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METAL FLOW AND HEAT TRANSFER IN BILLET DC CASTING USING WAGSTAFF® OPTIFILL™ METAL DISTRIBUTION SYSTEMS

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Outline

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- Model Description
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  - **Metal fill start time and fill complete time**
  - **Metal temperature contour and flow during run cast**
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- Acknowledgements

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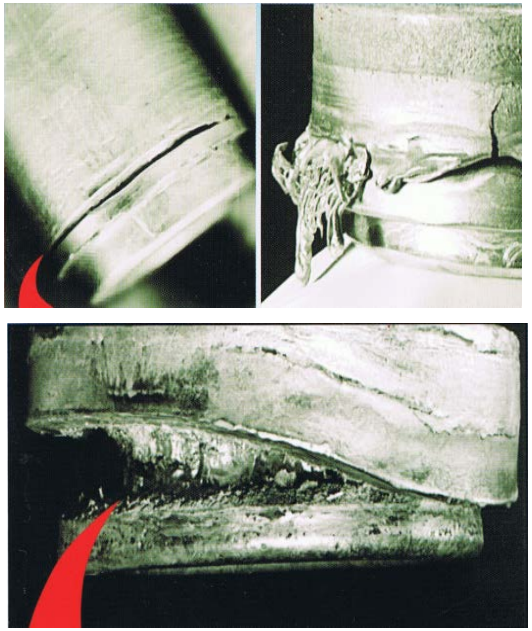
Introduction

Goal: Optimize the design of a metal distribution system to improve metal fill uniformity, obtain consistent start-up process control and premium quality billet

- Decrease total metal fill time and Optimize fill uniformity - **eliminate bleed-out, butt defects (hot/cold butt separations)**
- Reduce heat loss - **obtain less temperature gradient across casting positions**
- Minimize turbulence and pre-solidification **- Maintain good process and metallurgical quality**



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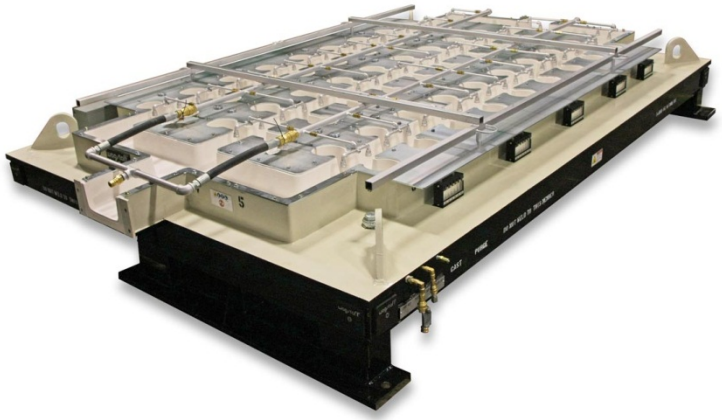
Original, RapidFill™ and OptiFill™

Original: simple and maximized pit utilization

RapidFill™: improve the uniformity of fill and reduce the total fill time and overall heat loss; but require superstructure with motorized start dam and might reduces the maximum number of billet positions



OptiFill™ : draws desirable features from both RapidFill™ and the Original systems, thereby maintaining simplicity while optimizing metal fill performance.

Investigation: Original and OptiFill™ systems:

- Metal fill uniformity and metal residence time
- Thermal, fluid flow fields and heat losses

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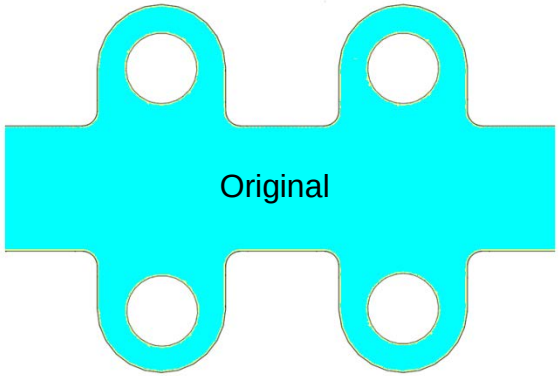
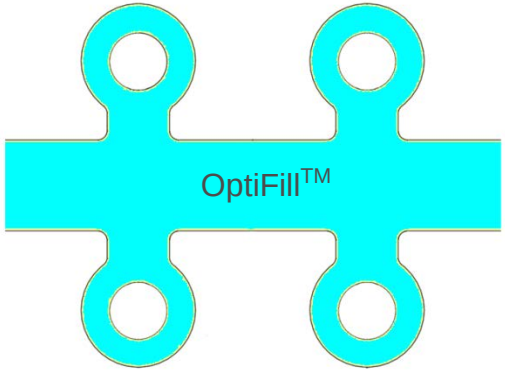
Model Development

- **Billet Systems**
  - 7" 96 strands, 6063
  - Original = 165" × 60.0"
  - OptiFill™ = 165" × 60.0"
  - Cavity cross section area
- **The Model**
  - Turbulent model
  - Thermal buoyancy convection
  - Solidification
- **Meshing**
  - Cell size = ~10 mm
  - Total cells = ~1.9 million
- **Initial Condition (IC) and Boundary Condition (BC) Assumptions**
  - $T_{inlet\ metal}$ = 700 ° C
  - Constant metal height = 110 mm
  - $T_{refractory}$ = 27 ° C
  - Run cast speed = 2.17mm/sec. (130.2mm/min)





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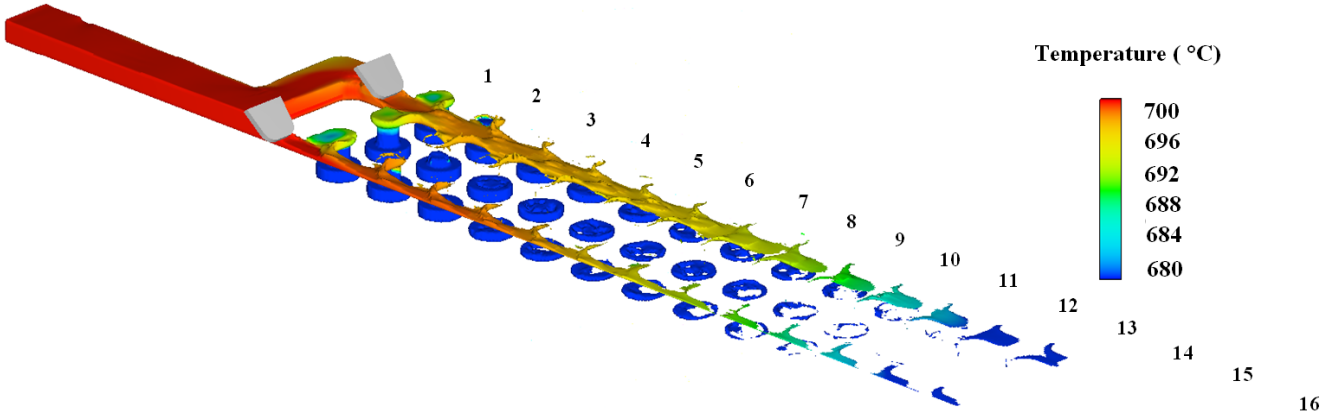
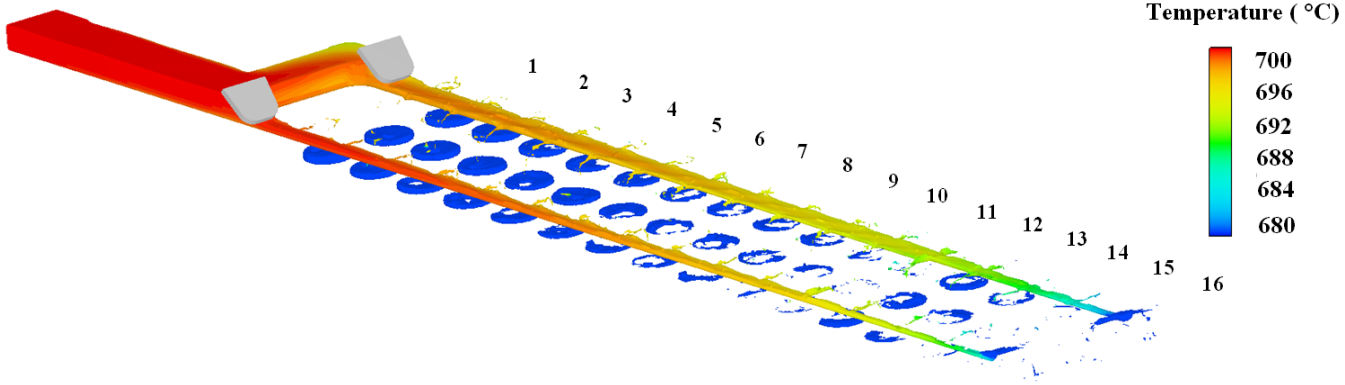
Metal Fill and Temperature Contour

Original



OptiFill™



Metal fill and temperature contours ~5.0 sec. after dams are tilted open

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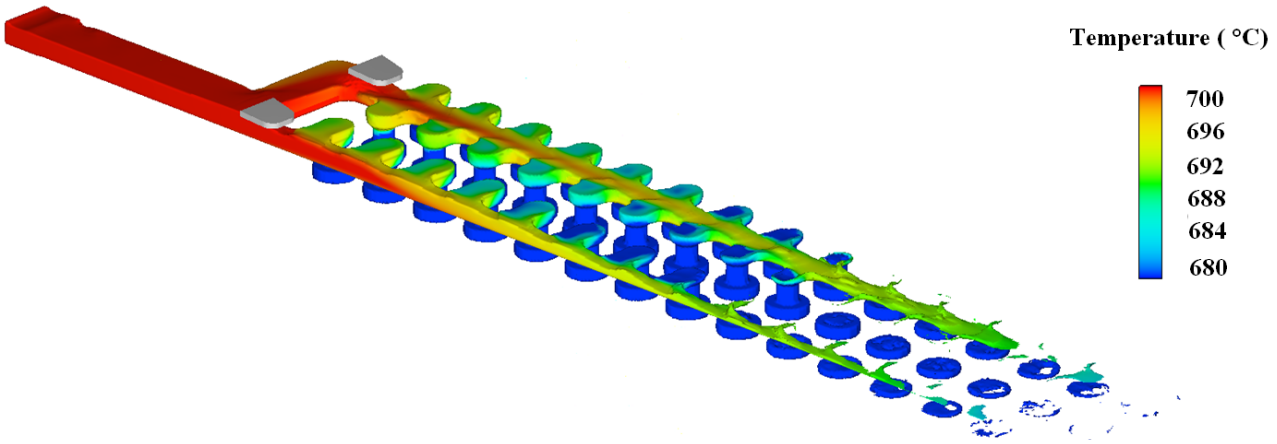
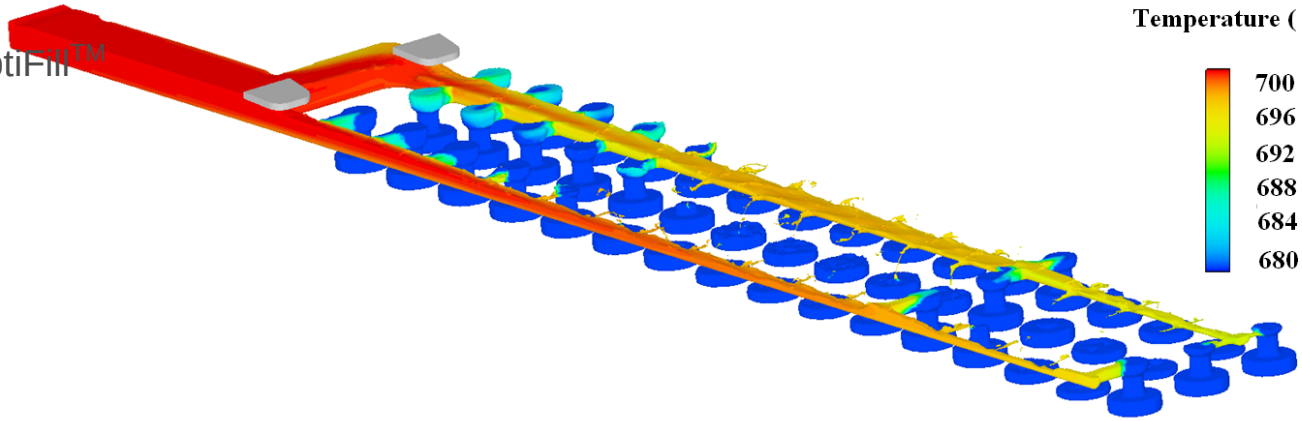
Metal Fill and Temperature Contour

Original



OptiFill™



Metal fill and temperature contours ~15.0 sec. after the dams are tilted open

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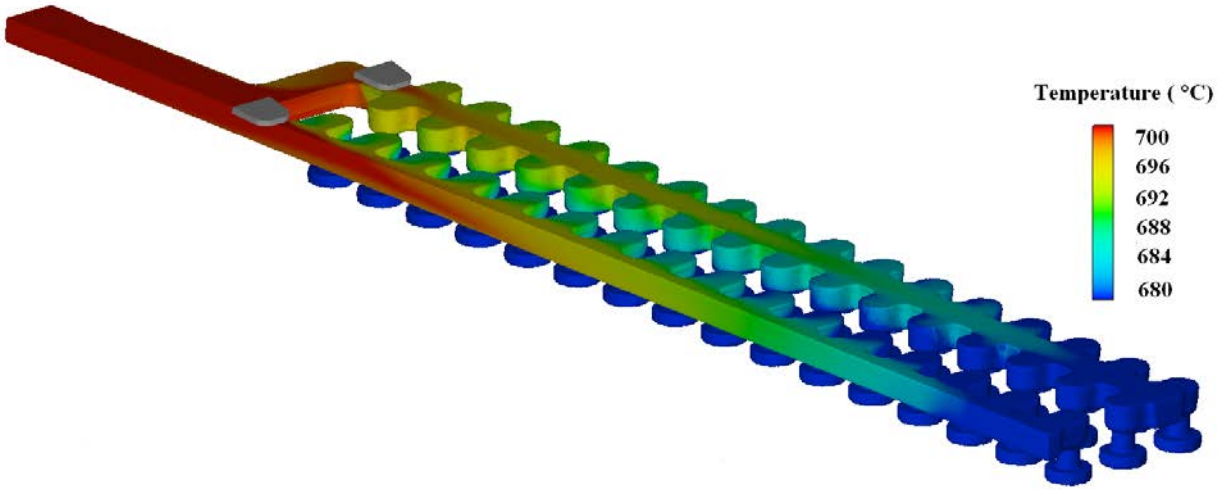
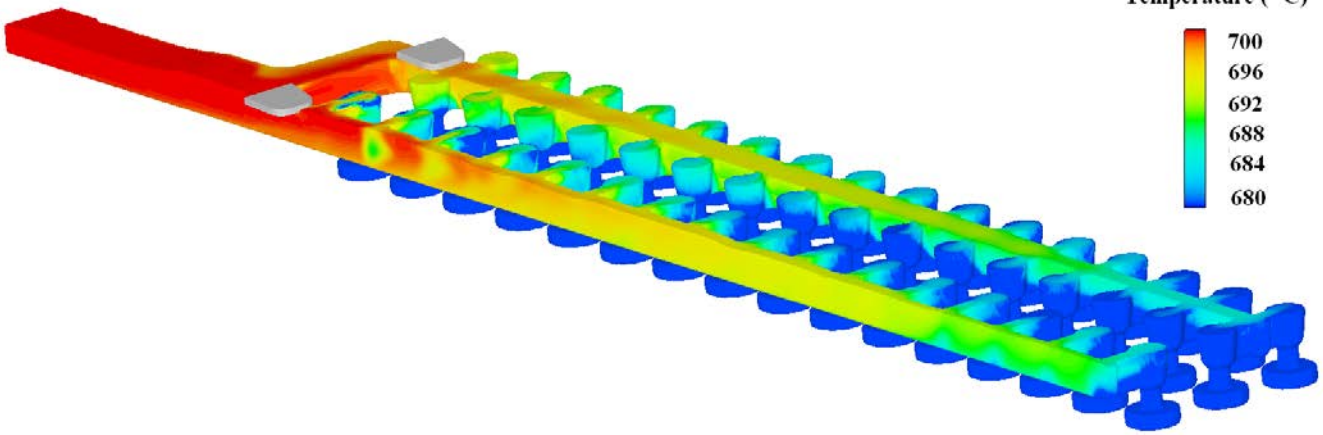
Metal Fill and Temperature Contour

Original



OptiFill™



Metal fill and temperature contours at cast start

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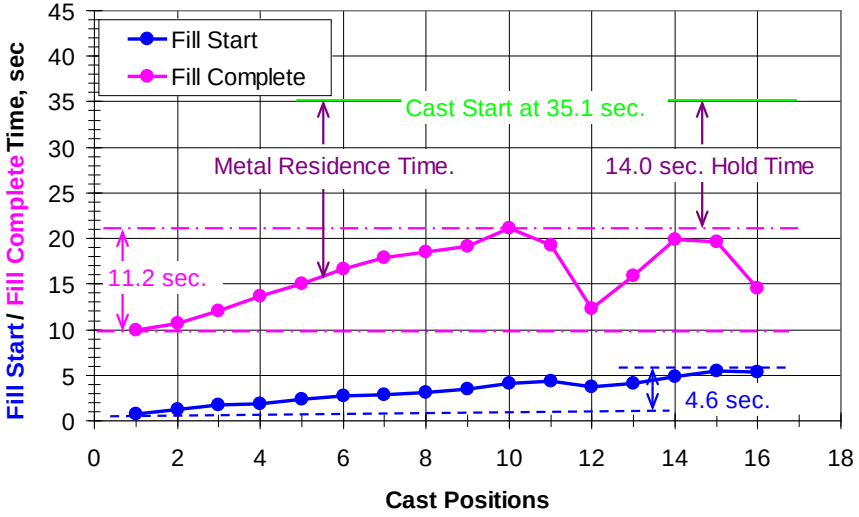
Metal Fill Uniformity

Original



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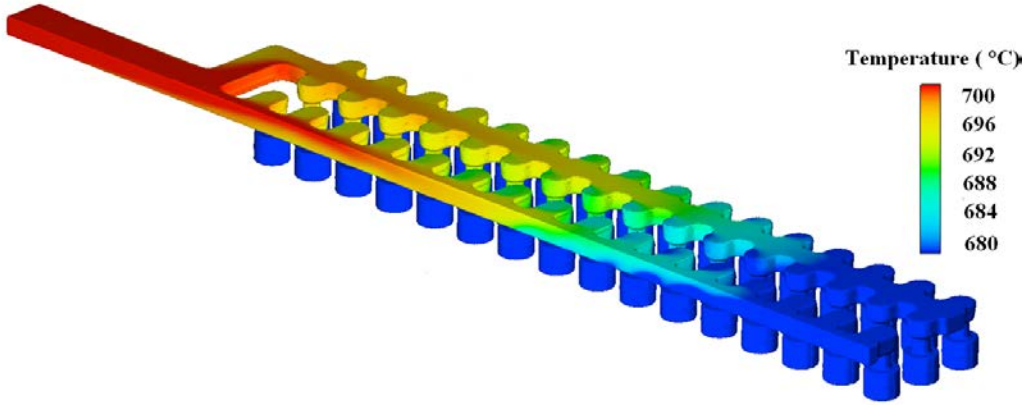
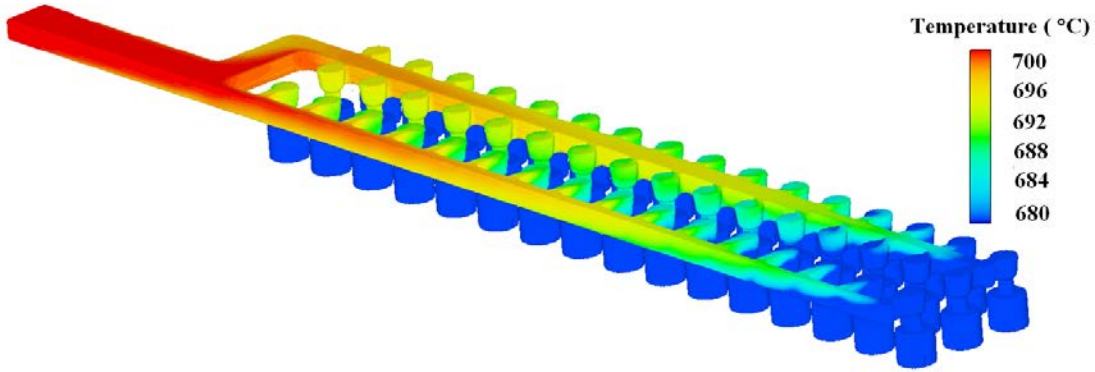
The metal fill start time, fill complete time and residence time for the two systems

Temperature Contour during Cast

Original



OptiFill™



Metal temperature contours at ~100 sec. of casting (Cast Length ≈ 199 mm)

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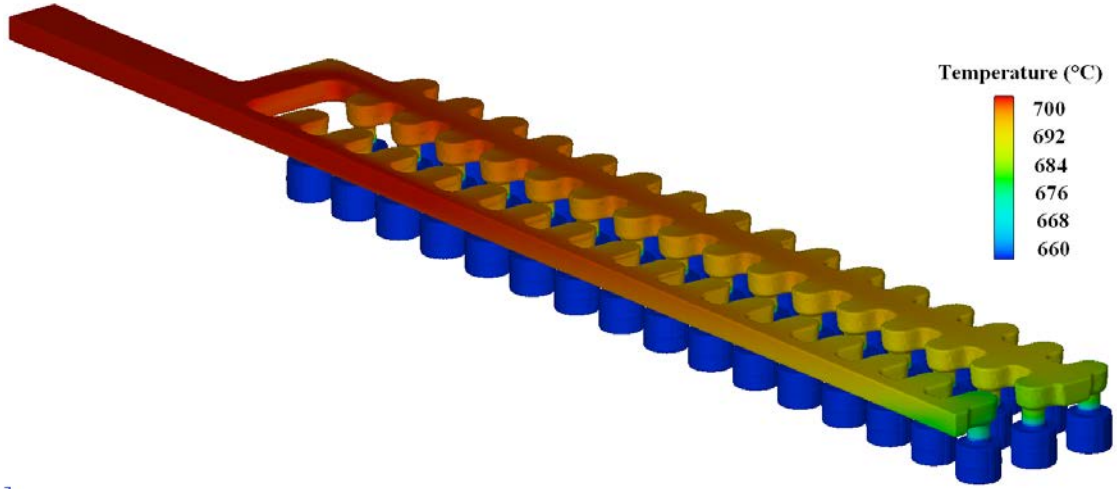
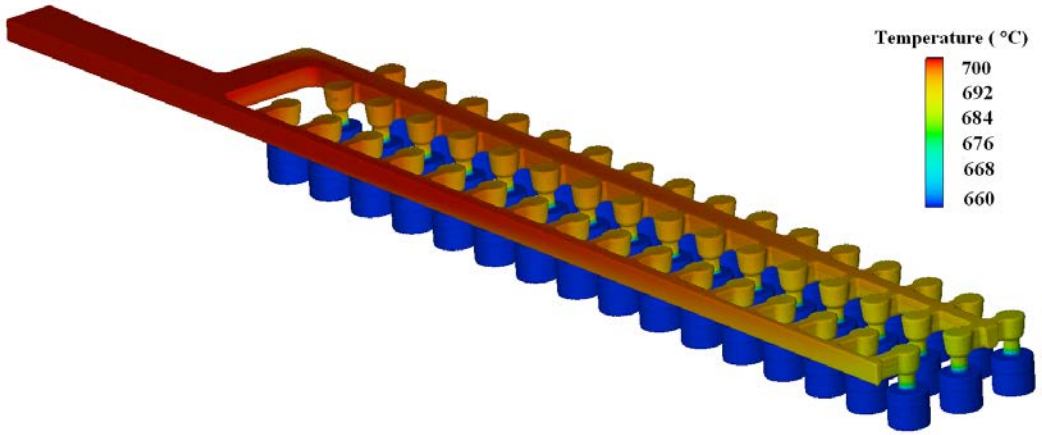
Temperature Contour during Cast

Original



OptiFill™



Metal temperature contours at ~350sec casting (Cast Length ≈ 742 mm)

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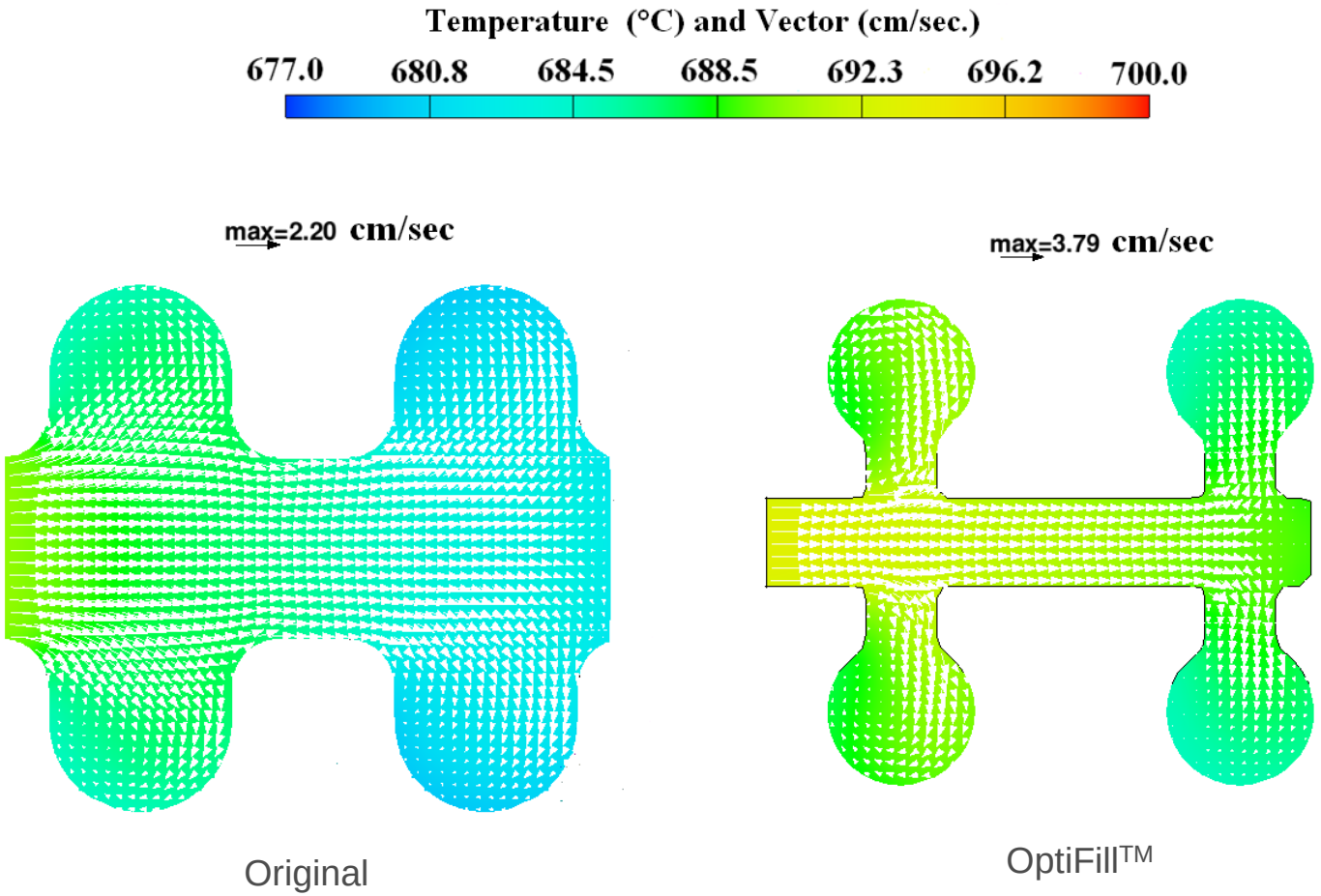
Temperature Contour and Flow



Original

OptiFill™

Metal temperature and flow at ~350 sec. casting
(~ 6.5 cm from trough bottom, cast length ≈ 742 mm)

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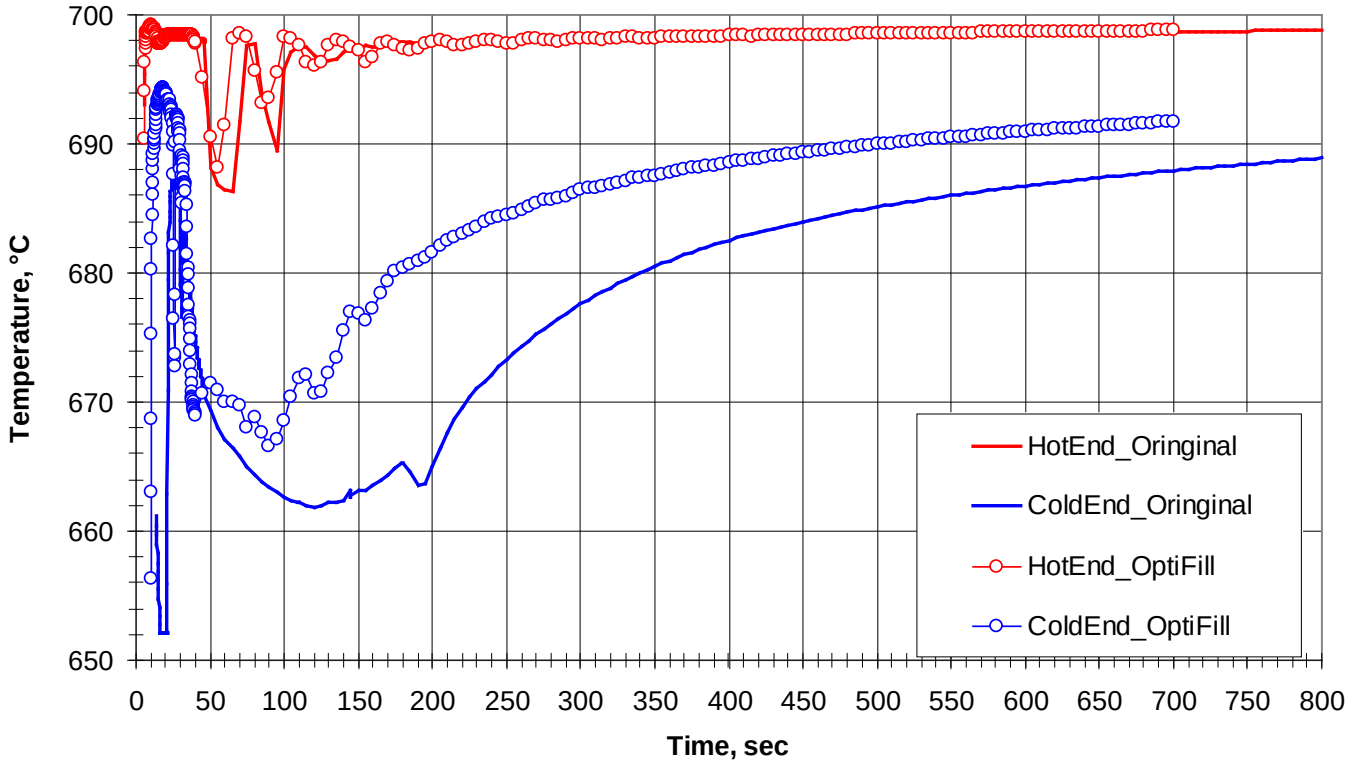
Temperature History and Heat Loss



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Summary

Heat transfer and fluid flow models for Original and Wagstaff® OptiFill™ metal distribution systems for billet casting have been developed to investigate metal flow and heat losses. Optifill™ has the following benefits:

- **Less fill start time difference in OptiFill™** (more metal to cold end early)

  OptiFill™ → ~4.6 sec, Original → ~17.4 sec

- **Less fill complete time difference in OptiFill™** (more metal to cold end)

  OptiFill™ → 11.2 sec, Original → 22.6 sec

- **Less total fill time in OptiFill™** (smaller runner trough + ingate + melt pool)

  OptiFill™ → ~21.1 sec, Original → ~26.3 sec

- **Less heat loss in OptiFill™** (faster metal flow in the runner trough)

  OptiFill™ → ΔT is ~15 °C less at start of cast and 3-5 °C less in run state

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Rahab Original System to OptiFill™

Old System: 7“ x 44 strands Original

Rehabbed System: 7“ x 44 strands OptiFill™

Benefits:

- ~12 sec less total fill time (OptiFill™ = ~15.0 sec, Original = ~28.0 sec)
- ~10-15 °C less heat loss (OptiFill™ = ~10 °C, Original = ~20-25 °C)
- Consistent start-up process

Wagstaff® OptiFill™ metal distribution system is the preferable choice in production of premium quality billets

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Acknowledgement

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