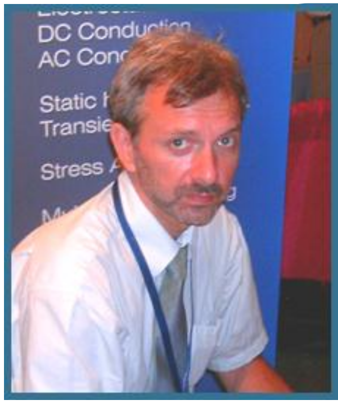
Thermal engineering with QuickField



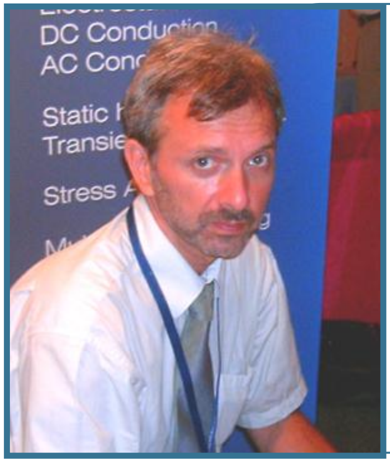
Vladimir Podnos
Director of marketing and support, Tera Analysis Ltd.

Thermal problems in QuickField

Sergey Ionin
Support engineer, Tera Analysis Ltd.

Basics of the thermal problem setup

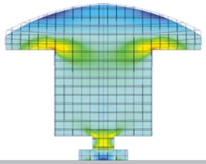
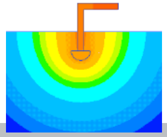
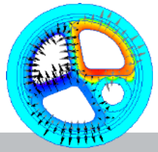
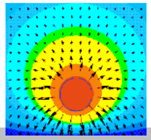
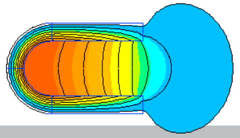
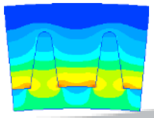
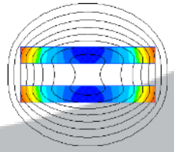
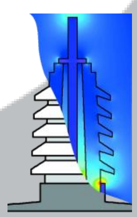
Thermal problems in QuickField



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
	AC Magnetics
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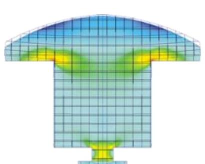
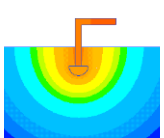
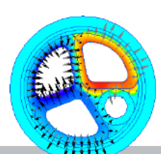
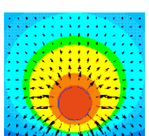
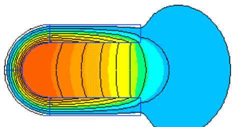
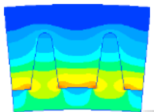
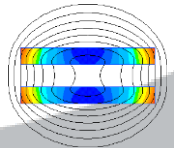
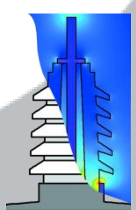
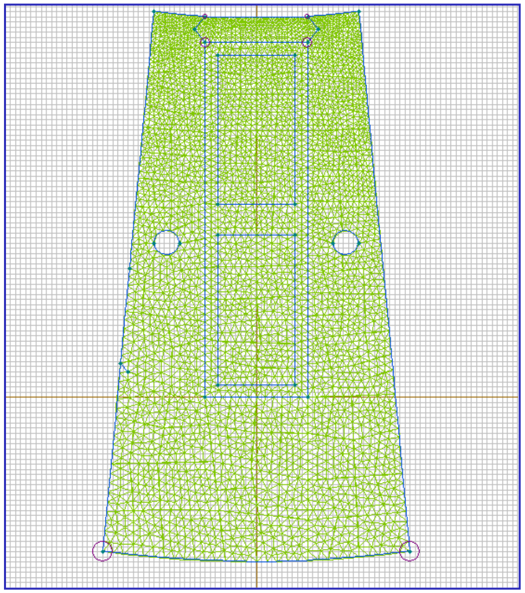
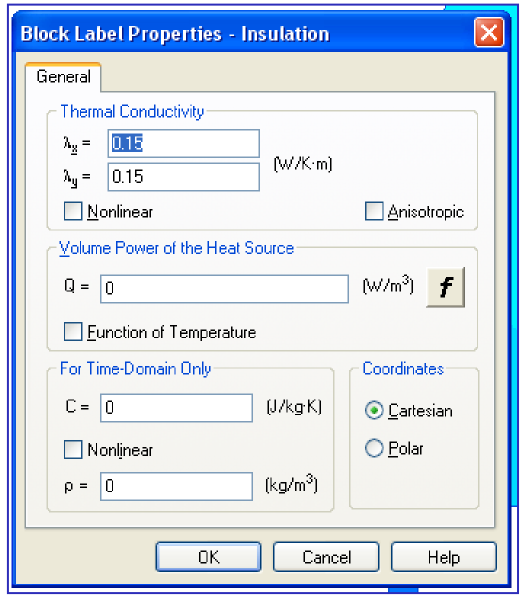
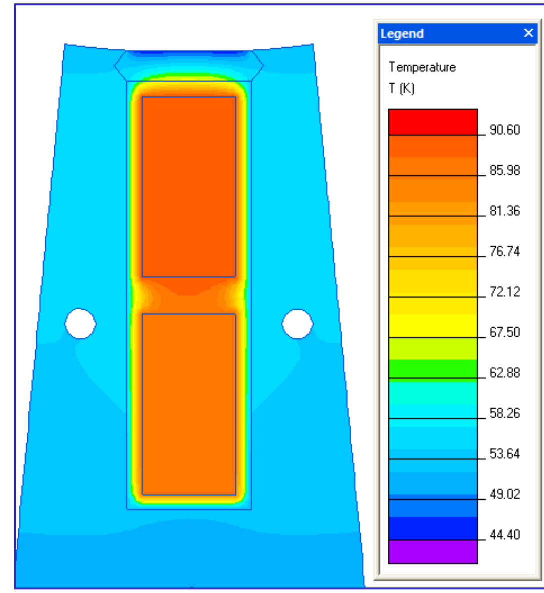









Stages of solution







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

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

Basics of the thermal problem setup

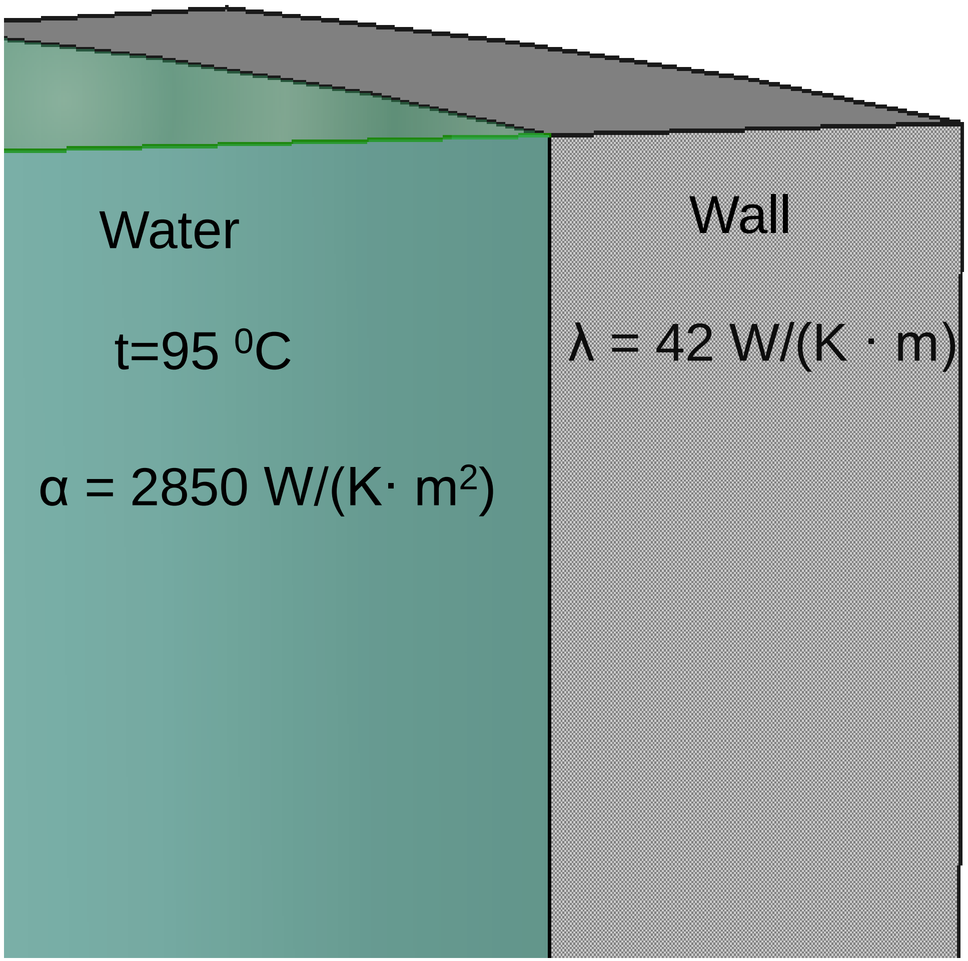
Sergey Ionin

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.



Air

$t = 15\ ^0C$

$\alpha = 10\ W/(K \cdot m^2)$

Find:

1. Temperature of the wall surface
2. Heat flux

	t, ^0C	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

1. Heat transfer through the wall. Heat Losses.
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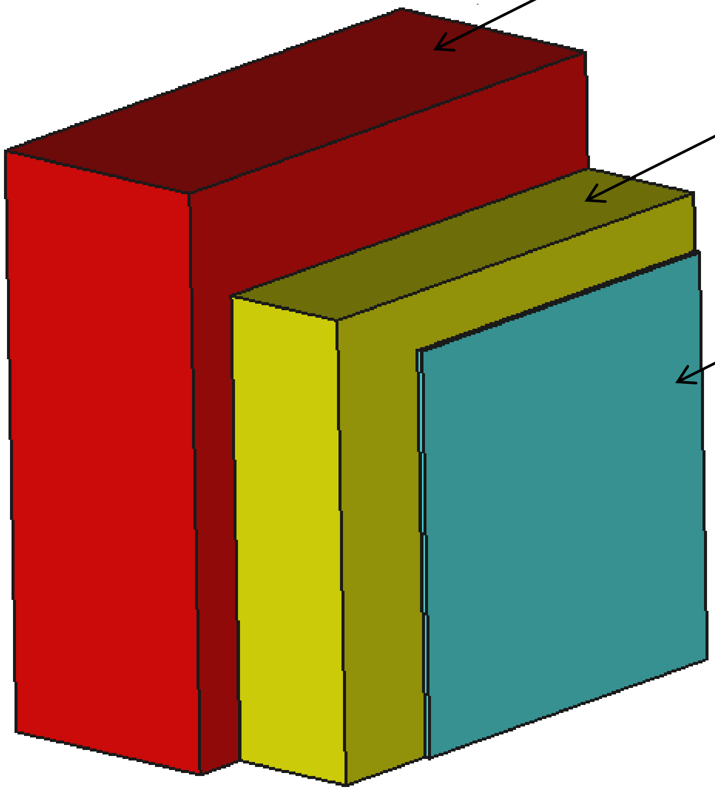
Convection

inside

t = +20 ^{0}C

α = ?



outside

t = -10 ^{0}C

α = ?

Find:

1. Convection coefficients
2. Temperature of the wall
3. In what layer the condensation may occur (dew point $10^{0}C$)

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

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

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

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

$$Nu = 141.4$$

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

---

outside

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

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

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

$$Nu = 159.7$$

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

Convection

inside

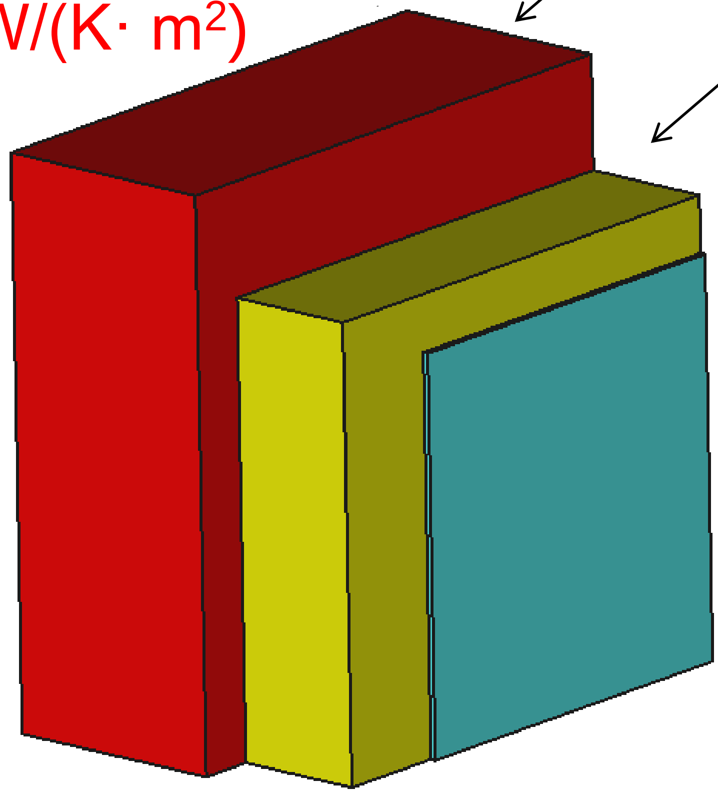
$t = +20\ ^{0}C$

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

$\lambda = 0{,}7\ W/(K \cdot m)$

$\lambda = 0{,}04\ W/(K \cdot m)$

$\lambda = 0{,}21\ W/(K \cdot m)$



outside

$t = -10\ ^{0}C$

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

Basics of the thermal problem setup

1. Heat transfer through the wall. Heat Losses.
2. Natural Convection. Calculation of the convection coefficient.
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Radiation

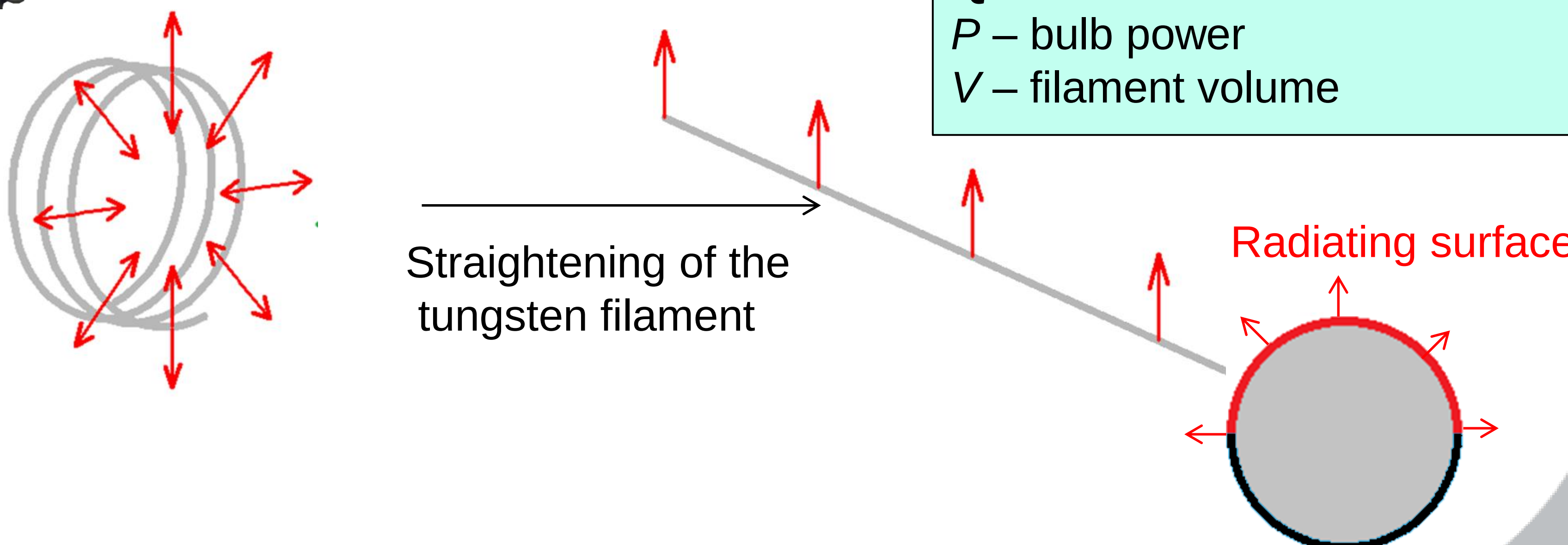
Find:

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.
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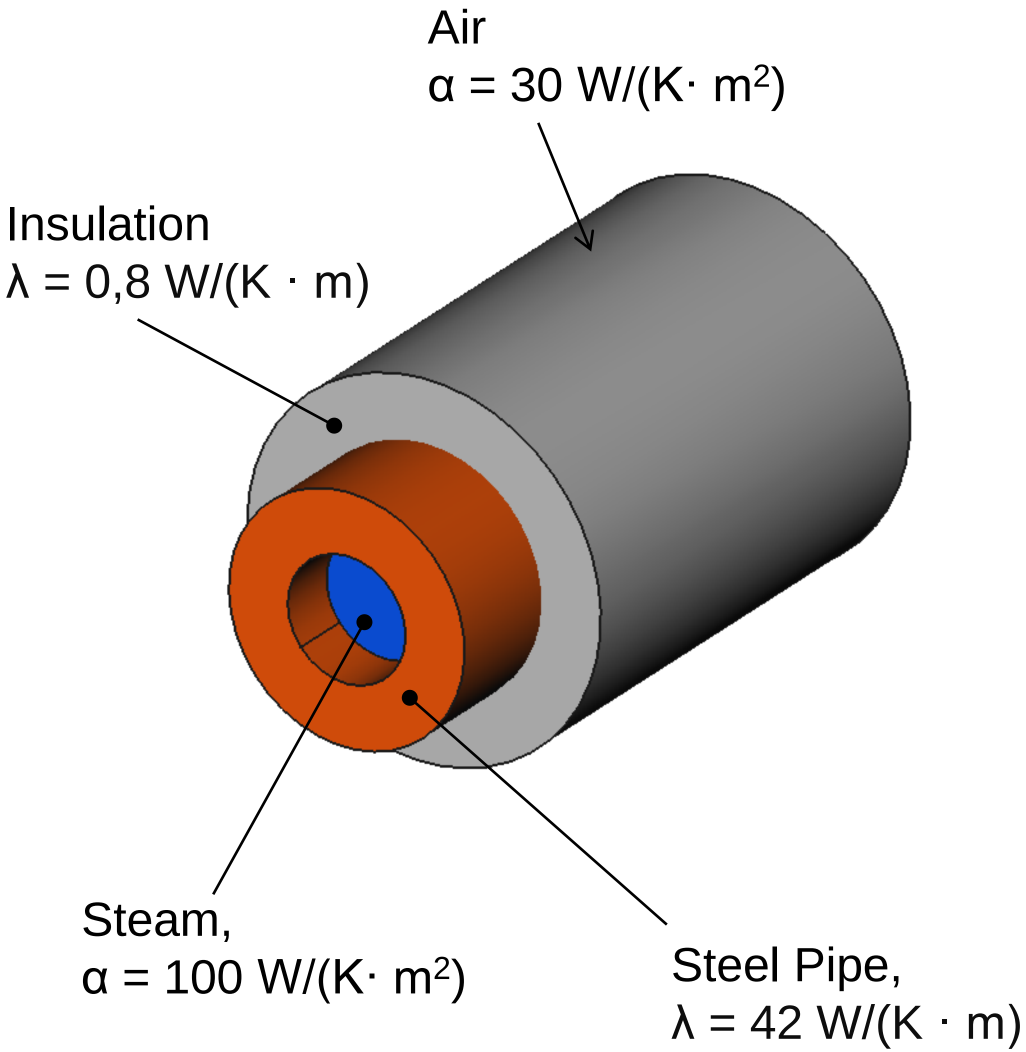
Steam Pipe



Find:

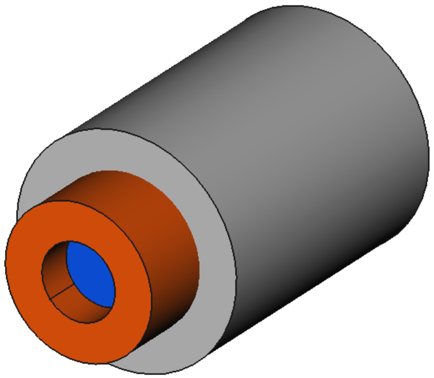
1. Insulation thickness to limit heat losses by 2.1 kW

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

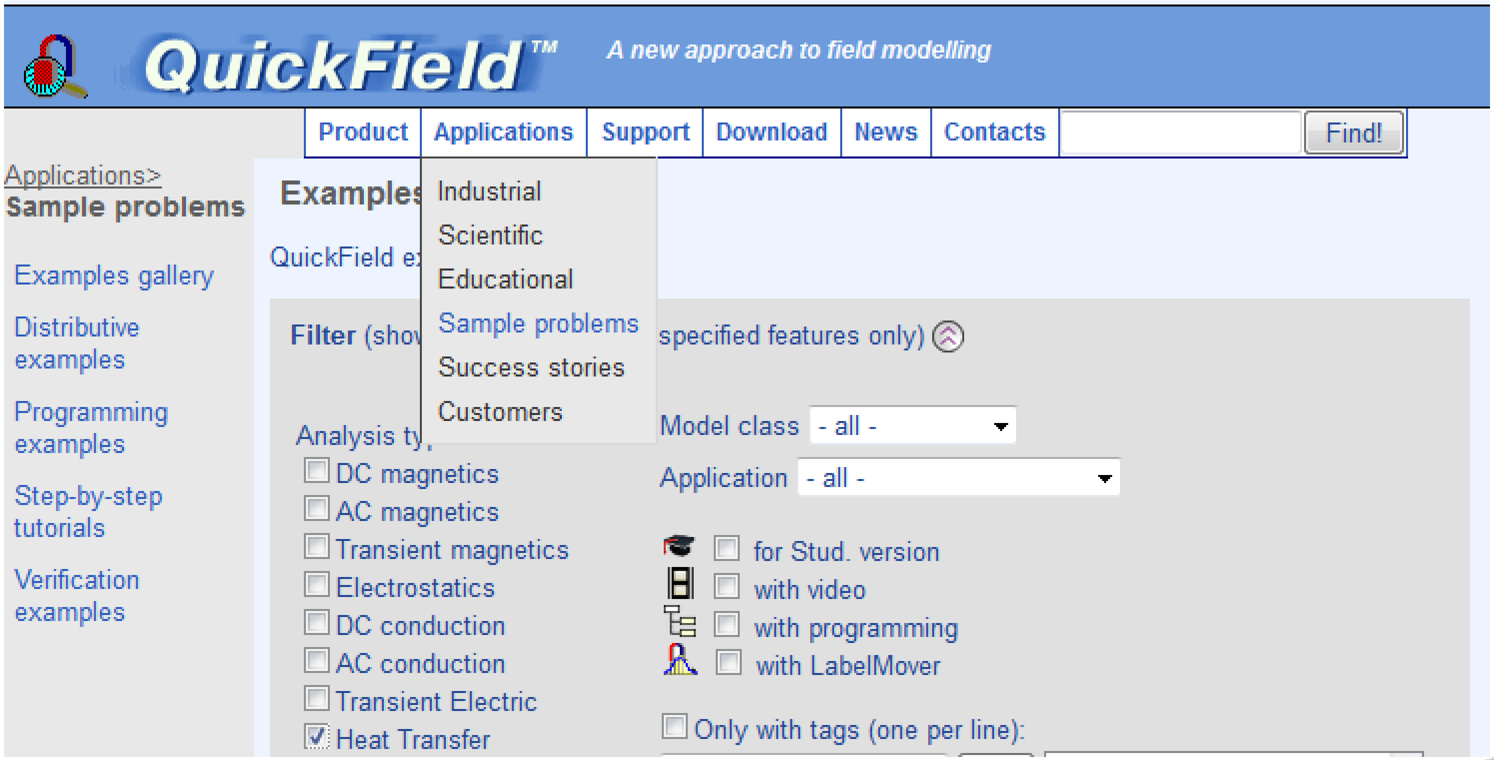
Convection coefficient $$\alpha = \frac{Nu \, \lambda}{L}$$

More examples

QuickField.com >

Applications > Industrial > Thermal models

Applications > Sample problems> Examples gallery



Thank you