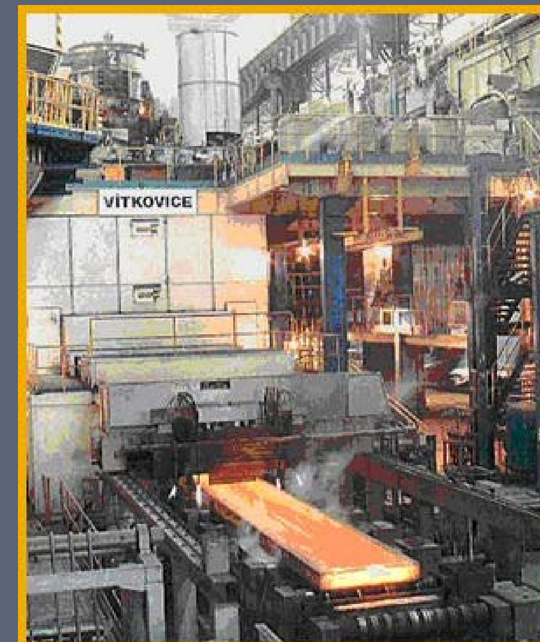
OPERATIONAL EXPERIENCES WITH THE OPTIMIZATION OF SECONDARY COOLING



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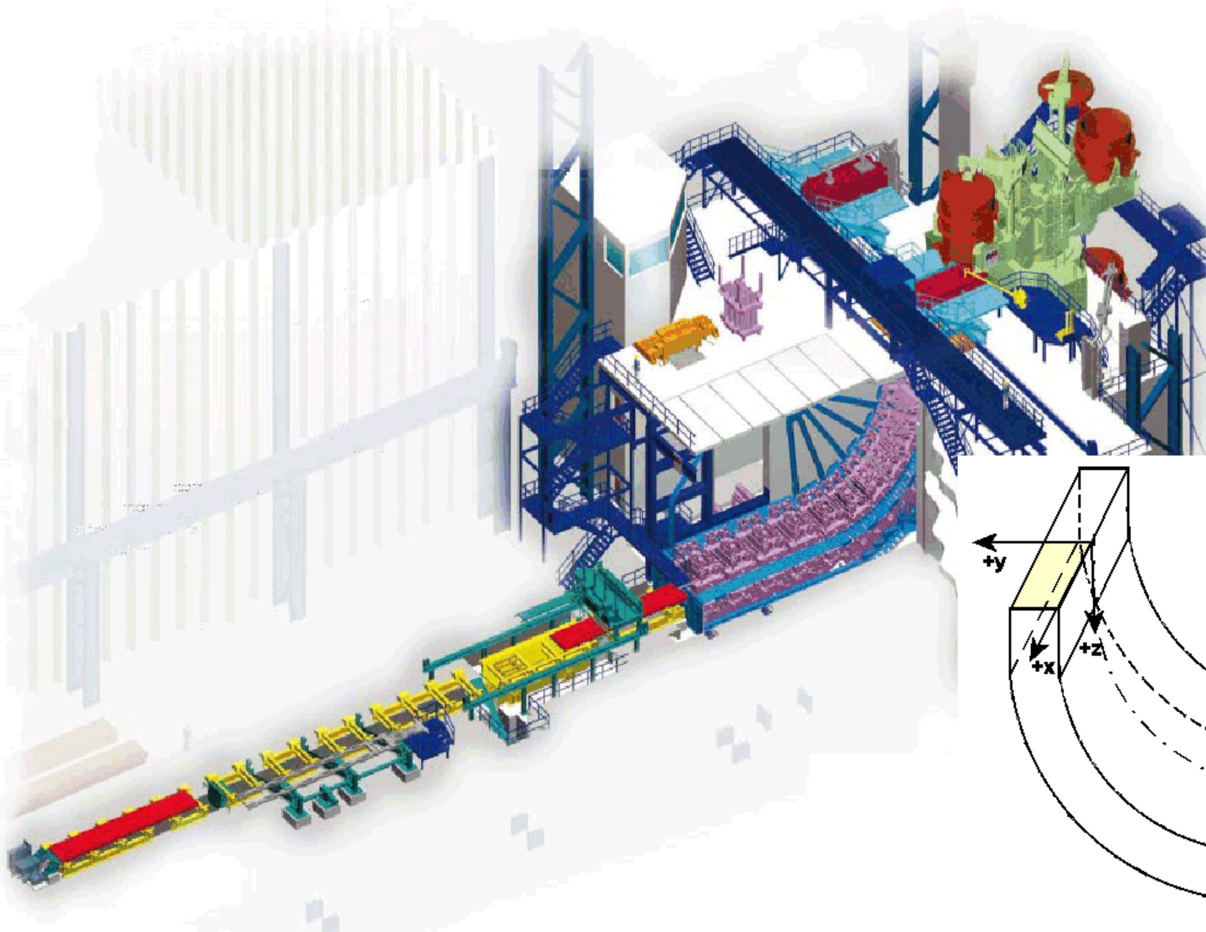
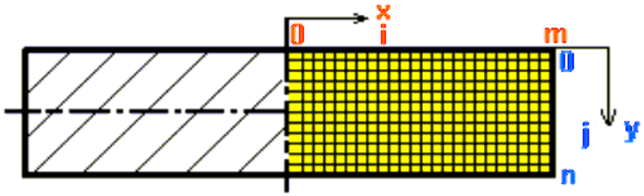
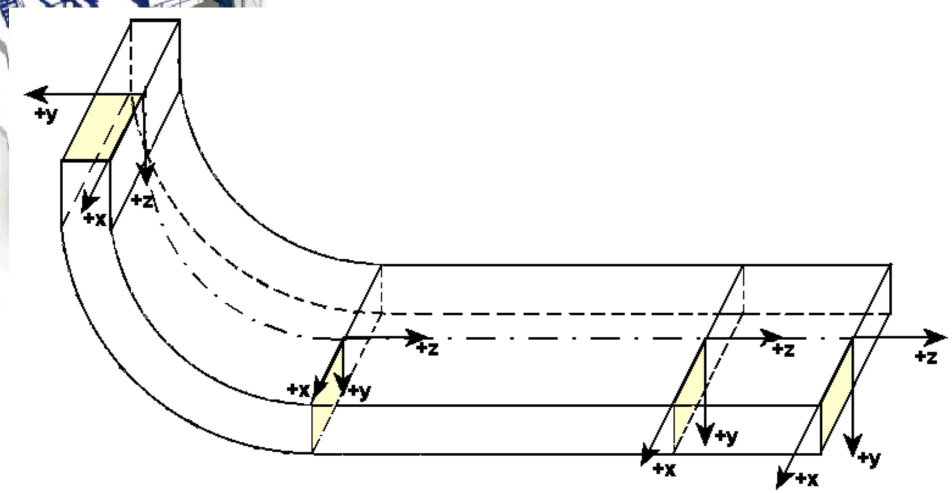
MODEL OF RADIAL SLAB CASTER



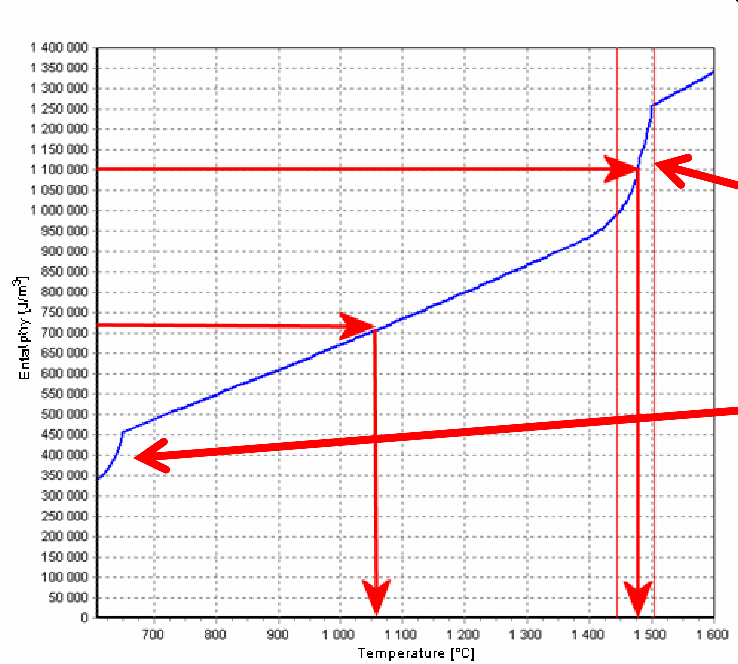


x - axis - index i	0 to m	<25,50>	
y - axis - index j	0 to n	<25,50>	
z - axis - index k	0 to p	<500,1000>	
m x n x p		2 500 000 nodes	



ENTHALPY AS A FUNCTION OF TEMPERATURE

$$\frac{\partial H_v}{\partial t} + \frac{\partial}{\partial z}\left(\rho . w_z . H_v\right) = k\left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} + \frac{\partial^2 T}{\partial z^2}\right)$$



$\rho(t)$ [kg.m^{-3}]

$k(t)$ [W.m^{-1}.K^{-1}]

$c(t)$ [J.kg^{-1}.K^{-1}]

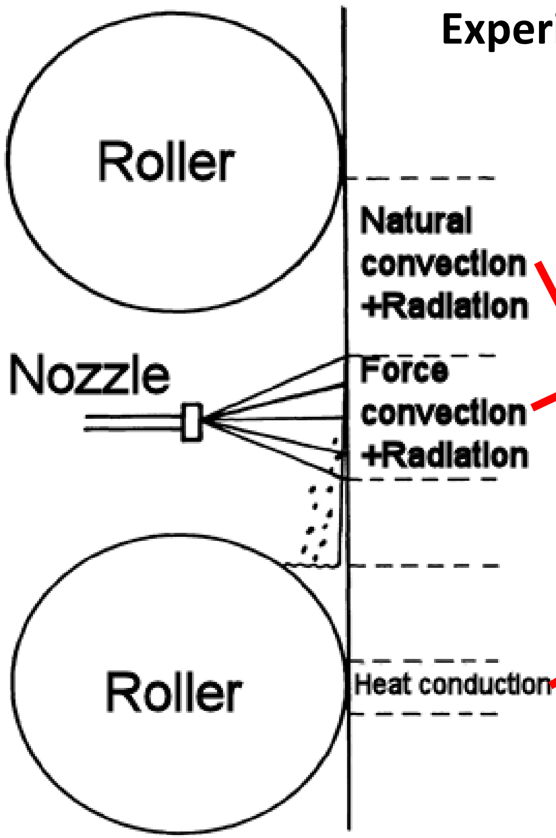
$H_v(t)$ [J.m^{-3}]

L [J]

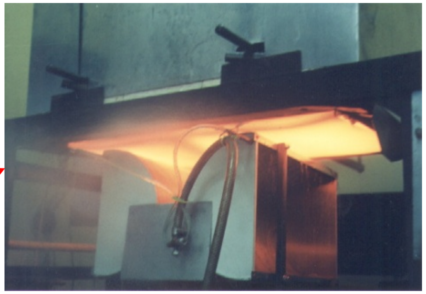
This function must be known for the relevant steel.

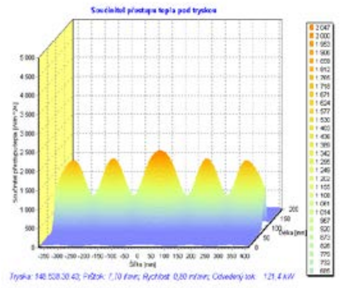
This point can change its phase or structure during the simulated process. The enthalpy function contains the latent or structural heat of each change.

BOUNDARY CONDITIONS



Experiment for each nozzles





$$\dot{Q}_{rol} = htc_{rol} \cdot \pi \cdot \frac{l}{2} \cdot d \cdot (T_{rol} - T_{amb})$$

$$htc_{rol} = htc_{rolnat} + \varepsilon_{rol} \cdot \sigma \cdot (T_{rol}^2 + T_{amb}^2) \cdot (T_{rol} + T_{amb})$$

Natural convection

$$htc_{nat} = 0{,}84 \cdot \sqrt{(T_{surface} - T_{amb})}$$

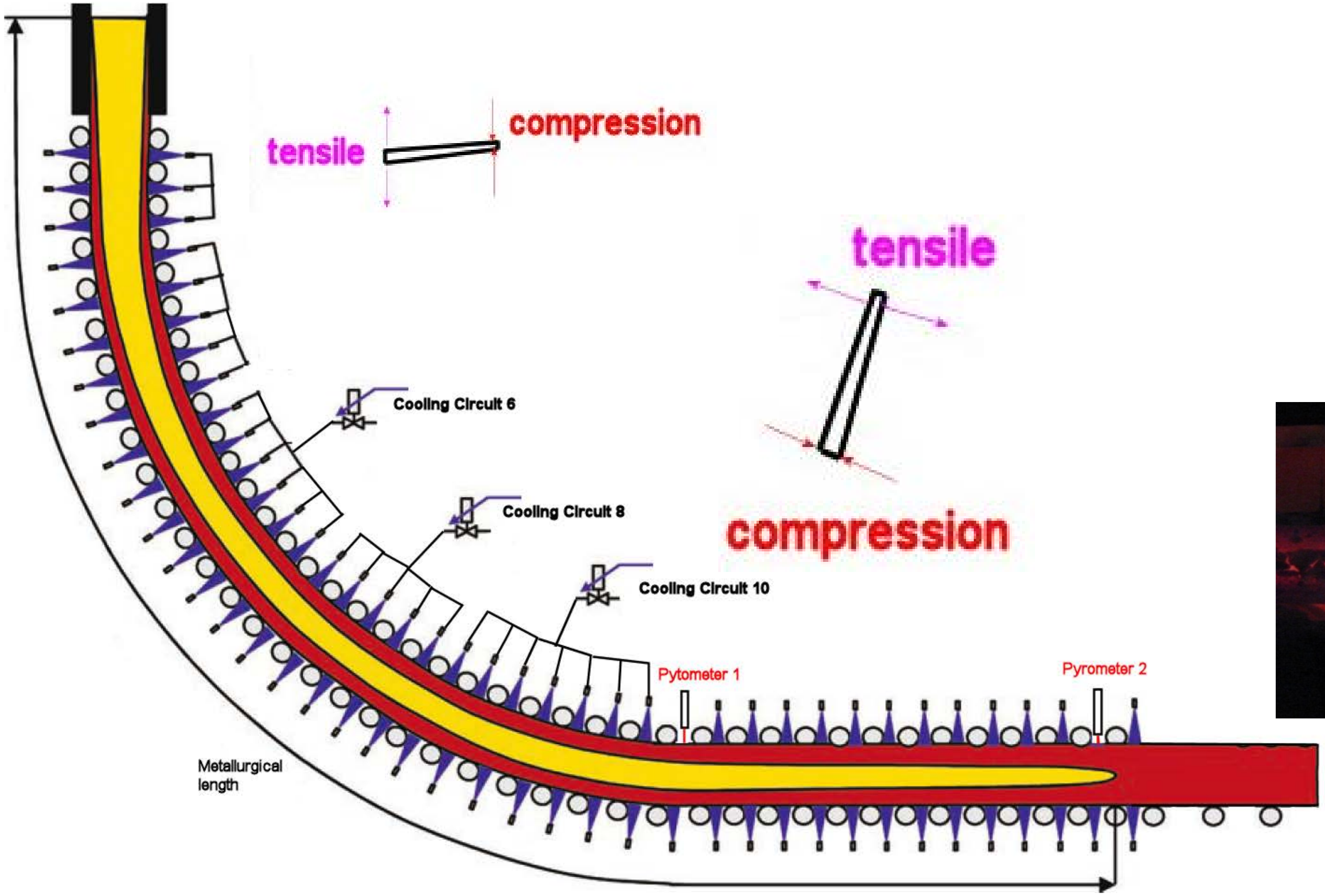
Radiation

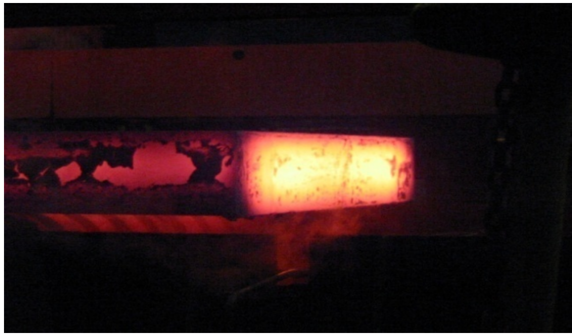
$$htc_r = \varepsilon \cdot \sigma \cdot (T_{surface}^2 + T_{amb}^2) \cdot (T_{surface} + T_{amb})$$

$$\varepsilon = 0{,}78828571429 + 0{,}0003375 \cdot T_{surface} - 40{,}17857143 \cdot 10^{-6} \cdot T_{surface}^2$$

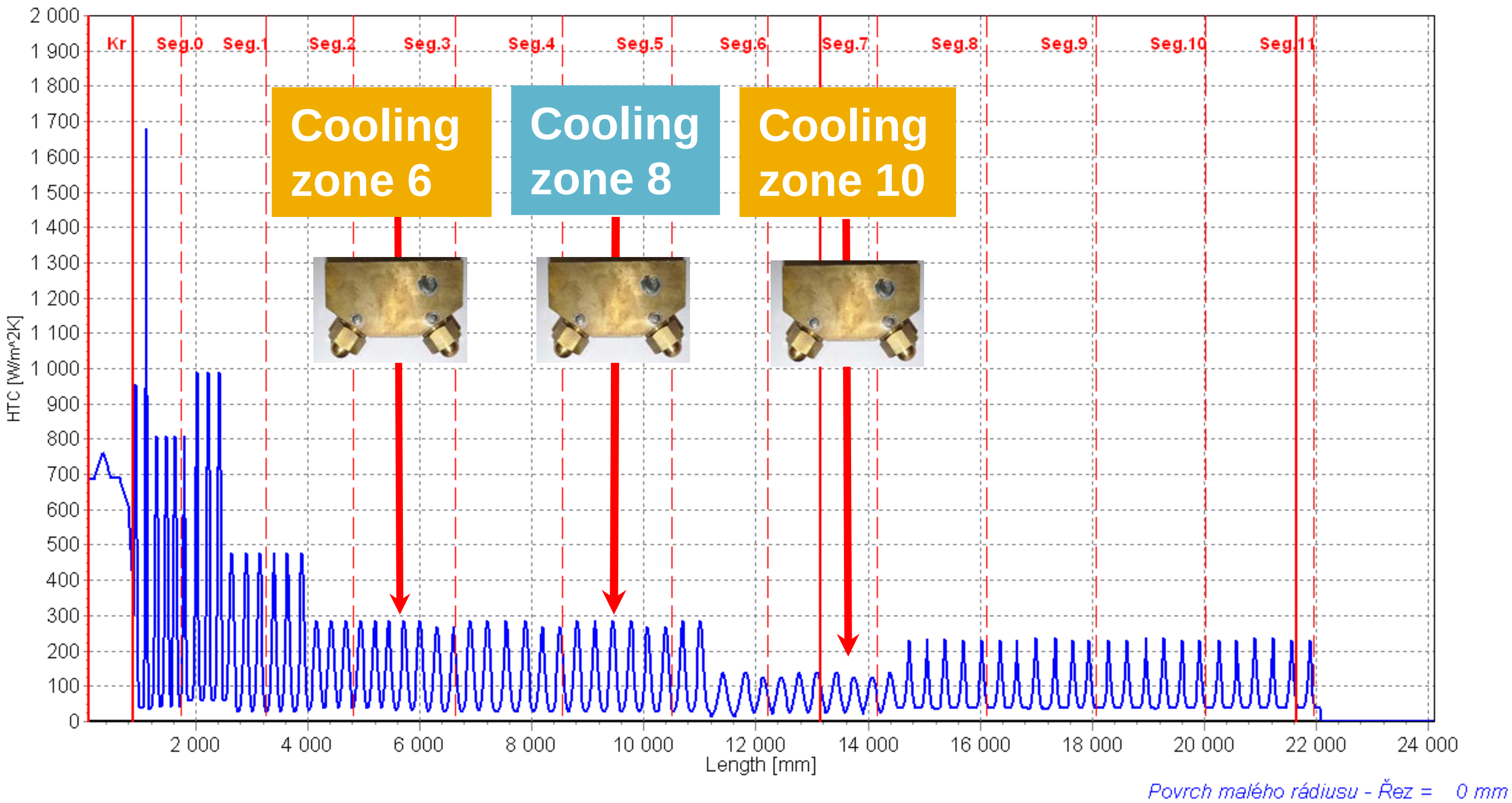
Q [W] heat flow   *htc [W.m^{-2}.K^{-1}]* heat transfer coefficient   *l, d [m] roller dimensions* ε [-] emissivity

OPTIMAL SURFACE TEMPERATURE AT UNBENDING POINT

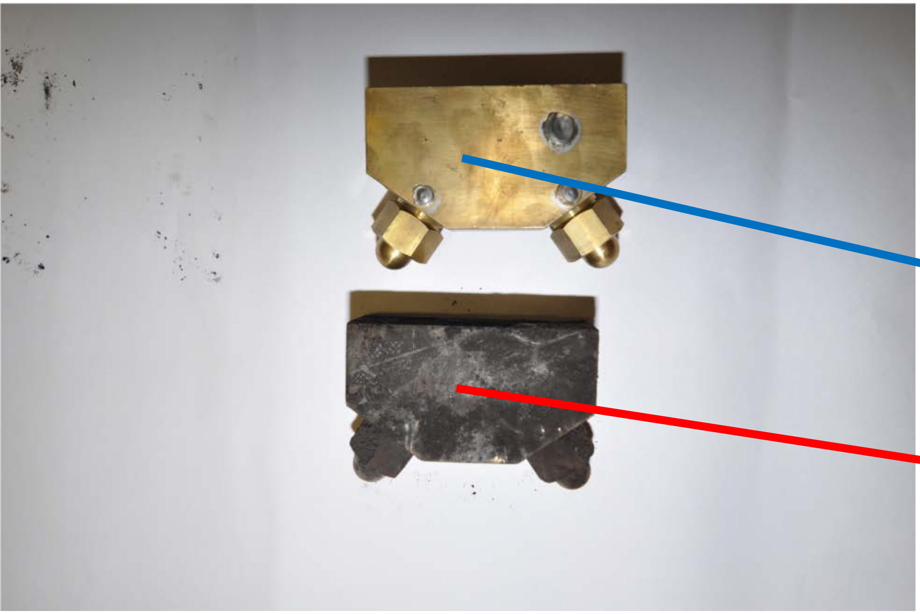




BOUNDARY CONDITIONS ALONG THE CASTER



CHARACTERISTICS OF NOZZLES LECHLER 100.638.30.24 AND 100.528.30.24



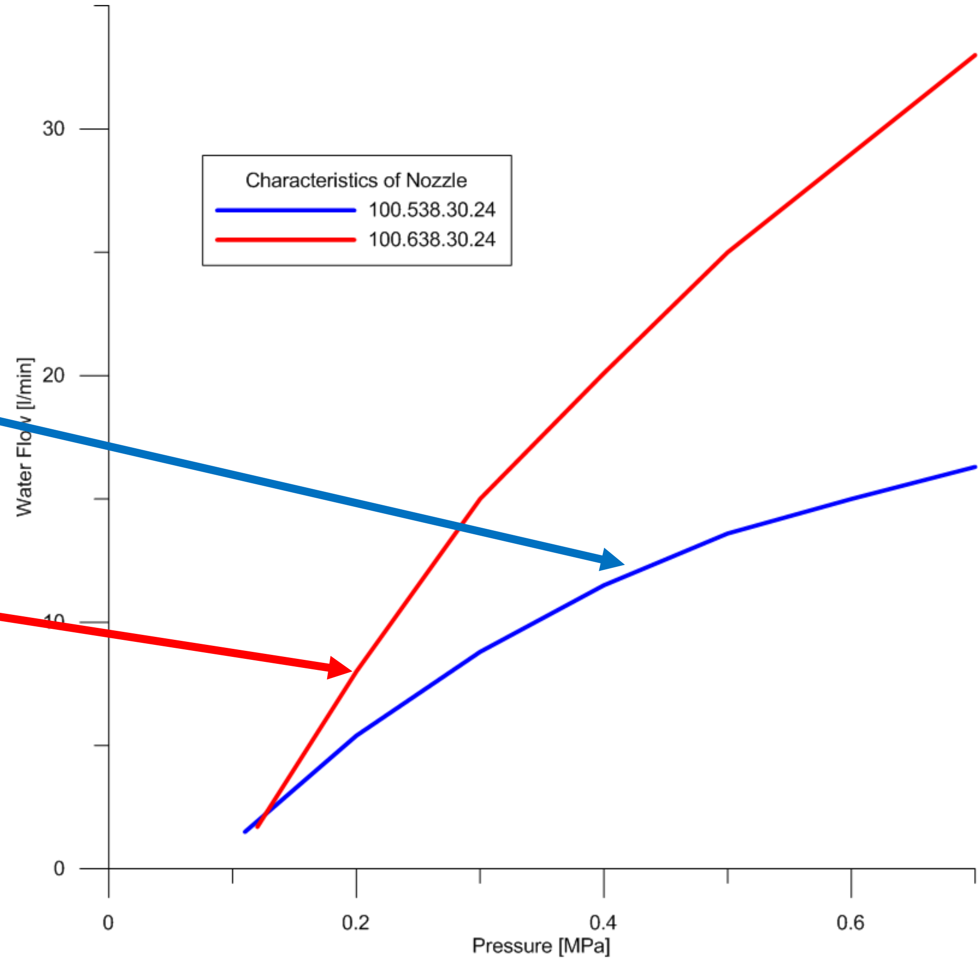
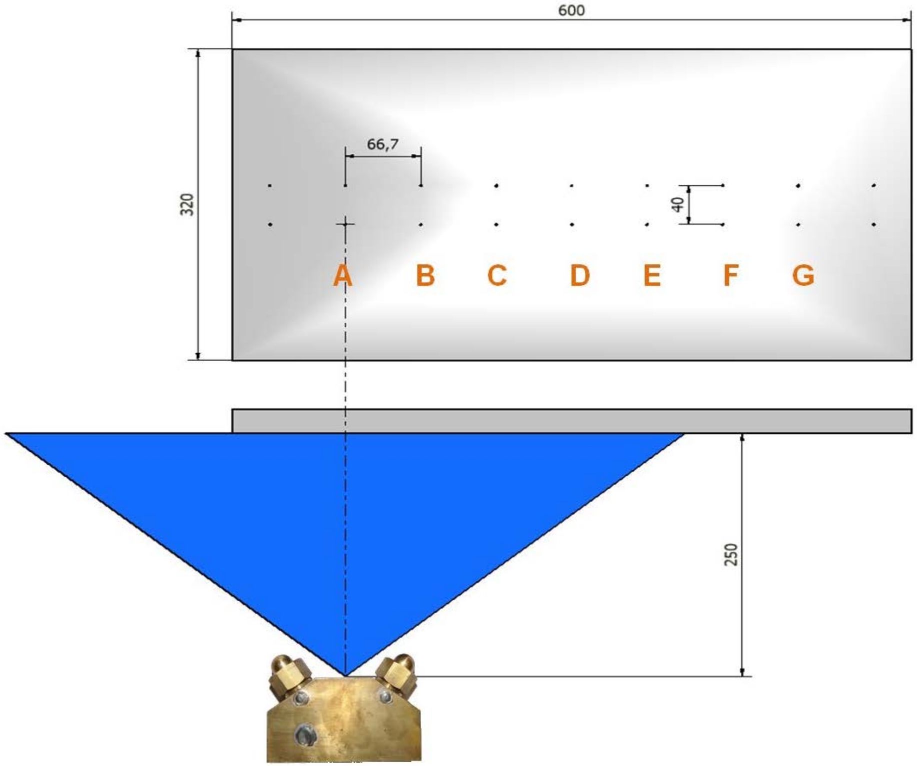
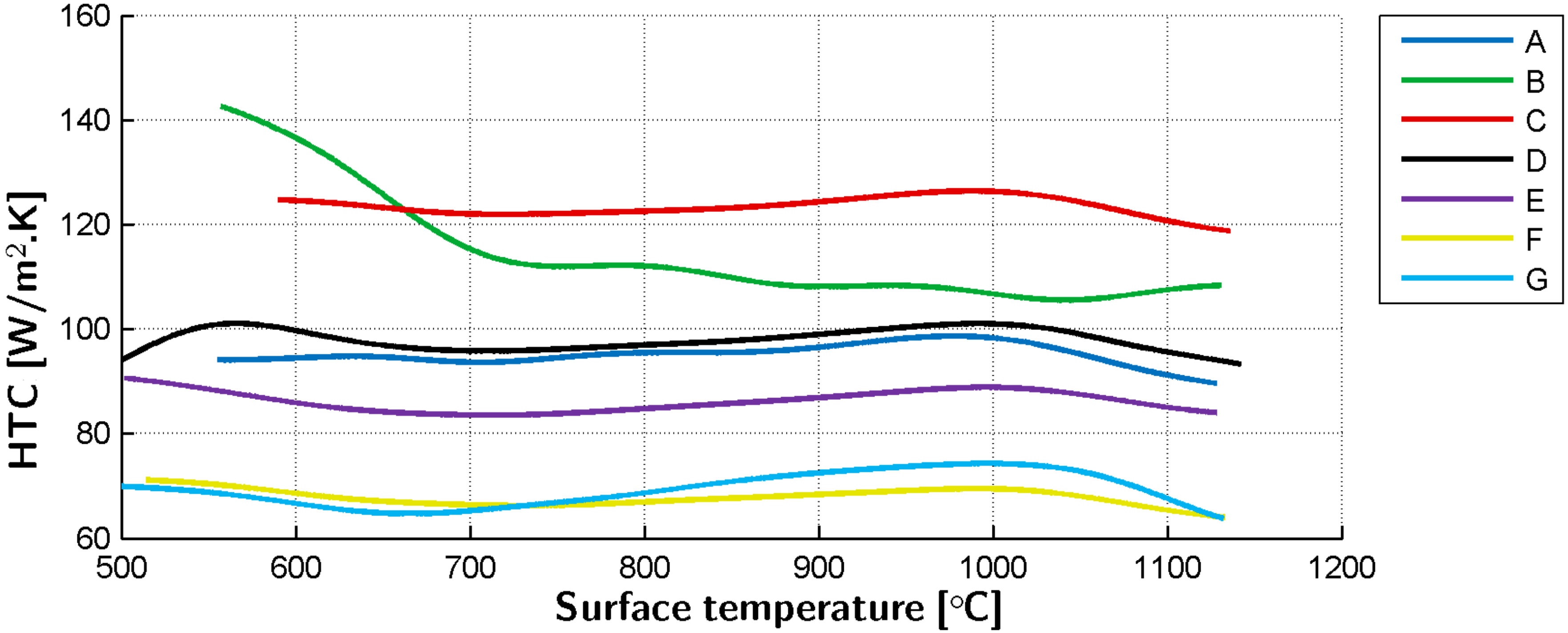


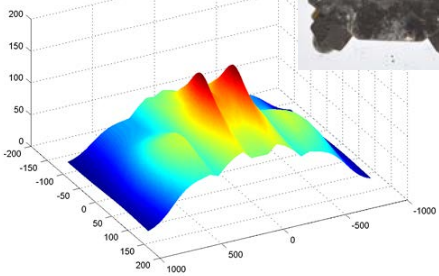
DIAGRAM OF MEASUREMENT CONFIGURATION OF THE COOLING EFFECTS OF NOZZLE

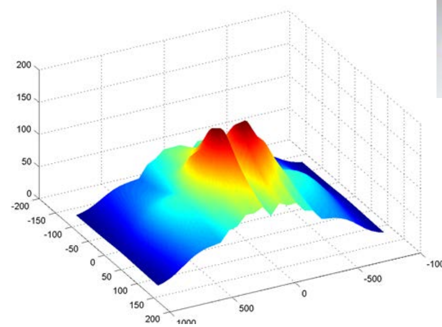


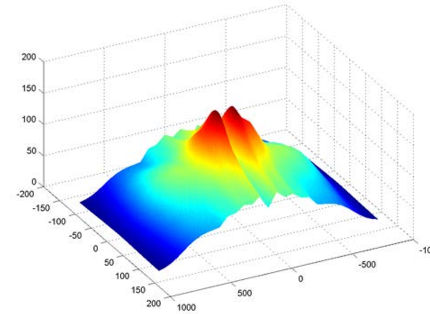
INFLUENCE OF SURFACE TEMPERATURE ON HTC

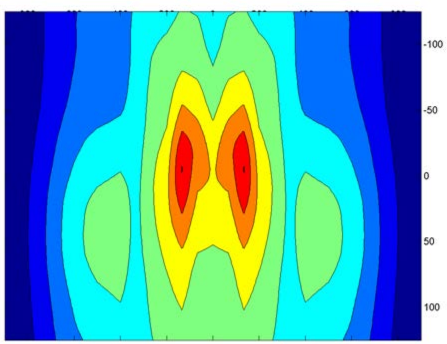


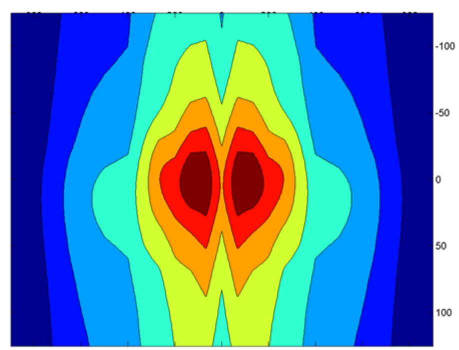
HEAT TRANSFER COEFFICIENT OF THE NOZZLE

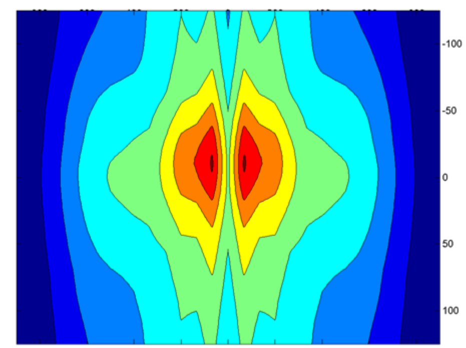










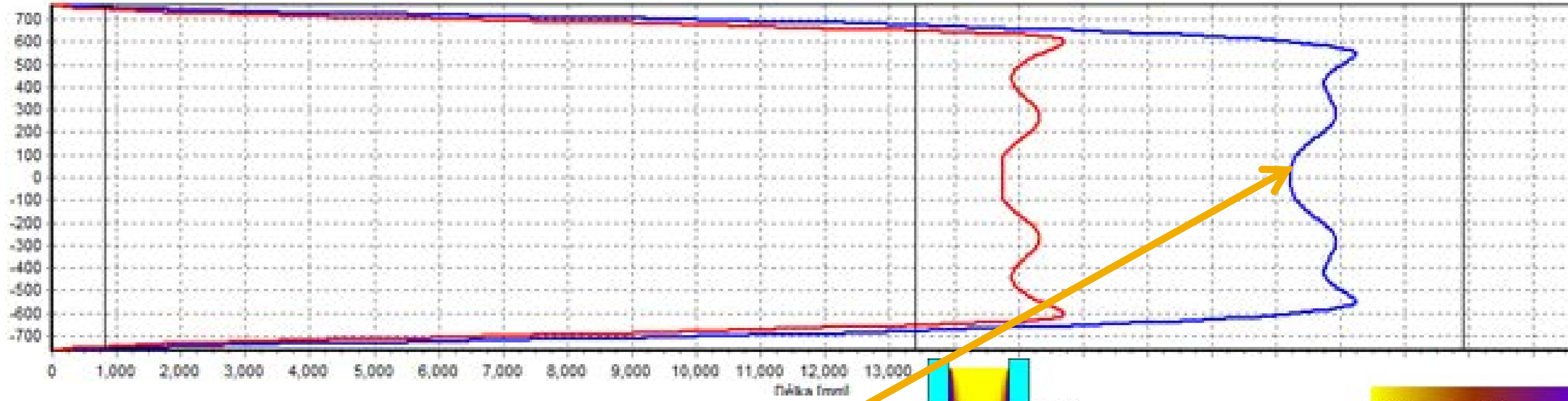


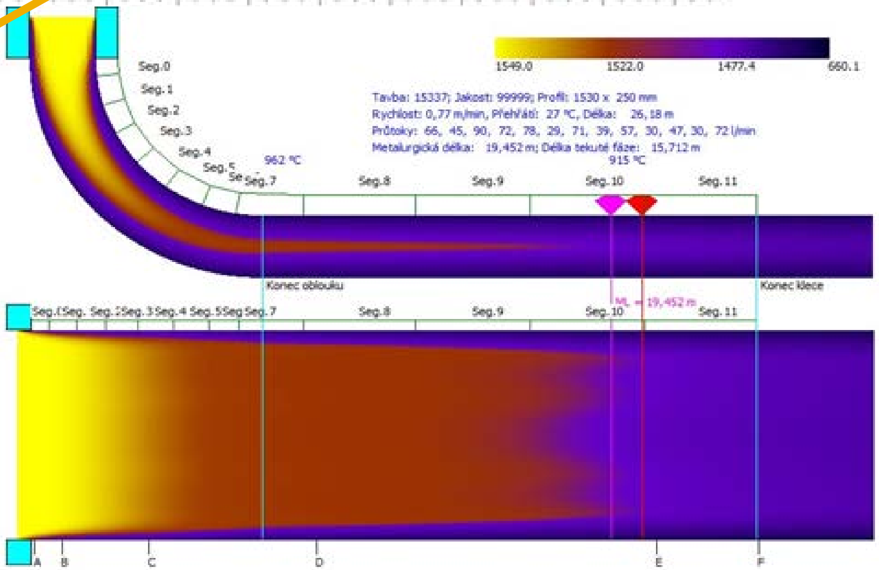
Nozzle 100.638.30.24
Water flow 2.2 l/min
Air pressure 0,2 MPa

Nozzle 100.528.30.24
Water flow 2.2 l/min
Air pressure 0,2 MPa

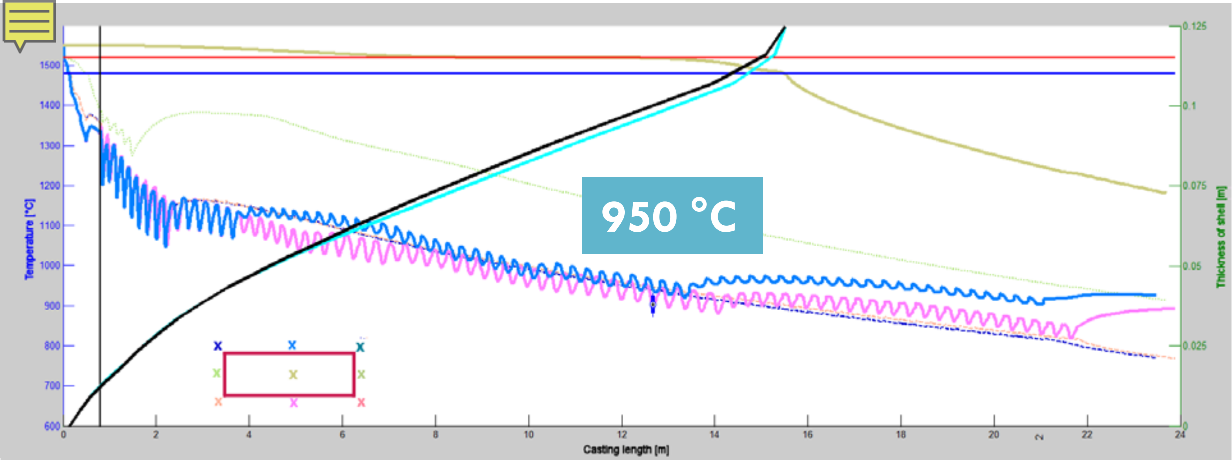
Nozzle 100.528.30.24
Water flow 1.5 l/min
Air pressure 0,2 MPa

TEMPERATURE FIELD OF CURRENT STATUS

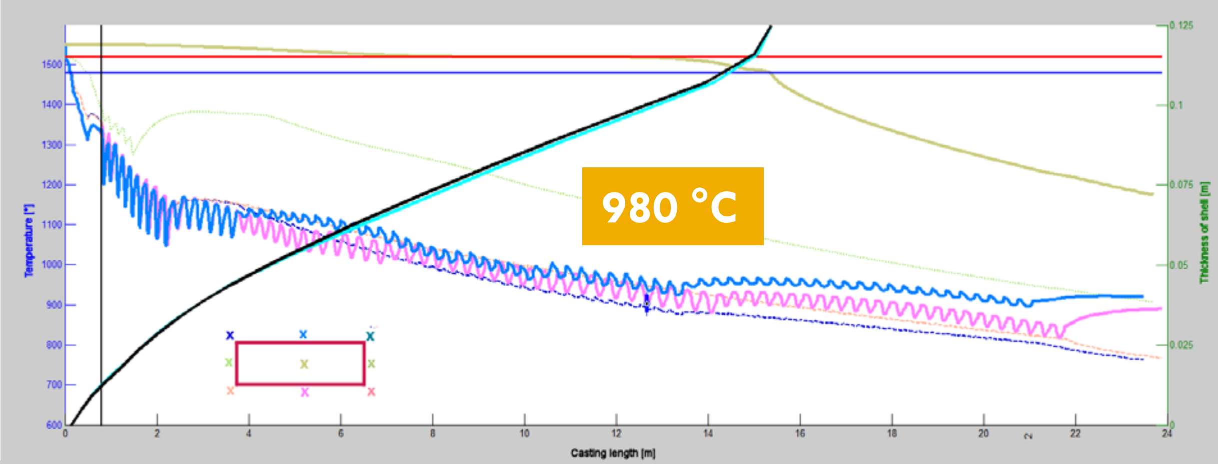




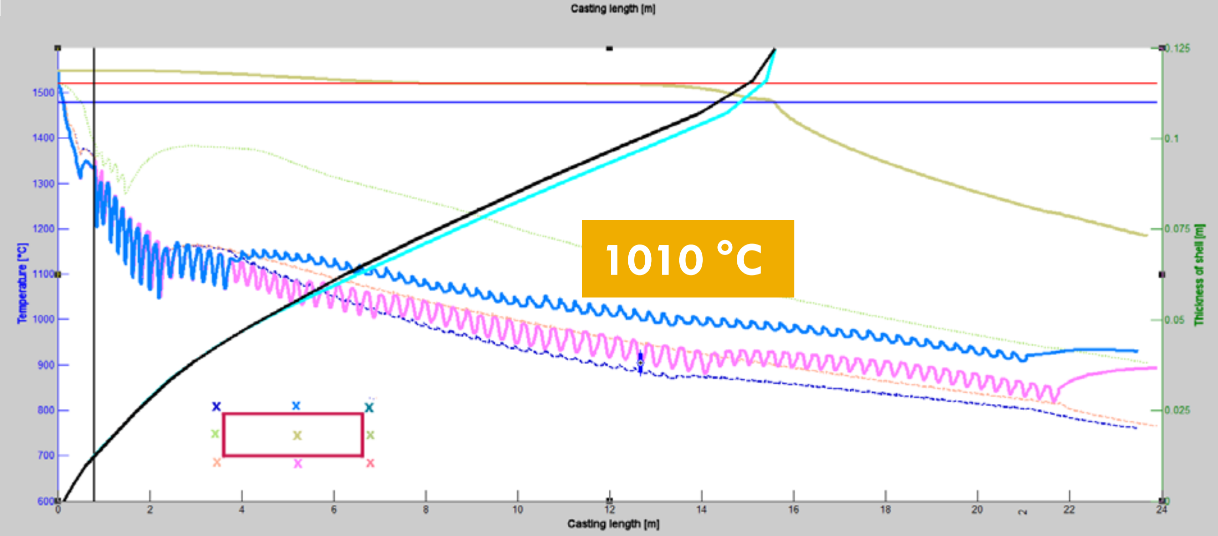
More intensive cooling in the middle of slab



Nozzles 100.638.30.24
Water flow per nozzle 2.2 l/min
Circuit 6 - 29 l/min
Circuit 8 - 39 l/min
Circuit 10 - 30 l/min

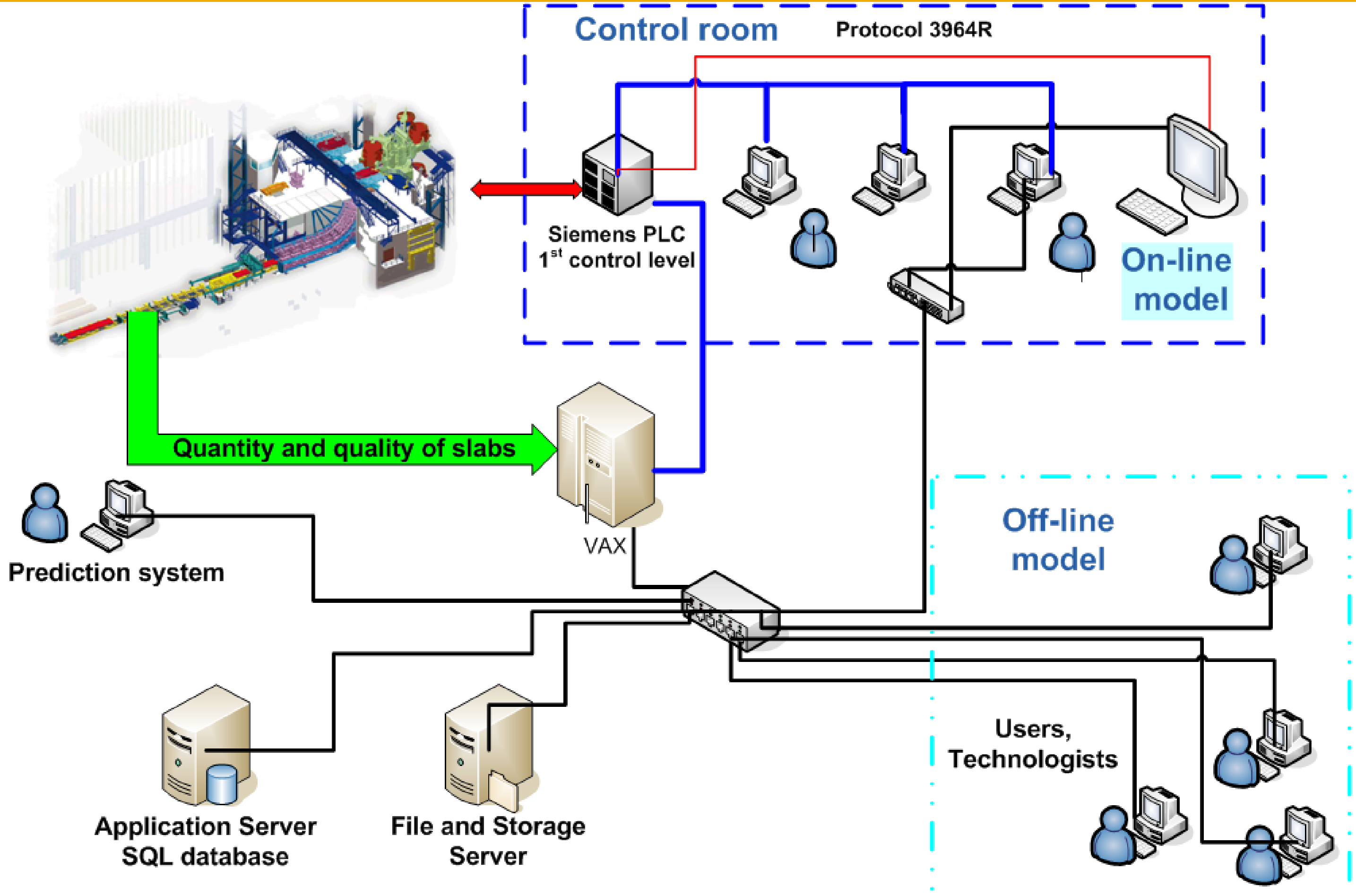


Nozzles 100.528.30.24
Water flow per nozzle 2.2 l/min
Circuit 6 - 29 l/min
Circuit 8 - 39 l/min
Circuit 10 - 30 l/min

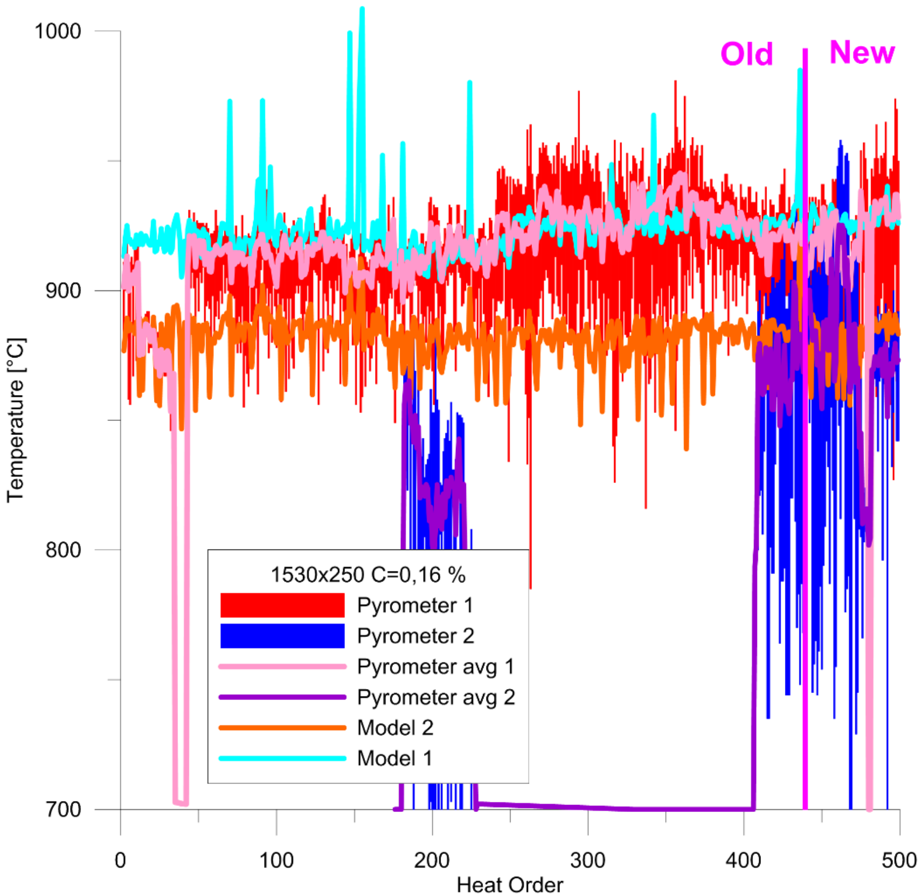


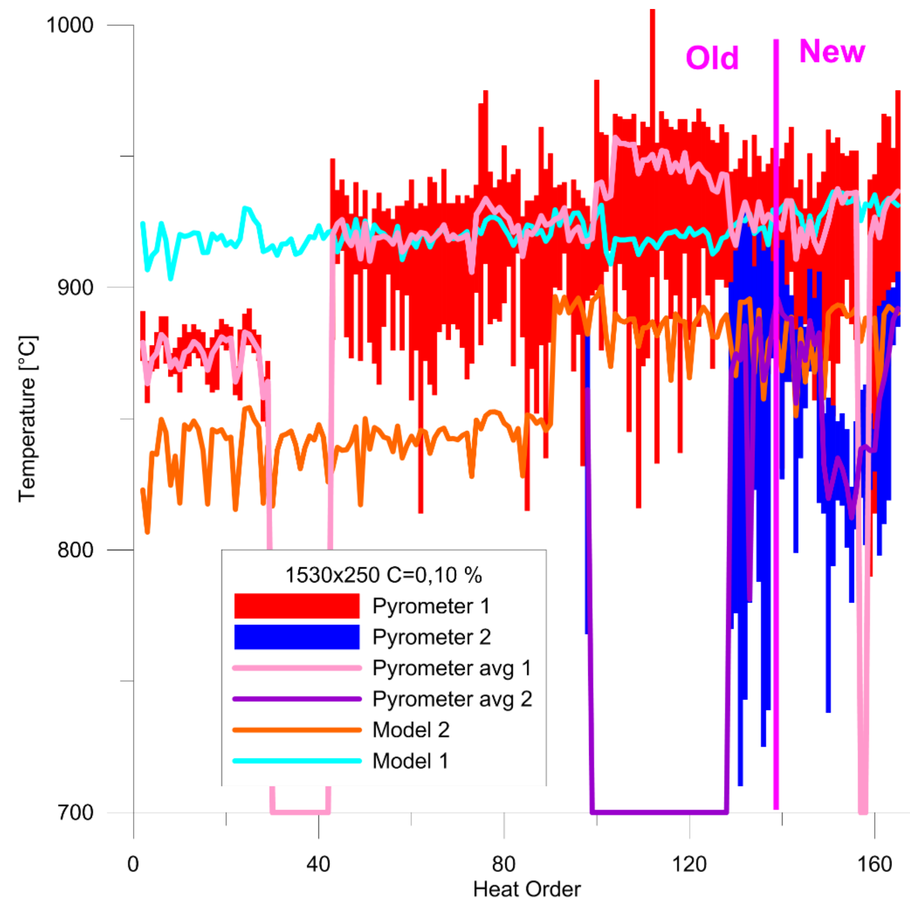
Nozzles 100.528.30.24
Water flow per nozzle 1.5 l/min
Circuit 6 - 18 l/min
Circuit 8 - 18 l/min
Circuit 10 - 15 l/min

THE CASTING TECHNOLOGY CONTROL SYSTEM

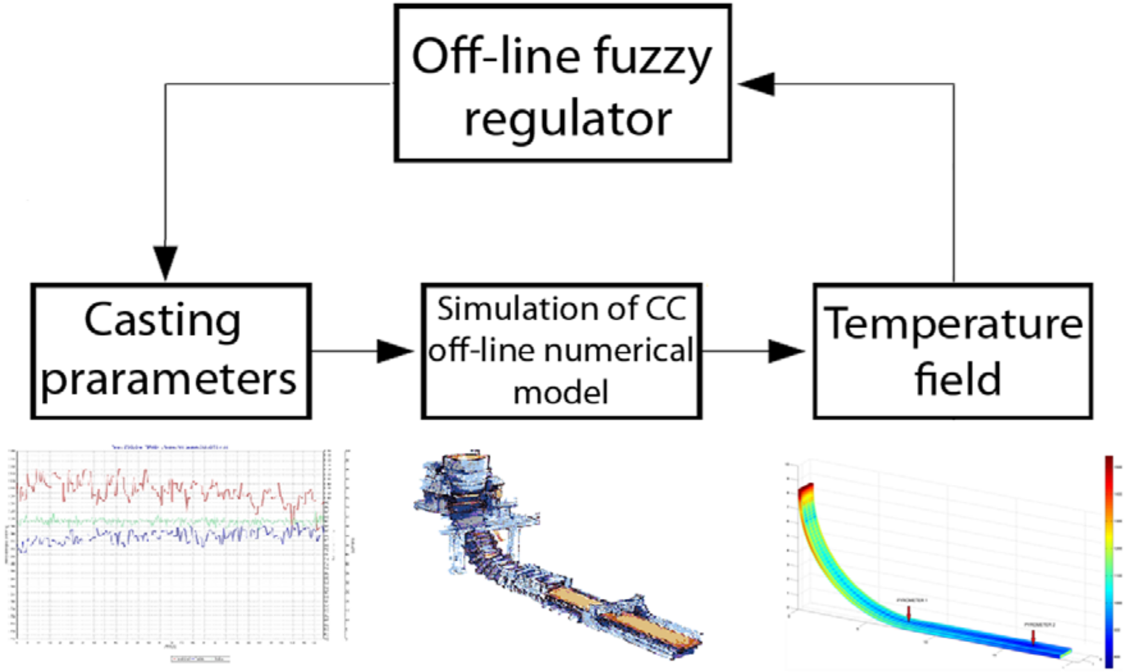


COMPARISON OF MEASURED AND CALCULATED TEMPERATURES



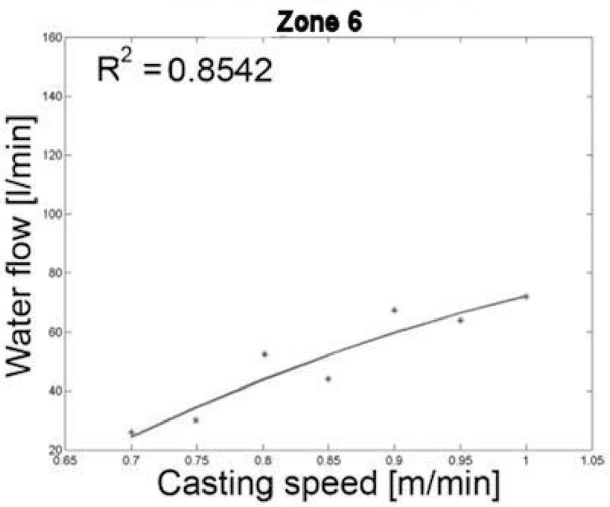


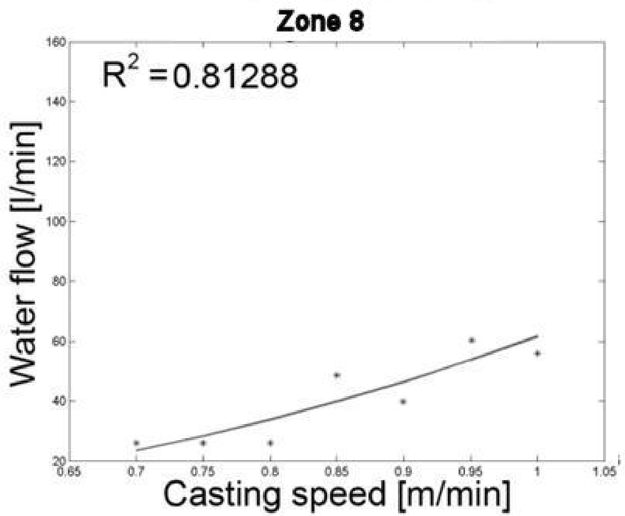
FUZZY REGULATOR FOR OPTIMIZATION CONTINUOUS CASTING PROCESS

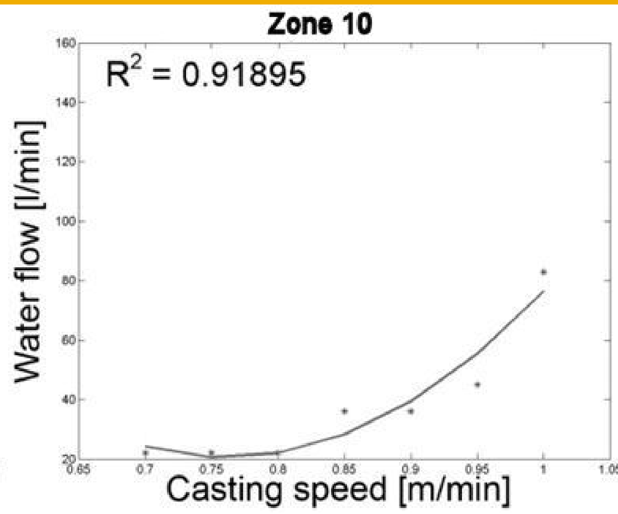


- Maximize the productivity of casting by maximizing the casting speed
- Reach good surface quality by keeping the surface temperature at certain intervals.
- Control the inner quality which is influenced by the position of the metallurgical length
- Optimal react on dynamic changes of process parameters

POSSIBLE USAGE OF FUZZY REGULATOR







The optimal relationship between casting speed and cooling intensity.

$$WaterFlow = \beta_0 + \beta_1 Speed + \beta_2 Speed^2$$

CONCLUSION

- Using numerical simulations, experimental measurements and inverse task has been verified that the replacement of a smaller type of nozzle will meet the requirement to increase the surface temperatures on a small radius at point of unbending
- Cooling effect of nozzle in the temperature interval from 700 to 1100 ° C does not depend on surface temperature of slabs
- The new smaller nozzle reduces cooling of the surface at the same flow rate of 10 % and allows use of smaller water flow and then cooling reduce by up to 20 %
- Monitoring of secondary cooling and operation of the caster using the on-line model

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