Effect of Water Slot Design on Beam Blank Mold Temperature

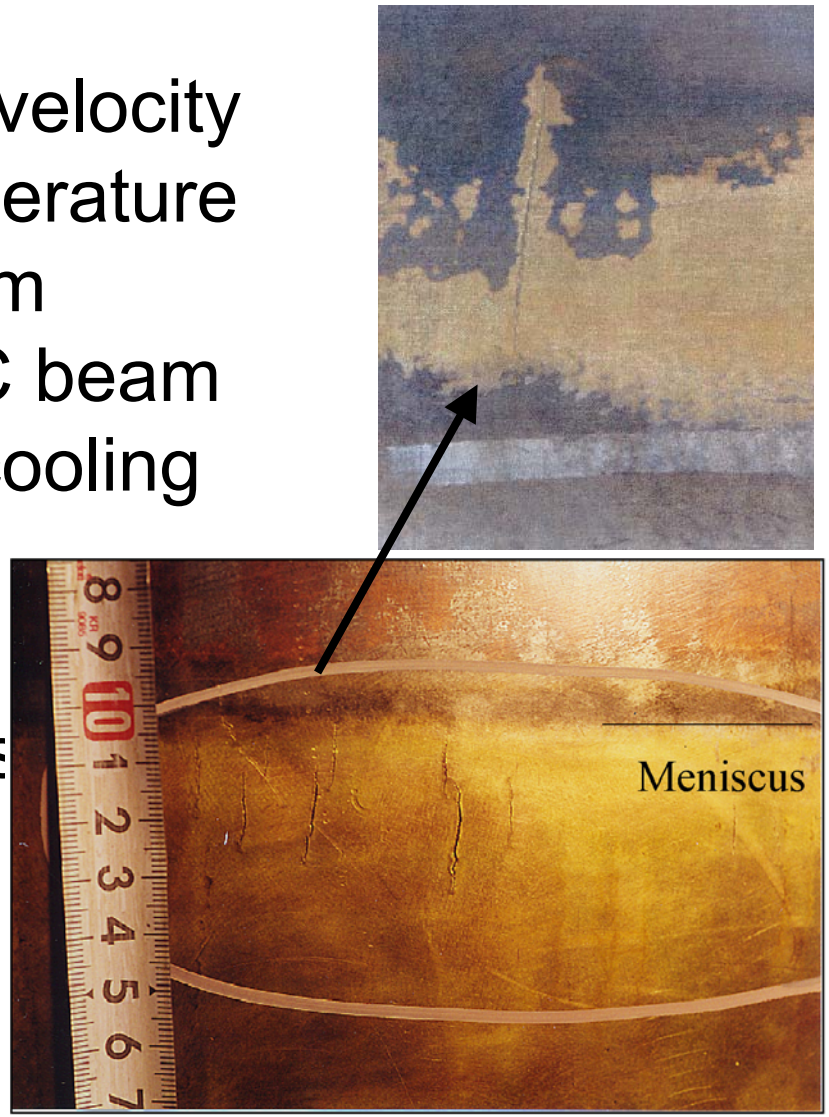
Jianbo Jiang & Brian G. Thomas

Department of Mechanical &. Industrial Engineering
University of Illinois at Urbana-Champaign

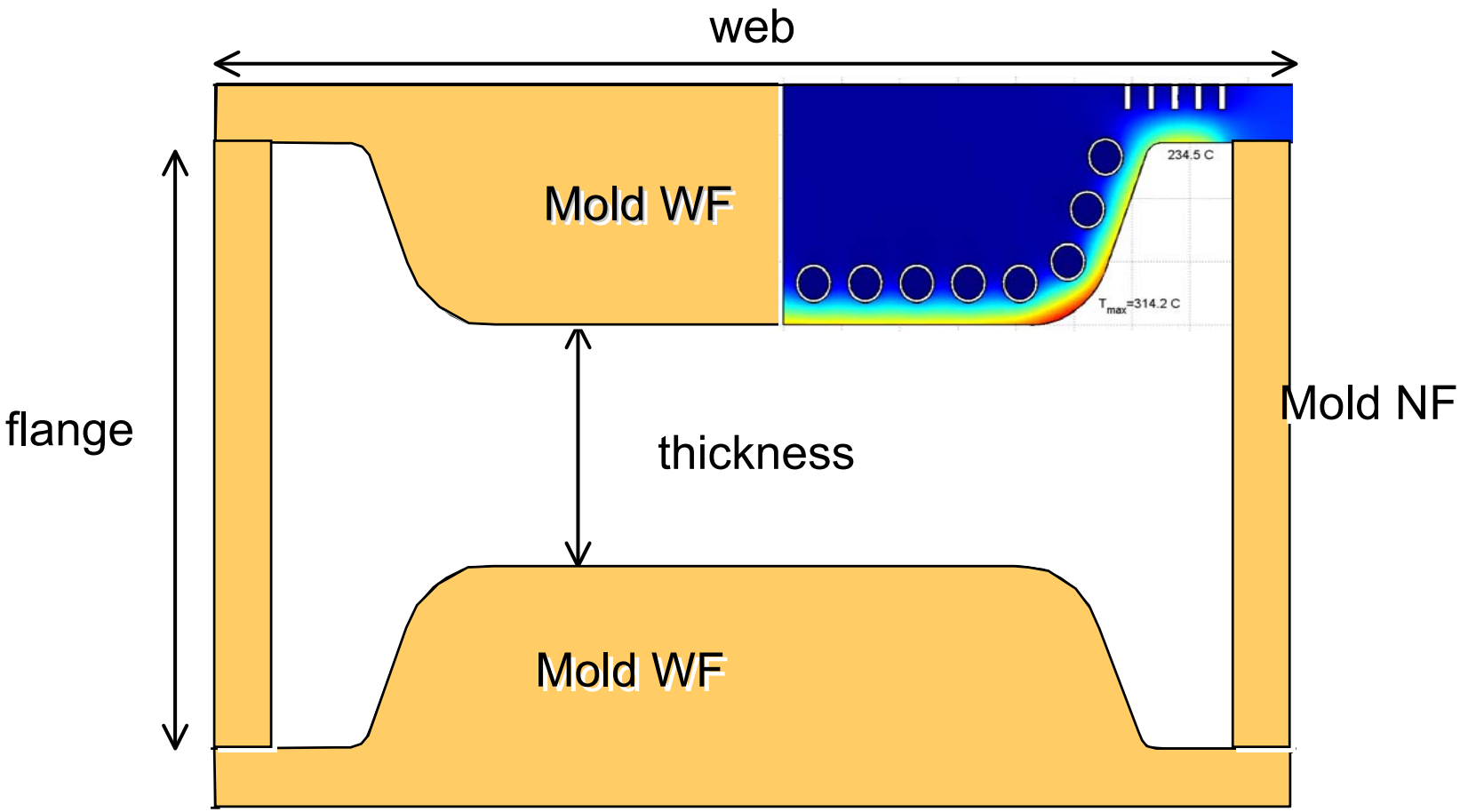
May 10, 2004

Objective

- Investigate effect of water velocity on maximum hotface temperature in a 730mm (web) x 370mm (flange) x 90mm (thick) CC beam blank mold for 5 different cooling water slot designs
- Optimize design to avoid hotface cracks at meniscus
- Lower maximum hotface temperature



Beam Blank mold design

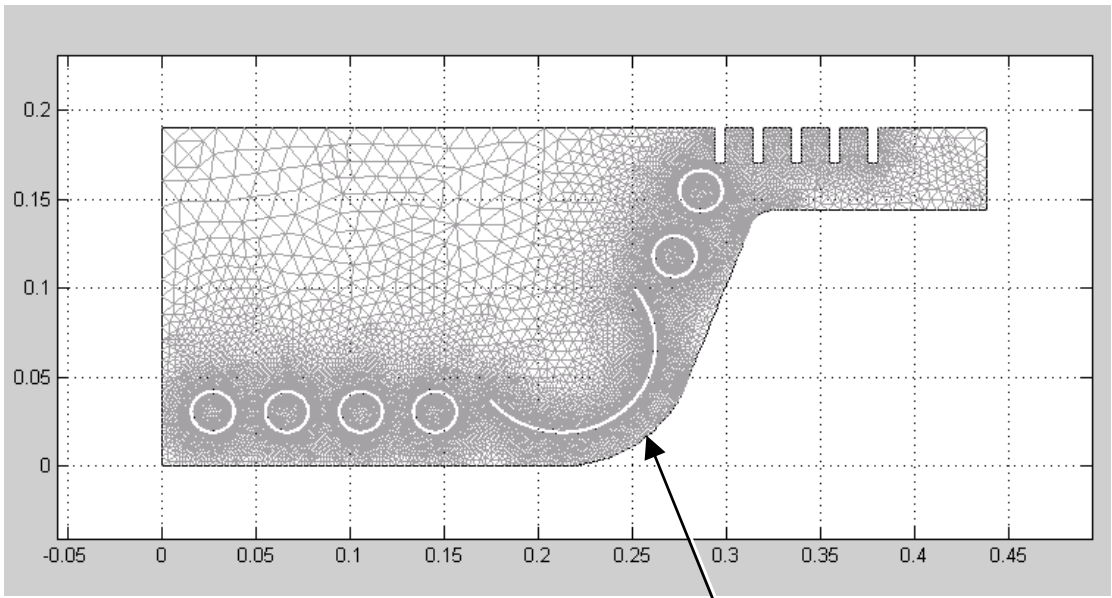


2-D Finite-element model

Steady-state heat conduction

6-node triangle elements using FEMLAB-1 Software

19440 nodes and 36716 elements

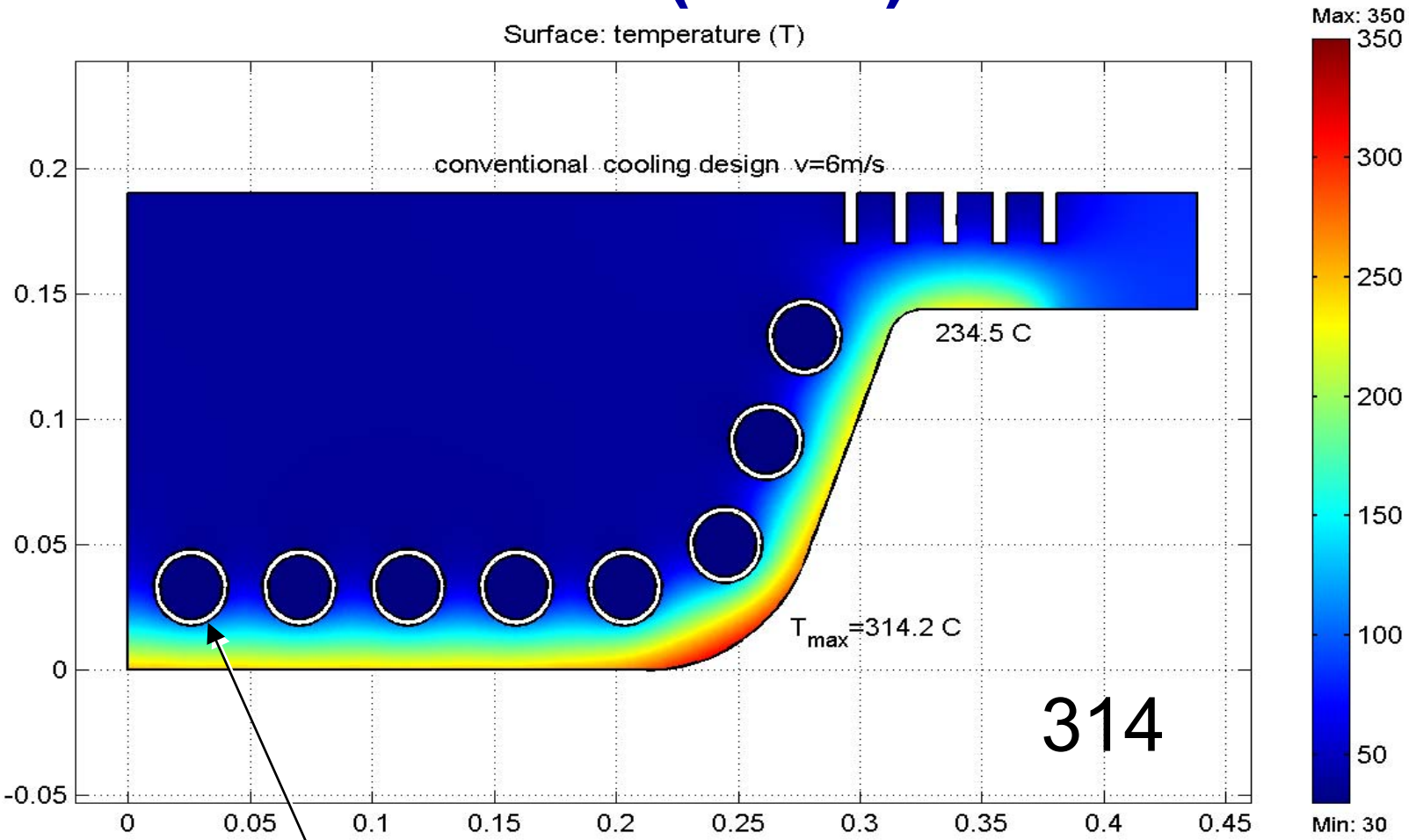


Refined mesh (15-20 elements from hotface to slot)

Casting Conditions

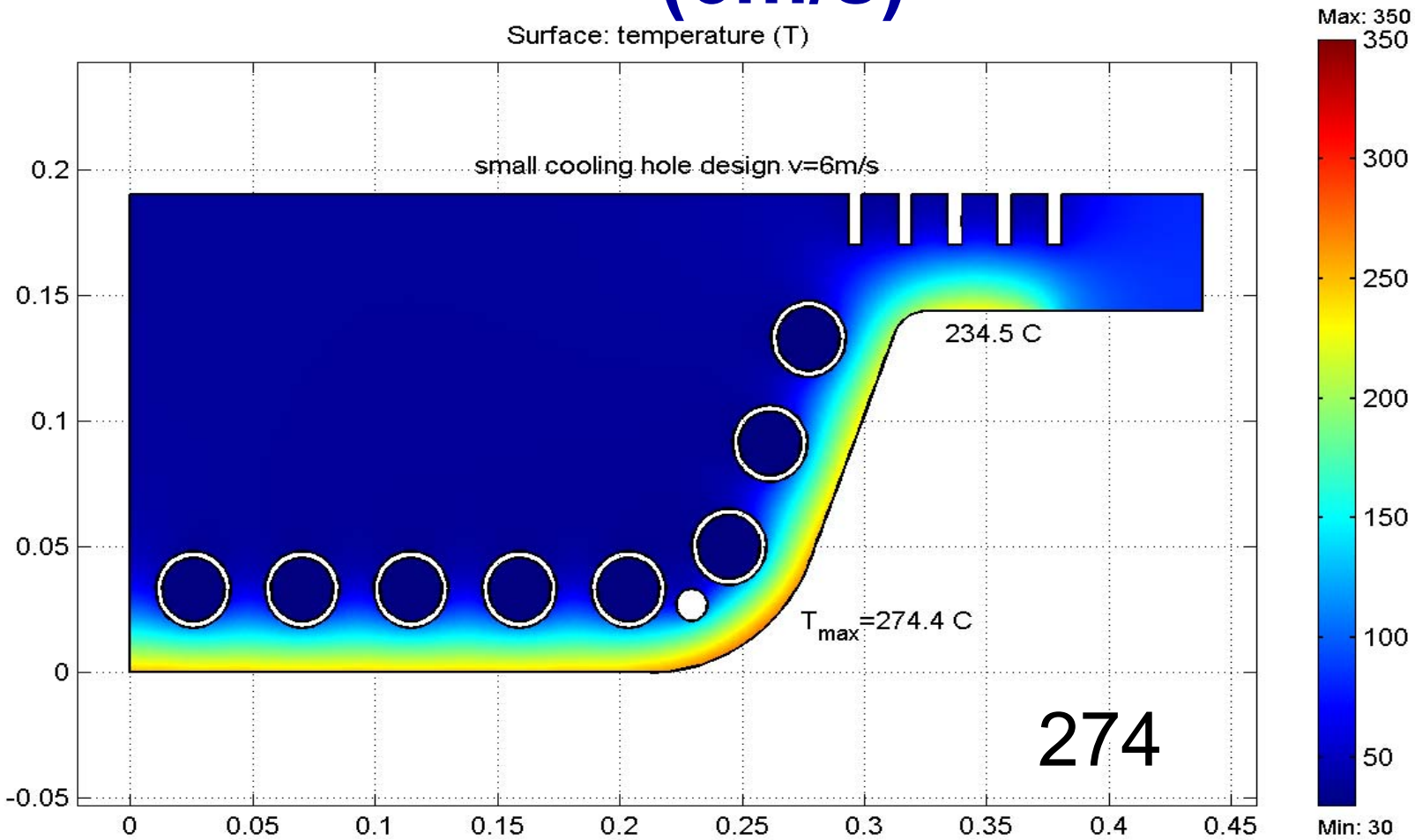
Section at mold exit web flange thickness	 379.5mm 748.7mm 92.3mm
Casting speed	0.6 m/min
Hot-face heat flux (constant with water velocity)	$q = 2400\ kW/m^2$
Cooling water temperature	30 ^oC
Copper thermal conductivity	350 W/m-K
Cooling water velocity	6 or 12 m/s
Water heat transfer coef.	32 or 48 kW/m-K

Conventional cooling design (6m/s)

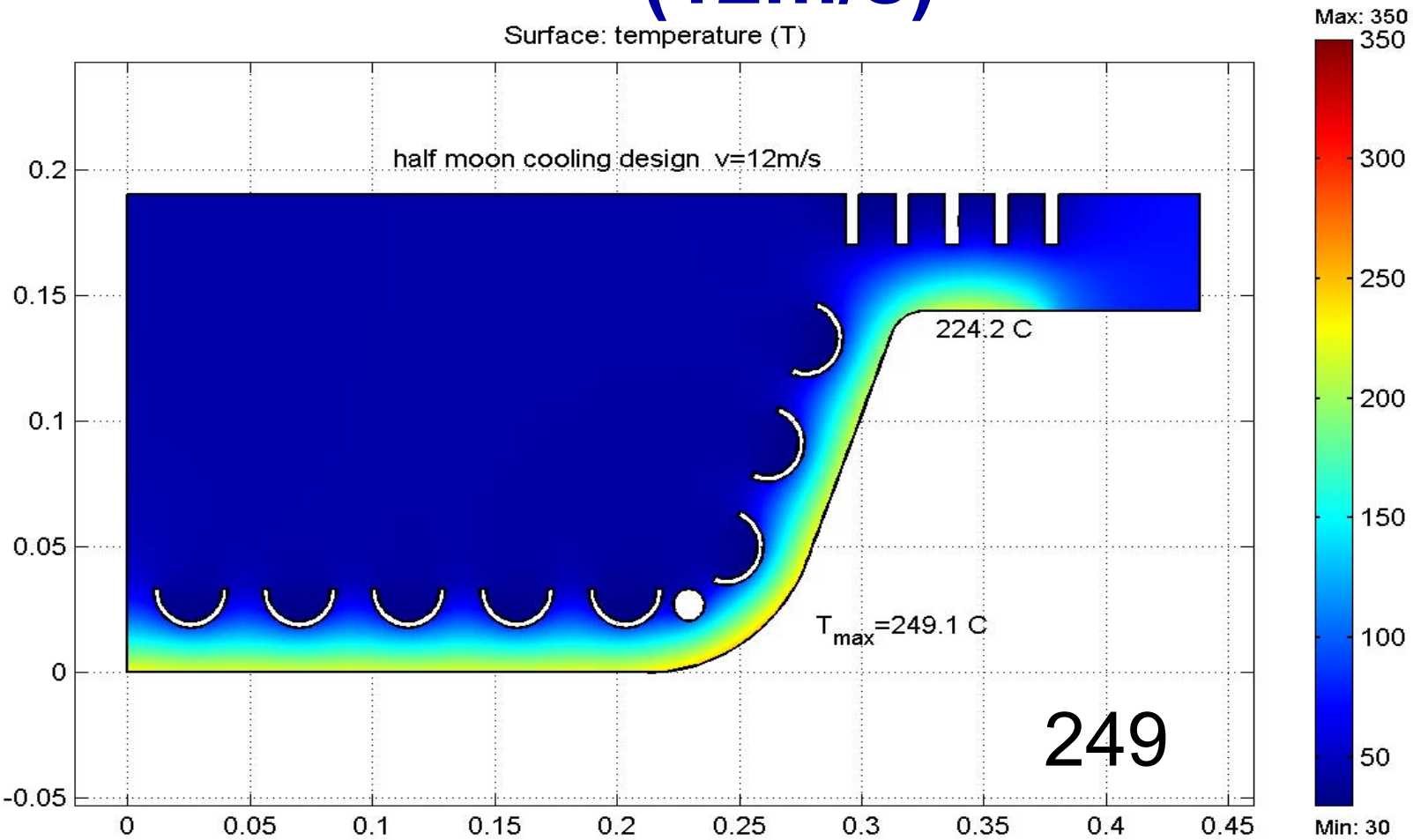


Annular slot: gun-drilled hole with cylindrical insert

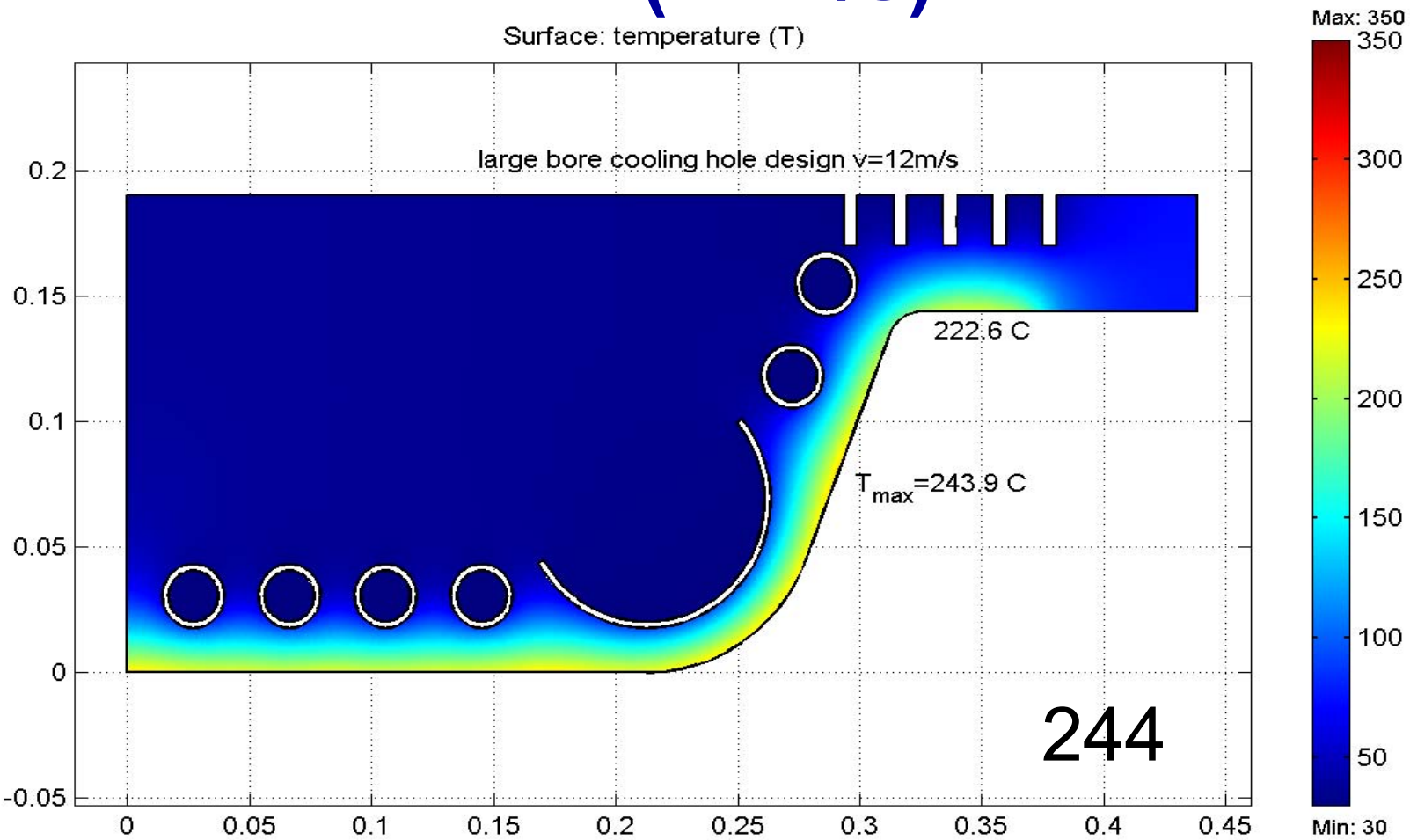
Small extra-hole design (6m/s)



Half-moon hole/insert design (12m/s)

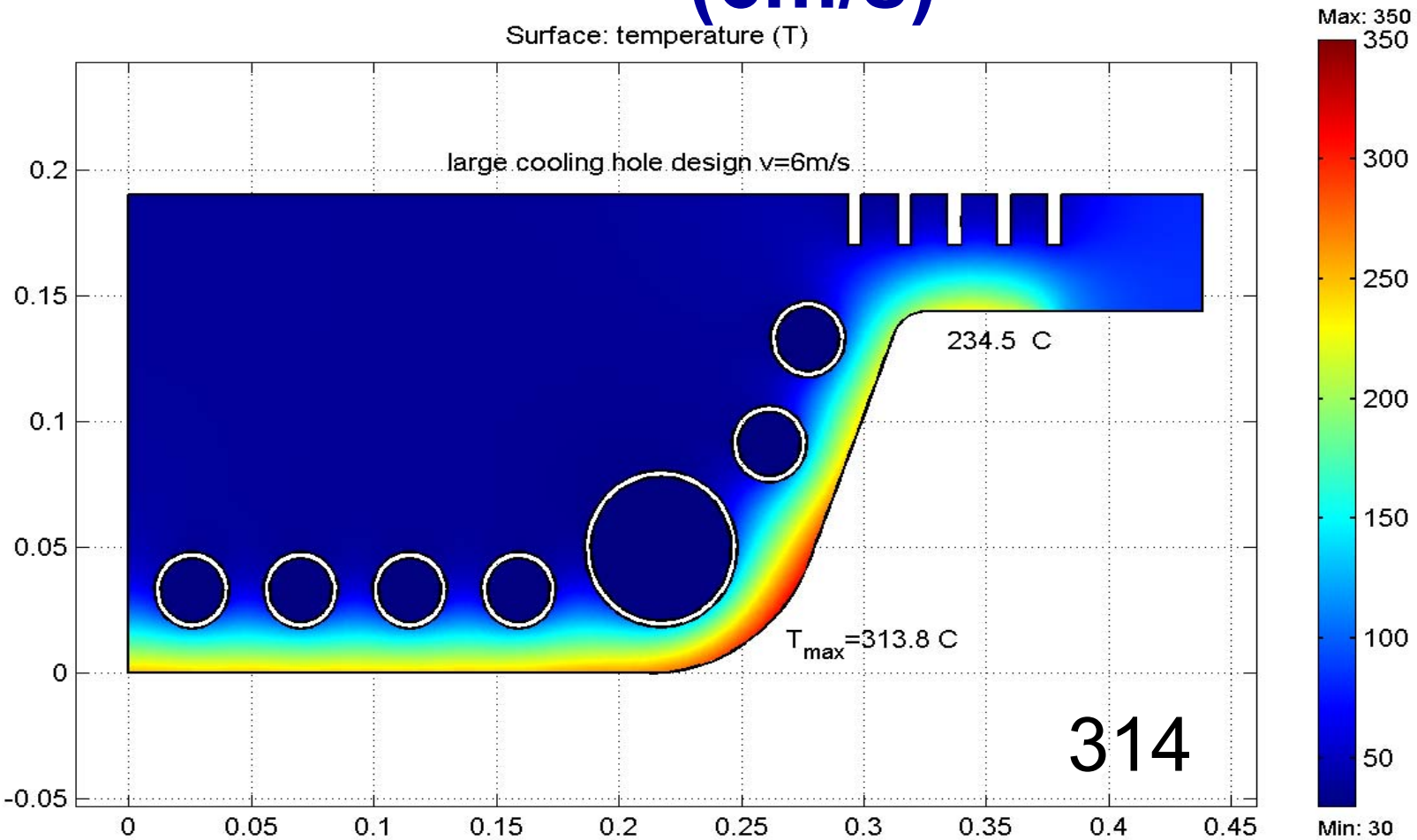


Half-moon large-hole design (12m/s)



Best design

Retro-fitted large hole design (6m/s)



Warning: non-optimal positioning makes worse!

Results

velocity / case	Maximum Hotface Temperature (°C)		Typical Hotface Temperature (°C)	
	6 m/s	12 m/s	6 m/s	12 m/s
Conventional cooling	314.2	288.0	234.5	224.1
large cooling hole (retro-fit)	313.8	286.4	234.5	224.2
small cooling hole	274.4	249.0	234.5	224.0
half moon cooling	274.5	249.1	234.7	224.2
Improved large cooling hole	271.3	243.9	233.1	222.6

Recommendations

- Surface at convex-curved corner is hottest
- Hotface temp controlled by max. distance from hotface surface to water slot
- Adding small hole decreases hotface temp 40 ^{o}C
- Adding inserts to create half-moon channels decreases channel area, increasing water velocity, & decreasing hotface temp 65^{o}C
- Adding large hole with insert at convex corner decreases hotface temp 70 ^{o}C. (assuming no detrimental effect on steel quality)