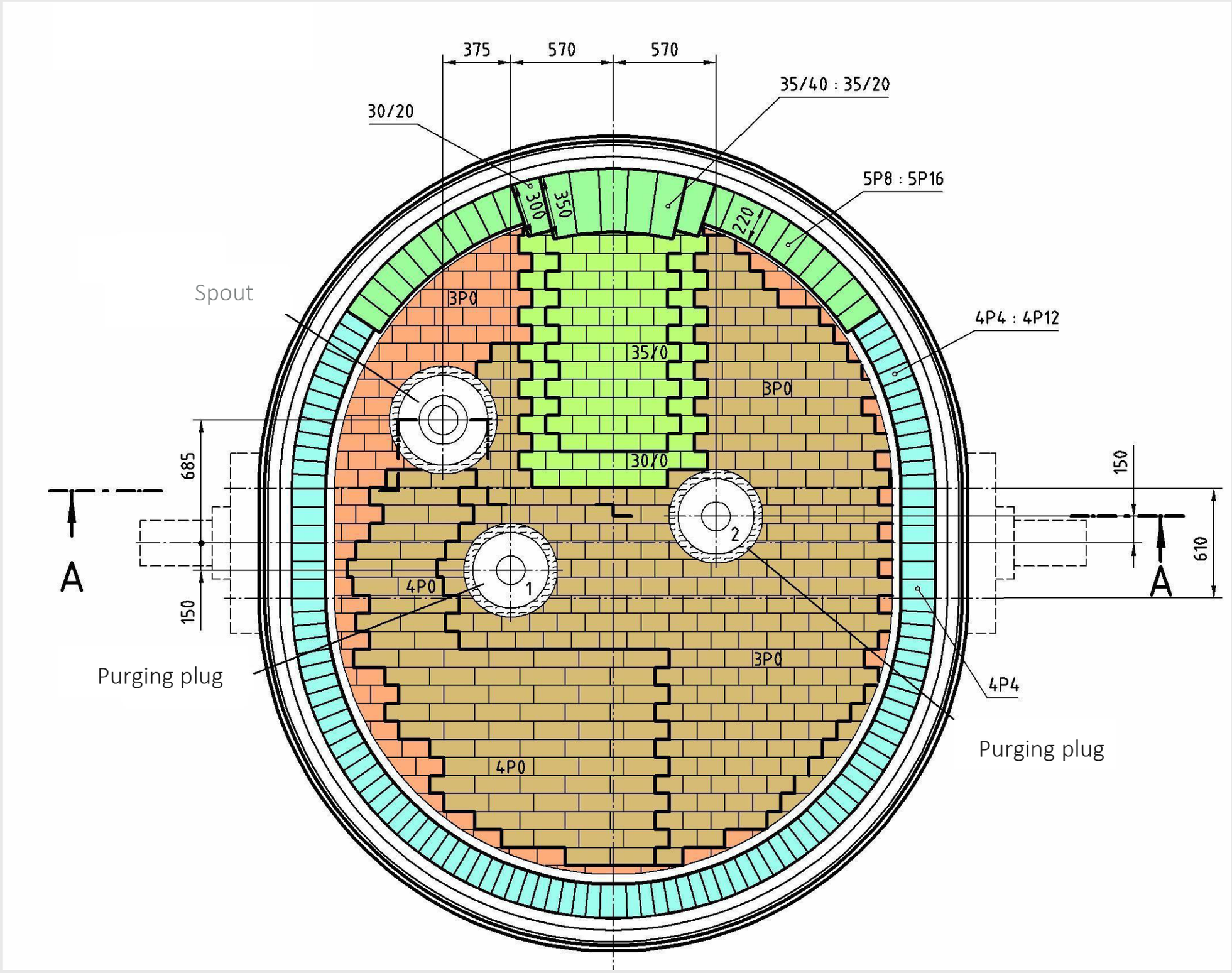
# Purging plugs in steel ladles - important factors for reliable performance

28.04.2022, Dr. Stephan Clasen

# AIMS OF THE PURGE GAS TREATMENT

- Homogenisation of the temperature and the distribution of the alloying elements
- Realization of a two-phase equilibrium between molten steel and slag
- Reduction of harmful trace elements
- Transfer of non-metallic inclusions and other impurities into the slag

# PURGING PLUGS



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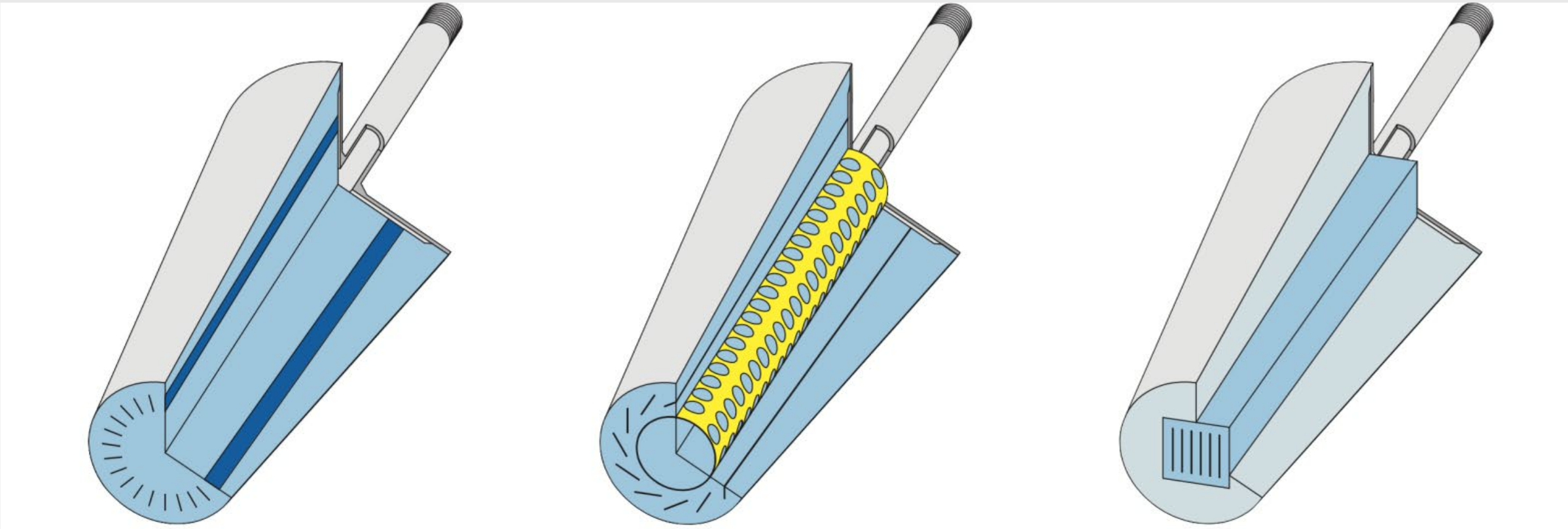

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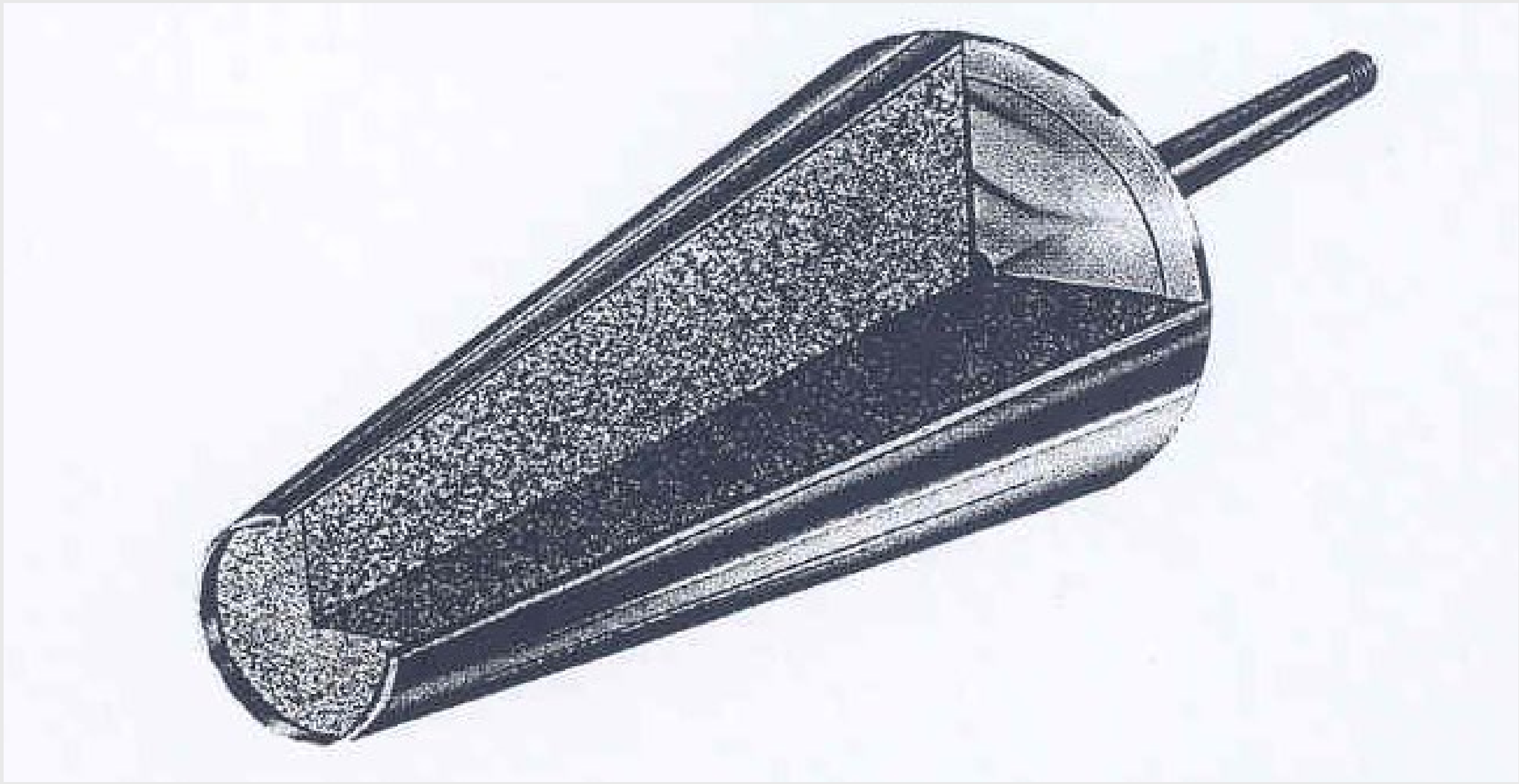
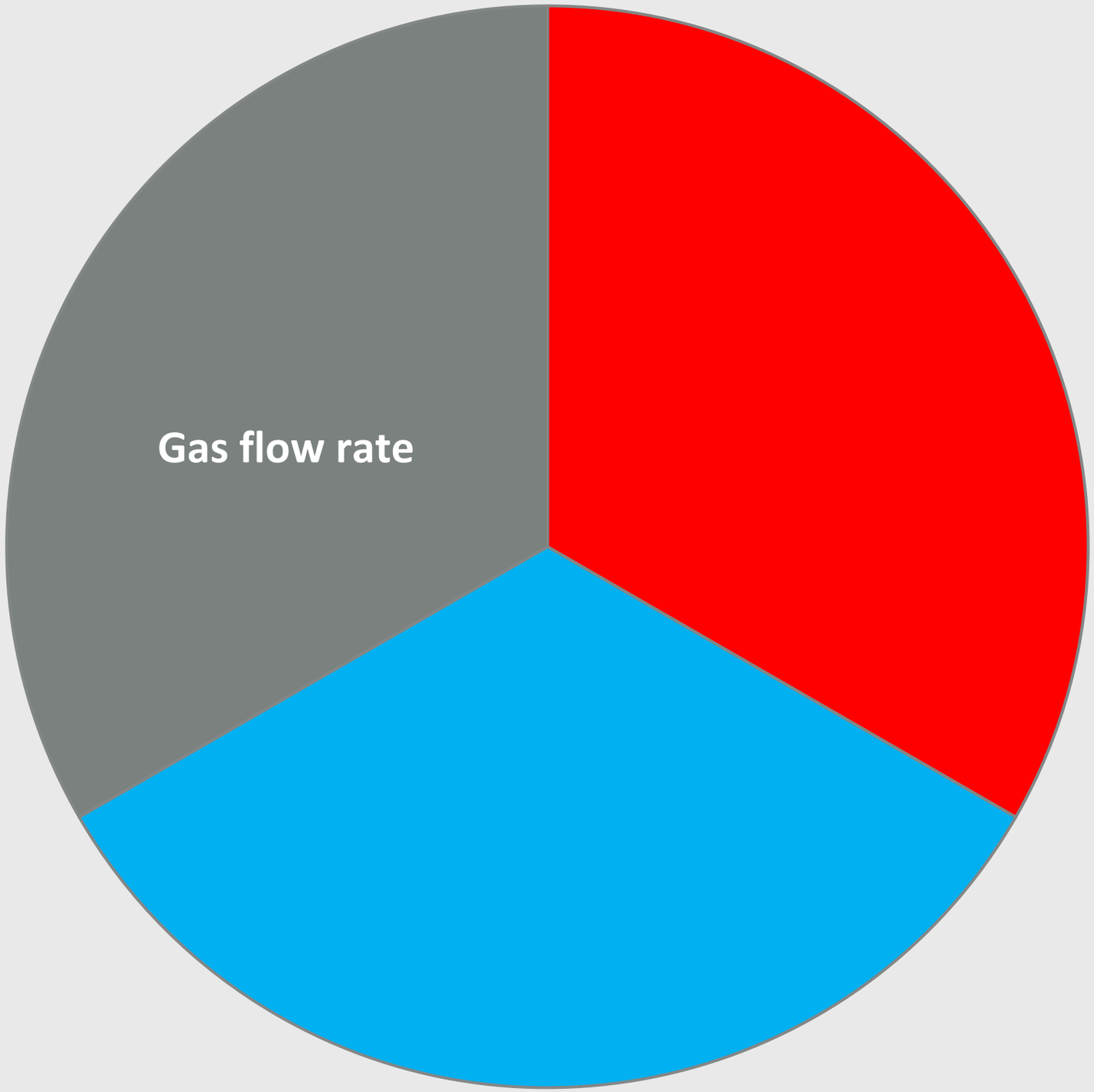


Source: Kneis, L., Trummer, B., Knabel, B., The Hybrid Plug -An Innovative Puring Plug for Steel Ladles, RHI Bulletin, 2004, S. 34-38

# PURGING PLUG REQUIREMENTS



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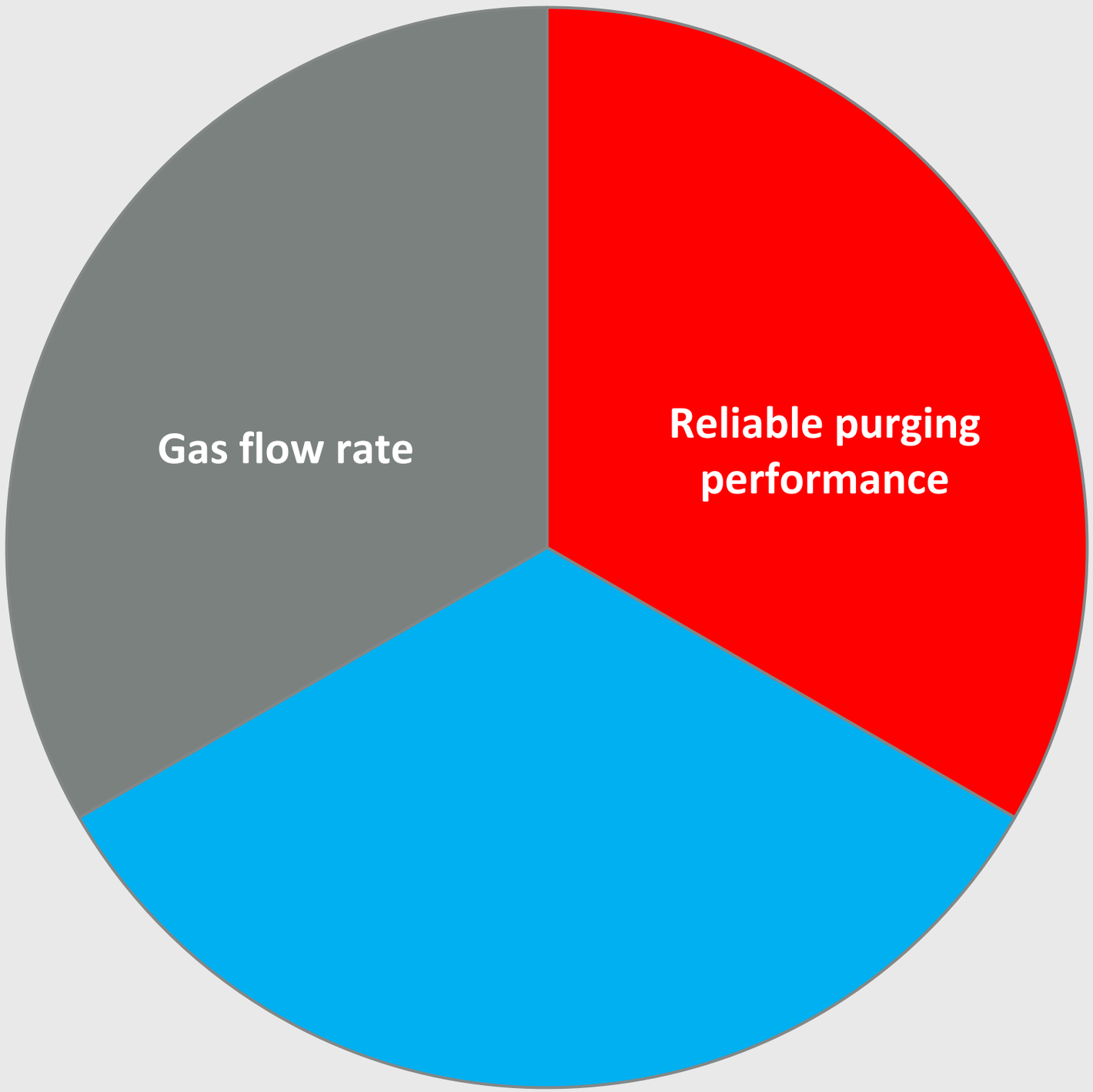

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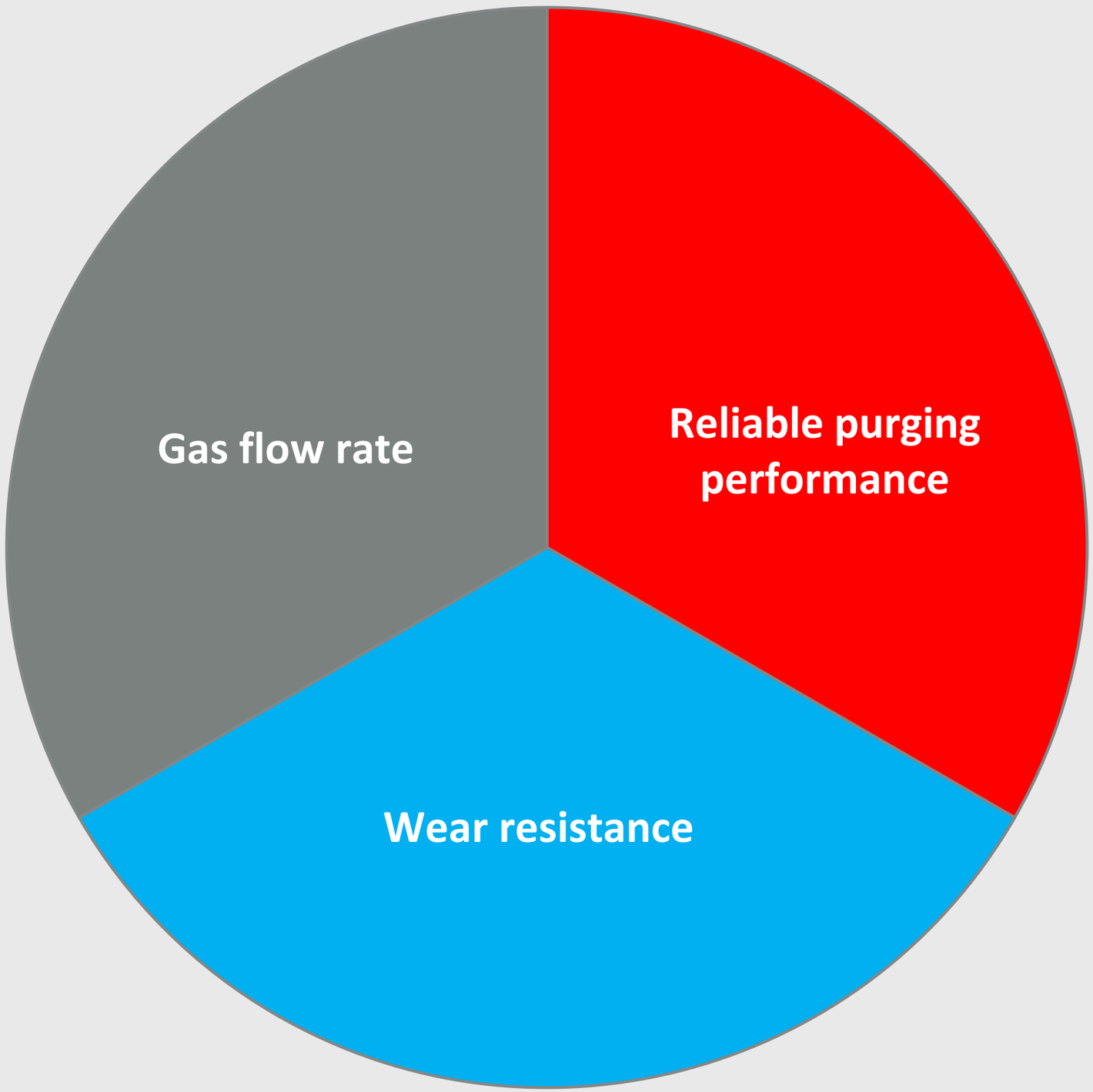

# THE MAIN CAUSE FOR THE INSUFFICIENT PURGING PLUG AVAILABILITY

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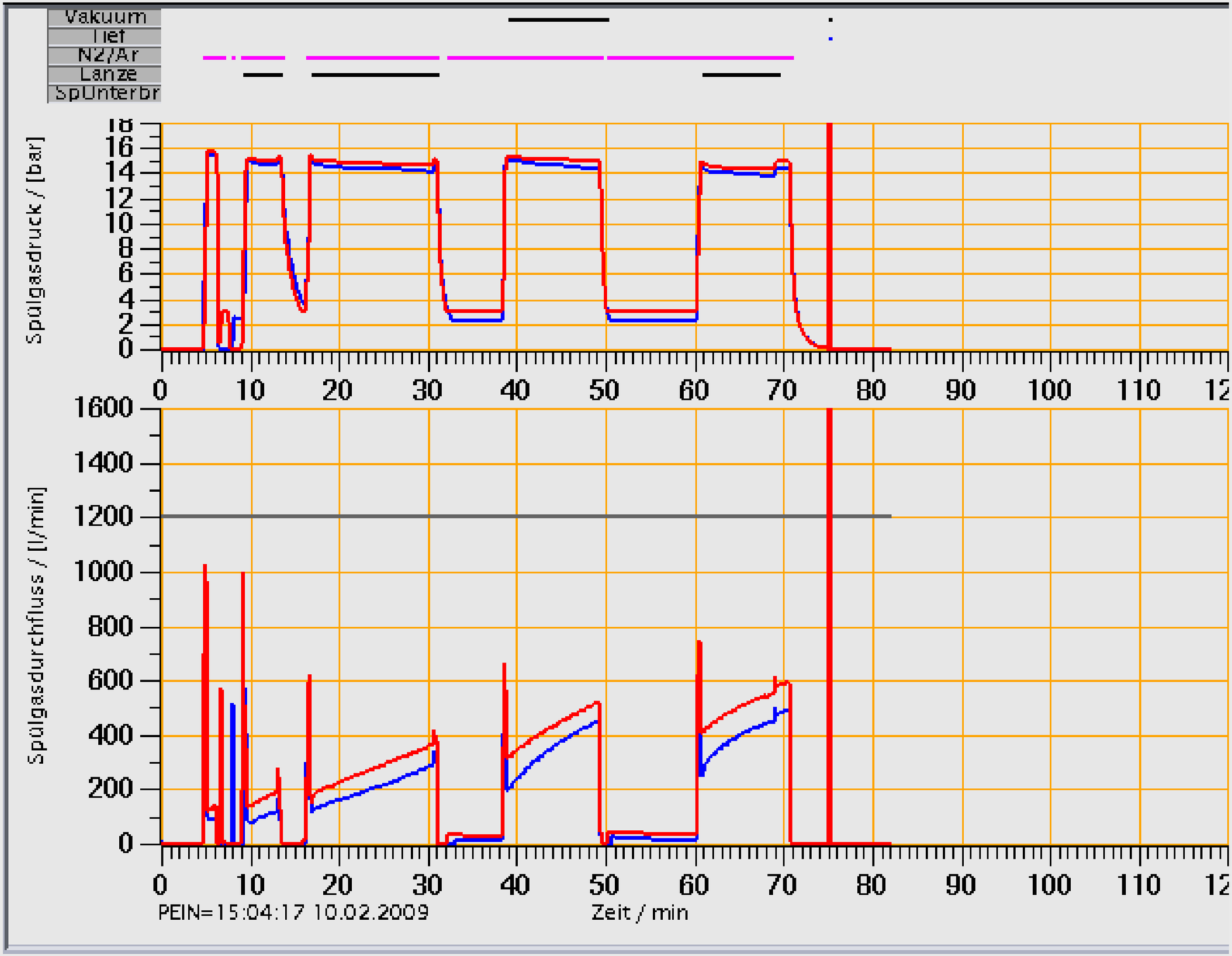
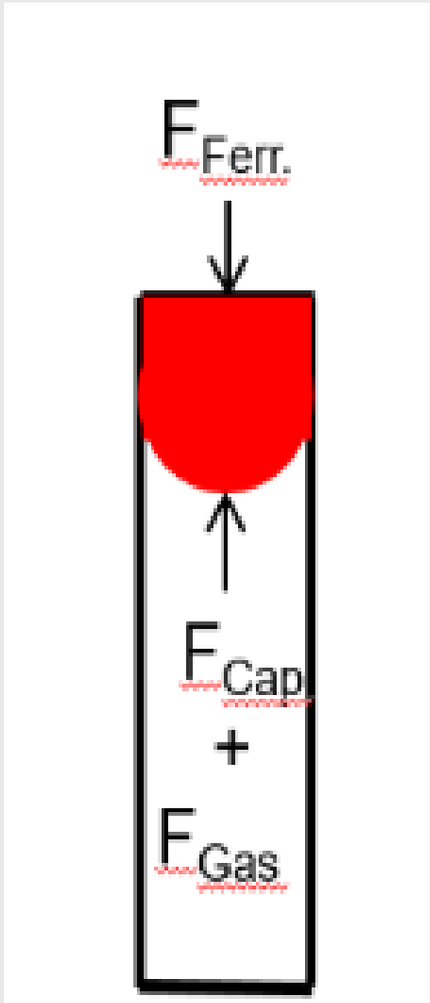


- The treatment time is extended
- Downgrade of the steel melt
- Reprocess of the steel melt

# CRITICAL INFILTRATION PRESSURE (SLIT GAS CHANNEL)

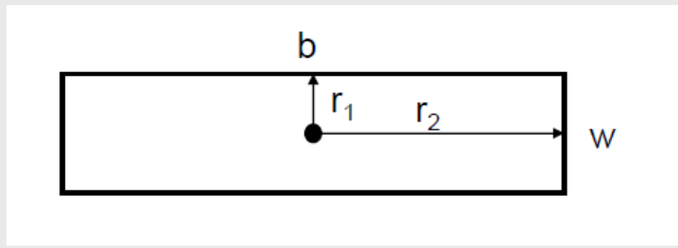
Equilibrium of forces without purge gas pressure

$$(g \cdot h_{Steel} \cdot \rho_s) \cdot w \cdot b = \left( -\left( \frac{\gamma_{LV}}{r_1} + \frac{\gamma_{LV}}{r_2} \right) \cdot \cos\theta \right) \cdot w \cdot b$$




Equilibrium of forces with purge gas pressure

$$(g \cdot h_{Steel} \cdot \rho_s) \cdot w \cdot b = \left( -\left( \frac{\gamma_{LV}}{r_1} + \frac{\gamma_{LV}}{r_2} \right) \cdot \cos\theta + p_{Gas} \right) \cdot w \cdot b$$



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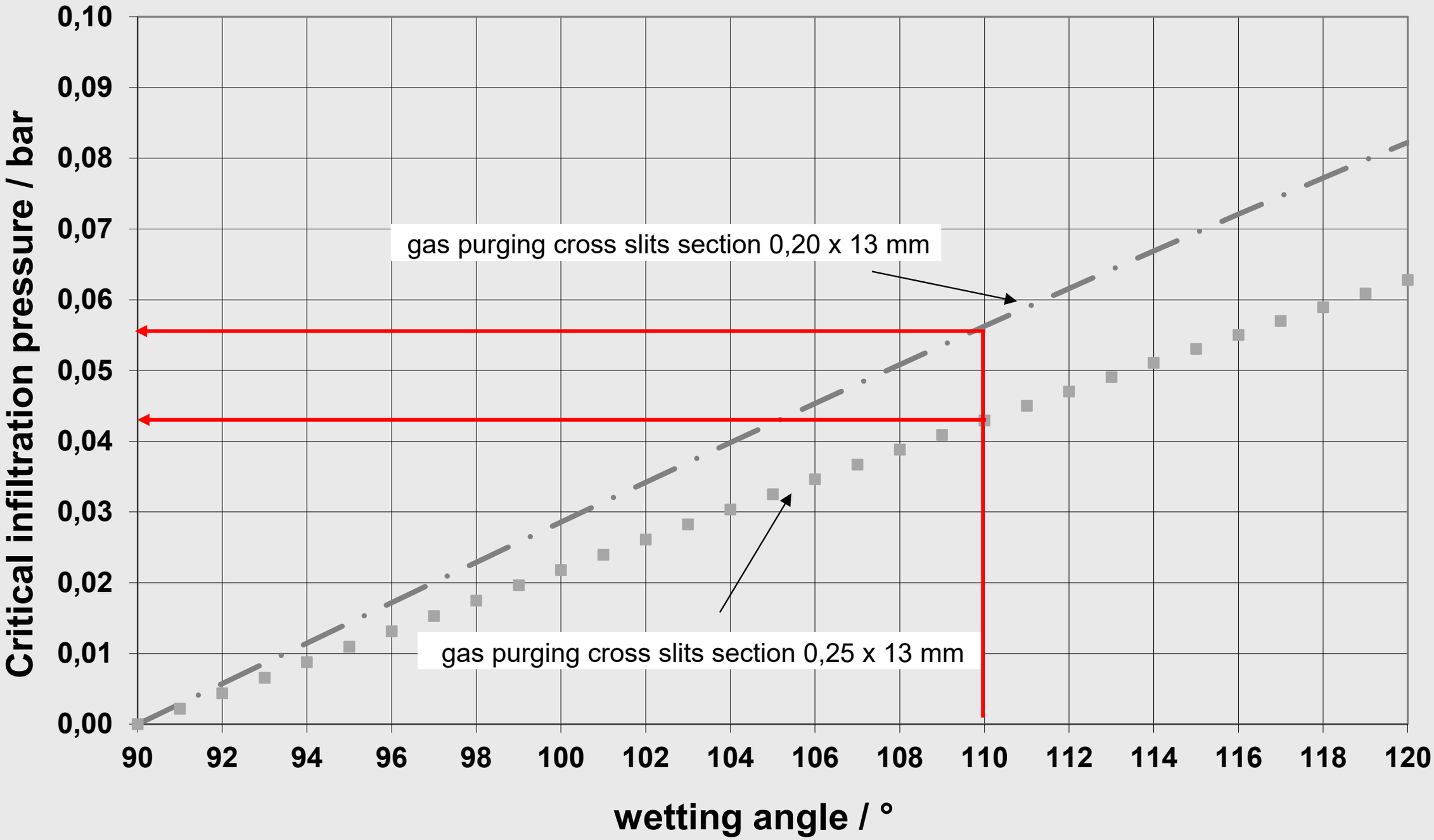
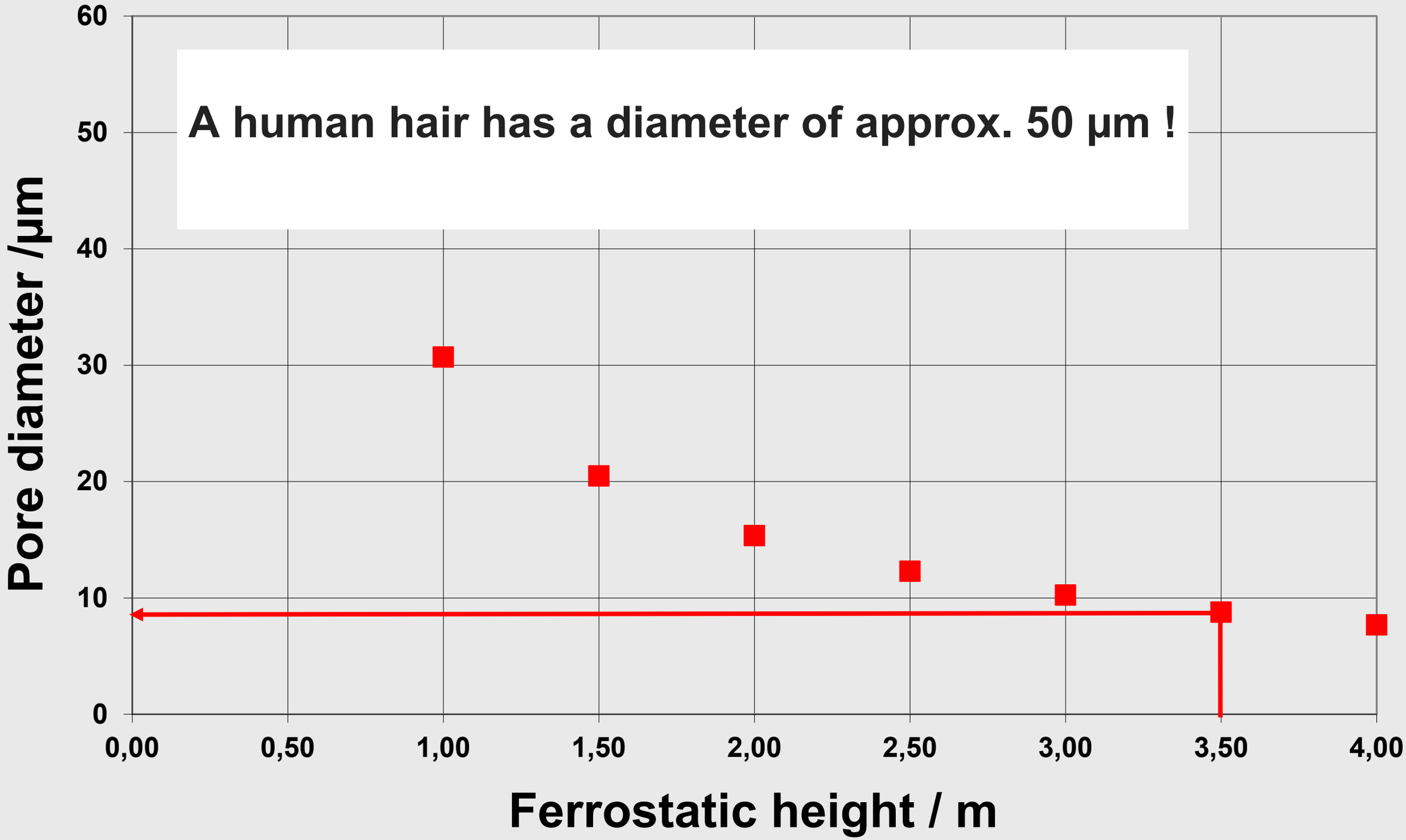


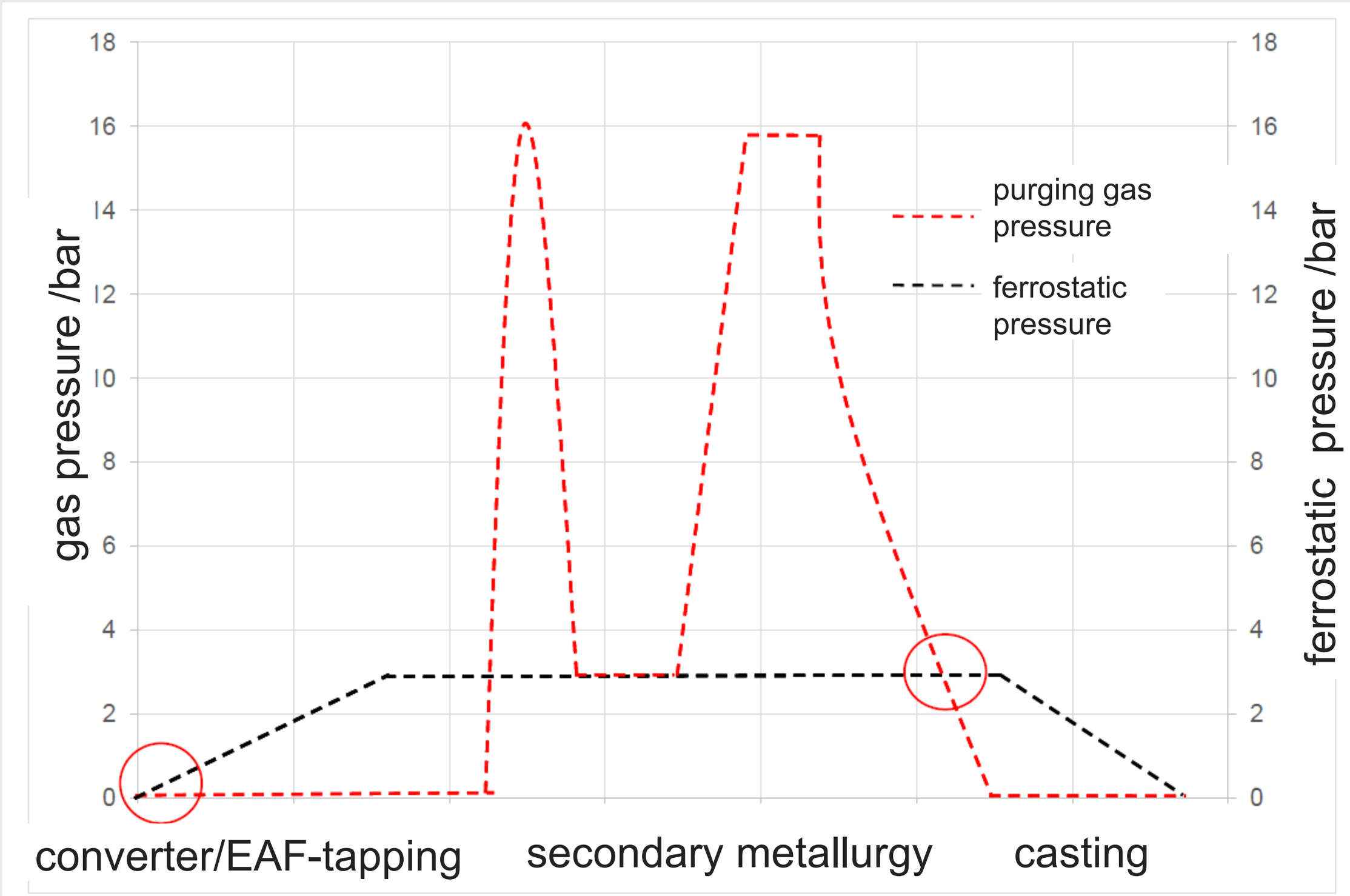

$$\left(g \cdot h_{Steel} \cdot \rho_s\right) \cdot w \cdot b = \left( -\left( \frac{\gamma_{LV}}{r_1} + \frac{\gamma_{LV}}{r_2} \right) \cdot \cos\theta \right) \cdot w \cdot b$$

# CRITICAL PORE SIZE (POROUS PLUG)




$$d=\frac{-4\cdot\gamma_{LV}\cdot cos\theta}{g\cdot h\cdot\rho}$$

# CRITICAL PROCESS SITUATIONS FOR INFILTRATION



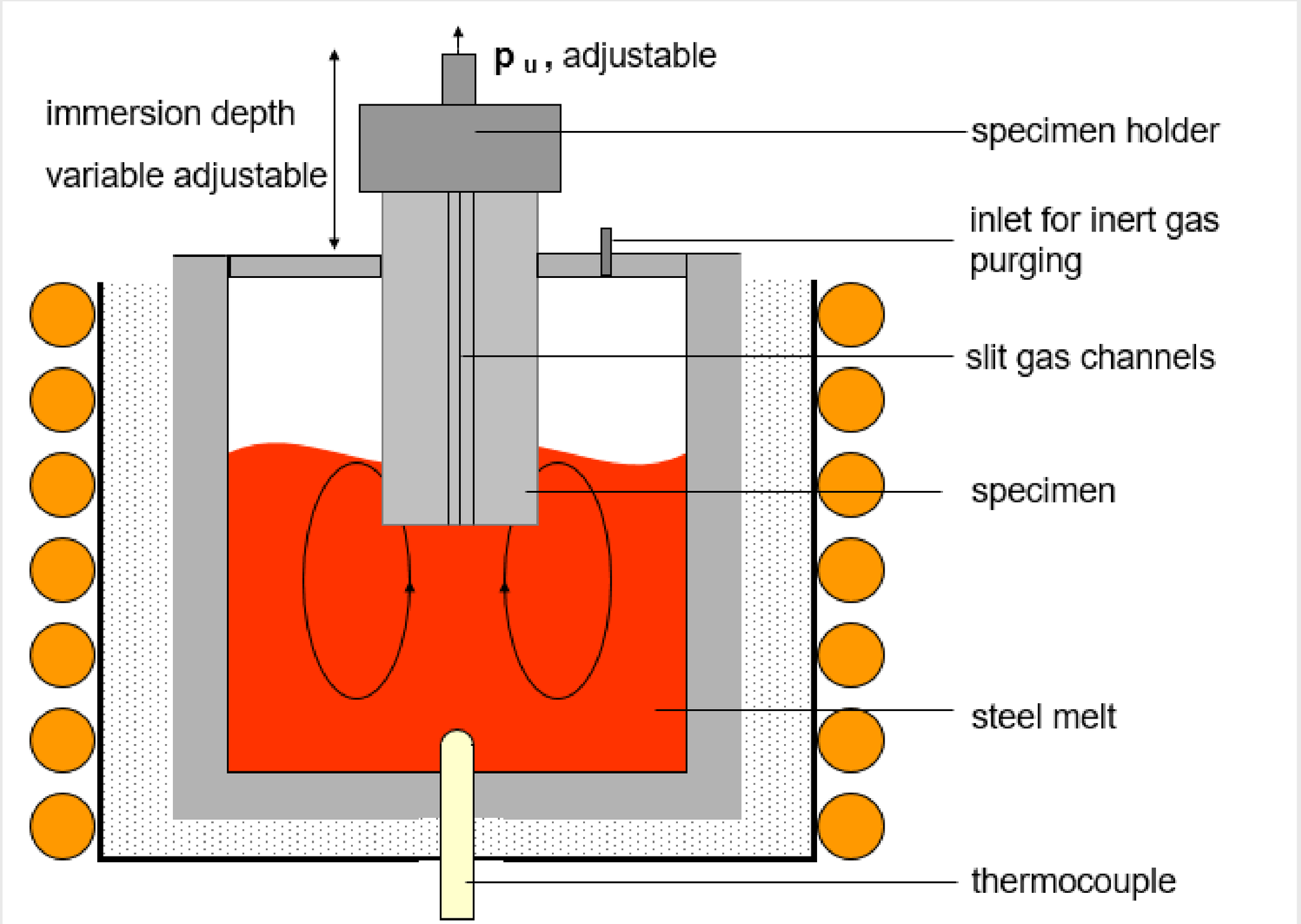
## WHICH PARAMETERS AFFECT THE DEPTH OF INFILTRATION ?

Is the depth of infiltration influenced by:

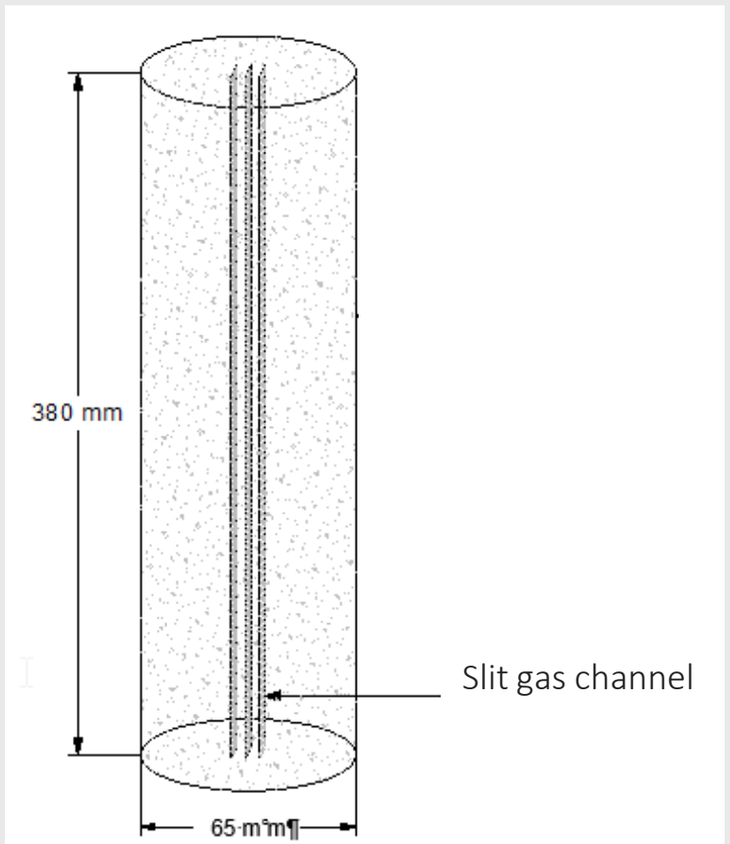
- the pressure difference ?
- the gas channel width ?
- the steel melt temperature ?

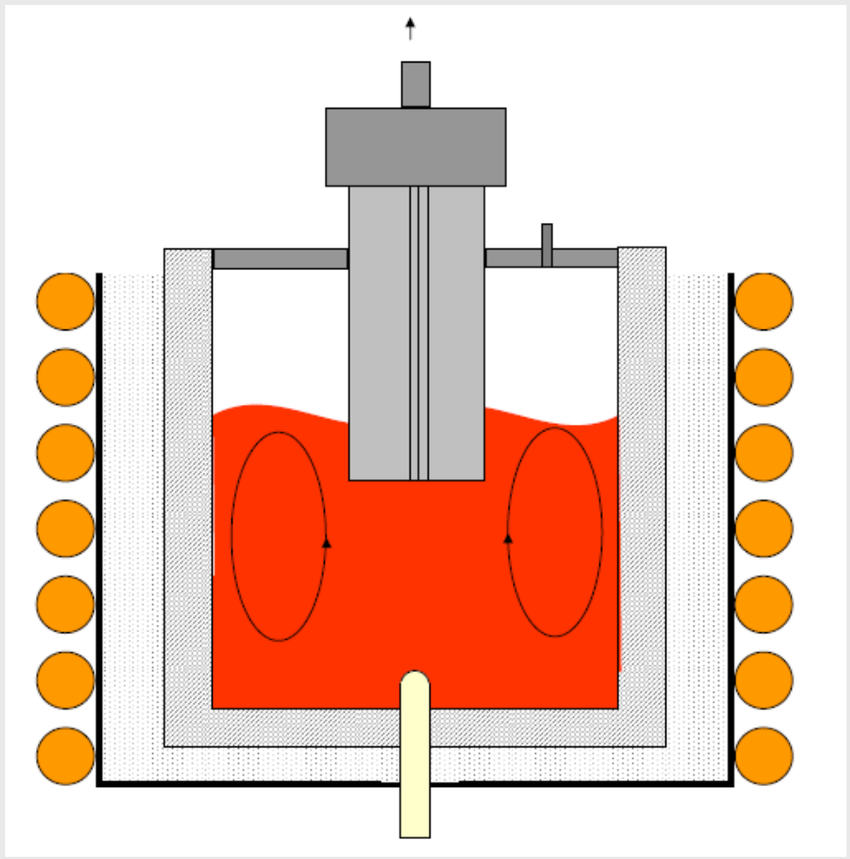
Which operational infiltration behavior can be expected ?

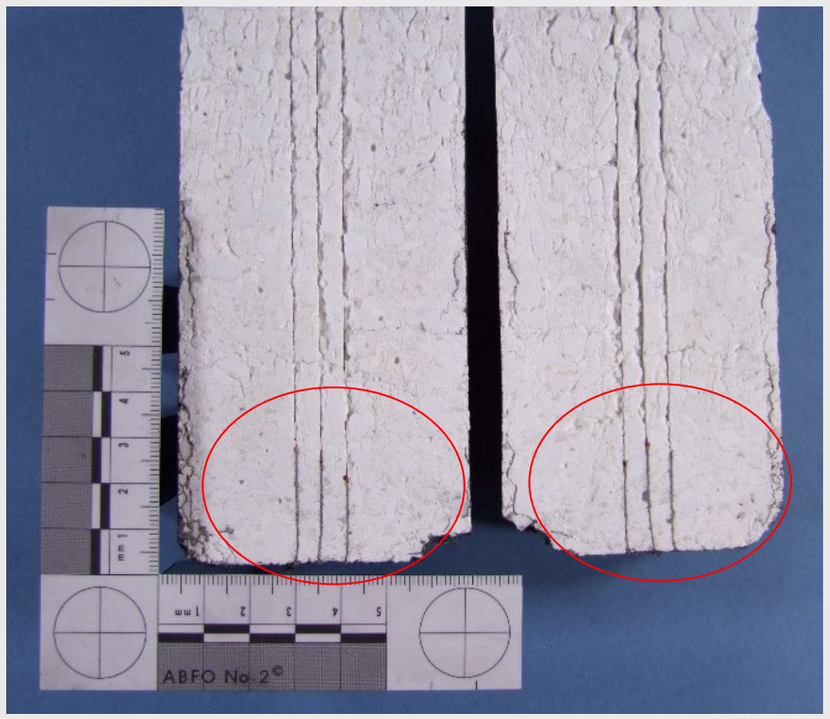
# EXPERIMENTAL SETUP



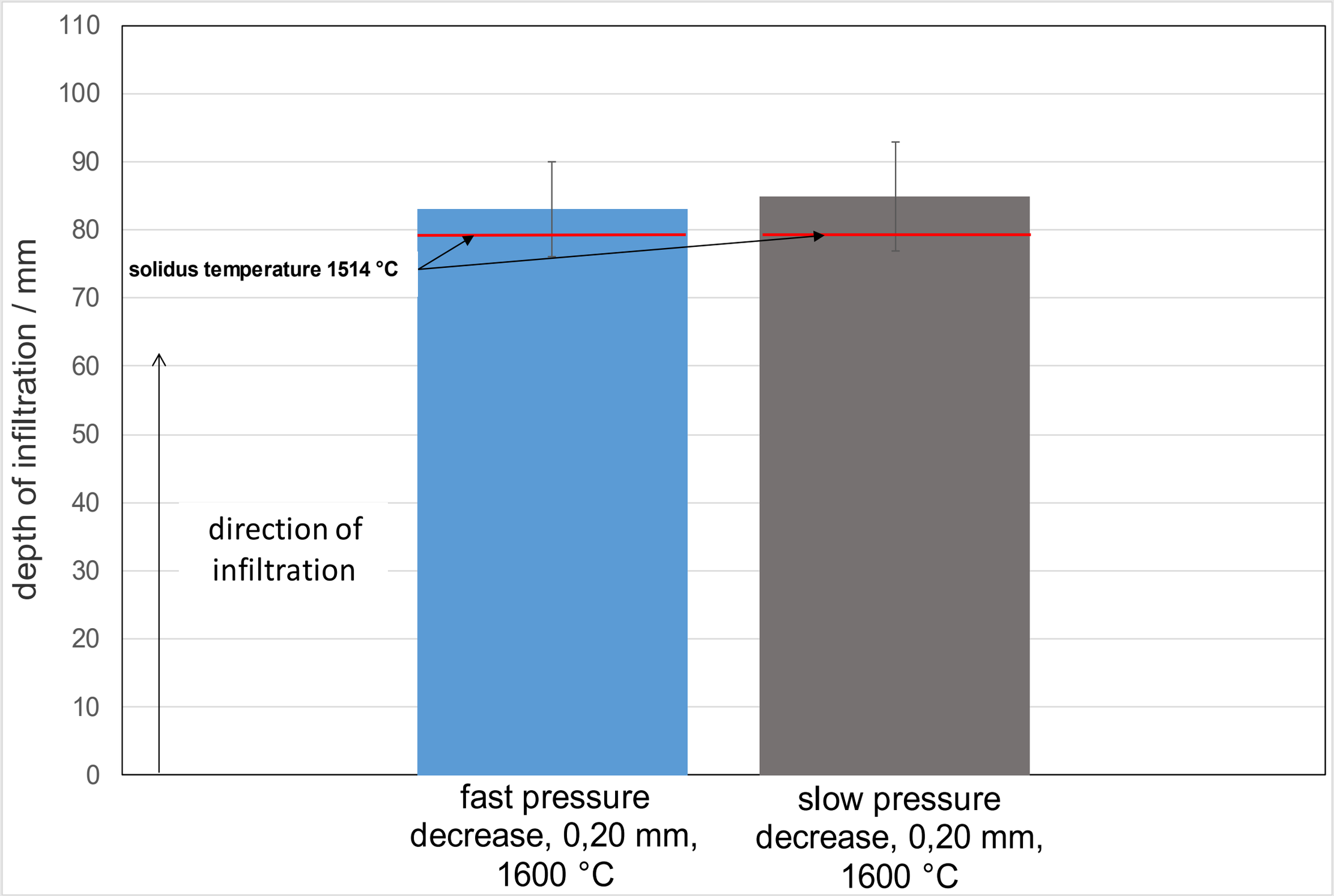
# TEST PROCEDURE



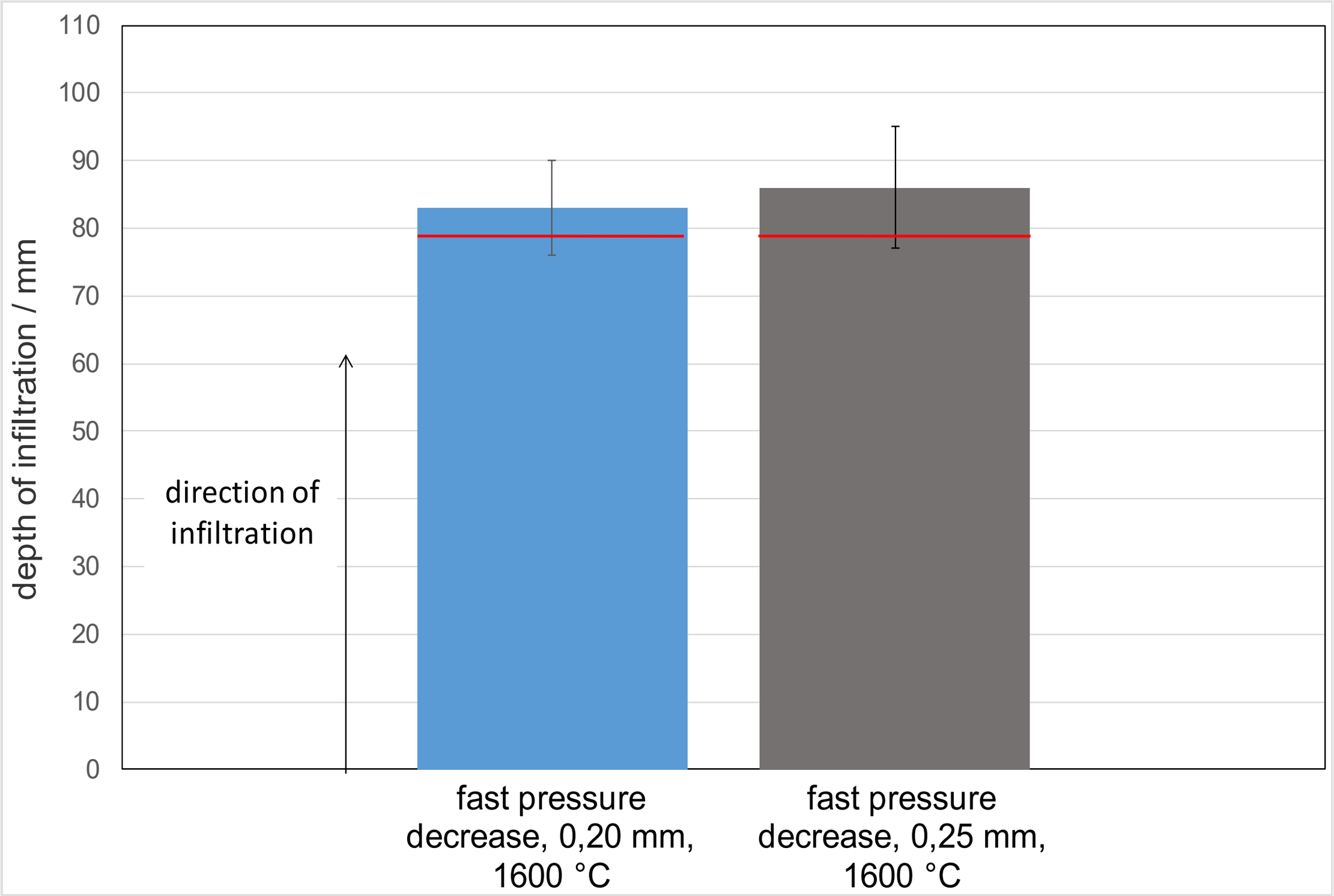





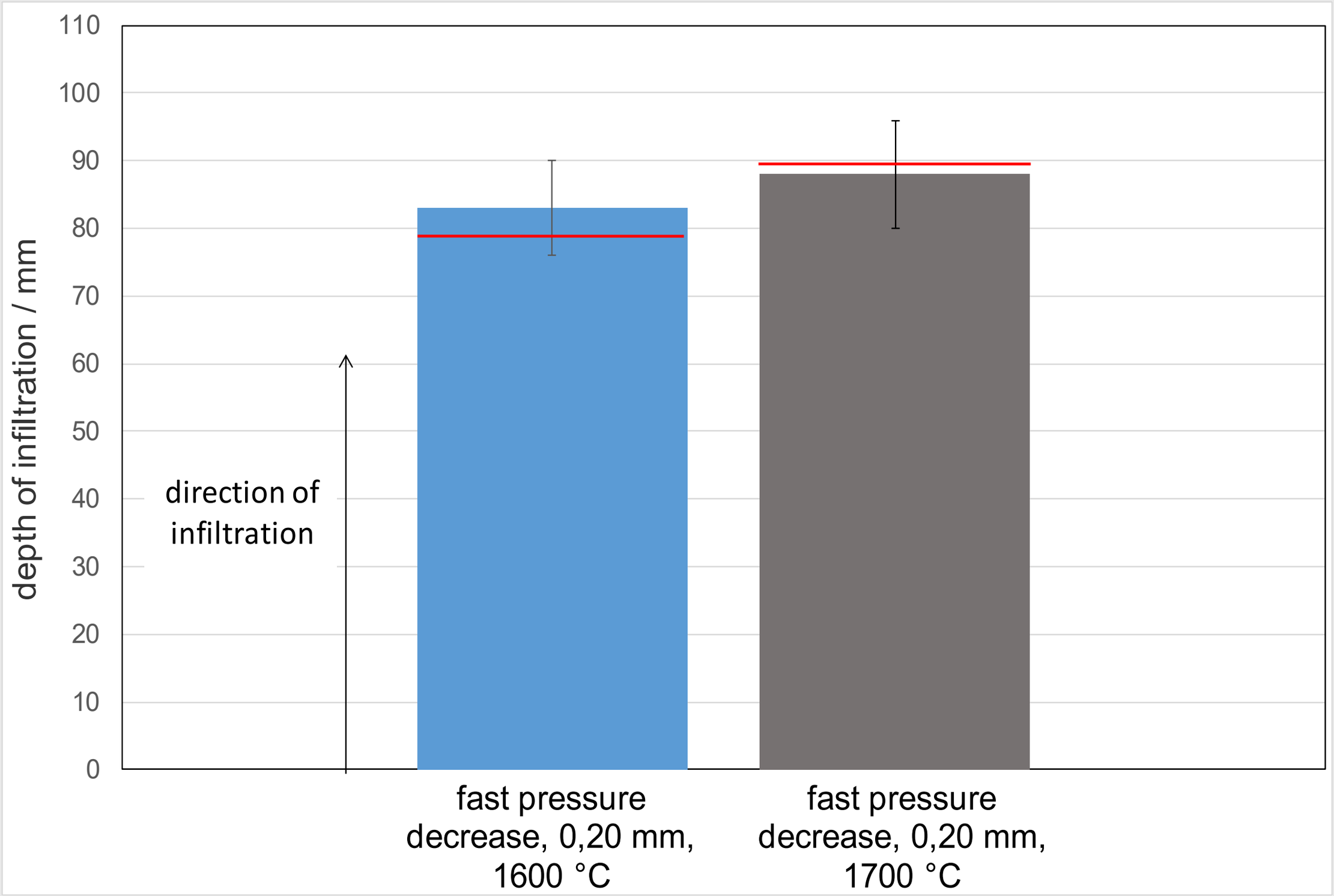
# EXPERIMENTAL RESULTS (PRESSURE DECREASE)



# EXPERIMENTAL RESULTS (GAS CHANNEL WIDTH)



# EXPERIMENTAL RESULTS (STEEL TEMPERATURE)



## CONCLUSION: LABORATORY EXPERIMENTS

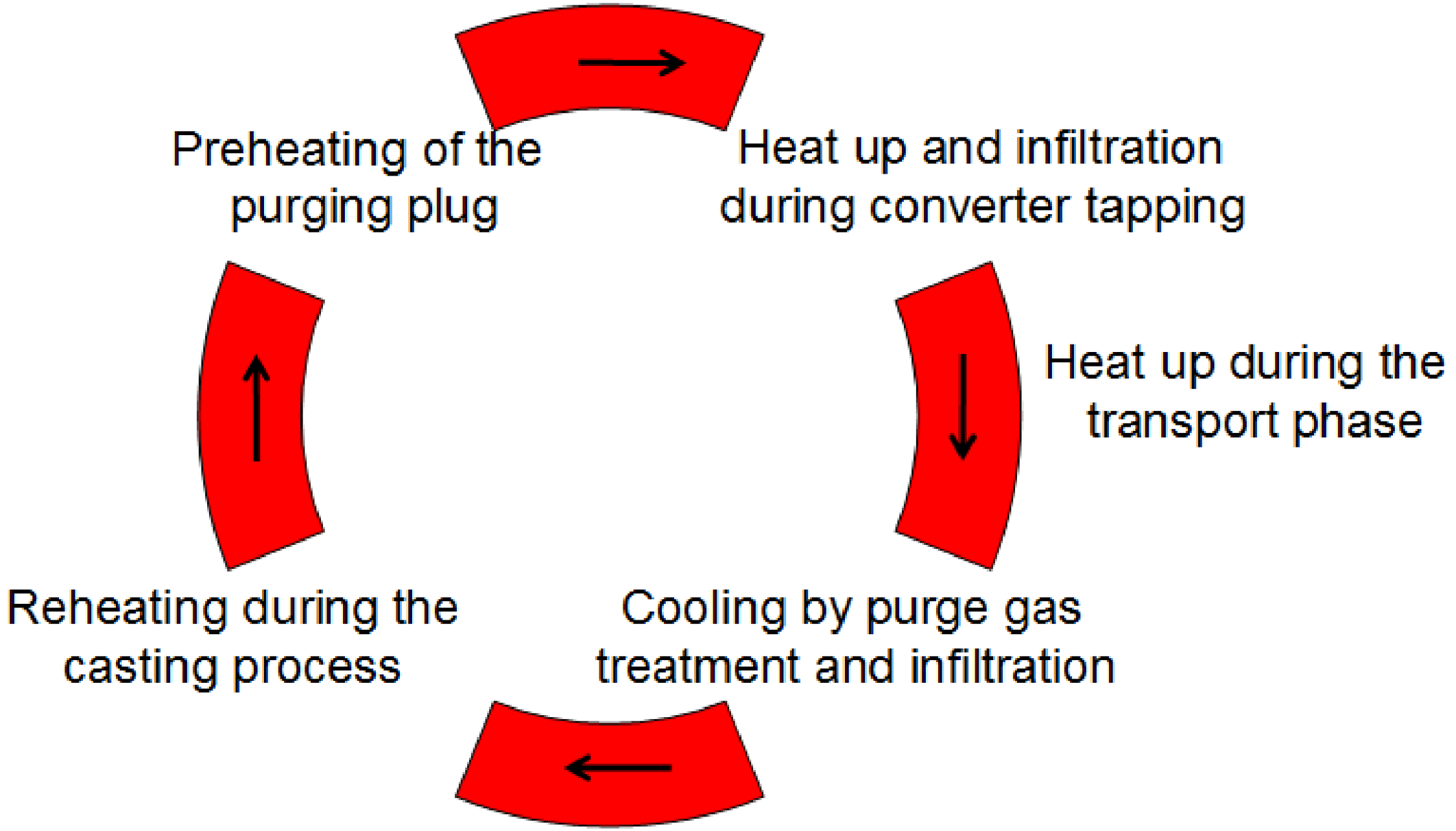
The depth of infiltration is **not affected** by:

- the pressure difference,
- the gas channel width and
- the steel melt temperature.

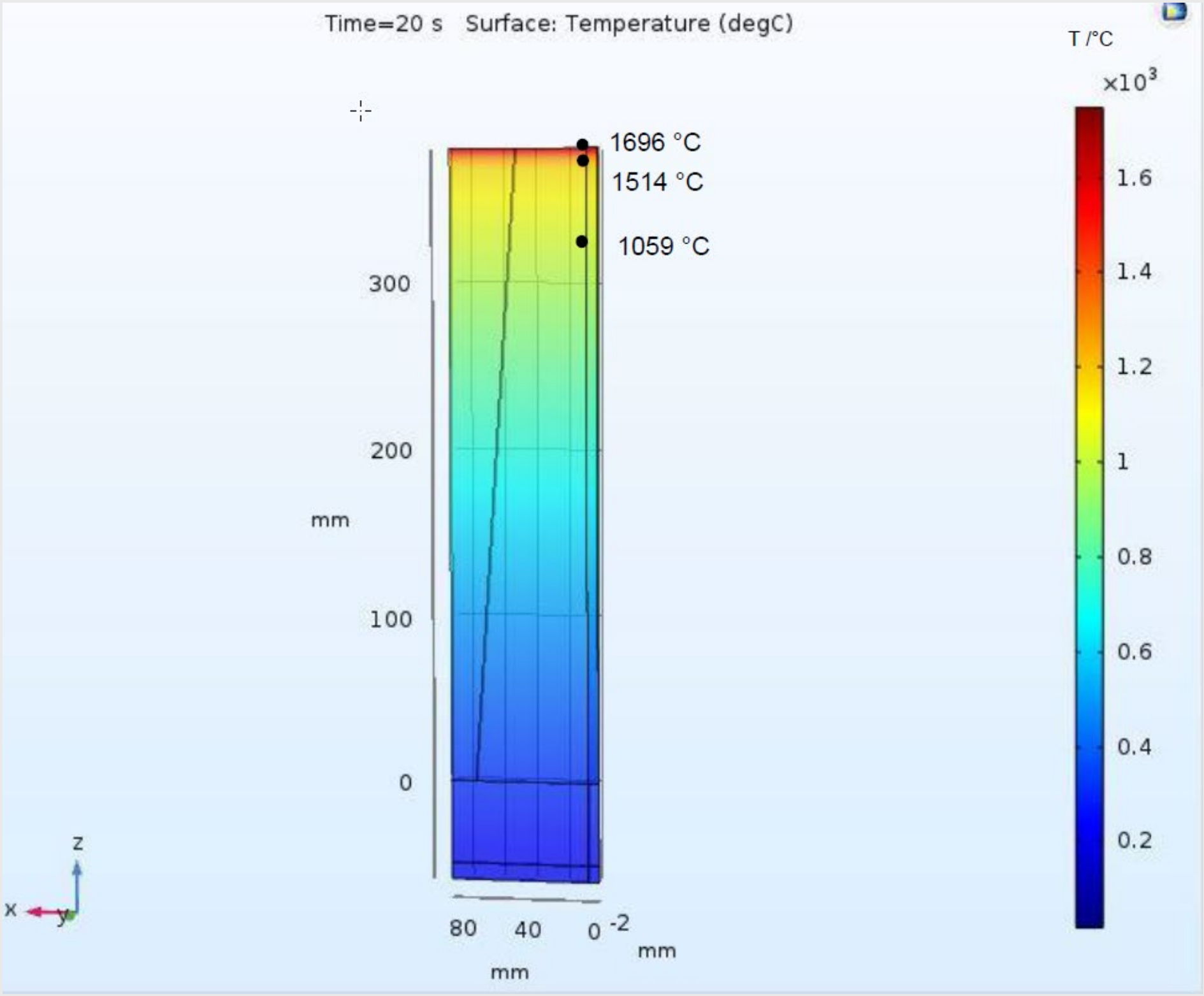
The depth of infiltration is only **affected** by:

- purging plug temperature

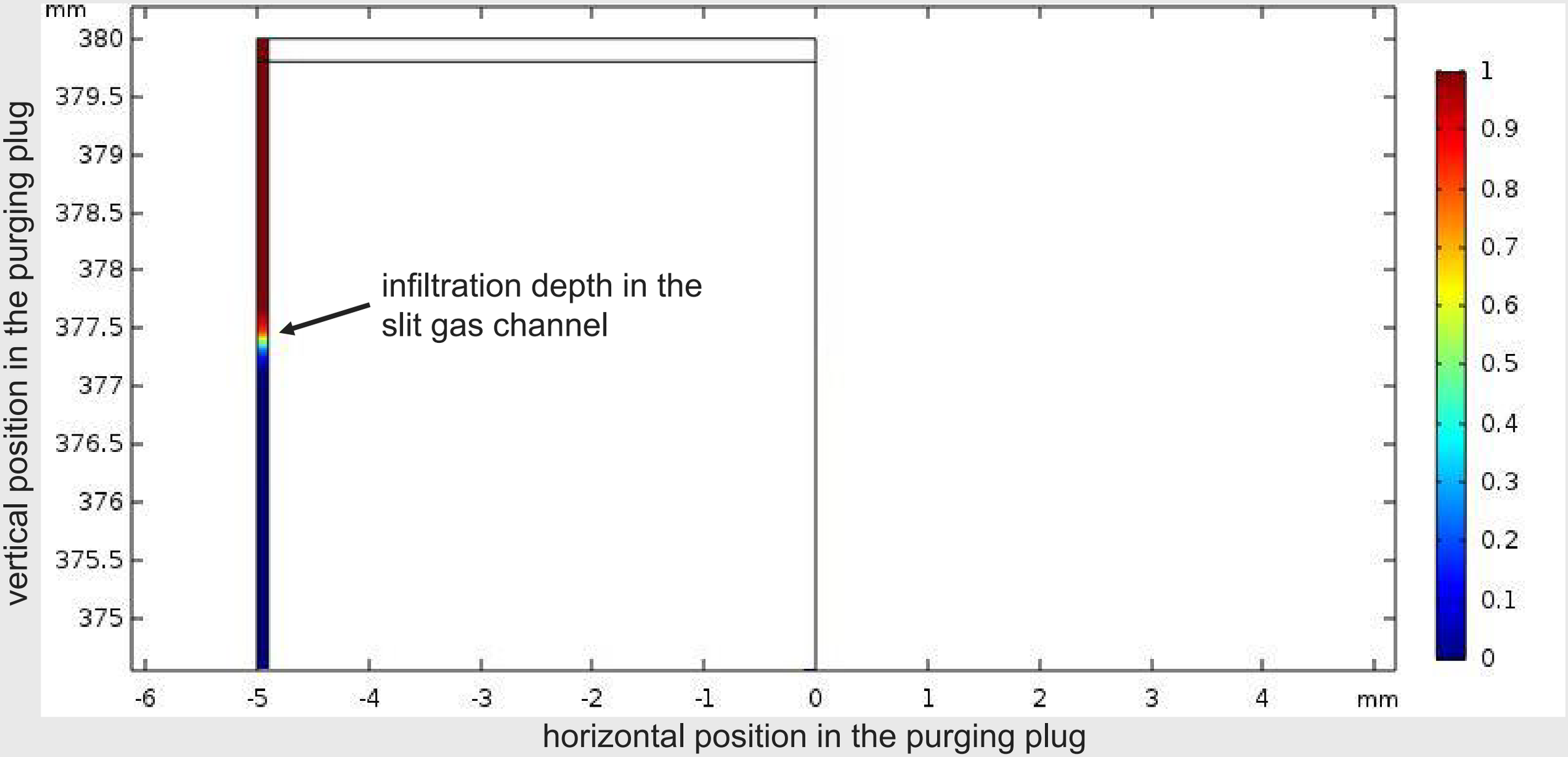
# PRACTICAL BEHAVIOR – WHAT WAS SIMULATED ?



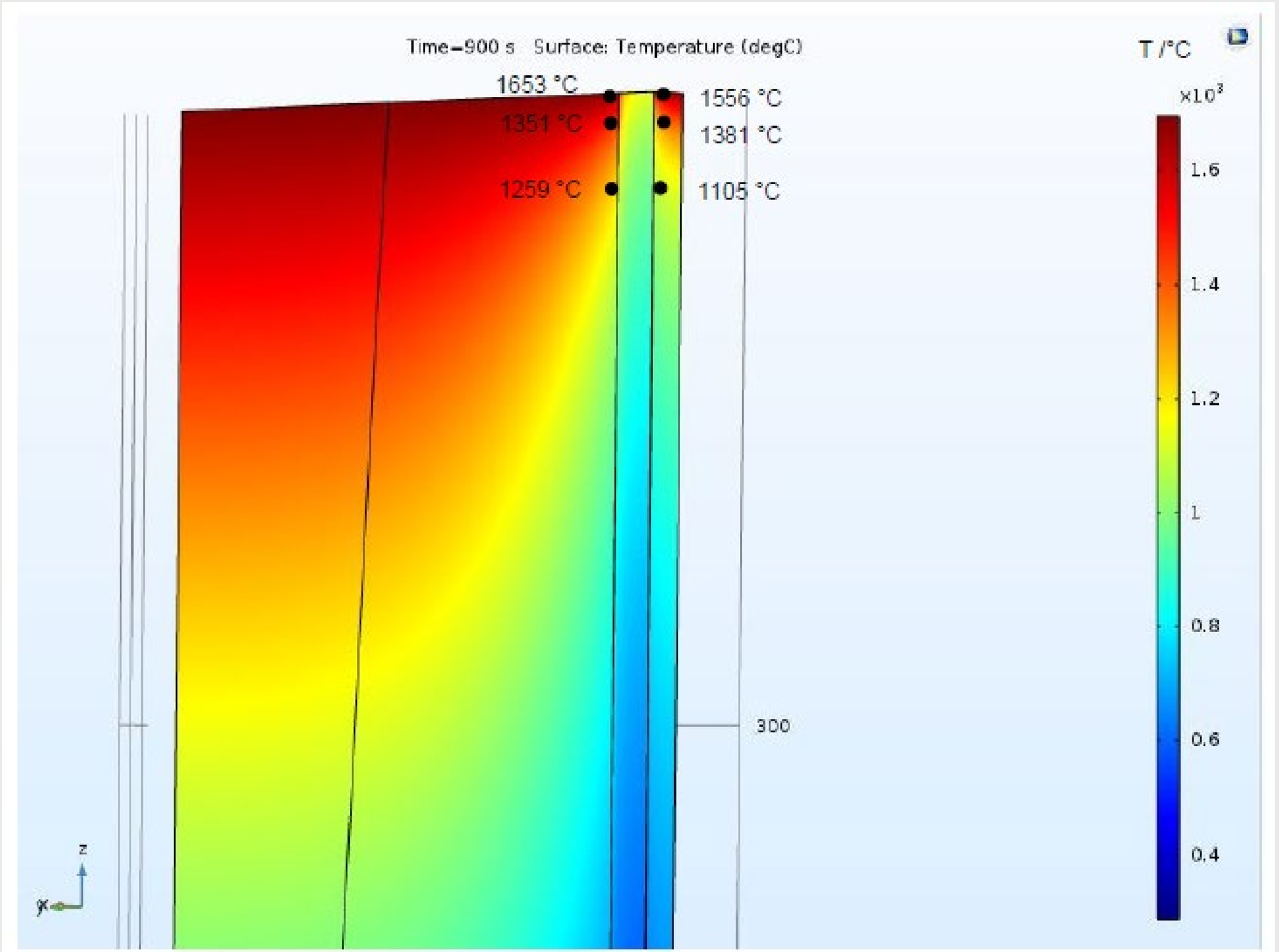
# HEAT UP DURING CONVERTER TAPPING OF A PURGING PLUG SEGMENT



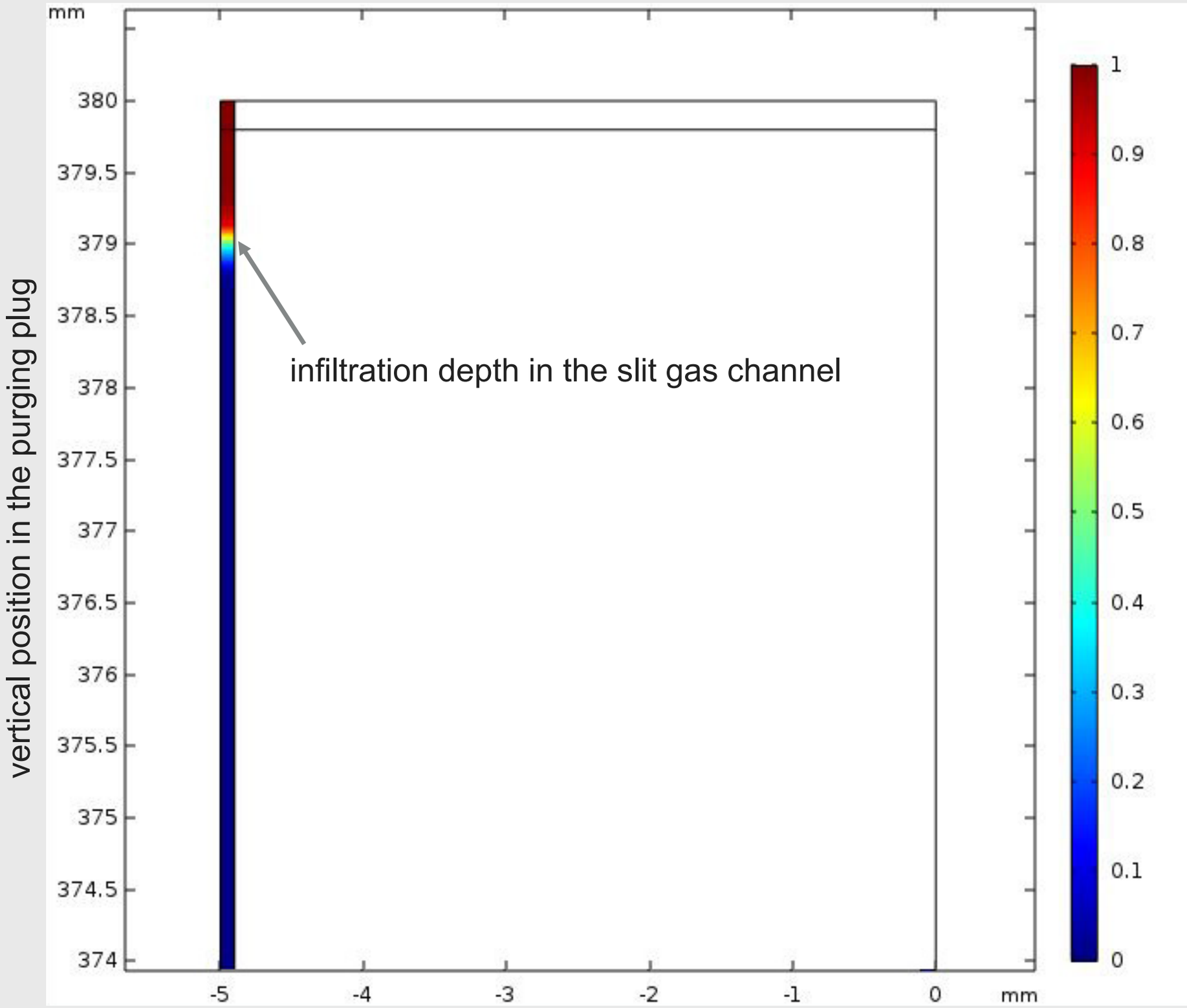
# EXPECTED INFILTRATION DEPTH (CONVERTER TAPPING)



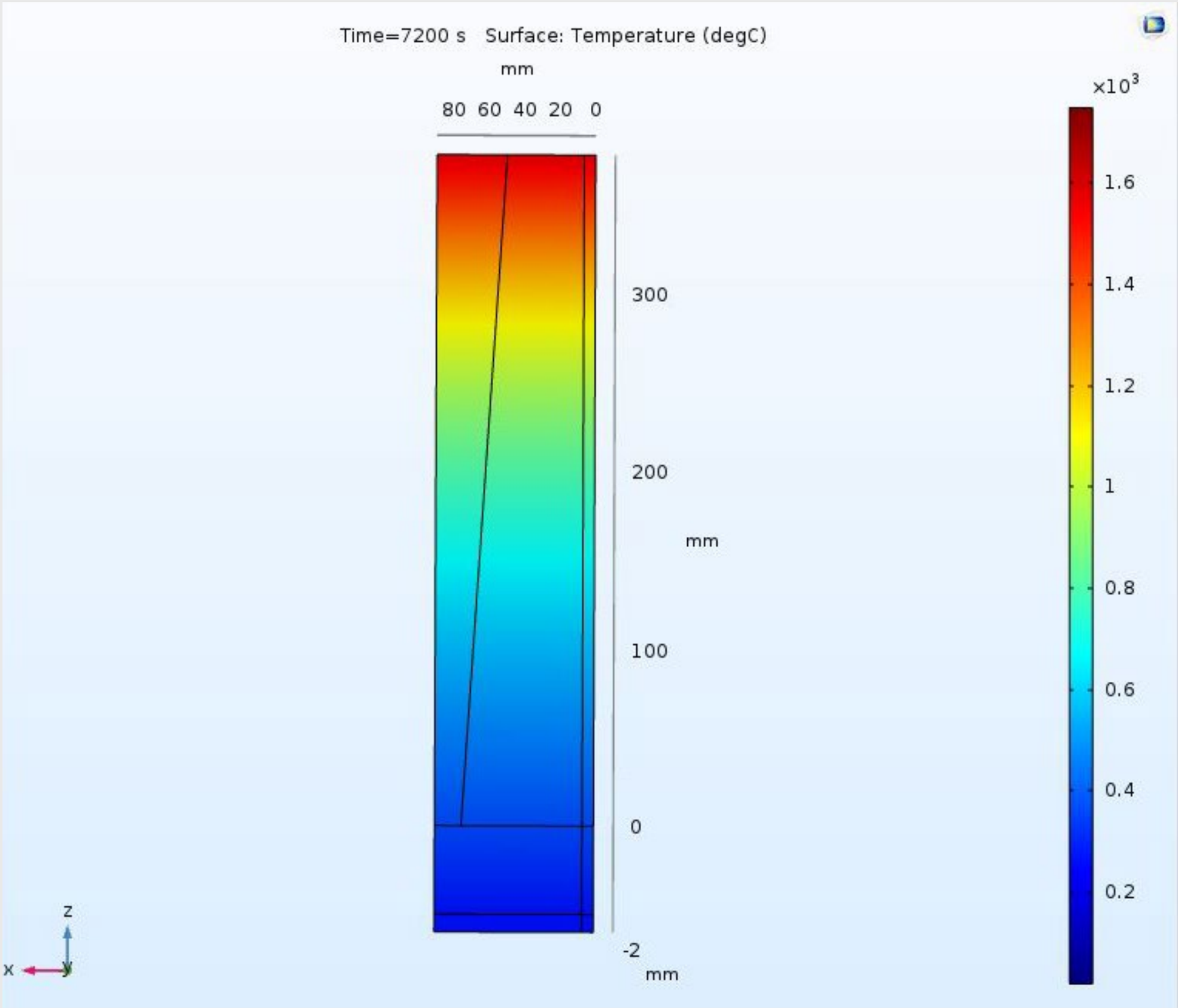
# COOLING BY PURGE GAS TREATMENT



# EXPECTED DEPTH OF INFILTRATION (END OF PURGE GAS TREATMENT)



# TEMPERATURE DISTRIBUTION AFTER CASTING



## CONCLUSION: SIMULATION OF PRACTICAL BEHAVIOR

- Converter/EAF- tapping and purge gas treatment end are **not** critical for infiltration depth and process reliability

- The casting process is particularly critical for the infiltration depth and process reliability

## POSSIBILITIES TO IMPROVE THE RELIABLE PERFORMANCE

- Purging and cooling of the purging plug after casting

- Reduction of the idle times of the steel ladles

- To improve the free flushing behavior

- Maintaining the purge gas pressure in the gas channels of the purging plug

# Thank you for your attention!