Heat Transfer for Thermal Properties

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The Problem

Power Plant

Jet Engine

Nd.edu

hubpages.com
Solution: Thermal Barrier Coatings

- Protect components in high temperature environments from thermal damage, increasing efficiency
Challenges with Thermal Barrier Coatings
Our Goals

• Gain familiarity with heat transfer equations to better understand Thermal Barrier Coatings

• Determine the thermal conductivity of:
  • Brass
  • Aluminum
  • Steel
Heat Transfer Equation: Fourier’s Law

\[ q'' = -k \frac{\Delta T}{\Delta x} \]

- Heat Flux Rate
- Thermal Conductivity
- Temperature Gradient
Determining thermal conductivity

\[ q'' = -k \frac{\Delta T}{\Delta x} \quad \Rightarrow \quad k = \frac{-q''}{\Delta T / \Delta x} \]
Laser Power vs. Intensity Setting

Experimental Data

Power [Watts]

Laser Intensity Setting [%]
Laser Beam Characterization (q’’)

1

Laser

Focusing Lens

Razor

Power Meter

Reference [mm]

Power (Watts)

0

13

25
Laser Beam Characterization (q’’)

Focusing Lens

Laser

Razor

Power Meter

Reference [mm]

Power (Watts)

0  7  13  25

0  13  25
Laser Beam Characterization (q’’)

3

Laser

Focusing Lens

Razor

Power Meter

Power (Watts)

Reference [mm]

0  7  13  25

0  13  25
Determining Heat Flux Rate

\[ k = \frac{-q''}{\left(\frac{\Delta T}{\Delta x}\right)} \]

Surface Area: 20.5 mm²

\[ q'' = 1257 \text{ kW/m}^2 \]
Results

Aluminum
k = 191 W / m K
% Error = 18%

Brass
k = 121 W / m K
% Error = 4.3%

Steel
k = 43 W / m K
% Error = 65%
What We Learned

• Thermal barrier coatings & their importance

• Fourier’s Law & Its Implementation
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