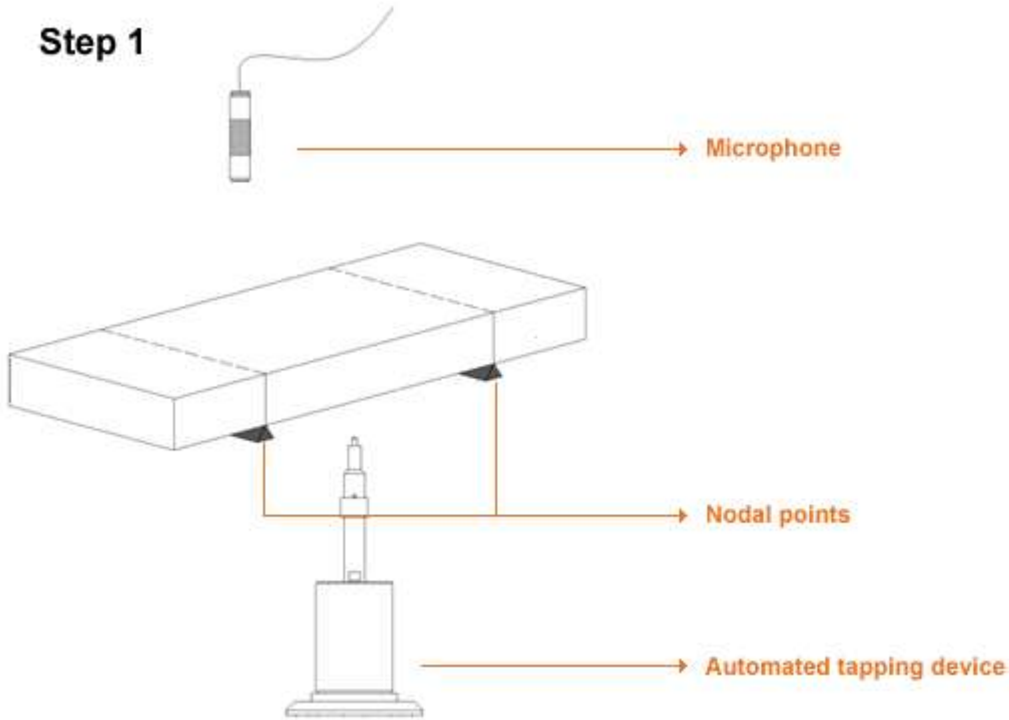
- Introduced in the mid 1930s
- Not sufficient progress until late 1950s
- The first ASTM (C623) in 1969

The Principle of Impulse Excitation



- Figure 1. A method for supporting a rectangular bar to induce the flexural mode of vibration. The sample is supported on two knife edges placed at the standing wave nodes, which occur at 0.224 of the length from each end. The bar then flexes freely in and out of its plane, as indicated by the vertical lines.
- ASTM standards E1867 and C1259

Step 1



High performance IET devices,

- **1) The Grindosonic**

  Frequency range 100 Hz - 50 kHz (limited by microphone)
- **2) The RFDA-software**

  Frequency range 100 Hz - 250 kHz (limited by data-acquisition card)
- **3) The air-furnace**

  Temperature range 20°C - 1100°C (limited by suspension wires)

  Heating rates < 5°C/min, recommended value 2°C/min

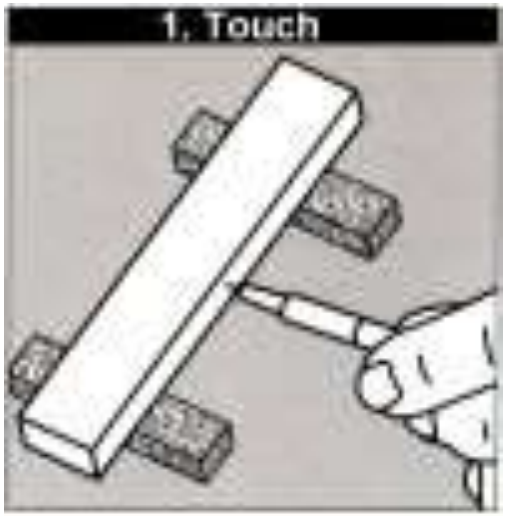
  Maximum sample length = 160 mm, recommended length between 40 and 100 mm
- **4) The graphite-furnace**

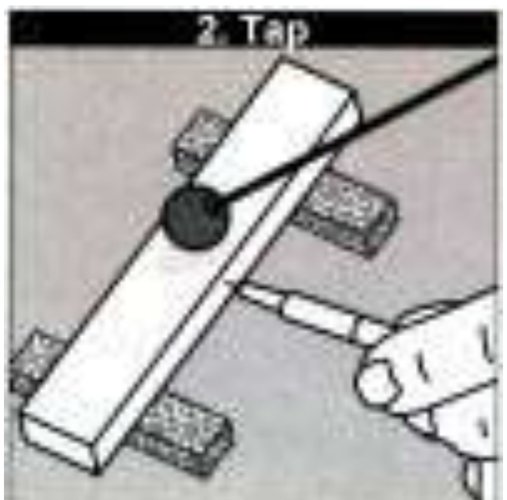
  Temperature range 20°C - 1750°C

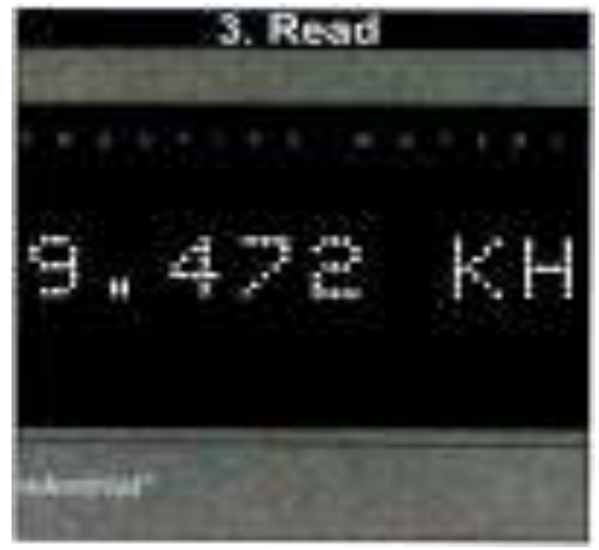
  Heating rates < 5°C/min, recommended value 2°C/min

  Maximum sample length = 160 mm, recommended length between 40 and 100 mm

Measuring with GrindoSonic





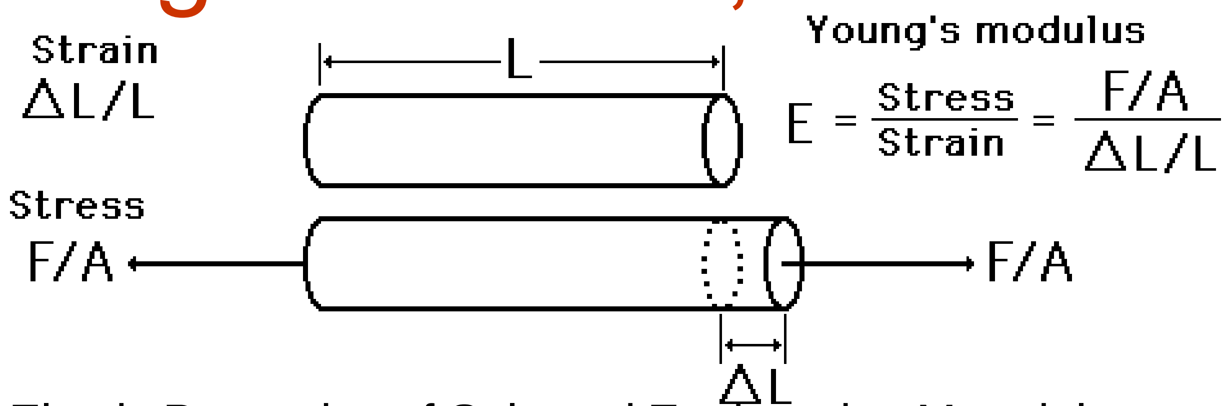


Measurement Systems

In RFDA software calculates,

- Young's modulus
- Shear modulus
- Poisson ratio

Young's Modulus;

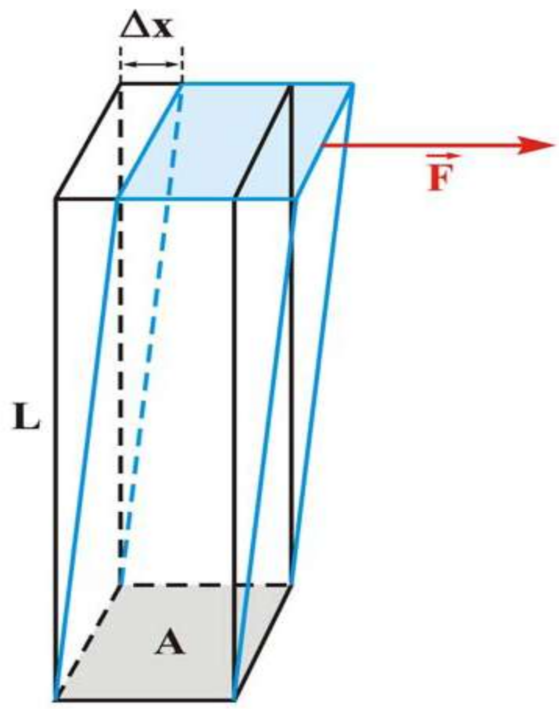


Elastic Properties of Selected Engineering Materials

Material	Density (kg/m^3)	Young's Modulus 10^9 N/m^2	Ultimate Strength S_u 10^6 N/m^2	Yield Strength S_y 10^6 N/m^2
Steel[a]	7860	200	400	250
Aluminum	2710	70	110	95
Glass	2190	65	50[b]	...
Concrete[c]	2320	30	40[b]	...
Wood[d]	525	13	50[b]	...
Bone	1900	9[b]	170[b]	...
Polystyrene	1050	3	48	...

a Structural steel (ASTM-A36), b In compression, c High strength, d Douglas fir
Data from Table 13-1, Halliday, Resnick, Walker, 5th Ed. Extended.

Shear Modulus;



- deformation which takes place when a force is applied parallel to one face of the object while the opposite face is held fixed by another equal force

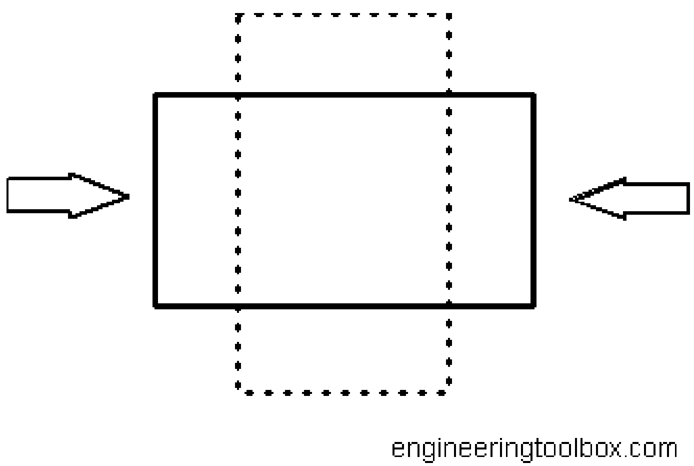
S= shear stress/shear strain

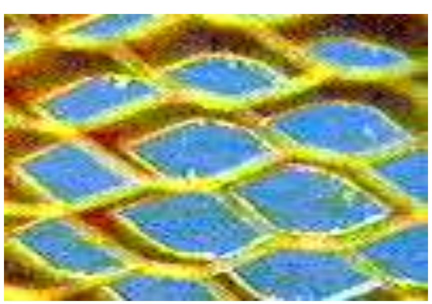
$= (F/A) / (\Delta x / L)$

$= F L / A \Delta x$ (units are Pascals)

Poisson Ratio;

is the ratio of the relative contraction strain to the relative extension strain in the direction of the applied load.





- *υ = - εt / εl* *(1)*

where

υ = Poisson's ratio

εt = transverse strain

εl = longitudinal or axial strain

Strain can be expressed as

ε = dl/L *(2)*

where

dl = change in length

L = initial length

- For most common materials the Poisson's ratio is in the range *0 - 0.5*.

Rectangular bar

Young's modulus

$$E = 0.9465 \left(\frac{m f_f^2}{b}\right) \left(\frac{L^3}{t^3}\right) T$$

$$T = 1 + 6.858 \left(\frac{t}{L}\right)^2$$

- *E* is Young's modulus
- *m* is mass
- *ff* is natural frequency in flexure dimension
- *b* is width
- *L* is length
- *t* is thickness
- The above formula can be used should L/t ≥ 20

Shear modulus

$$G = \frac{4 L m f_t^2}{bt} \left(\frac{B}{1 + A}\right)$$

$$B = \left(\frac{b/t + t/b}{4\,(t/b) - 2.52\,(t/b)^2 + 0.21\,(t/b)^6}\right)$$

$$A = \left(\frac{0.5062 - 0.8776\,(b/t) + 0.3504\,(b/t)^2 - 0.0078\,(b/t)^3}{12.03\,(b/t) + 9.892\,(b/t)^2}\right)$$

- *ft* is the natural frequency in the torsion mode
- *m* is mass
- *b* is width
- *L* is length
- *t* is thickness

Cylindrical Rod

Young's Modulus

$$E = 1.6067 \left(\frac{L^3}{d^4}\right) m f_f^2 T'$$

$$T' = 1 + 4.939 \left(\frac{d}{L}\right)^2$$

- *E* is Young's modulus
- *m* is mass
- *ff* is the natural frequency in flexure dimension
- *d* is diameter
- *L* is length
- The above formula can be used should L/t ≥ 20

Shear Modulus

$$G = 16 \left(\frac{L}{\pi d^2}\right) m f_t^2$$

- *ft* is the natural frequency in the torsion mode
- *m* is mass
- *d* is diameter
- *L* is length

Poisson ratio

$$\nu = \left(\frac{E}{2G}\right) - 1$$

RFDA MF basic

Temperature:
RT
Atmosphere:
Air

RFDA MF professional

Temperature:
RT
Atmosphere:
Air

HT650
Temperature:
RT up to 650°C
Atmosphere:
Air, Inert flow

HT1750
Temperature:
RT up to 1750°C
Atmosphere:
Air

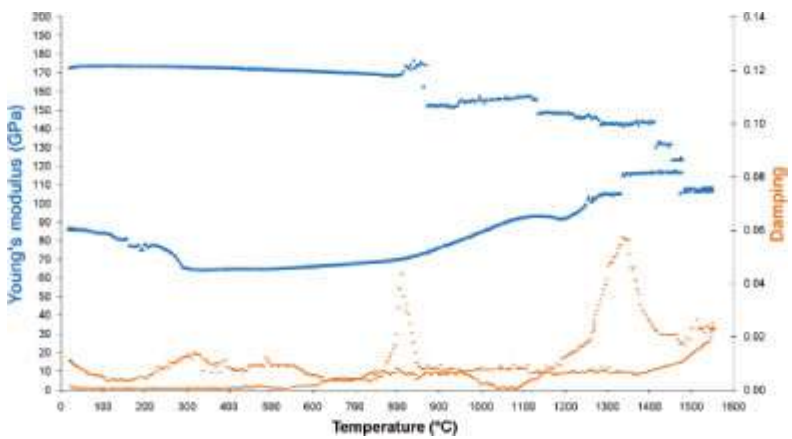
HTVP1600
Temperature:
RT up to 1600°C
Atmosphere:
Air, Inert, Reducing

HTVP1750-C
Temperature:
RT up to 1750°C
Atmosphere:
Vacuum, Inert

LTVP800
Temperature:
-100°C up to 800°C
Atmosphere:
Vacuum

Sample supports
RT sample support devices for different geometrical shapes.

Measurements can be performed continuously from room temperature (RT) up maximum 1750°C,



- **Room temperature**
- Samples should be machined to predefined shapes as good as possible
- measure samples of different dimensions
- **High temperature**
- Measurements are performed every couple of seconds onto the sample while the temperature is rising

Application Fields

- Steel

  Detecting defects through internal friction measurements

- Refractories

  High temperature properties modeling

- Coatings

  Measurement of coating's elastic properties at different temperatures

Application Fields

- Ceramics

  Non destructive testing in different stages

- Cast iron

  Non destructive testing

- Porous materials

  Non destructive measurements of elastic properties

Advantages in the use of impulse excitation technique,

- Quick
- Easy
- Repeatable
- Non-destructive
- Highly accurate analyse
- much lower costs than traditional analog instruments
- understanding the physical properties of certain materials

Disadvantages of IET,

- Serious noise
- Signal truncation
- illsuited for frequency response testing of highly nonlinear structures and certain other types of structures

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