MATERIAL PROPERTIES (SIFAT-SIFAT BAHAN)

Materi kuliah bahan teknik
Sifat-sifat material

• Ciri-ciri atau kondisi yang dimiliki oleh suatu material yang meliputi:
  – Physical
  – Mechanical
  – Thermal
  – Electrical
  – Magnetic
  – Environmental
  – Production
  – Aesthetic
  – Economic
# Classes of property

<table>
<thead>
<tr>
<th>No</th>
<th>Ability</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Economic</td>
<td>• Price and availability&lt;br&gt;• Recyclability</td>
</tr>
<tr>
<td>2</td>
<td>General Physical</td>
<td>• Density</td>
</tr>
<tr>
<td>3</td>
<td>Mechanical</td>
<td>• Modulus&lt;br&gt;• Yield and tensile strength&lt;br&gt;• Hardness&lt;br&gt;• Fracture toughness&lt;br&gt;• Fatigue strength&lt;br&gt;• Creep strength&lt;br&gt;• Damping</td>
</tr>
<tr>
<td>4</td>
<td>Thermal</td>
<td>• Thermal conductivity&lt;br&gt;• Specific heat&lt;br&gt;• Thermal expansion coefficient</td>
</tr>
<tr>
<td>5</td>
<td>Electrical and Magnetic</td>
<td>• Resistivity&lt;br&gt;• Dielectric constant&lt;br&gt;• Magnetic permeability</td>
</tr>
<tr>
<td>6</td>
<td>Environmental Interaction</td>
<td>• Oxidation&lt;br&gt;• Corrosion&lt;br&gt;• Wear</td>
</tr>
<tr>
<td>7</td>
<td>Production</td>
<td>• Ease of manufacture&lt;br&gt;• Joining&lt;br&gt;• Finishing</td>
</tr>
<tr>
<td>8</td>
<td>Aesthetic</td>
<td>• Colour&lt;br&gt;• Texture&lt;br&gt;• Feel</td>
</tr>
</tbody>
</table>
Density (berat jenis)

Density $\rho = \rho_\text{fl} \frac{m_1}{m_1 - m_2}$

Sample of unknown volume $V$

Fluid of known density $\rho_\text{fl}$
Modes of loading and states of stress

(a) A tie
(b) A column
(c) A beam
(d) A shaft
(e) A shell
The definitions of stress, strain and elastic moduli

(a) Stress
- Tensile stress $\sigma = F/A$
- Strain $\varepsilon = (L - L_0)/L_0$
- Elastic deformation $\sigma = E\varepsilon$

(b) Shear stress $\tau = F_s/A$
- Shear strain $\gamma = w/L_0$
- Slope $G$

(c) Pressure $p$
- Volume strain (dilatation) $\Delta = (V-V_0)/V_0$
- Slope $K$
- $p = K\Delta$
Tensile stress–strain curves for ceramics, metals and polymers.
Stimuli leading to strain
The modulus–density chart.
The modulus–relative cost chart. (The CES software contains material prices, regularly updated.)
what determines density and stiffness

Metal

(a) The CPH unit cell

(b) The FCC unit cell

(c) The BCC unit cell

Glass

(a) Crystalline

(b) Amorphous

Polymer

\[
\begin{align*}
\text{Carbon} & \quad \text{Hydrogen} \\
(-\text{C}=-\text{C}=-\text{C}=-\text{C}=-\text{C}=-\text{C}=-) & = (-\text{CH}_2-)_{a}
\end{align*}
\]
The hierarchy of electrical behavior
Measuring heat capacity, $C_p$. Its units are $J/kg.K$. 

$$c_p = \frac{\Delta U}{\Delta T} \text{ J/kg.K}$$
Measuring the thermal expansion coefficient, $\alpha$. *Its units are 1/K or, more usually, 106/K (microstrain/K).*
Measuring the thermal conductivity, $\lambda$. Its units are $W/m \ K$. 

\[ q = -\lambda \frac{\Delta T}{\Delta X} \ W/m^2 \]
The linear expansion coefficient, $\alpha$, plotted against the thermal conductivity, $\lambda$. The contours show the thermal distortion parameter $\lambda/\alpha$. 
The thermal conductivity, $\lambda$, plotted against the thermal diffusivity, $a \lambda/\rho C_p$.
The contours show the specific heat per unit volume $\rho C_p$. 
Types of magnetic behavior

(a) Paramagnetic

(b) Anti-ferro-magnetic

(c) Ferro-magnetic

(d) Ferri-magnetic
Domains allow a compromise: the cancelation of the external field while retaining magnetization of the material itself. The arrows show the direction of magnetization.
Saturation magnetization and susceptibility for soft magnetic materials
Optically flat, reflective surfaces give specular reflection, such that $\theta_1 = \theta_2$. 
Oxidation mechanisms. (a) Growth by metal diffusion and electron conduction
(b) Growth by diffusion of oxygen and holes
The material–process compatibility matrix for shaping, joining and finishing processes color coded by material.
The classification of shape

- All shapes
  - Prismatic
    - Circular
    - Non-circular
  - Sheet
    - Flat
    - Dished
  - 3-D
    - Solid
    - Hollow