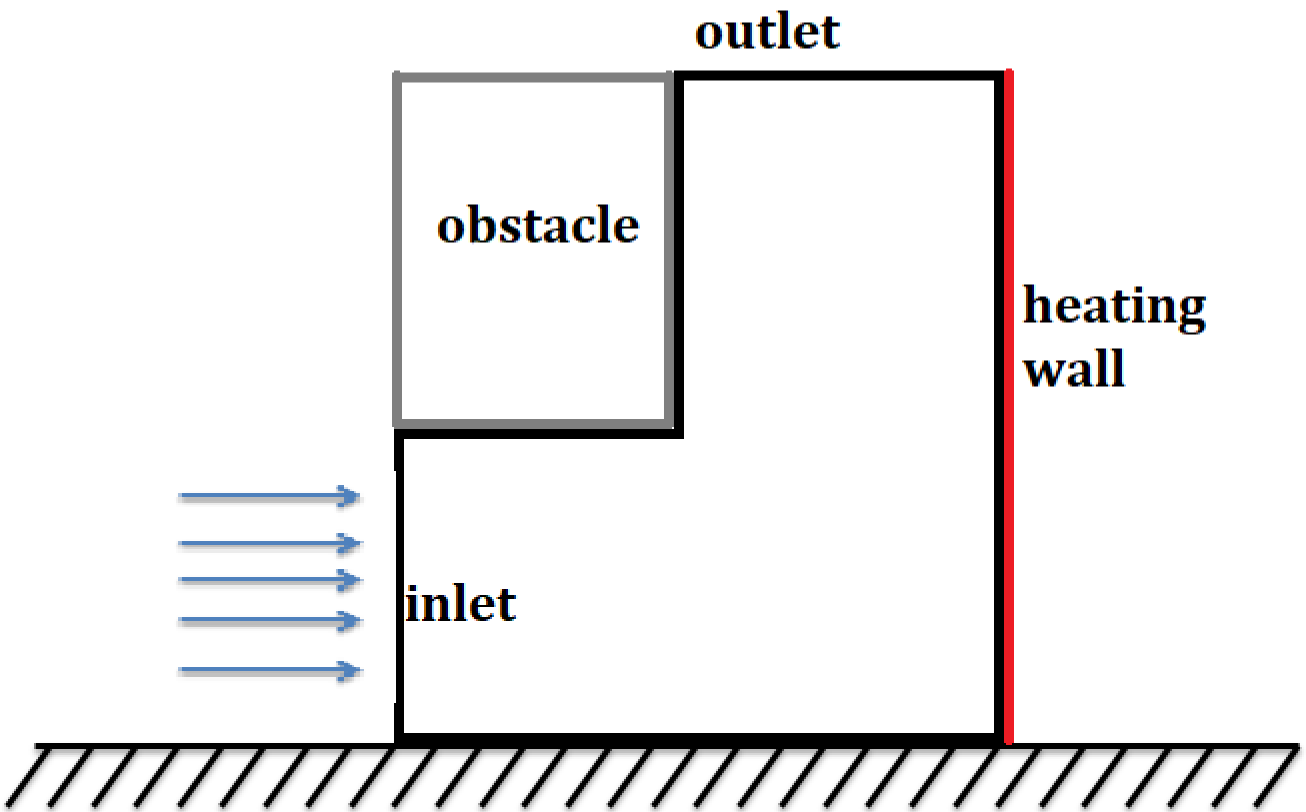
Physical background



Mathematical background

$$\begin{cases}\dfrac{\partial U_x}{\partial \tau}+U_x\dfrac{\partial U_x}{\partial x}+U_y\dfrac{\partial U_x}{\partial y}=-\dfrac{\partial P}{\partial x}+\dfrac{1}{\mathrm{Re}}\left(\dfrac{\partial^2 U_x}{\partial x^2}+\dfrac{\partial^2 U_x}{\partial y^2}\right);\\[2ex]\dfrac{\partial U_y}{\partial \tau}+U_x\dfrac{\partial U_y}{\partial x}+U_y\dfrac{\partial U_y}{\partial y}=-\dfrac{\partial P}{\partial y}+\dfrac{1}{\mathrm{Re}}\left(\dfrac{\partial^2 U_y}{\partial x^2}+\dfrac{\partial^2 U_y}{\partial y^2}\right)+\dfrac{Gr}{\mathrm{Re}^2}\Theta;\\[2ex]\dfrac{\partial U_x}{\partial x}+\dfrac{\partial U_y}{\partial y}=0.\end{cases}$$

Vorticity- Stream function formulation

$$U_x = \frac{\partial \Psi}{\partial y}; \; U_y = -\frac{\partial \Psi}{\partial x};$$

$$\Omega = \frac{\partial U_x}{\partial y} - \frac{\partial U_y}{\partial x}$$

$$\frac{\partial \Omega}{\partial \tau} + U_x \frac{\partial \Omega}{\partial x} + U_y \frac{\partial \Omega}{\partial y} = \frac{1}{\mathrm{Re}} \left(\frac{\partial^2 \Omega}{\partial x^2} + \frac{\partial^2 \Omega}{\partial y^2} \right) - \frac{Gr}{\mathrm{Re}^2} \frac{\partial \Theta}{\partial x}$$

$$\frac{\partial \Theta}{\partial \tau} + U_x \frac{\partial \Theta}{\partial x} + U_y \frac{\partial \Theta}{\partial y} = \frac{1}{\mathrm{Re} \cdot \mathrm{Pr}} \left(\frac{\partial^2 \Theta}{\partial x^2} + \frac{\partial^2 \Theta}{\partial y^2} \right)$$

Boundary Conditions

- Inlet: $\mathit{\Omega} = 0;\ \mathit{\Theta} = 0;\ U_x = 1;\ \Psi = y\big|_0^{y_{\max}}$

- On boundaries: $\Psi = 0;\ \Theta = 1;$

$$\Omega = \frac{2(\Psi_{w-1} - \Psi_w)}{\Delta n}.$$

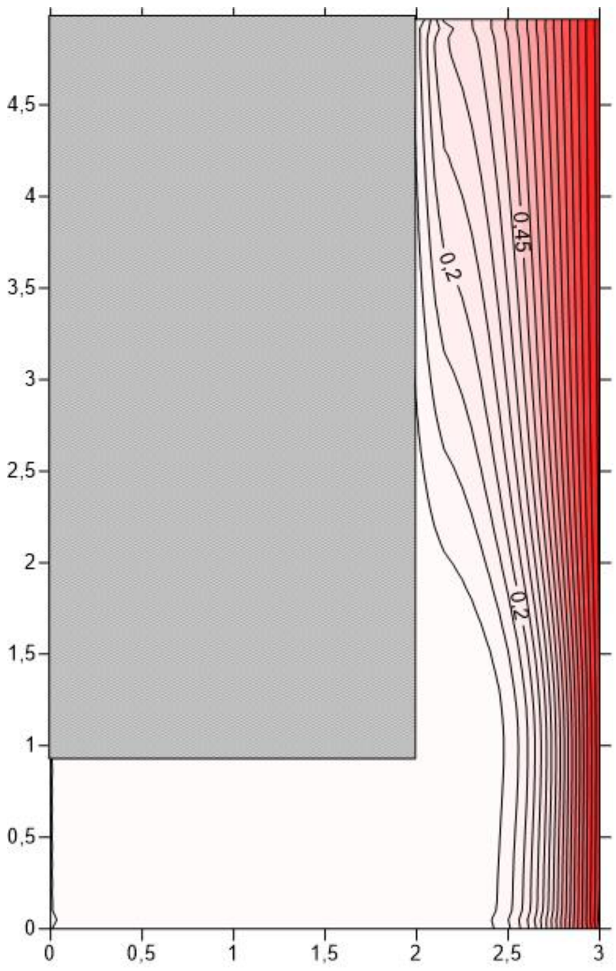
- Outet: $\frac{\partial}{\partial y} = 0$

Results

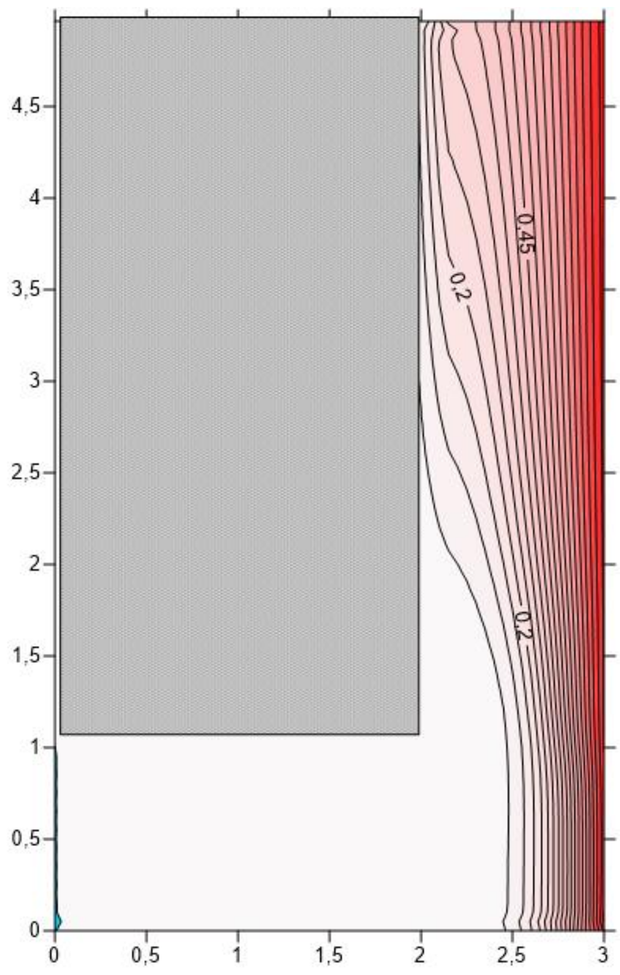
Re = 20
Gr = 0

Influence of the Prandtl Number on the result

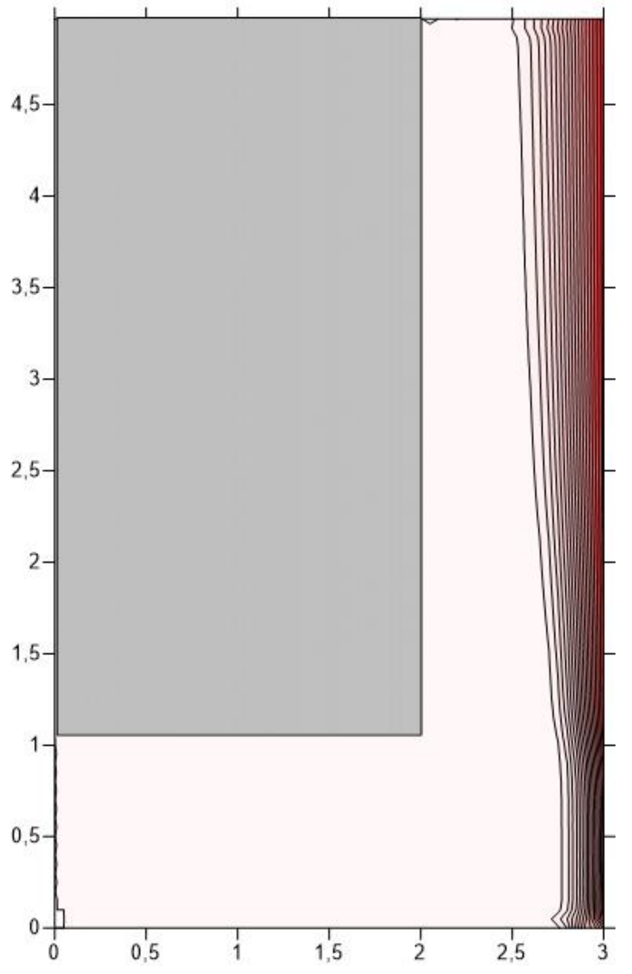
Pr=0,1



Pr=1



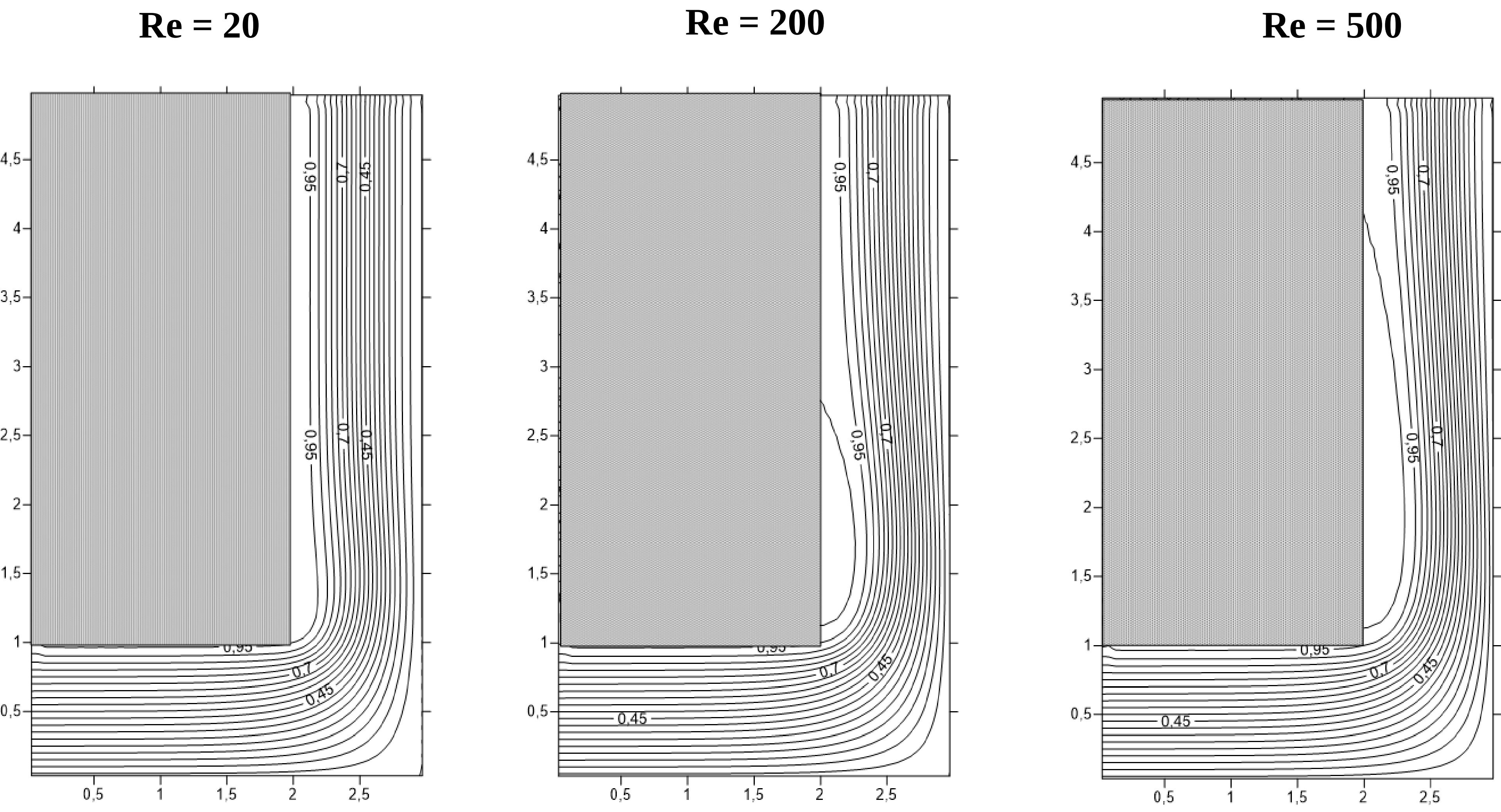
Pr=10



Pr = 1
Gr = 0

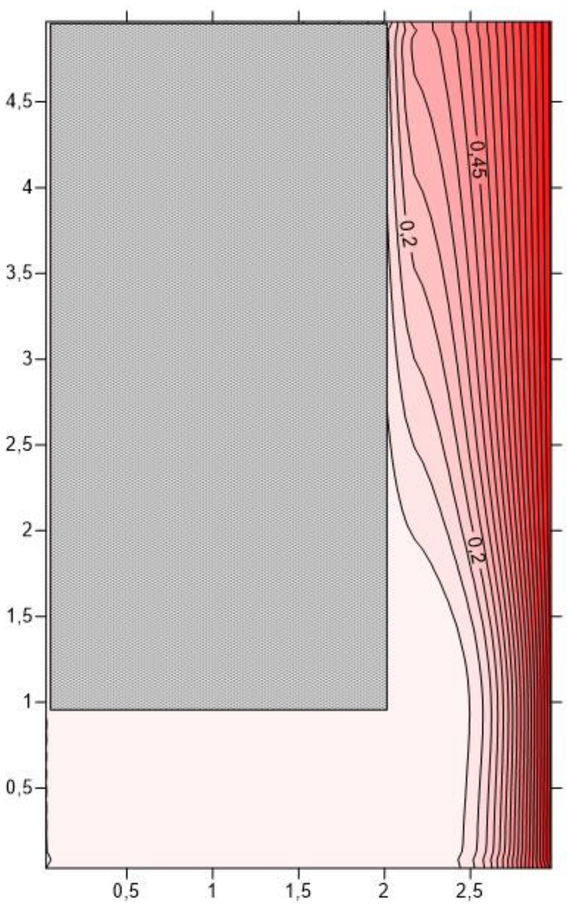
Influence of the Reynolds Number on the result

stream function distribution

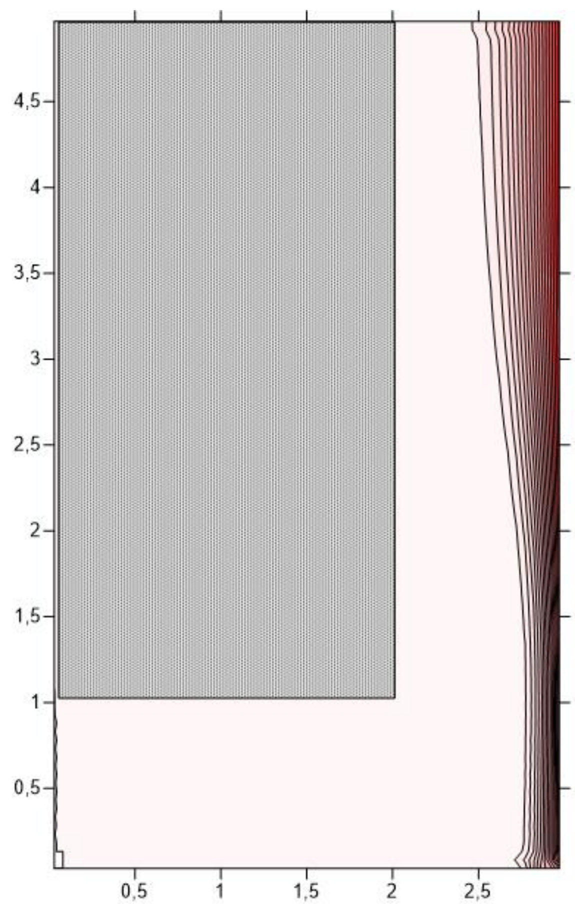


Pr = 1
Gr = 0

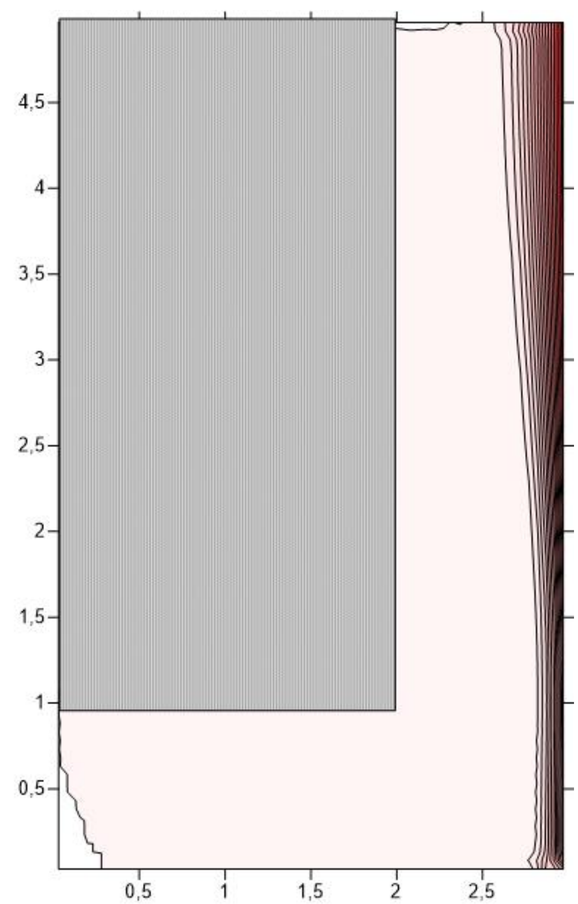
Re = 20



Re = 200



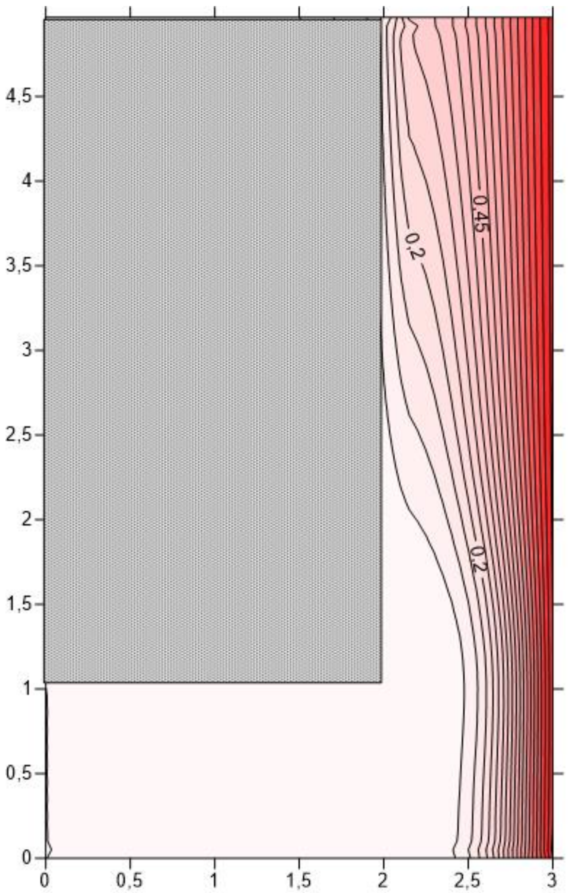
Re = 500



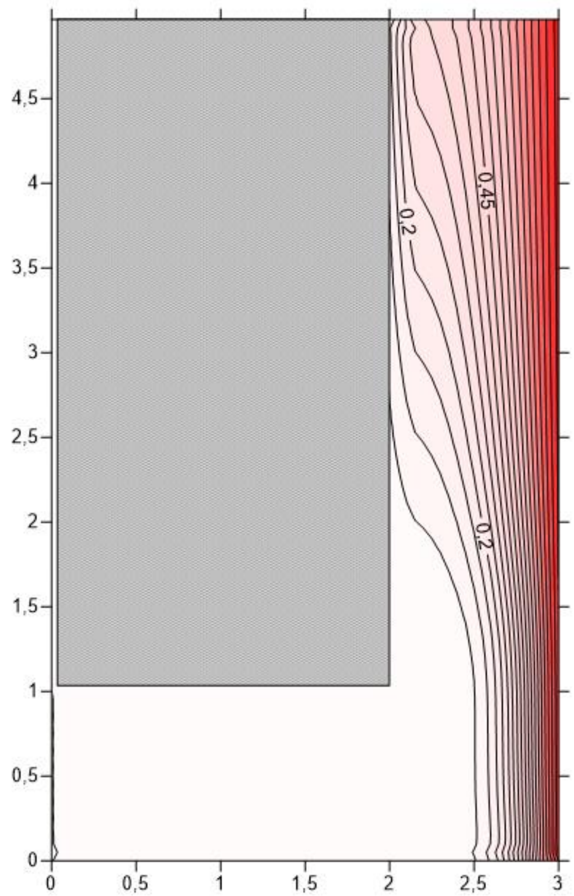
Re=20 ,Pr=1:

Influence of the Grashof number on the flow

Gr=0



Gr=1000



Gr=5000