CCC Report
October 18, 2001

Billet Casting Thermal Stress Modeling

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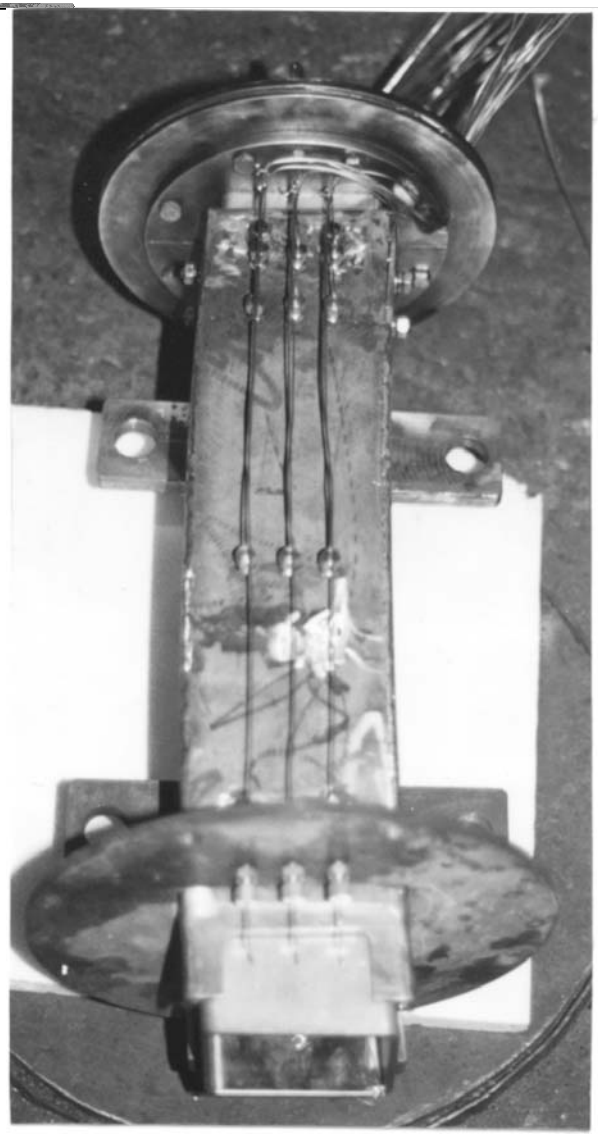
Objectives

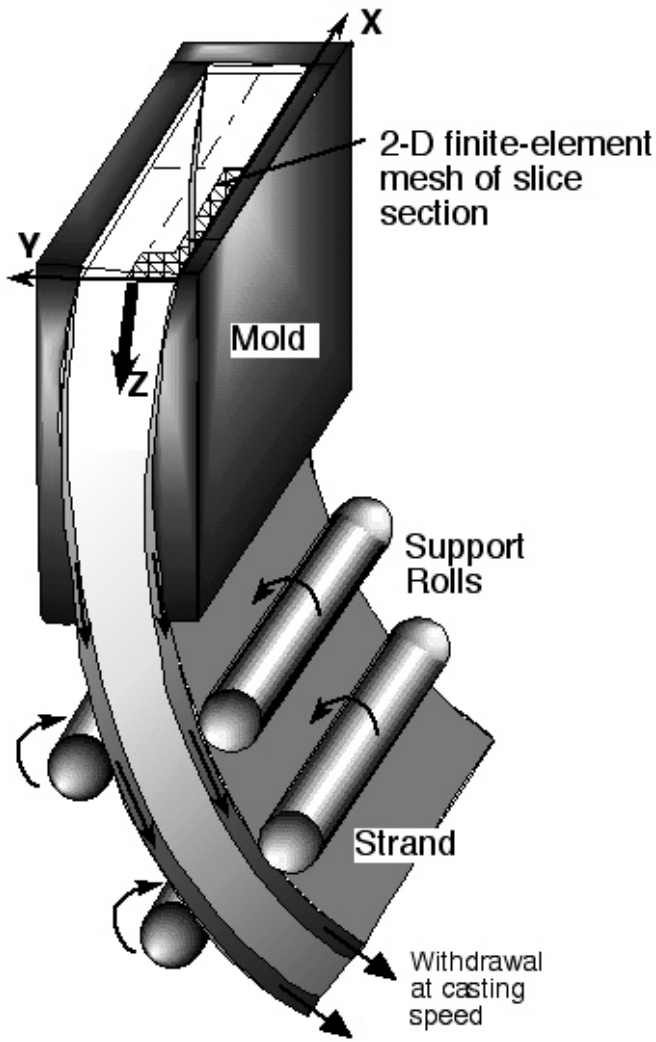
1. Model Validation
2. Effect of corner radius on cracks

Instrumented Billet Mold



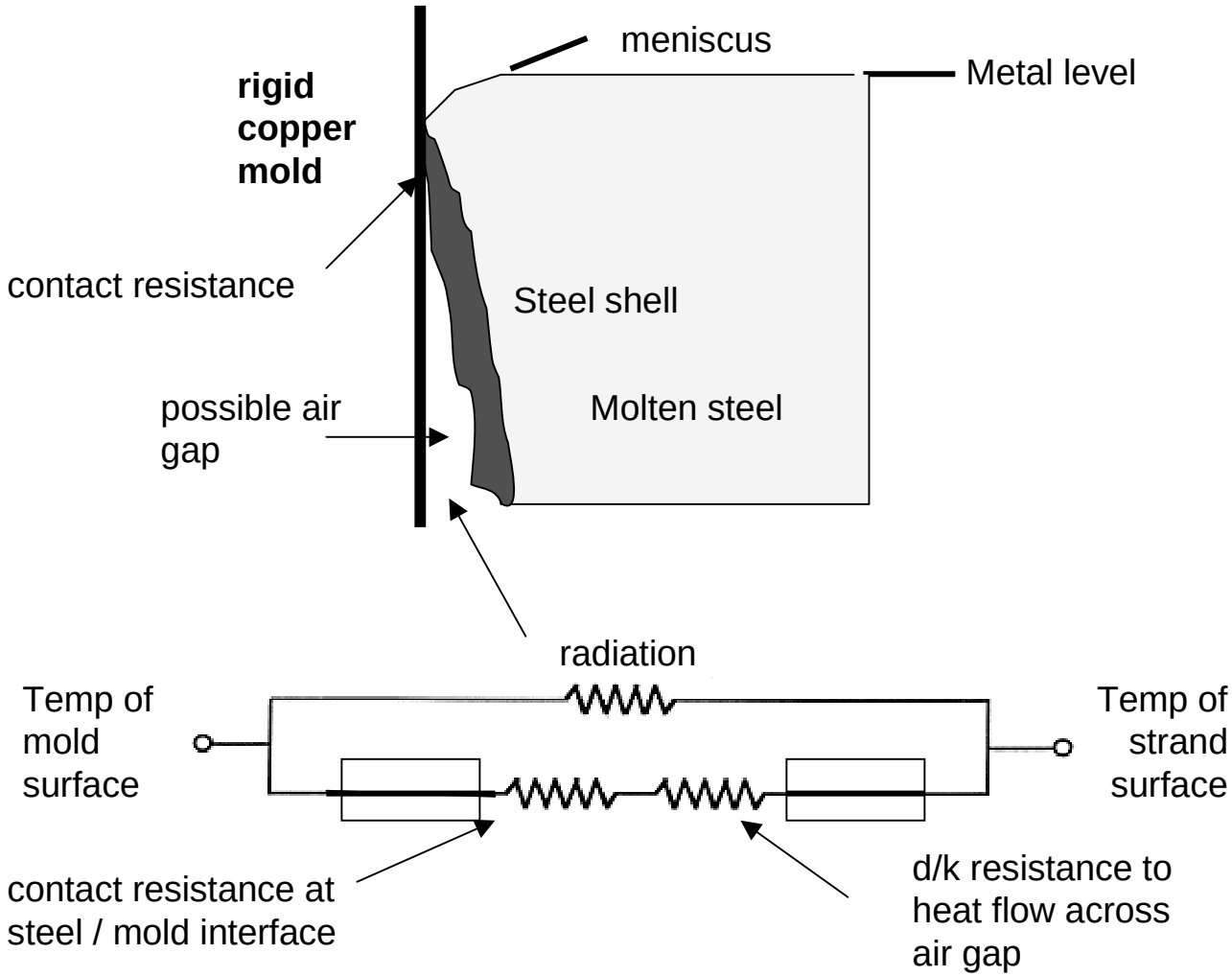
Thermocouples on mold tube

Finite Element Thermal-Stress Model

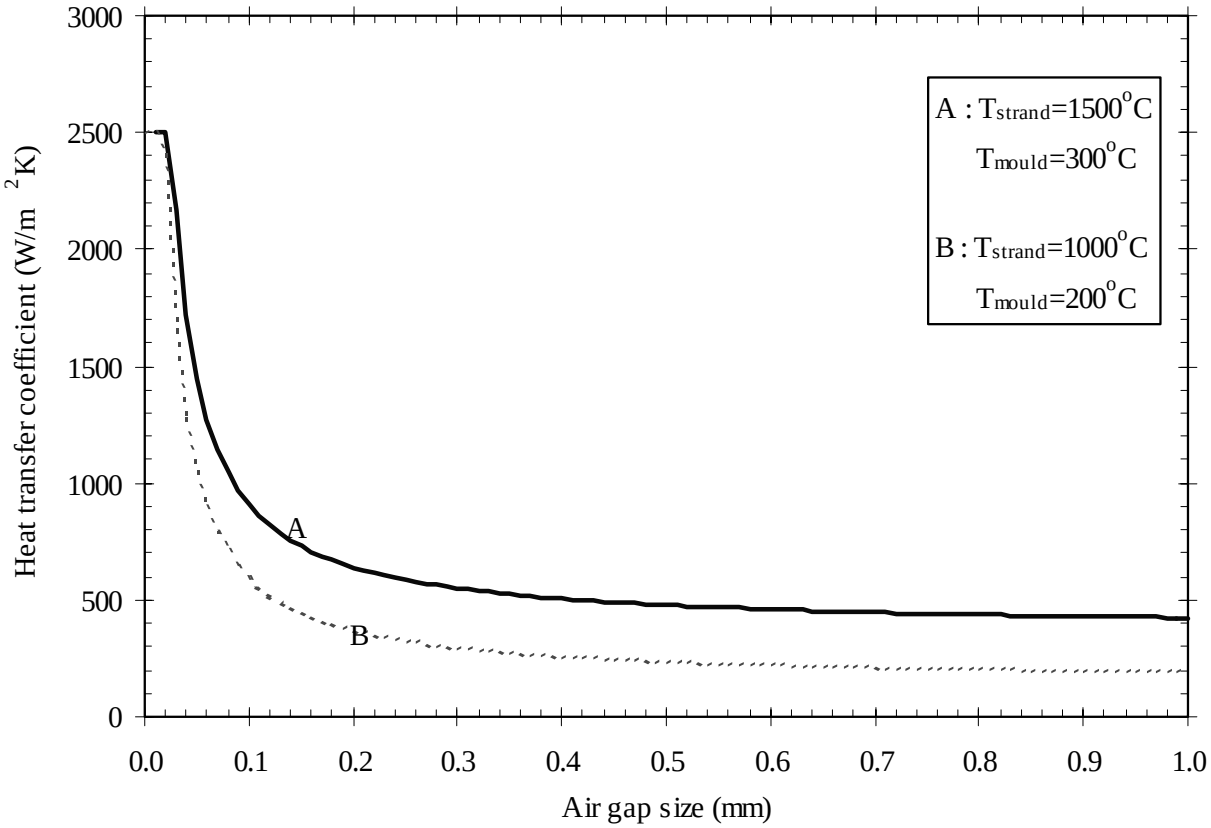


Thermocouples on mold tube

Heat Transfer across the Mold / Shell Interface



Heat Transfer across the Mold / Shell Interface



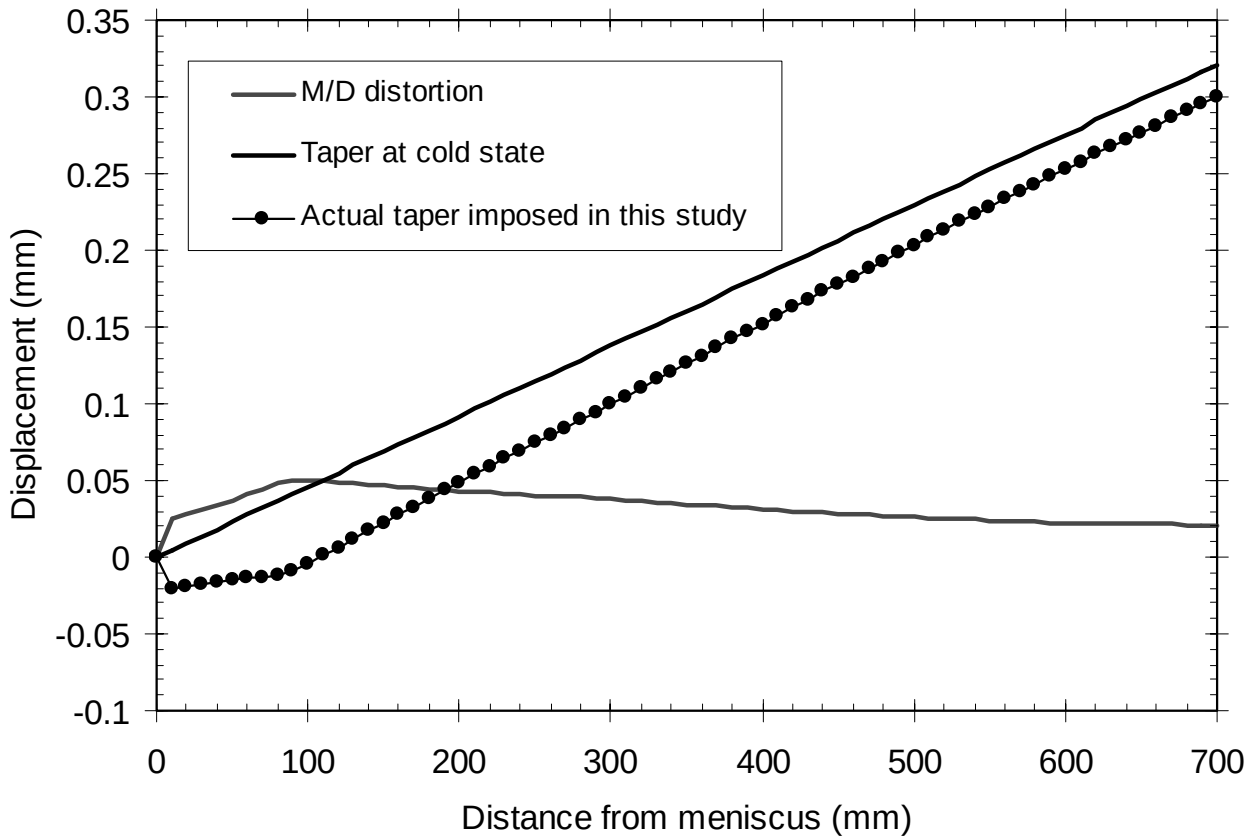
Interface heat transfer coefficient variation with air gap size

Casting Conditions Modeled

Billet Size	120mm sq.
casting speed	2.2 m/min.
Meniscus level	100mm
Oscillation type	Sinusoidal
Stroke length	8mm
SEN	Open pour
Machine radius	8m
Steel grade	0.04%C

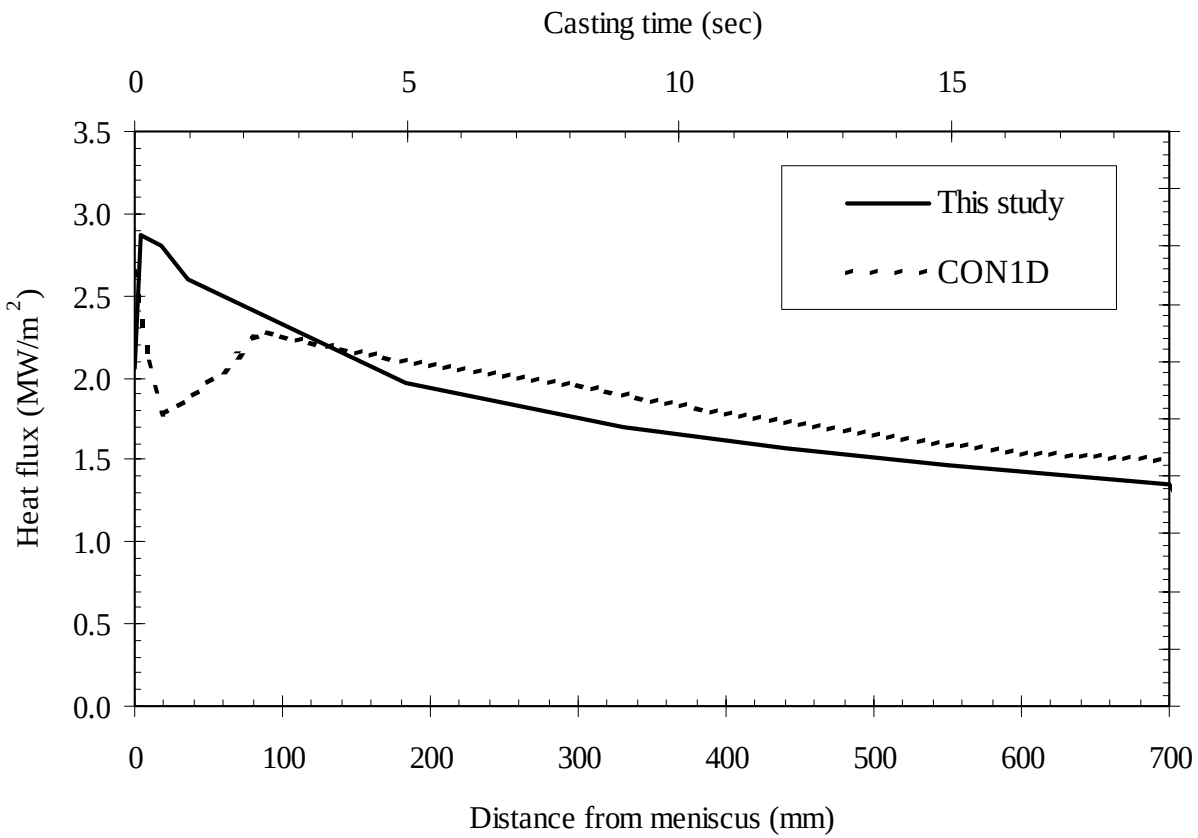
Mold Material	DHP-Cu
Mould length	800mm
Thickness	6mm
Construction / Lubrication	Tube / oil
Taper (linear)	0.785%/m
Corner radius	4mm
Cooling water	1100 l/min.
Cooling water velocity	9.2m/sec.

Model Mold distortion and taper



Mold wall profile (including taper and thermal distortion)

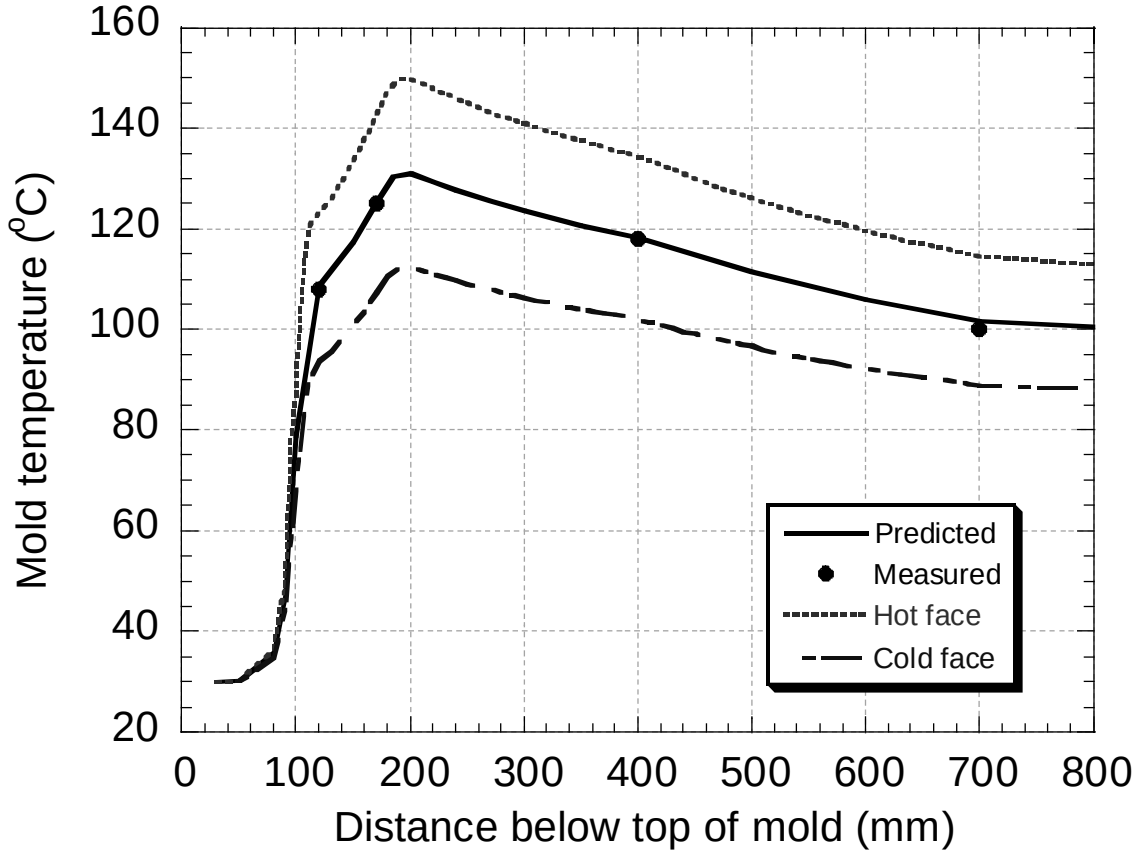
Model heat flux



T_{liq} 1529
T_{sol} 1511

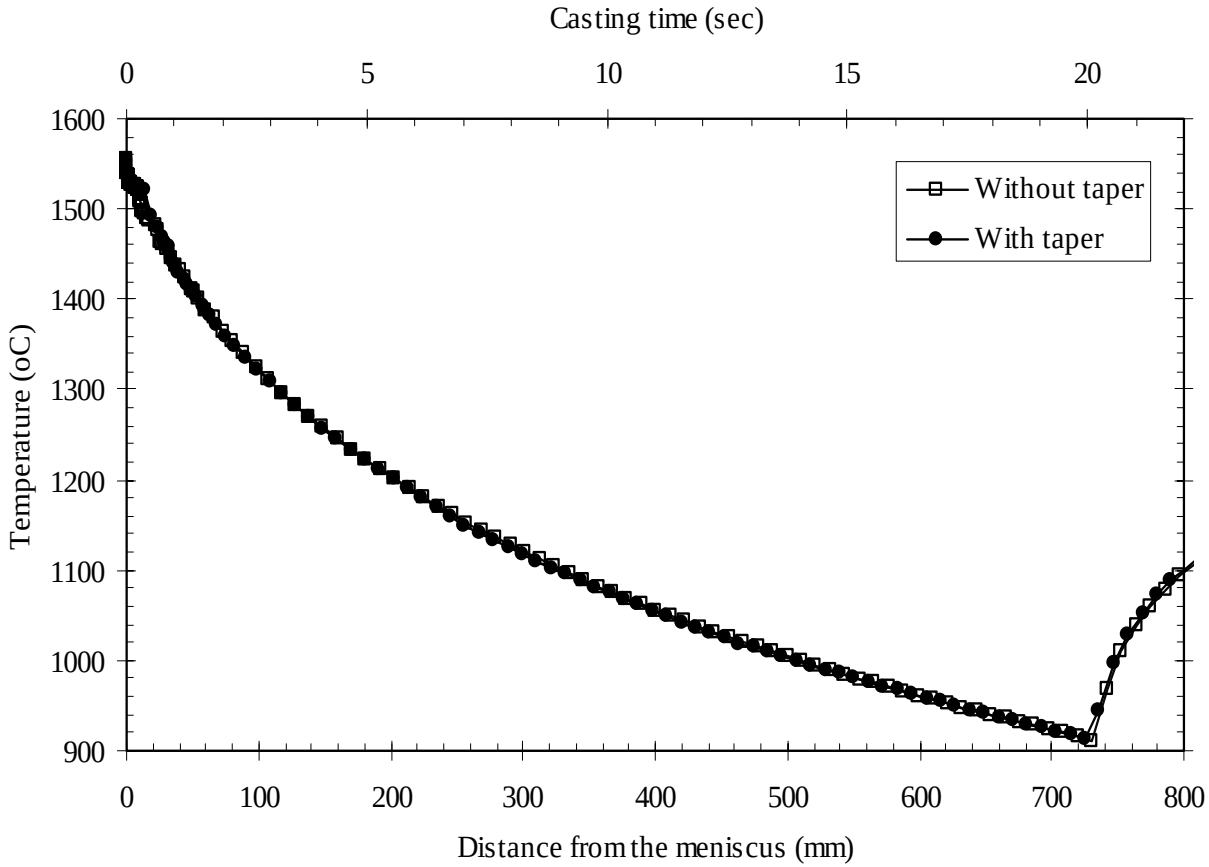
Heat Flux profile assumed
(chosen to match thermocouples and mold water heat-up)

Model Calibration



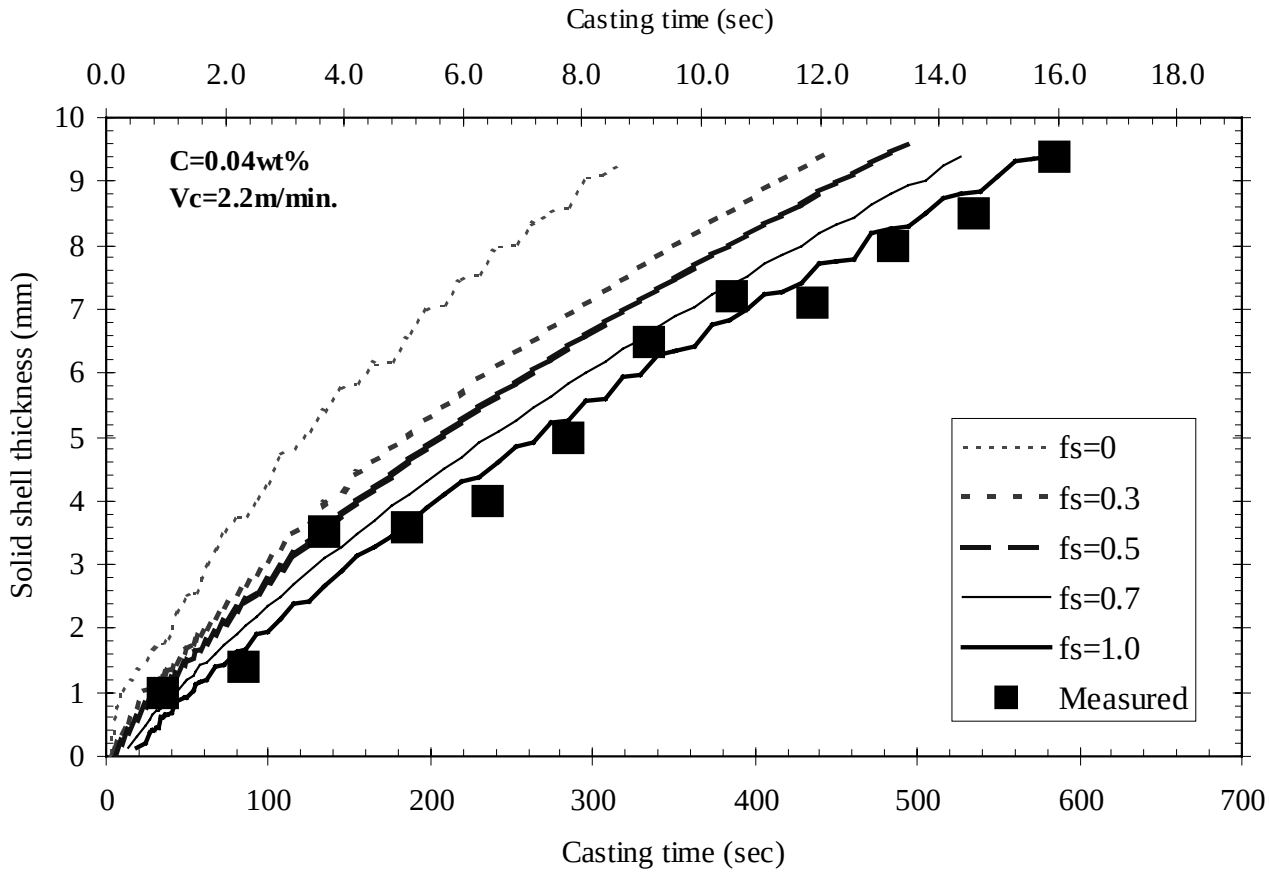
Comparison of predicted and measured mold temperatures (CON1D)

Temperature history predictions



Surface temperature along billet centerline

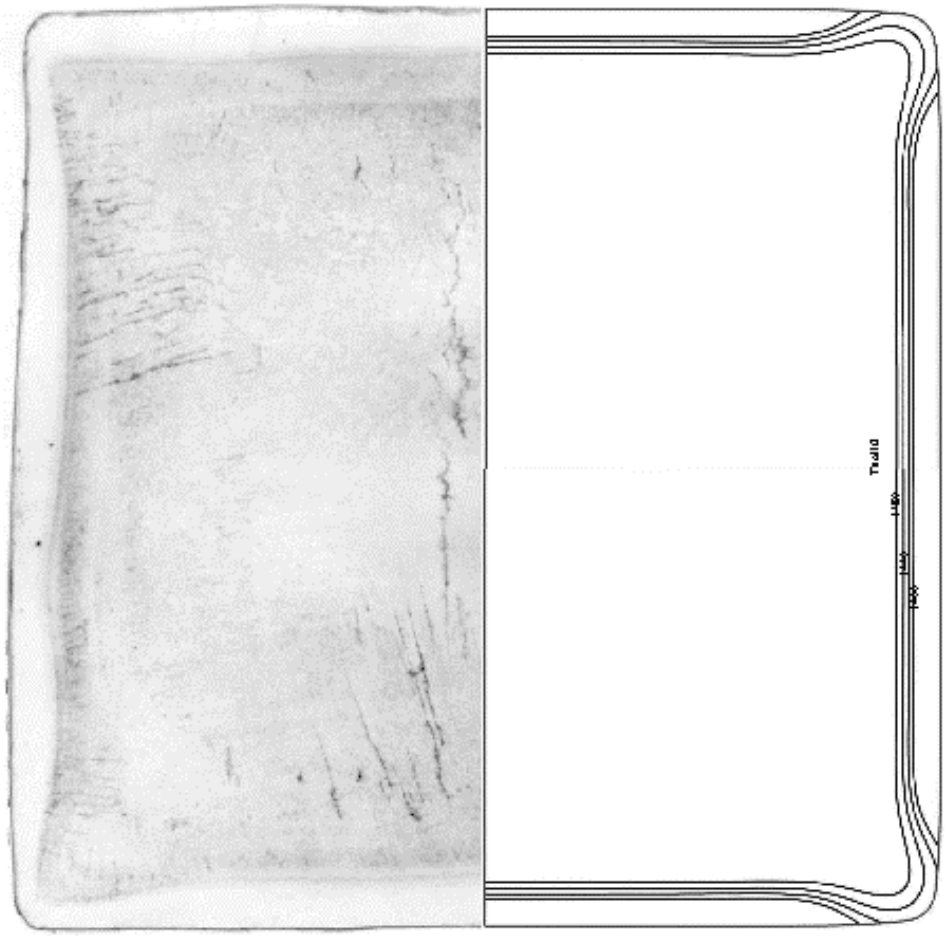
Model Validation



Comparison of predicted and measured shell thickness (based on FeS injection)

Comparison of Predicted and Measured Shell Growth

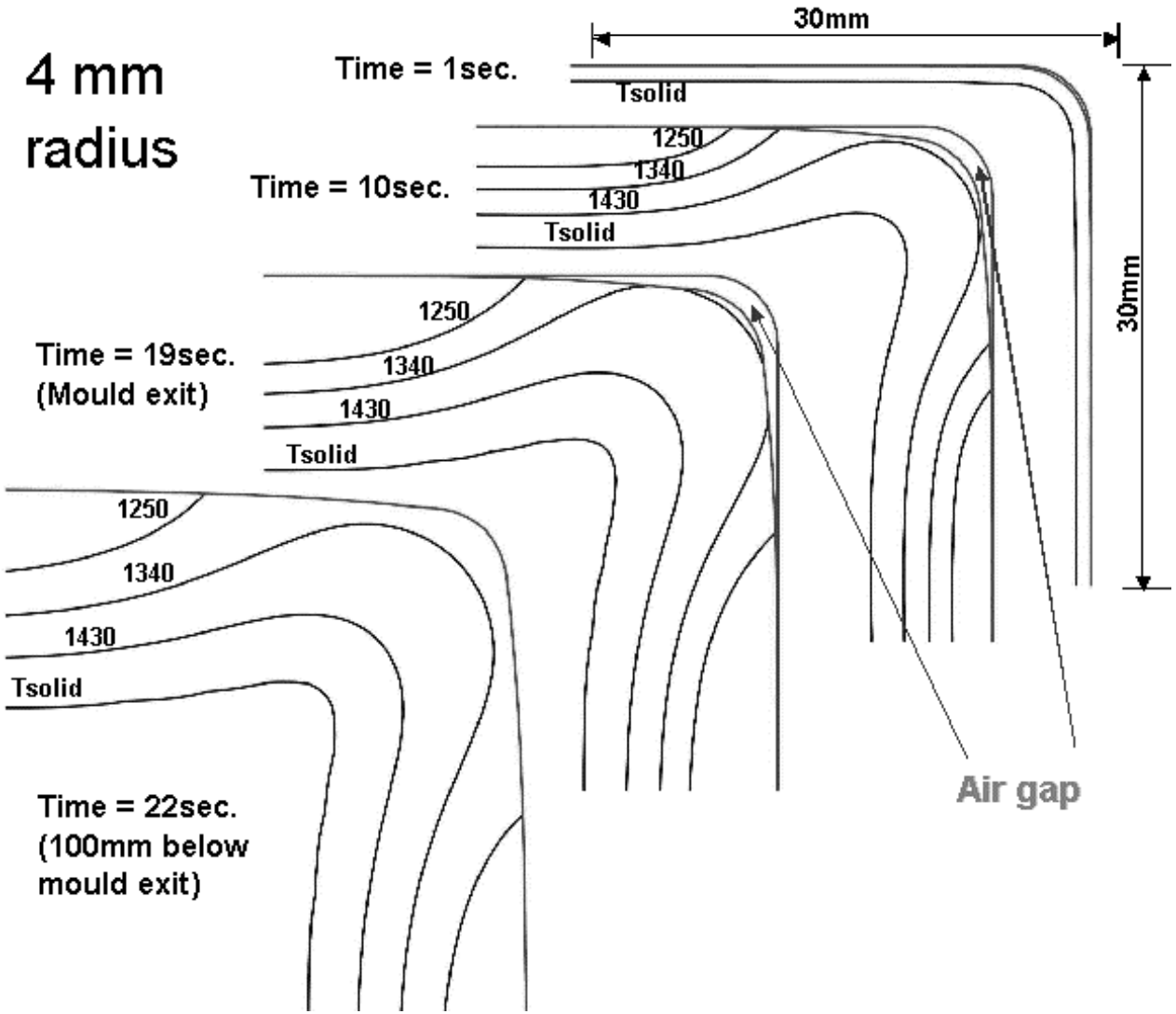
Billet section
(Sulfur print)



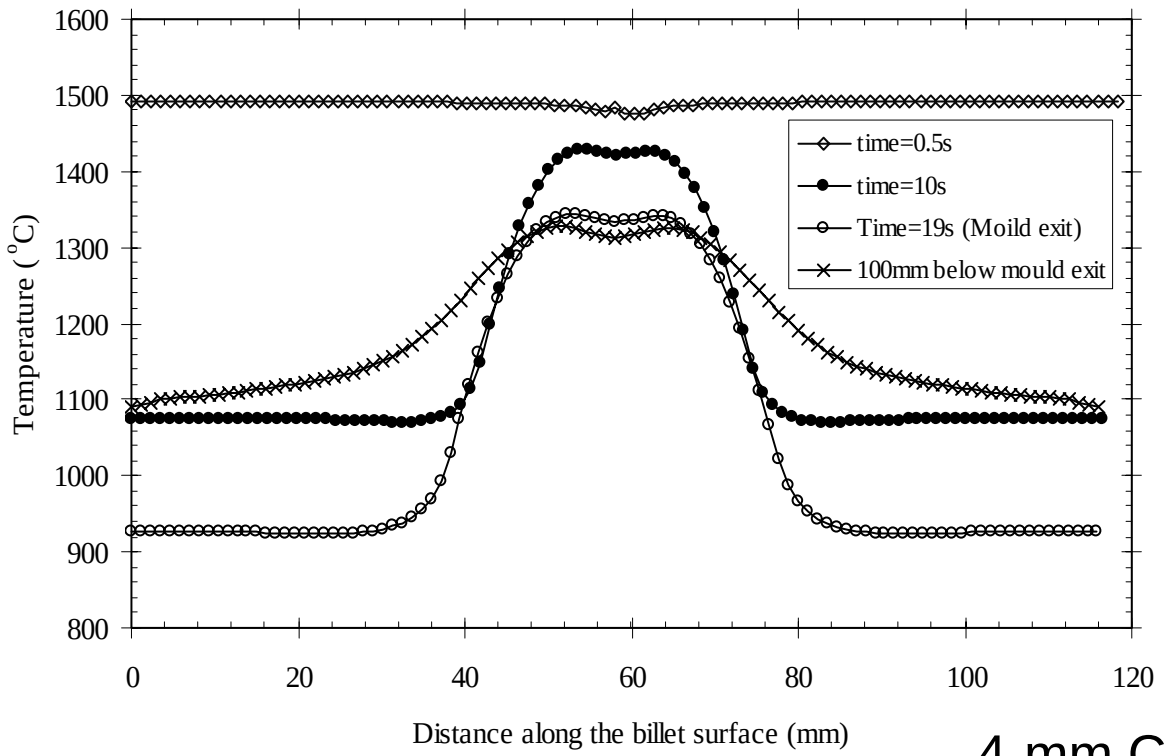
FEM Temp
Contours

4-mm Corner Radius

Shell Solidification in the Mold Corner



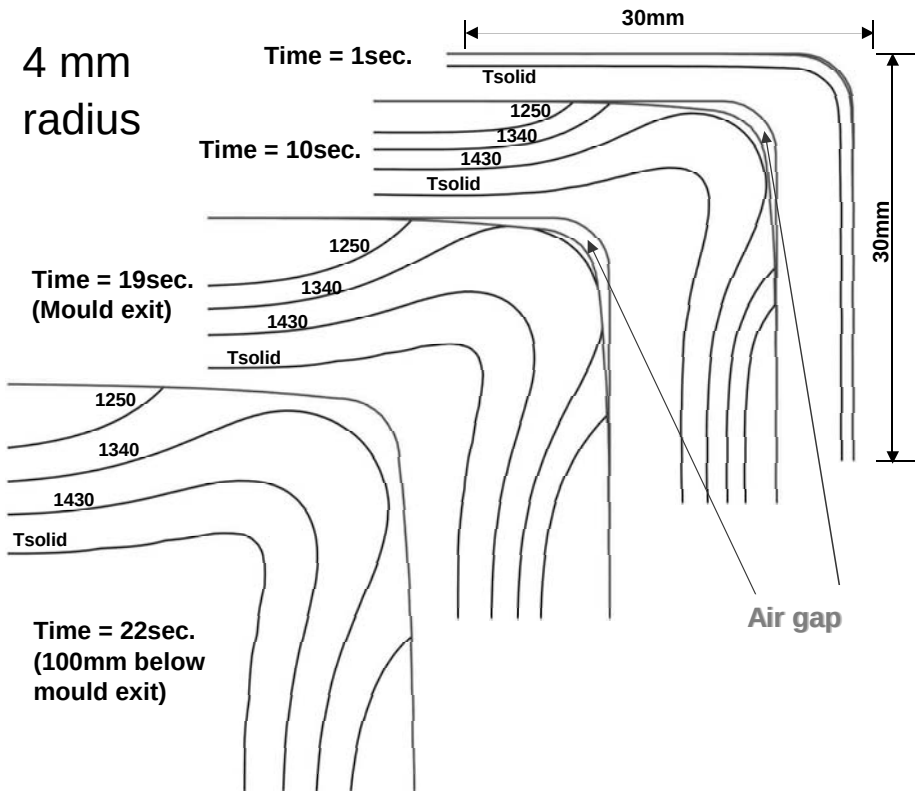
Shell Solidification in the Mold Corner

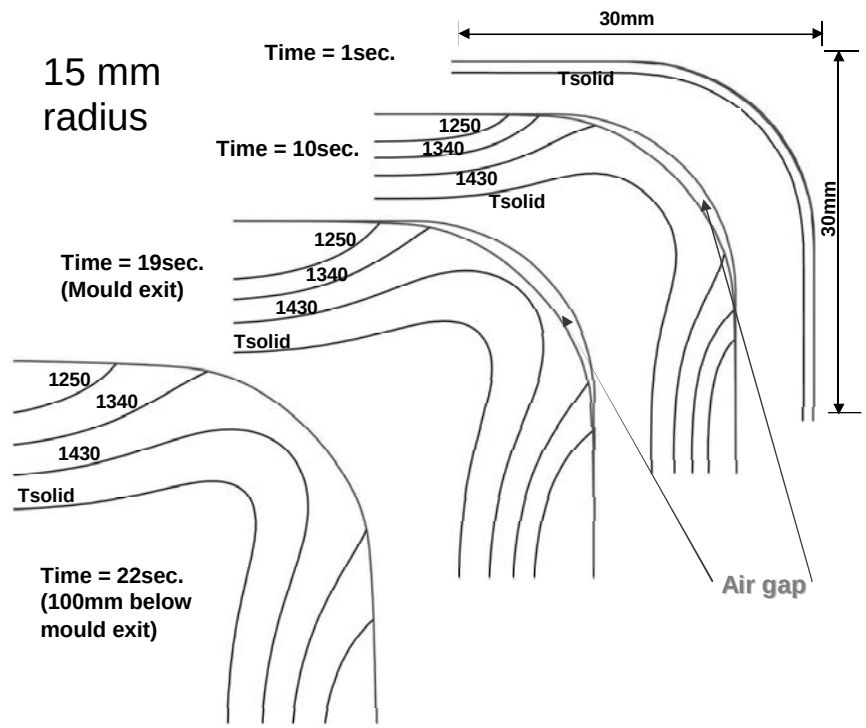


4-mm Corner Radius

Surface temperature profiles at different times

Shell Growth in the mold: Effect of corner radius

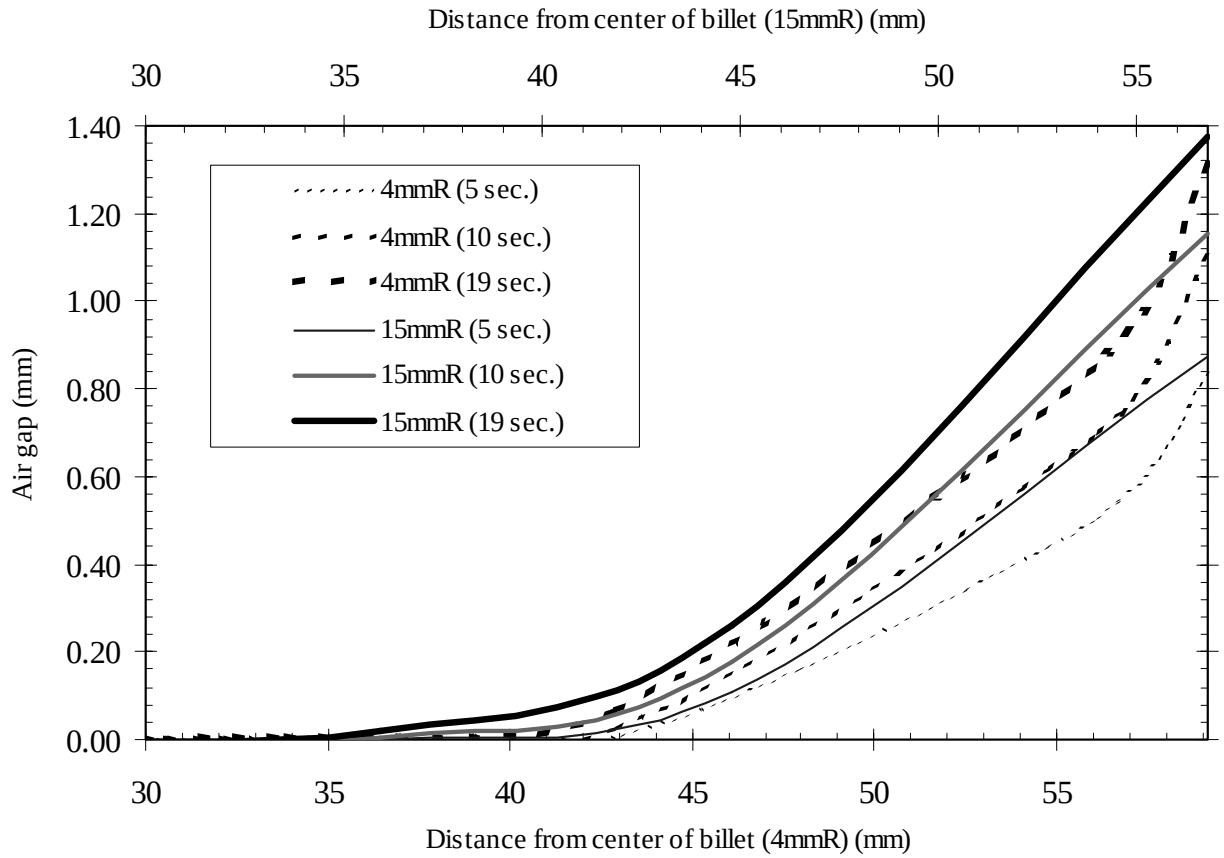




4-mm Corner Radius

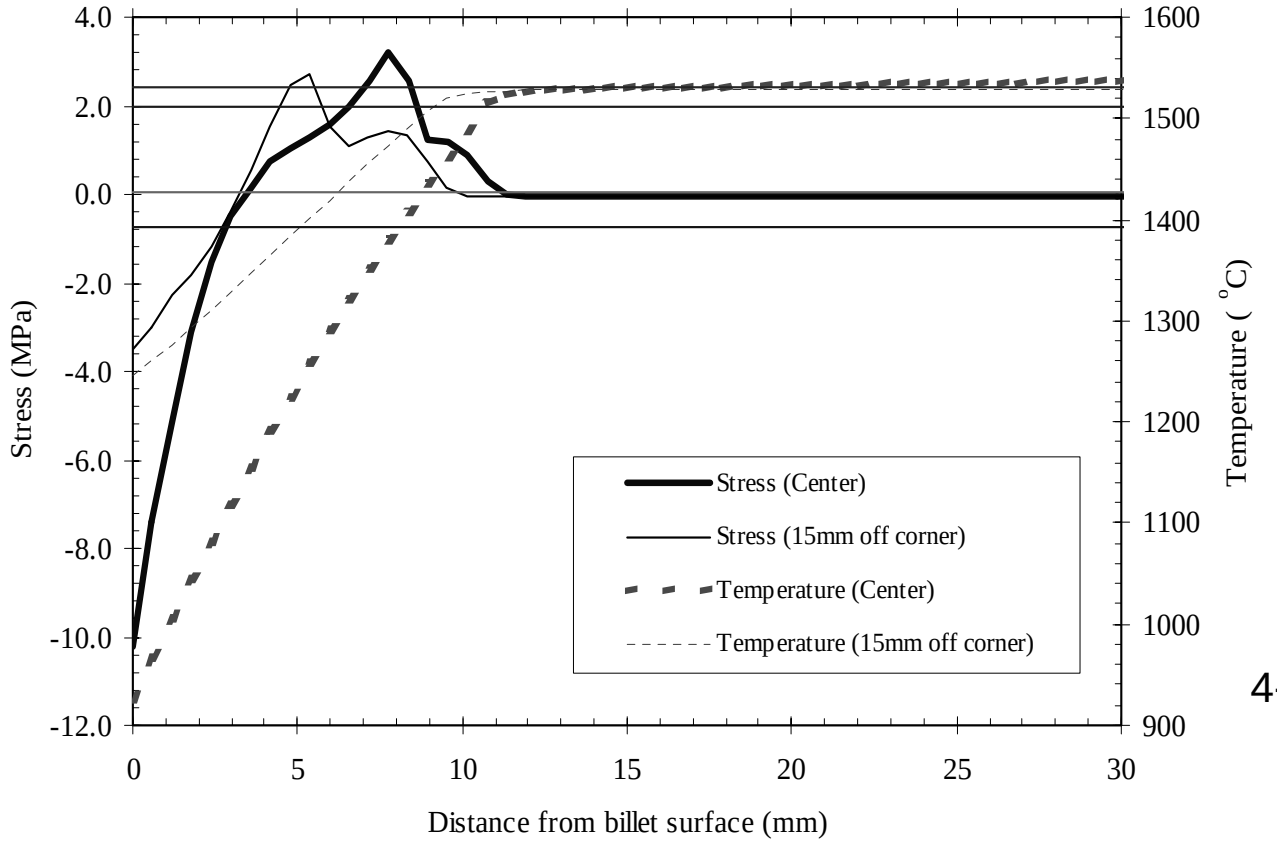
15-mm corner radius

Air gap profiles calculated (variation with time and position)



Comparison of 4-mm and 15-mm corner radius

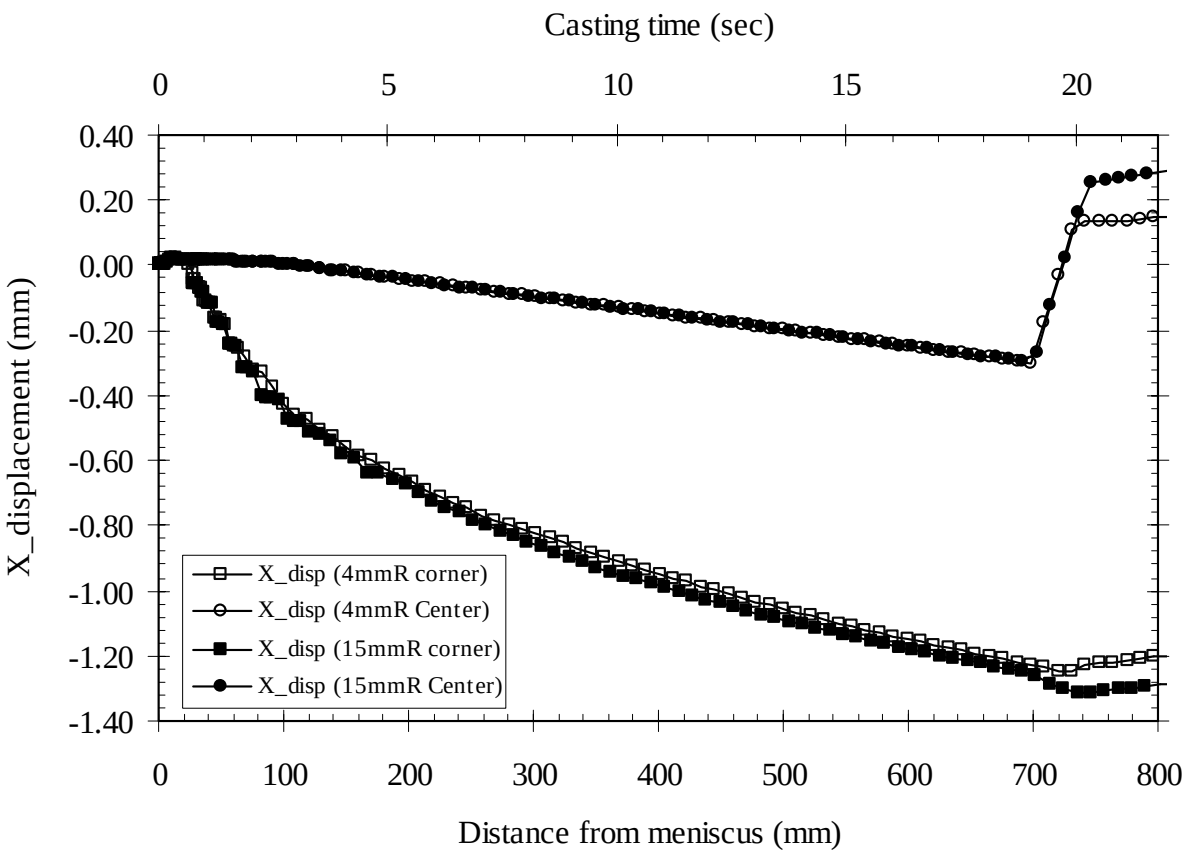
Stress Model Results



4-mm corner radius

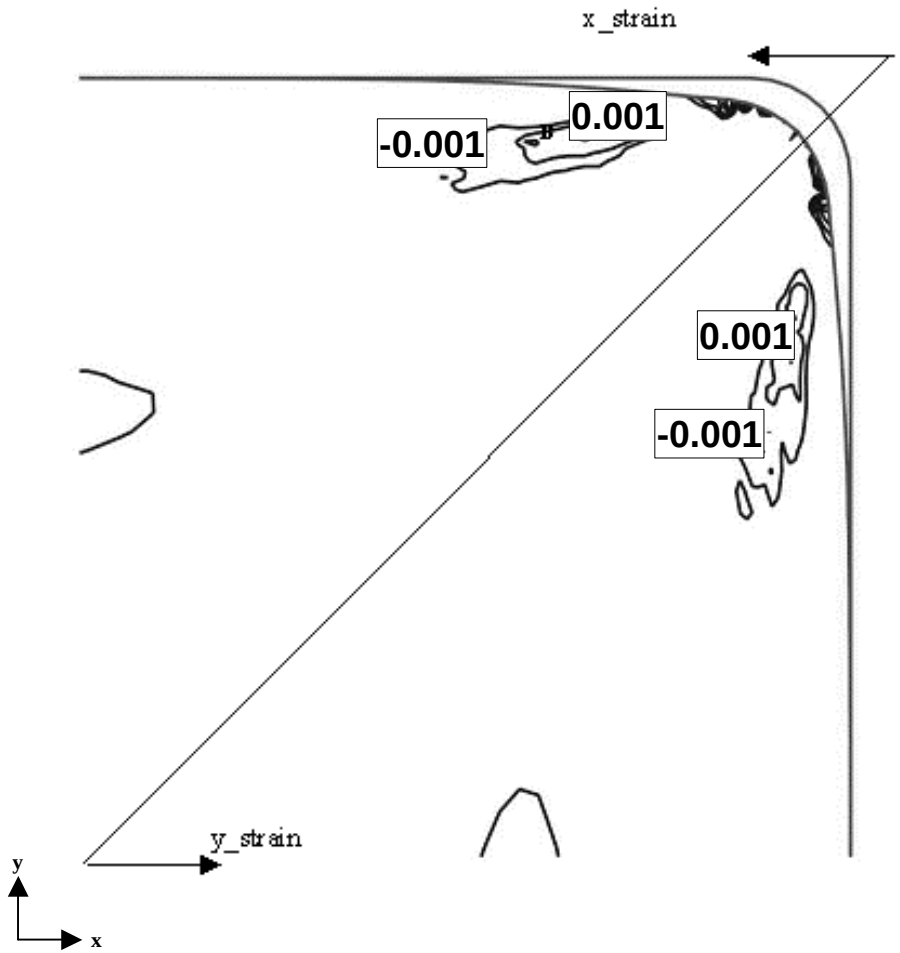
Stress Profile through shell thickness
(compared with corresponding temperature profile at mold exit)

Shell shrinkage and bulging profile

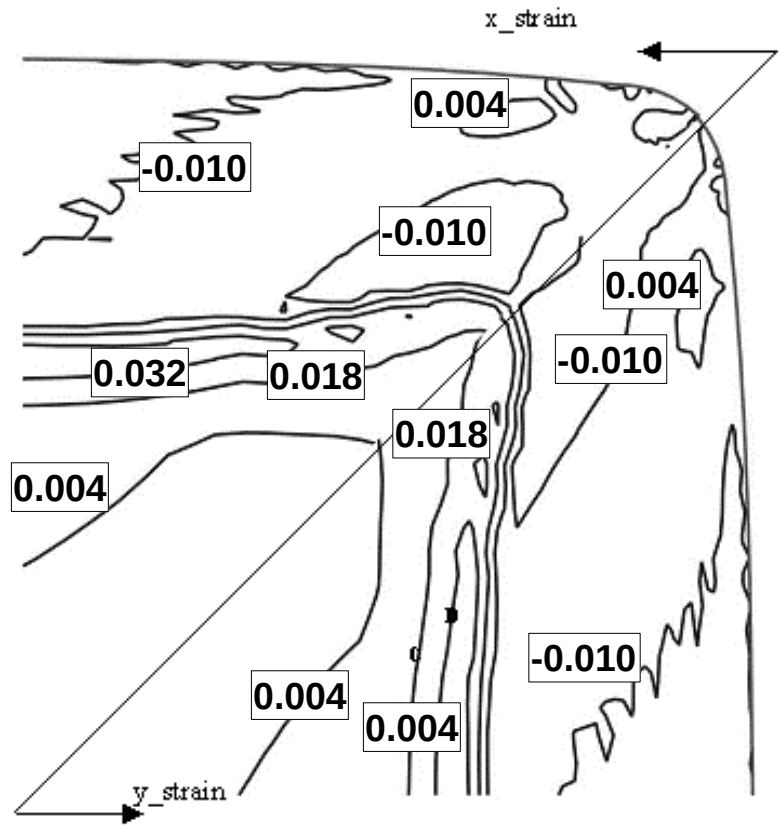


Profile of centerline and corner showing shrinkage in mold and bulging just below, comparing 4 and 15-mm corner radius

Off-corner Cracks: Caused by Strain from Bulging Below Mold



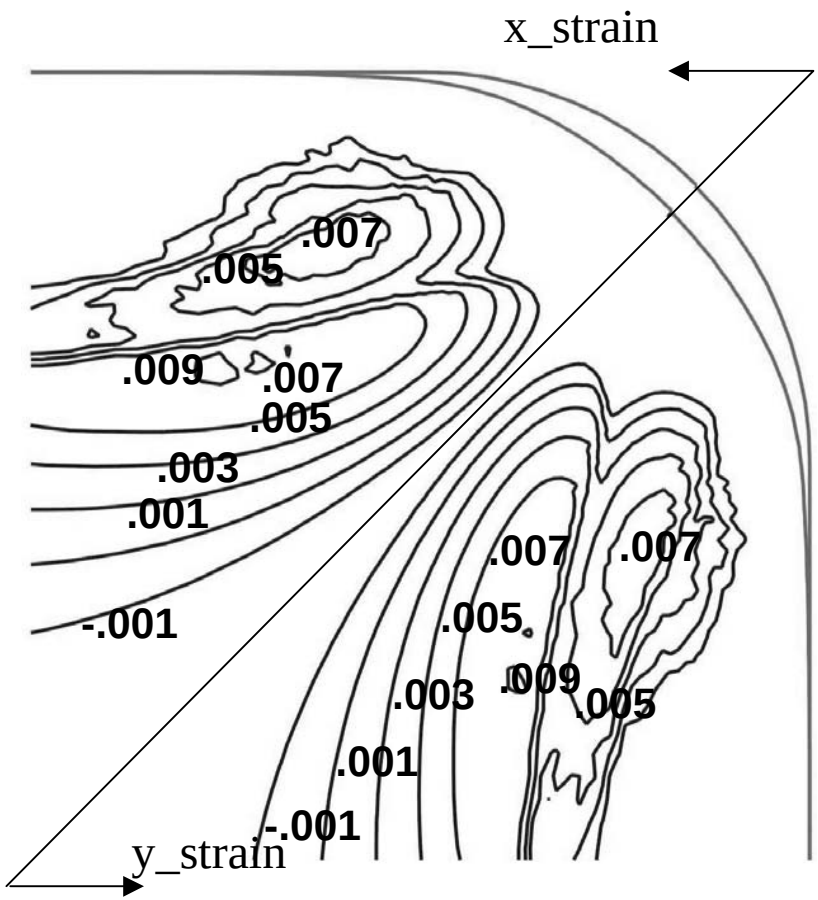
Mould exit



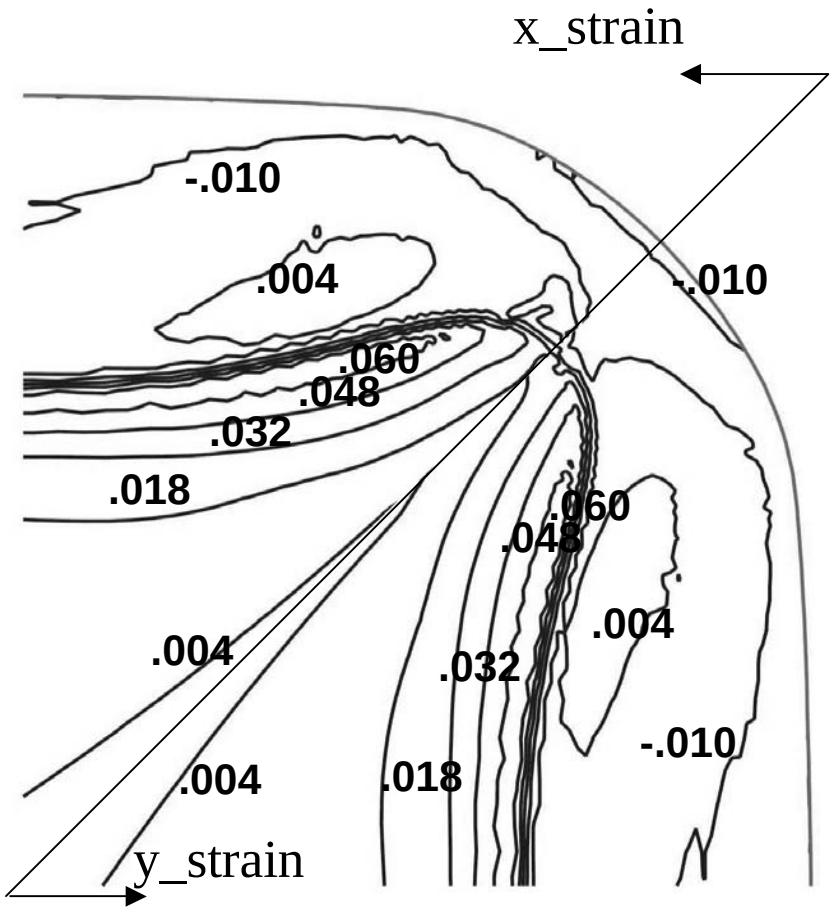
4-mm corner radius

100mm below mould exit

Off-corner Cracks: Worse with large corner radius



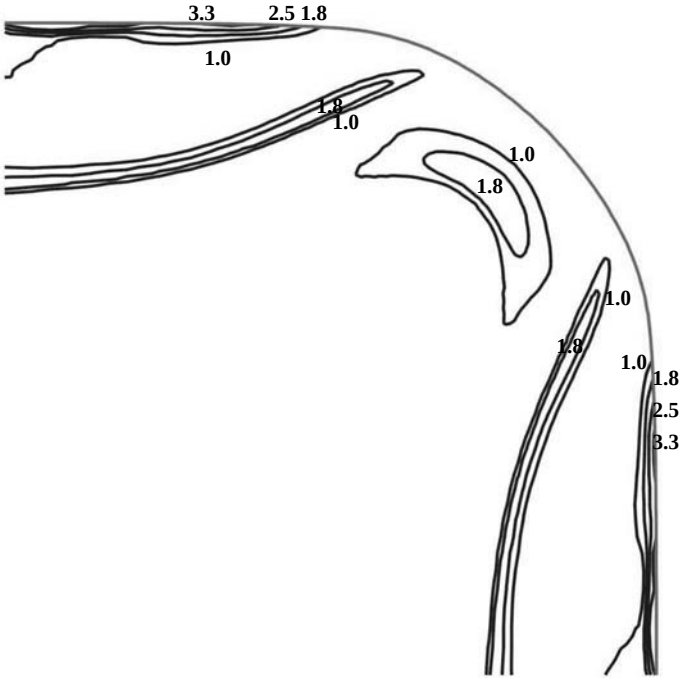
Mould exit

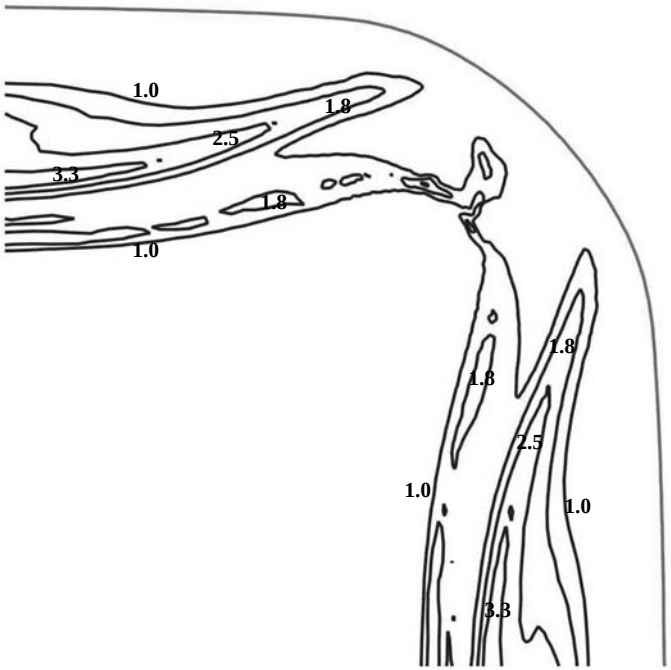


100mm below mould exit

15-mm corner radius

Off-corner Cracks: Worse with large corner radius





15-mm corner radius

Mould exit

100mm below mould exit

Comparison of principal stress contours in corner region