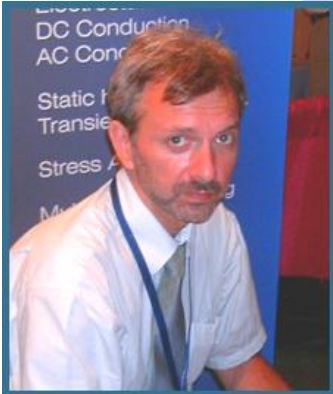




Thermal engineering with QuickField



Vladimir Podnos

Director of marketing and support, Tera Analysis Ltd.

Thermal problems in QuickField



Sergey Ionin

Support engineer, Tera Analysis Ltd.

Basics of the thermal problem setup



Thermal problems in QuickField

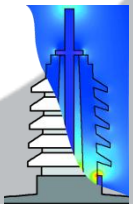
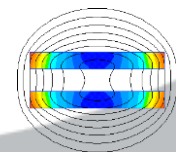
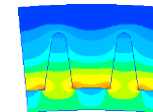
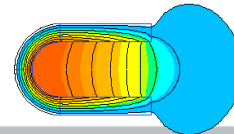
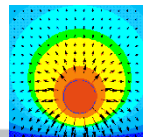
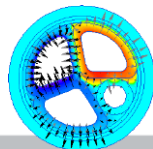
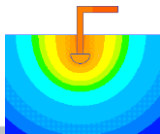
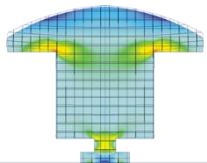


Vladimir Podnos,
Director of Marketing and Support,
Tera Analysis Ltd.



QuickField

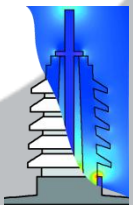
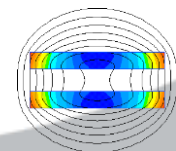
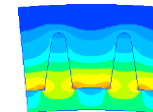
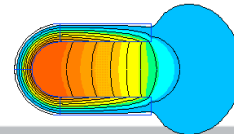
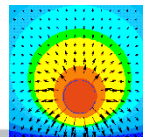
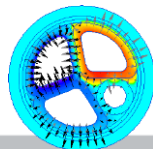
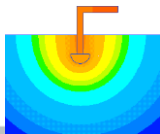
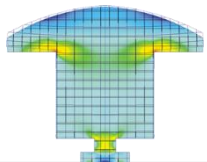
Magnetic analysis suite	
Magnetic Problems	Magnetostatics
	AC Magnetics
	Transient Magnetics
Electric analysis suite	
Electric Problems	Electrostatics and DC Conduction
	AC Conduction
	Transient Electric field
Thermostructural analysis suite	
Thermal and mechanical problems	Steady-State Heat transfer
	Transient Heat transfer
	Stress analysis





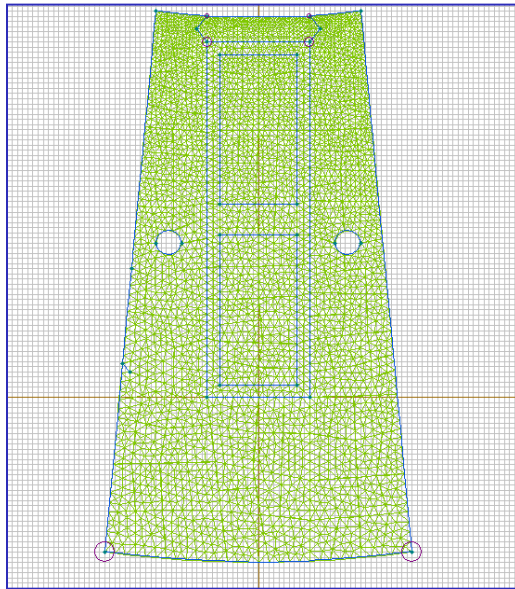
Thermal analysis

Magnetic analysis suite	
Magnetic Problems	Magnetostatics
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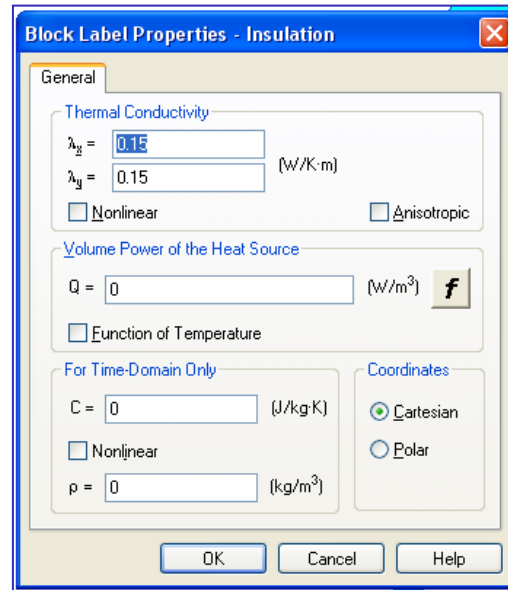




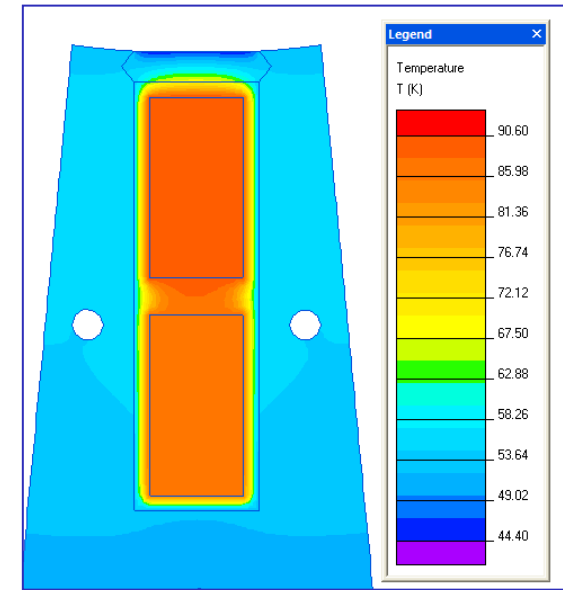
Stages of solution



Geometry



Physical parameters



Result



Thermal parameters

Blocks: Thermal conductivity (may be temperature-dependent or anisotropic);
Volume power of the heat source;

for time-domain

Specific heat (may be temperature-dependent);
Volume density.

Edges: Temperature, flux, convection, radiation;
Equal temperature, even and odd periodic
temperature.

Vertices: Temperature;
Heat sources.

Coupling: Heat Sources distribution may be imported
from Electromagnetic problems



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from Electromagnetic problems



Basics of the thermal problem setup



Sergey Ionin

Support engineer, Tera Analysis Ltd.

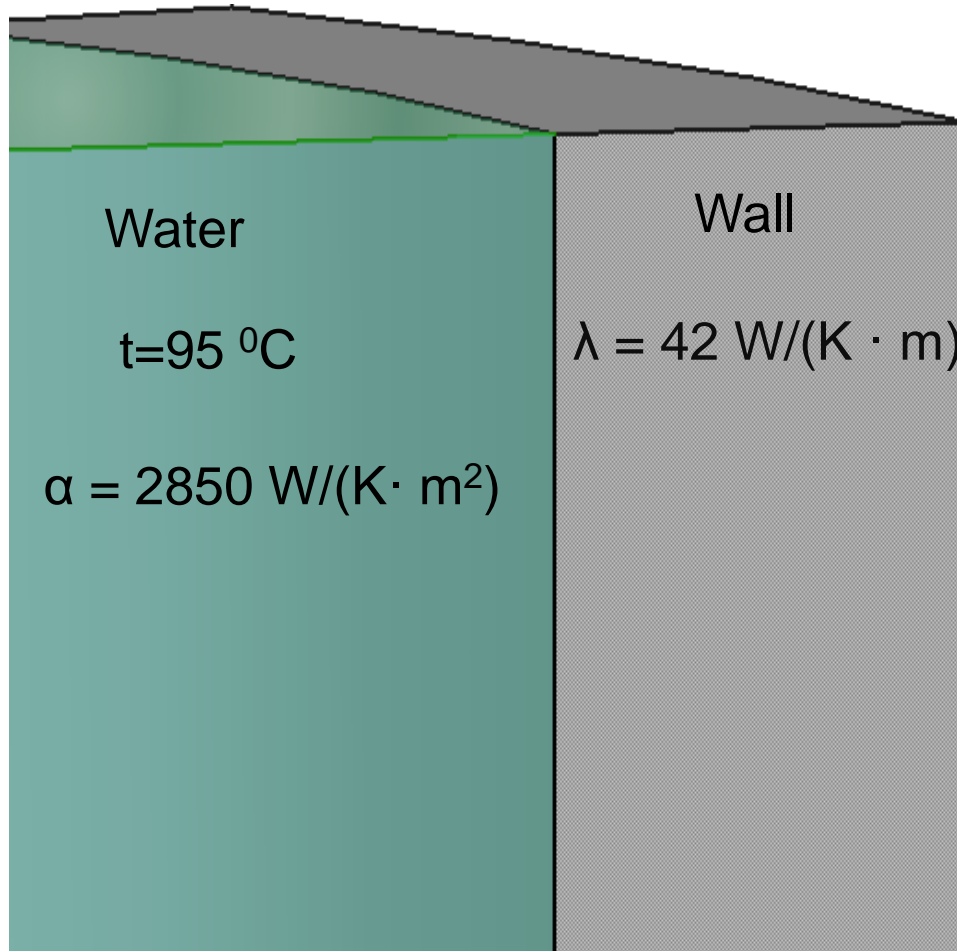


Basics of the thermal problem setup

1. Heat transfer through the wall. Heat Losses.
2. Natural Convection. Calculation of the convection coefficient.
3. Radiation. Heat Transfer in case of Radiation.
4. Complex problem with automation.



1. Heat transfer through the wall. Heat Losses.



Find:

1. Temperature of the wall surface
2. Heat flux

	$t, \text{ }^{\circ}\text{C}$	Flux, W/m^2
Theory*	94,52	795,2
QuickField	94,53	795,3

*Engineering Thermodynamics, Third Edition,
R.K.Rajput, example 15.6



Basics of the thermal problem setup

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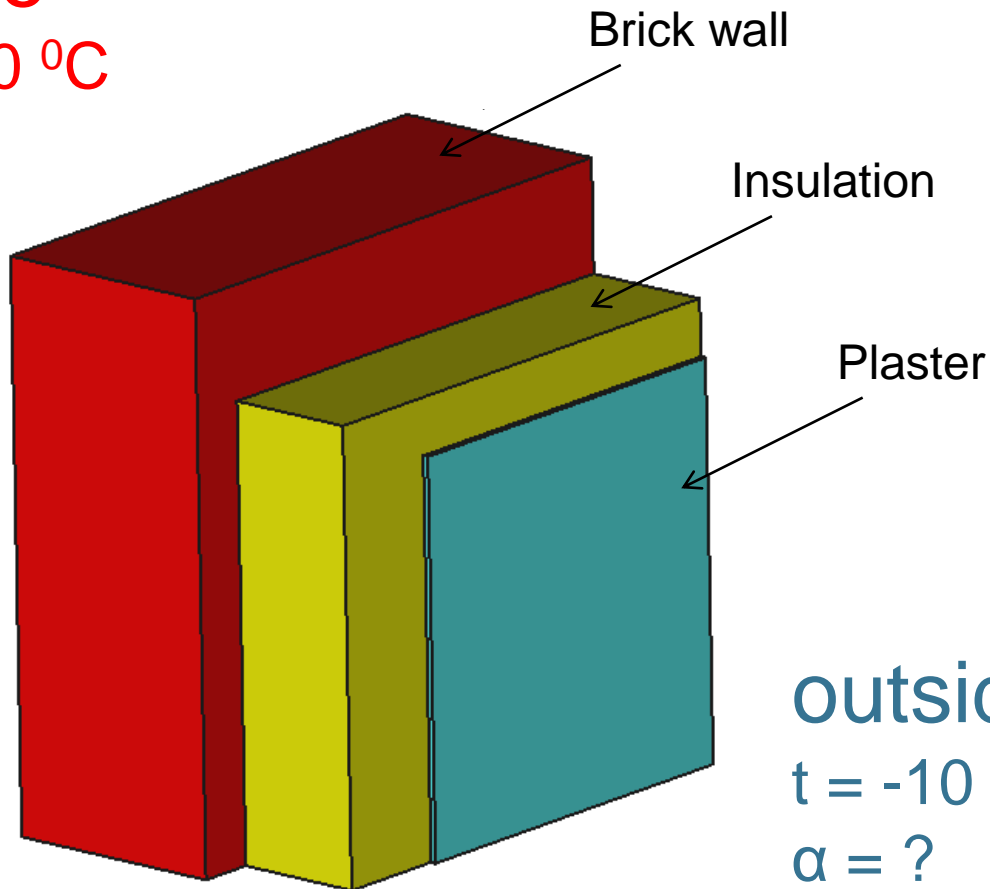


Convection

inside

$t = +20\text{ }^{\circ}\text{C}$

$\alpha = ?$



outside

$t = -10\text{ }^{\circ}\text{C}$

$\alpha = ?$

Find:

1. Convection coefficients
2. Temperature of the wall
3. In what layer the condensation may occur (dew point 10°C)



Convection

- Surface shape and orientation
- Specific dimensions, L
- Viscosity, μ
- Thermal conductivity, λ
- Density, ρ
- Thermal coefficient of volumetric expansion, β
- Heat capacity, C_p
- Temperature, T ; Temperature difference ΔT

Similarity theory formulas for the natural convection from the vertical plate

Grasshof number $Gr = \frac{L^3 \rho^2 g \Delta T \beta}{\mu^2}$

Prandtl number $Pr = \frac{\mu C_p}{\lambda}$

Rayleigh number $Ra = Gr Pr$

Nusselt number $Nu = \left(0.825 + \frac{0.387 Ra^{1/6}}{[1 + (0.492 / Pr)^{9/16}]^{8/27}} \right)^2$

Convection coefficient

$$\alpha = \frac{Nu \lambda}{L}$$



Convection

inside

$$Pr = \frac{1.87 \cdot 10^{-5} \cdot 1005}{0.0250} = 0.752$$

$$Gr = \frac{1^3 \cdot 1.205^2 \cdot 9.81 \cdot 15 \cdot 0.003501}{(1.87 \cdot 10^{-5})^2} = 2.14 \cdot 10^9$$

$$Ra = 0.752 \cdot 2.14 \cdot 10^9 = 1.61 \cdot 10^9$$

$$Nu = 141.4$$

$$\alpha = \frac{141.4 \cdot 0.0250}{1} = 3.59 \text{ W/(K} \cdot \text{m}^2)$$

outside

$$Pr = \frac{1.87 \cdot 10^{-5} \cdot 1009}{0.0238} = 0.793$$

$$Gr = \frac{1^3 \cdot 1.342^2 \cdot 9.81 \cdot 15 \cdot 0.003695}{(1.87 \cdot 10^{-5})^2} = 2.80 \cdot 10^9$$

$$Ra = 0.793 \cdot 2.80 \cdot 10^9 = 2.22 \cdot 10^9$$

$$Nu = 159.7$$

$$\alpha = \frac{159.7 \cdot 0.0238}{1} = 3.80 \text{ W/(K} \cdot \text{m}^2)$$

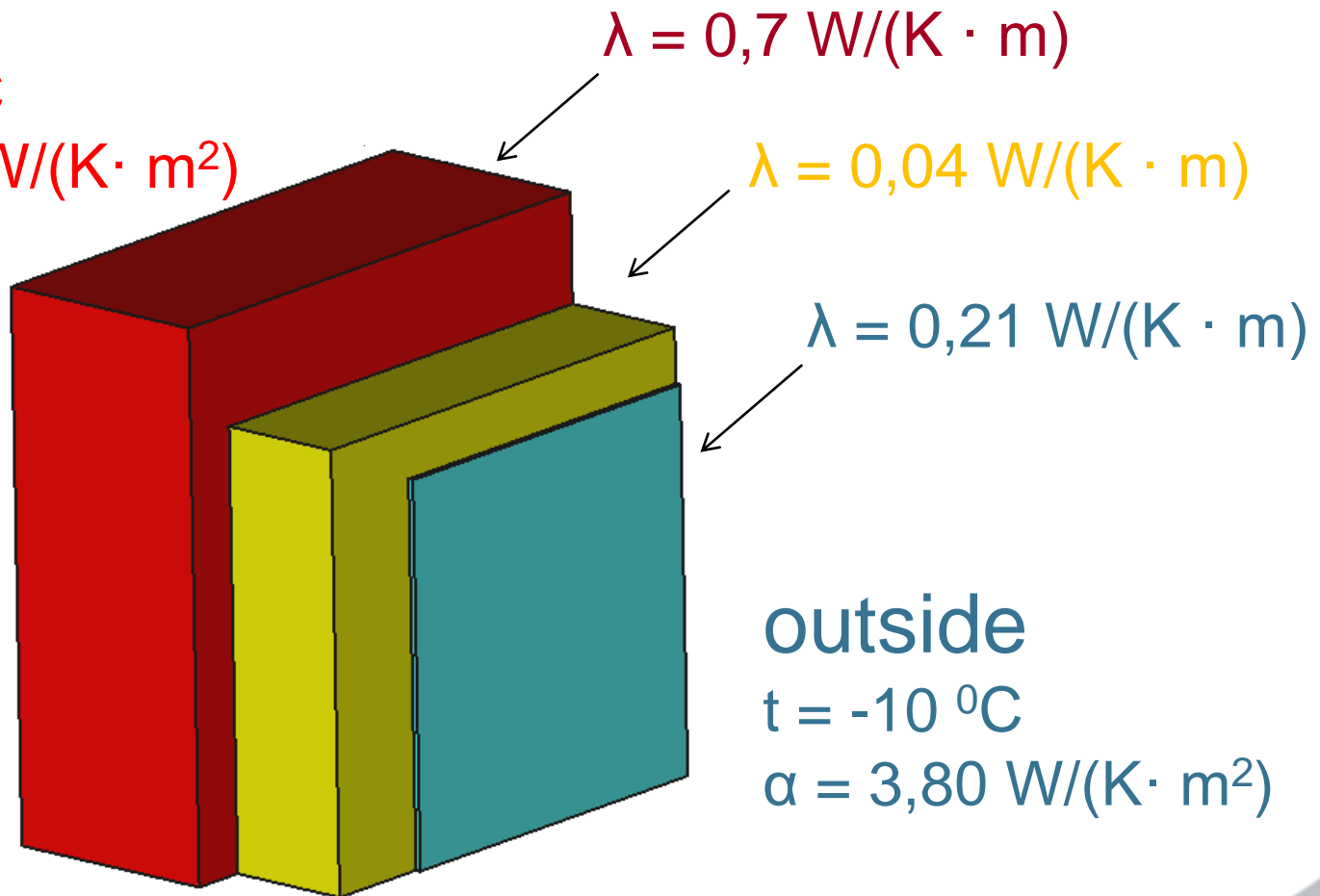


Convection

inside

$t = +20\text{ }^{\circ}\text{C}$

$\alpha = 3.59\text{ W}/(\text{K}\cdot\text{m}^2)$



outside

$t = -10\text{ }^{\circ}\text{C}$

$\alpha = 3,80\text{ W}/(\text{K}\cdot\text{m}^2)$

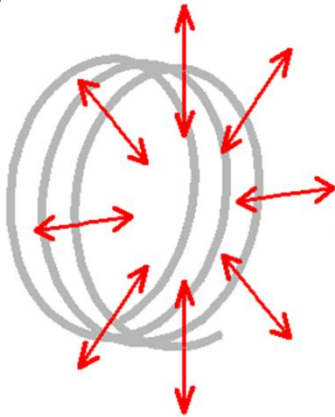


Basics of the thermal problem setup

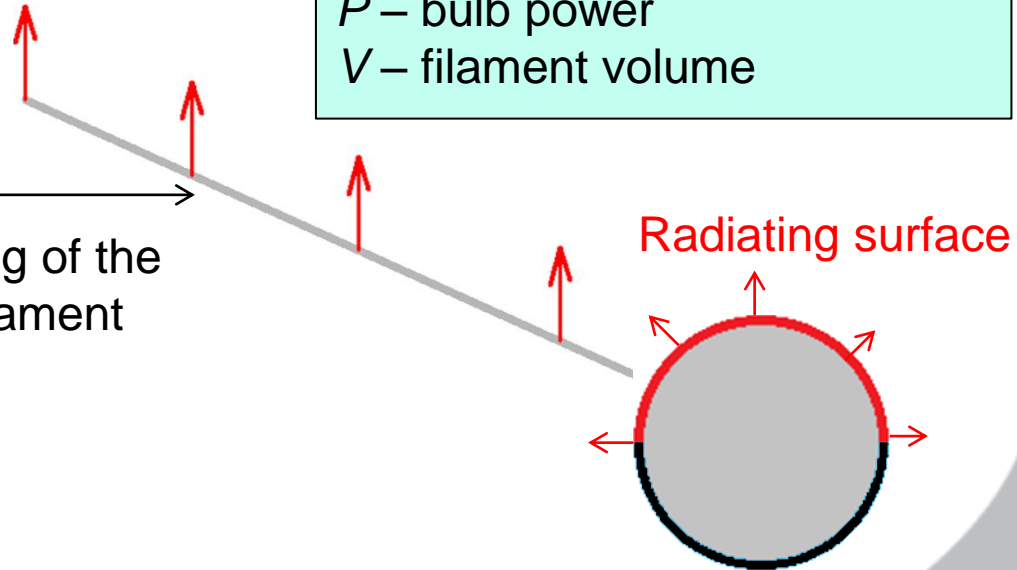
1. Heat transfer through the wall. Heat Losses.
2. Natural Convection. Calculation of the convection coefficient.
3. **Radiation. Heat Transfer in case of Radiation.**
4. Complex problem with automation.



Radiation



Straightening of the tungsten filament



Find:

1. Temperature of the filament

$$Q = P / V$$

P – bulb power

V – filament volume

Zero-flux surface
(radiated energy = absorbed energy)

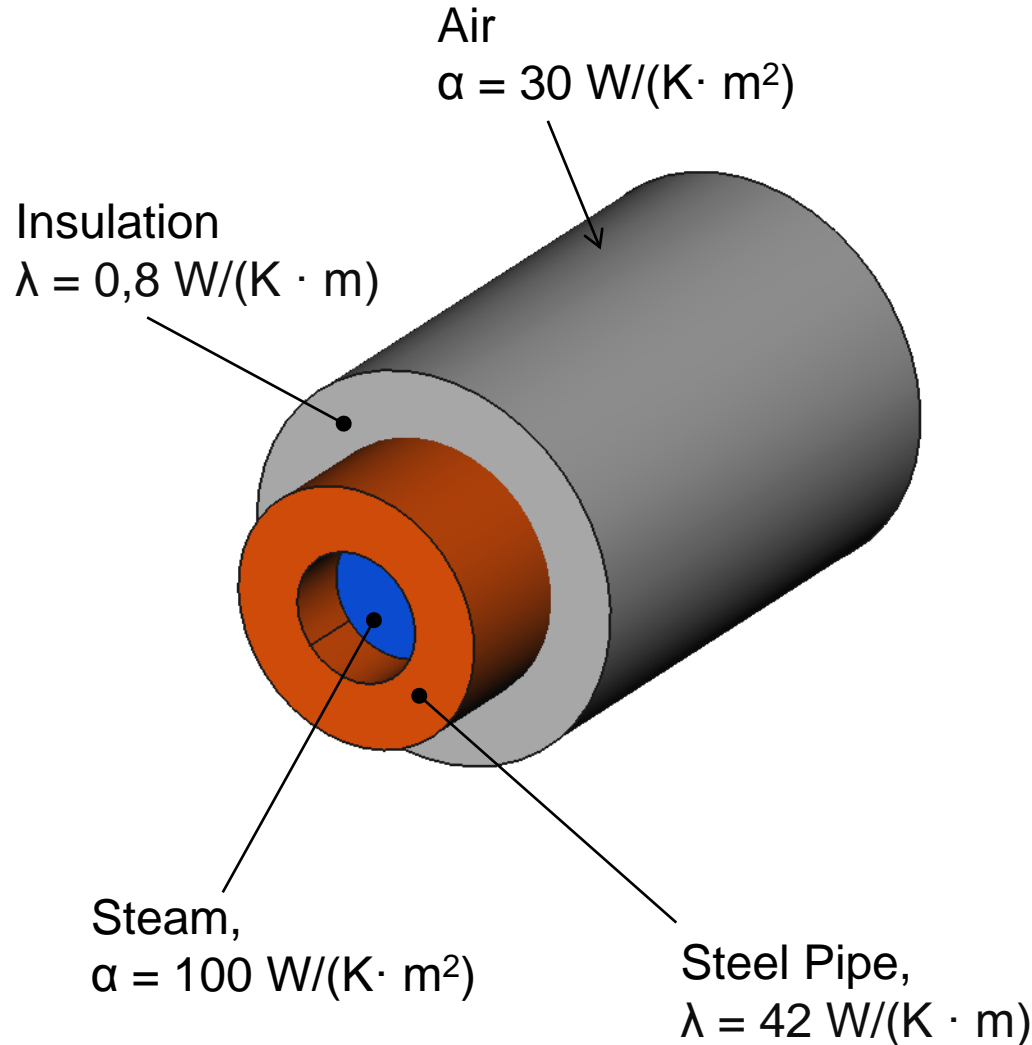


Basics of the thermal problem setup

1. Heat transfer through the wall. Heat Losses.
2. Natural Convection. Calculation of the convection coefficient.
3. Radiation. Heat Transfer in case of Radiation.
4. Complex problem with automation.



Steam Pipe



Find:

1. Insulation thickness to limit heat losses by 2.1 kW

	r, mm
Theory*	105
QuickField	104,65

*Engineering Thermodynamics, Third Edition, R.K.Rajput, example 15.11



Steam Pipe

Similarity theory formulas for the natural convection from the cylindrical surface

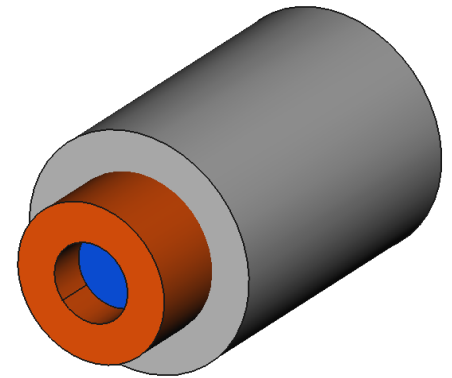
Grasshof number $Gr = \frac{L^3 \rho^2 g \Delta T \beta}{\mu^2}$

Prandtl number $Pr = \frac{\mu C_p}{\lambda}$

Rayleigh number $Ra = Gr Pr$

Nusselt number $Nu = \left(0.60 + \frac{0.387 Ra^{1/6}}{\left[1 + (0.559 / Pr)^{9/16} \right]^{8/27}} \right)^2$

Convection coefficient $\alpha = \frac{Nu \lambda}{L}$



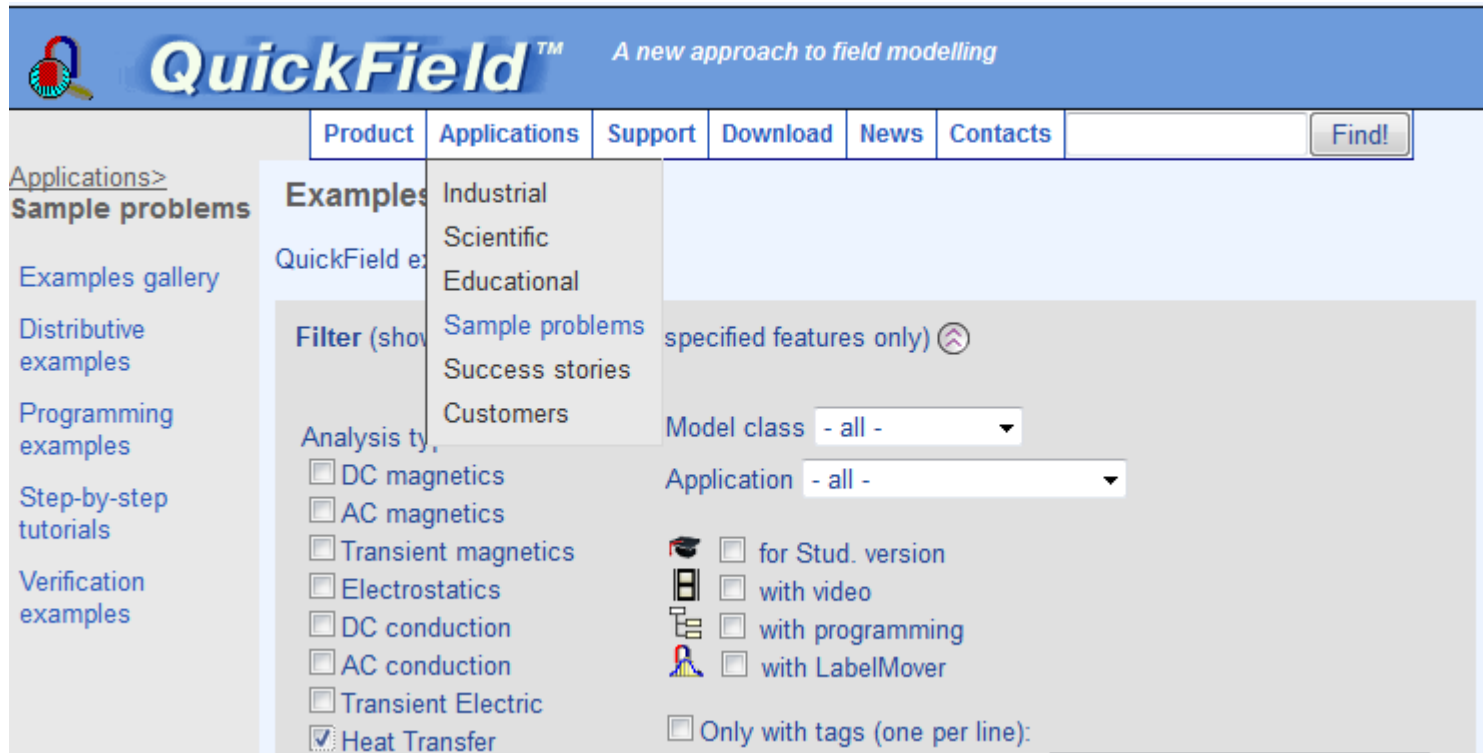


More examples

QuickField.com >

Applications > Industrial > Thermal models

Applications > Sample problems > Examples gallery



The screenshot shows the QuickField website interface. At the top, there is a blue header with the QuickField logo and the tagline "A new approach to field modelling". Below the header is a navigation bar with links for Product, Applications, Support, Download, News, and Contacts, along with a "Find!" search button. The "Applications" link is highlighted, and a dropdown menu is open, showing "Examples" as the selected item. The "Examples" dropdown menu lists categories: Industrial, Scientific, Educational, Sample problems, Success stories, and Customers. Below the dropdown, there is a "Filter (show)" section with a list of analysis types: DC magnetics, AC magnetics, Transient magnetics, Electrostatics, DC conduction, AC conduction, Transient Electric, and Heat Transfer (which is checked). To the right of the filter section, there are two dropdown menus for "Model class" and "Application", both set to "- all -". Below these are several checkboxes for filtering results: "for Stud. version", "with video", "with programming", "with LabelMover", and "Only with tags (one per line)".



Thank you