




Senior Flexonics Brazing Capabilities

BATTERY ELECTRIC VEHICLE  **TECHTALKWEBINARS**
BATTERY TECHNOLOGY INNOVATION 2022 **11-15 JULY**
CELLS&SYSTEMS, MANUFACTURING, MATERIALS, COST OPTIMIZATION AND TECHNOLOGIES



TECHTALKWEBINARS **WEAUTOMOTIVE**

BATTERY TECHNOLOGY INNOVATION 2022

**SENIOR FLEXONICS
BRAZING CAPABILITIES
WITH CASE STUDY REVIEW
OF BATTERY COOLER
BRAZING DEVELOPMENT**

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senior
Flexonics

FRI 15 JULY | 3PM (CET) | 9AM (ET)
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Introduction

Senior is an international, market-leading, engineering solutions provider with 27 operations in 12 countries.

We design, manufacture and market high-technology components and systems for the principal original equipment producers in the worldwide aerospace, defence, land vehicle and energy markets.

Senior PLC, Group Revenue 2021: Headquarters: Employees: London Stock Exchange:		£658m Rickmansworth, Nr London 5,800 FTSE 250	
Flexionics Division	34%	Aerospace Division	66%
WHAT WE DO Serving markets with products for land vehicle emission control and process control for industrial applications		WHAT WE DO Serving commercial aerospace and defence markets with a range of products and systems for structures required in aircraft, as well as systems for fluid conveyance in gas turbine engines	



- All our products are developed by a dedicated and customer focused team, manufactured in world class facilities, and proven through an exceptional warranty record



EGR & ICE Thermal Management



Gasoline & Diesel Common Rails



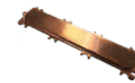
Flexible Connectors & Turbo Dampeners



Waste Heat Recovery



Fluid Transfer & EGR Tubes



Electronics Thermal Management



Battery Thermal Management



Fuel Cell Heat Exchangers



Recuperators & Cathode Air Pre-Heaters



Hybrid

Our expertise in a vast array of applications gives our customers the flexibility to develop efficient, market leading propulsion technologies to meet this growing demand.

The need for clean and efficient sources is greater than ever before. We are working with some of the world's leading companies to develop clean sources of energy generation, whilst dramatically improving efficiency and energy security.



Energy



Combustion

Our key focus for combustion engines is to improve fuel efficiency and reduce harmful emissions. We combine decades of manufacturing expertise with the latest technologies to ensure our customers are always one step ahead.

We are using our wealth of knowledge to implement creative solutions, enabling our customers to maximise battery life and performance. We also develop highly efficient range extender technologies.



Electric

- Brazing capabilities
 - Vacuum Furnace
 - Controlled atmosphere, very high control of temp, low contamination
 - Very versatile for temperature and time profiles
 - Batch process
 - Continuous (Belt Furnace)
 - Constantly moving in an endless loop (continuous throughput)
 - Designed to handle high volume production
 - Induction Brazing
 - Localized heating to Braze joint area
 - Fast process, ideal for semi or fully automated equipment
 - Flame Brazing
 - Localized heating to Braze joint area
 - Typically slower process than Induction, typically hand fed alloy



Vacuum Furnace



Belt Furnace

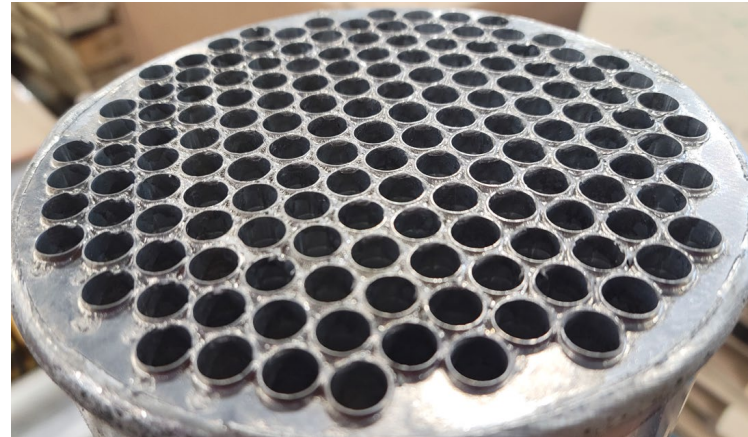


Induction Braze



Flame Braze

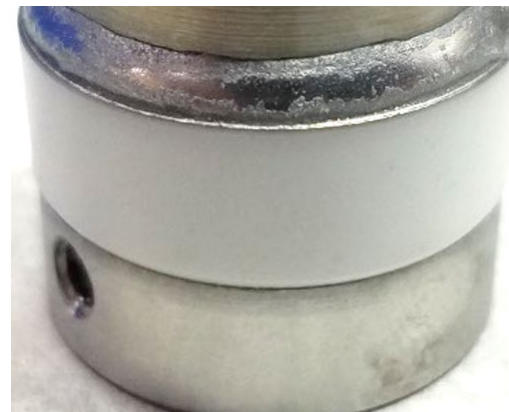
- Brazing material examples
 - Stainless Steels
 - 200, 300, 400, & 600 series Stainless steel, and Inconel
 - Copper and Copper Alloys
 - C110 (Oxygen free Copper)
 - C175 (Beryllium Copper)
 - C182 (Chromium Copper)
 - Aluminum
 - 3000 series
 - 6000 series
 - Brazing typically done using cladded alloys
 - Ceramic
 - Ceramic with Metalized surfaces



SS tube to SS bulkhead



Copper to Brass



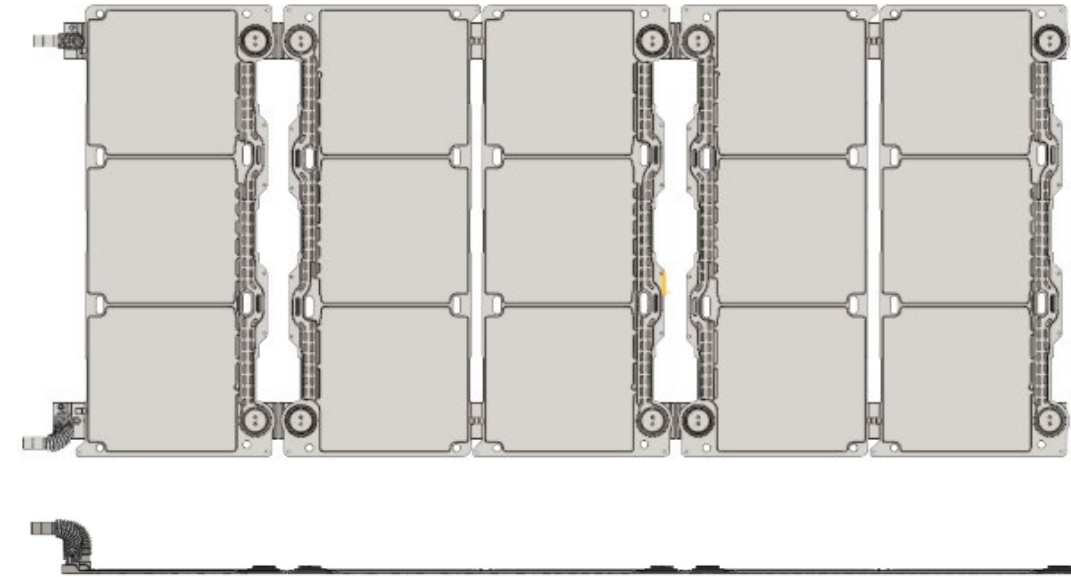
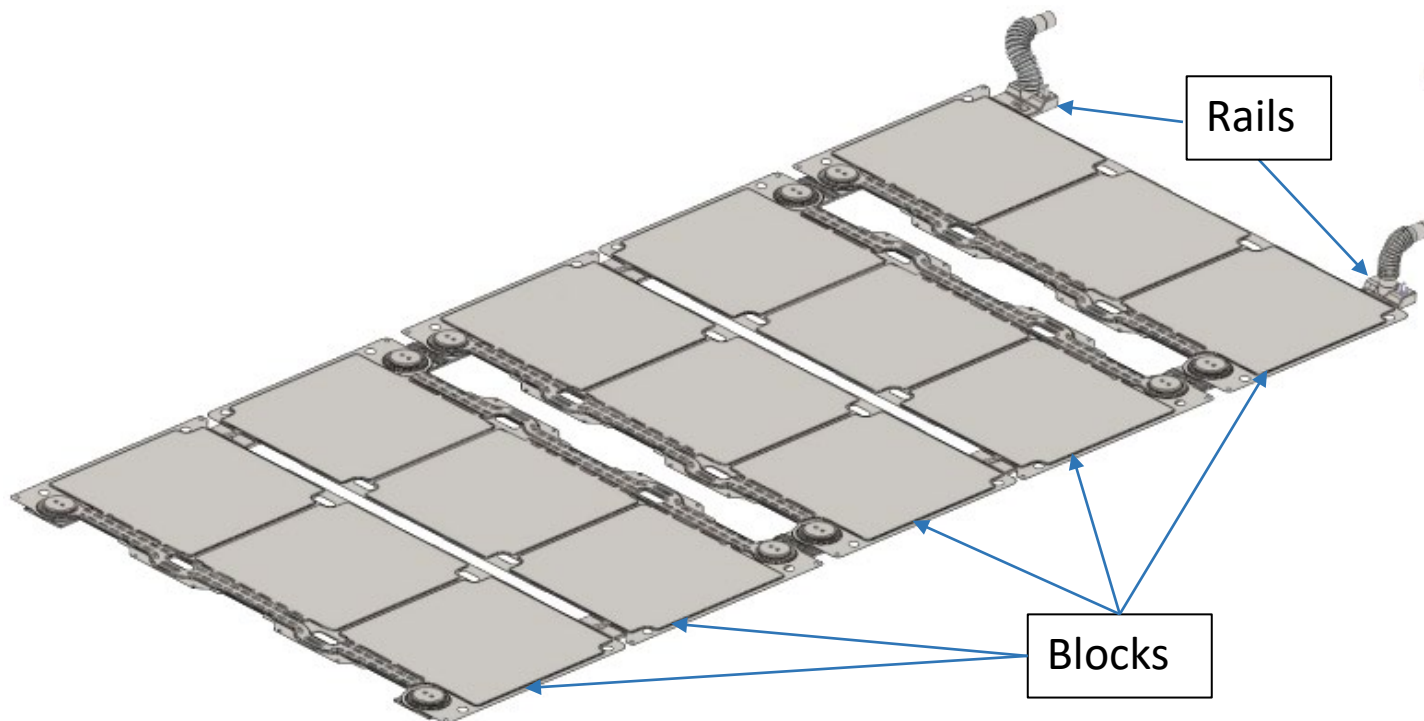
Metalized Ceramic to SS



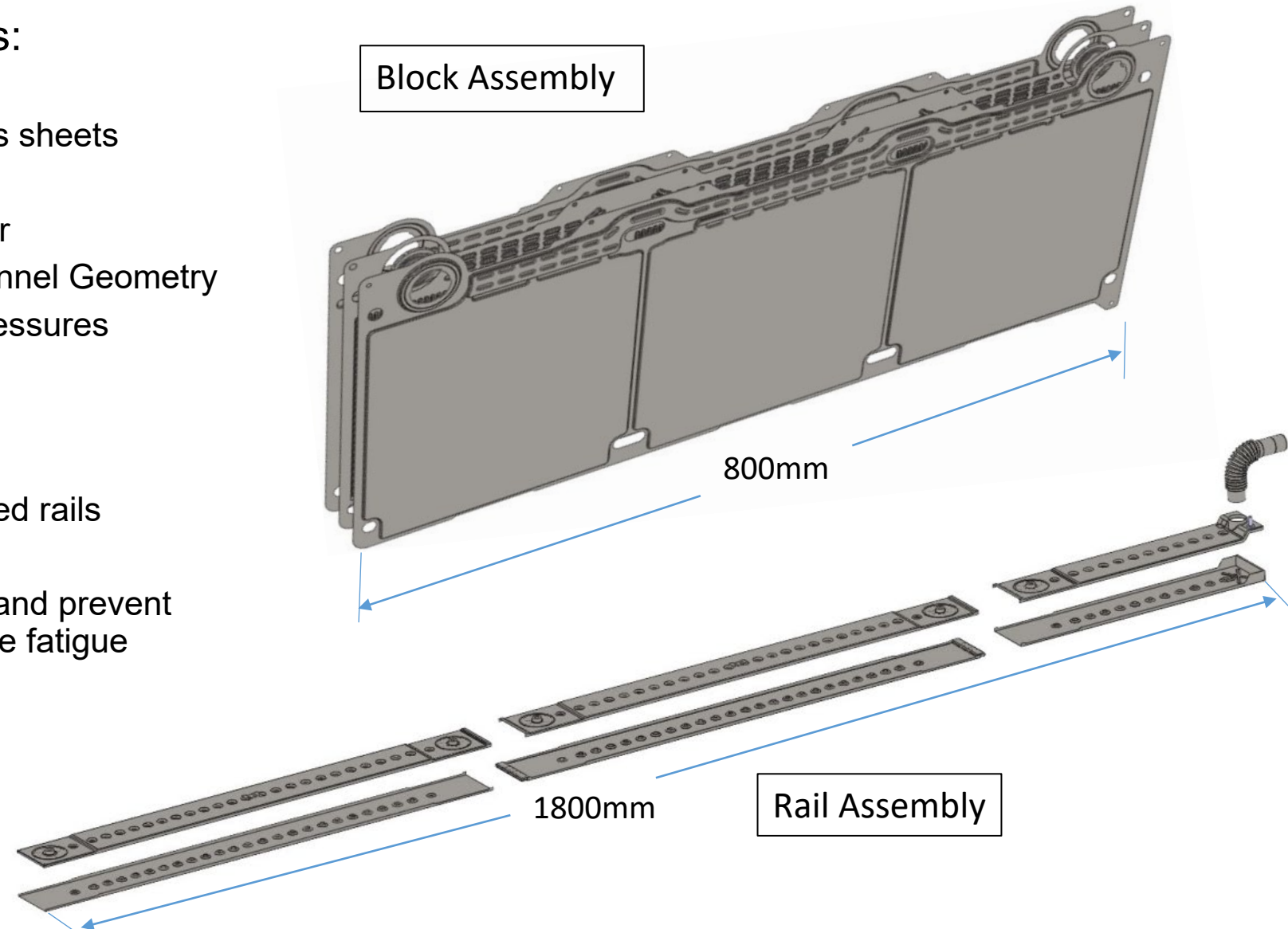
SS Casting to SS Tube

- Battery Cooler Assembly

- 5 cooling block plates
- 1 coolant inlet rail
- 1 coolant outlet rail
- Approximate size of assembly is 1850mm x 800mm

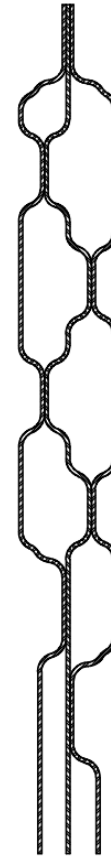


- Overview of component designs:
 - **Blocks**
 - 3 0.2mm thick formed stainless sheets
 - Tight tolerances
 - Critical Alignment to each other
 - Complex Internal Coolant Channel Geometry
 - Able to withstand operating pressures
 - Must be leak tight after braze
 - **Rails**
 - Multi-section sheet metal brazed rails
 - 1800mm in length
 - Features to maintain strength and prevent premature failure from pressure fatigue
 - Must be leak tight after braze

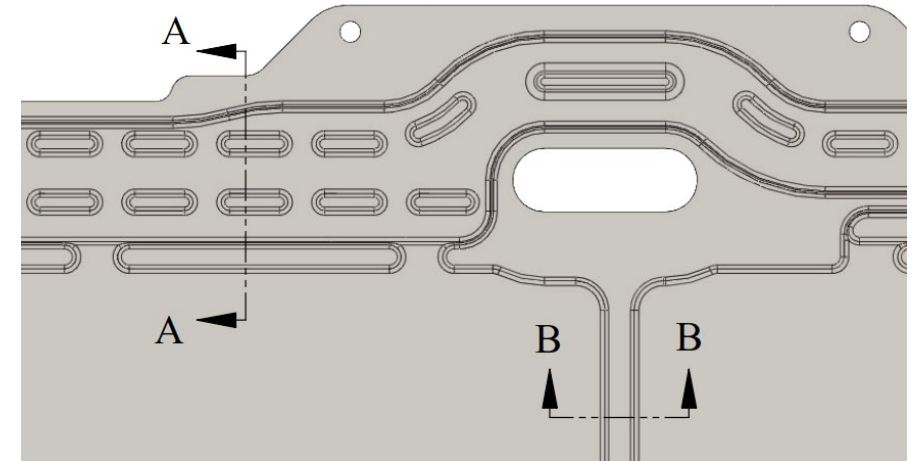
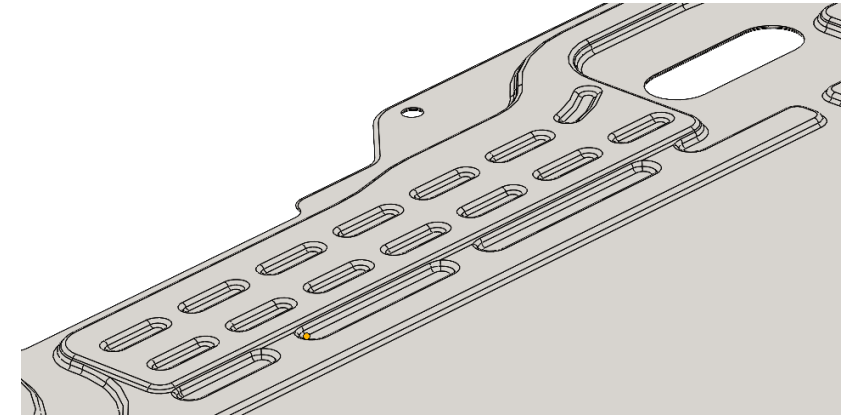


- Brazing Challenges -Blocks

- Multilevel Braze Joint surfaces of thin materials
- Braze paste required to be applied to 100's of critical joint locations
- Must maintain internal flow paths without clogging with braze alloy.
 - This requires optimizing the braze alloy application (locations and the amounts)
- Complex braze fixtures
 - Maintain pressure to multilevel surfaces during brazing
 - Not become damaged during thermal expansion of the assembly
- Maintain stringent flatness requirements after post brazing



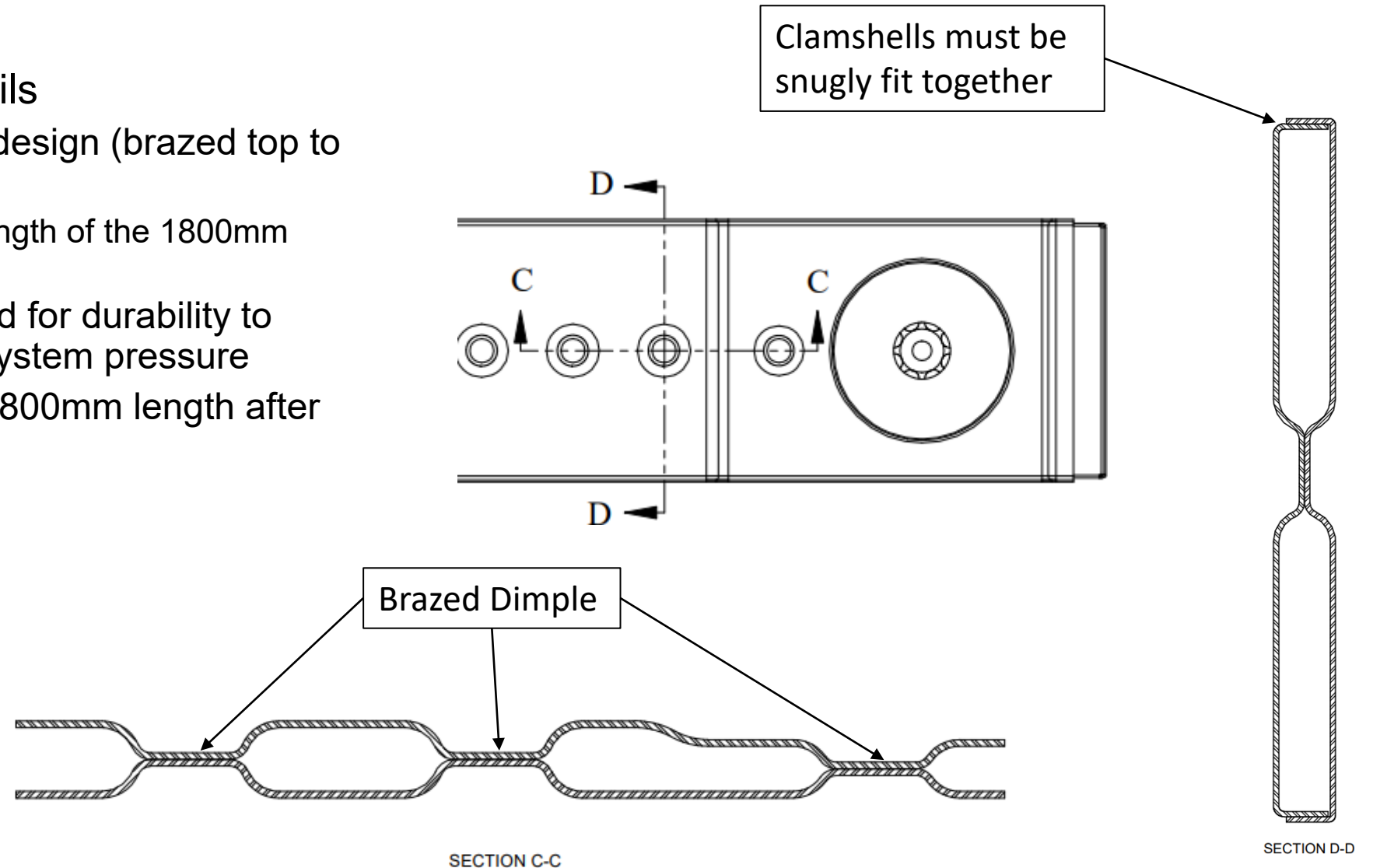
SECTION A-A



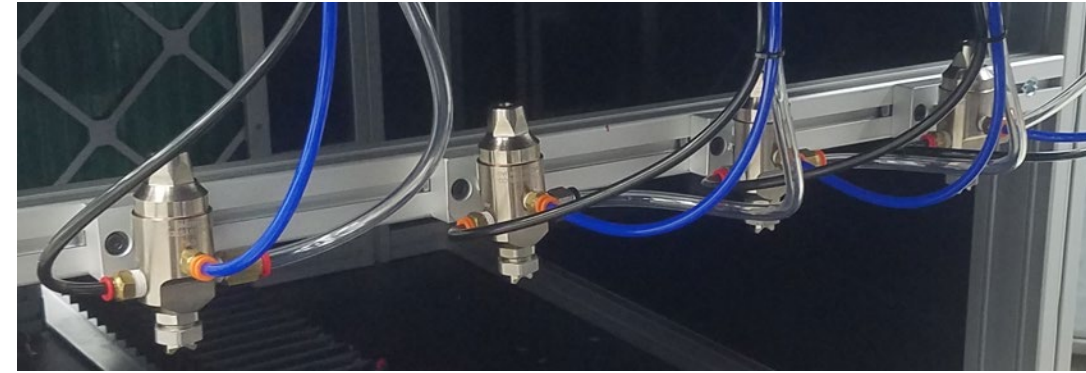
SECTION B-B

- Brazing Challenges – Rails

- Sheet metal clamshell design (brazed top to bottom)
 - Lap joints along the length of the 1800mm long rail
- Dimples must be brazed for durability to withstand the coolant system pressure
- Straightness over the 1800mm length after brazing



- Block braze alloy application development
 - Due to multi-surface levels, a spray application was chosen for the blocks
 - Prototypes used a Separated binder/powder manual spray system, which worked well for our small builds.
 - Heavily operator dependent for even distribution
 - Requires spray booth, ventilation, and proper PPE for operator safety
 - Production developed a custom premixed slurry paste that is sprayed directly onto the components in a custom automated machine
 - Spray paste is applied using custom spray nozzles with an servo driven conveyor system in an enclosed chamber
 - The paste application system provides a uniform application thickness each time
 - Adjusting the application amount is as simple as slowing down the conveyor or speeding it up to fine tune the amount of paste applied

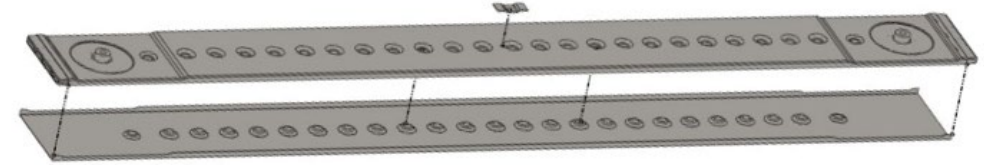


Custom slurry paste spray nozzles



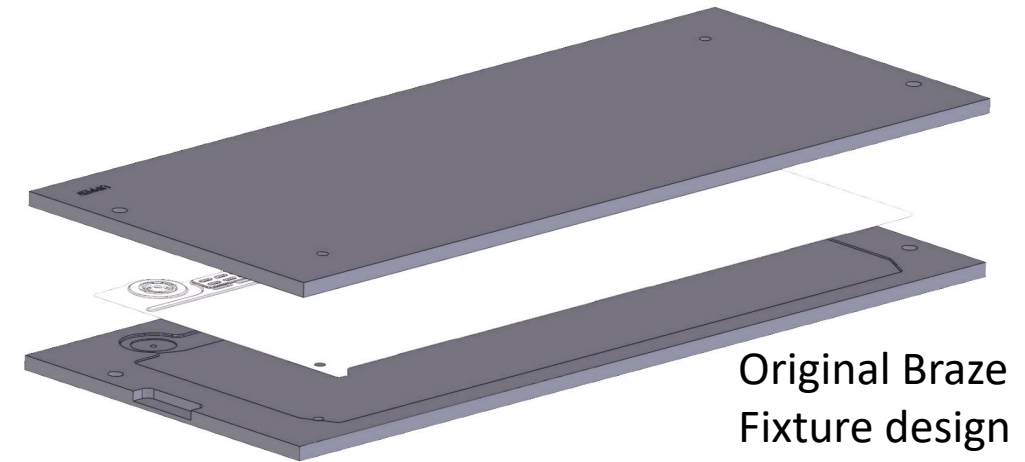
Block Plate Sprayed with

- Inlet/Outlet Rail paste development
 - For prototypes the rails were sprayed with the same separated binder/powder spray system as blocks.
 - The entire interior of the rail was coated.
 - Paste was sprayed to areas where paste was not required
 - Required masking to areas on the rail sections
 - Robotic nozzle dispensing was chosen for production
 - This process minimized paste required versus the spray method (for this application), and lowered material costs
 - A custom 6 station machine with a 6-axis robot was built and fitted with a nozzle dispensing system
 - With the robot, we can apply braze alloy to each braze joint location very accurately.
 - Each application point can be fine tuned and optimized to ensure the proper amount of paste is dispensed
 - The machine automatically identifies which of the 6 parts are present and applies the correct pattern and amount of paste for each component
 - Speed and versatility for production



- Braze Fixture Development

- Blocks require constant pressure on the critical surfaces to maintain optimum gaps for brazing
- Fixtures are designed to maintain those gaps as well as allow for thermal expansion of the assembly at temperature
 - Calculated thermal growth of the blocks when at temperature ~18mm
- Fixtures are designed to allow part to grow freely at temperature while maintaining minimum pressure to critical surfaces
- Optimizing Braze Fixtures
 - Optimizing total mass
 - Double sided fixtures
 - More parts per fixture mass
- Verification
 - Instrumentation is used to verify and optimize furnace profile for uniform heating
- Fixture life
 - Various coatings have been investigated and trialed to improve the life of the fixtures
 - Ceramic paper
 - Ceramic cement sprays
 - Thermal sprays
 - Challenges of coatings is the constancy of thickness applied



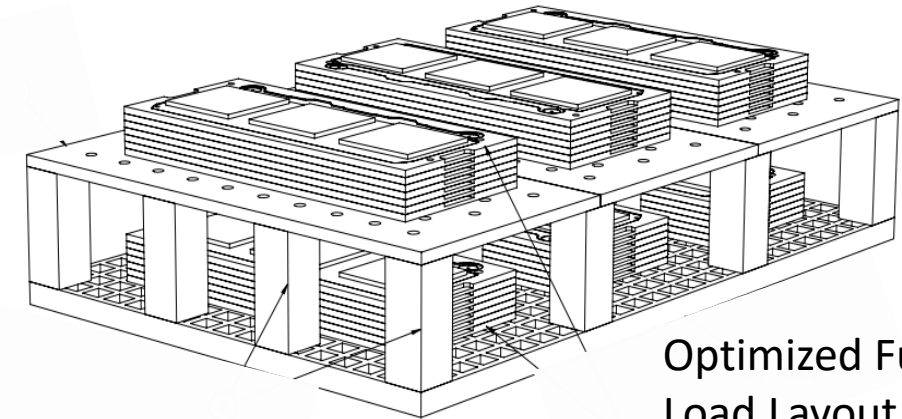
12 graphite plates= 6 parts



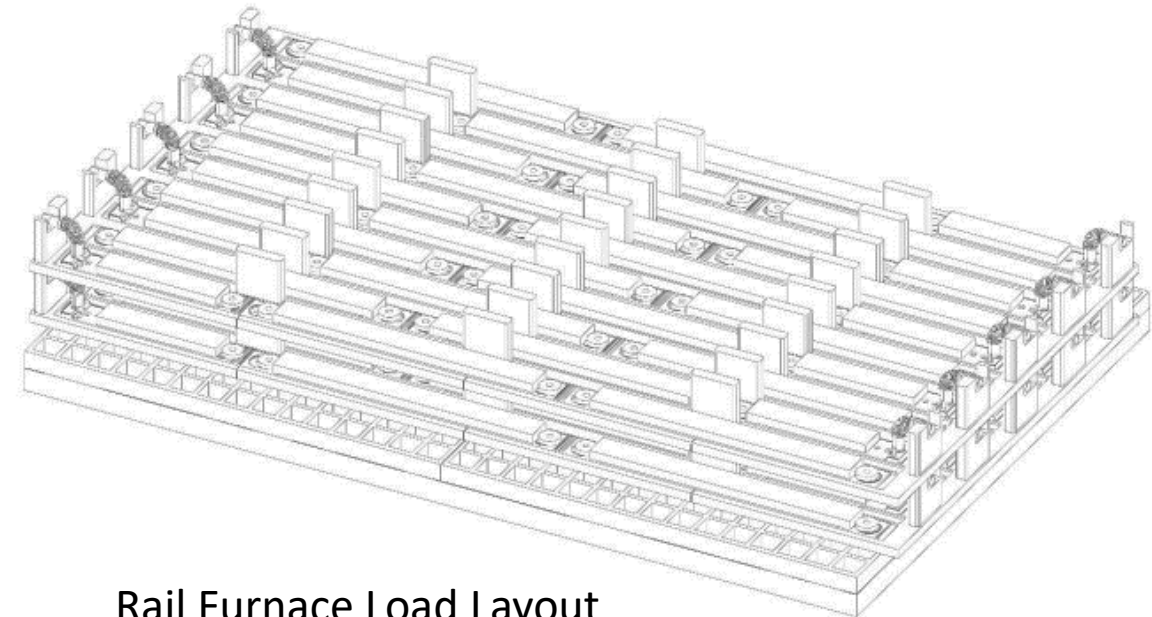
Reduced mass
Increased product

12 graphite plates= 11 parts

- Vacuum furnace
 - Vacuum furnace used for both applications (blocks and rails)
 - Size of components/fixtures were key factors
- Furnace loads
 - Blocks
 - Removing mass
 - Shorter Braze furnace cycles
 - Increased output
 - Loads were optimized by adding layers
 - Rails
 - Rail loads were mostly optimized during prototyping
 - Rail production was increased by adding layers
 - Ceramic vs coated graphite for fixture life




Optimized Furnace Load Layout



Rail Furnace Load Layout

- Conclusion
 - Paste application options
 - Dependent on component design
 - Optimization of paste application vs paste required
 - Spray systems
 - Nozzle application systems
 - Roller coating systems
 - Screen printing
 - Fixture Optimization
 - Increase FPY
 - Reducing mass
 - Increase fixture life
 - Increase braze furnace output

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