

Advanced Alloy Development

AUSC Manufacturing Cost Analysis



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Attribution



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About Me



Michael Verti

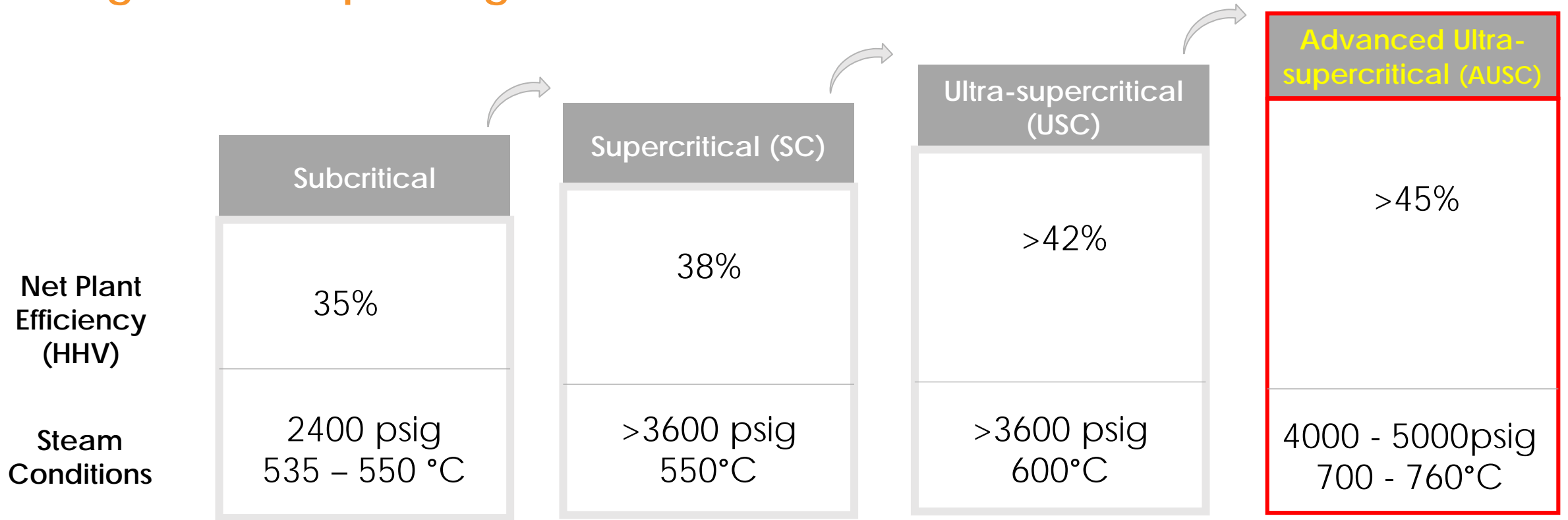
- **National Energy Technology Laboratory**
 - *Deloitte Consulting*: onsite support contractor
 - R&D and Technology Commercialization Strategy
- **New Pig Corporation**
 - Director, New Product Development & Product Strategy
 - Agile Product Development, Human-centered design, Web-as-lab strategies
- **Kennametal Inc**
 - Strategic Technology Manager
 - New-to-company technology and market
 - Advanced Manufacturing
 - High-performance Materials

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Advanced Ultrasupercritical (AUSC)

Next generation power generation




AUSC power plants require less coal per megawatt-hour, leading to lower emissions, higher efficiency and lower fuel costs per megawatt







AUSC: Well-Aligned with DOE Goals



New technology improves energy efficiency & lowers emissions

Fossil Energy Priorities



-  **Develop the Coal Plants of the Future**
Advancing small-scale modular coal plants of the future, which are highly efficient and flexible, with near-zero emissions
-  **Modernize the Existing Coal Fleet**
Improving the performance, reliability, and efficiency of the existing coal-fired fleet
-  **Reduce the Cost of Carbon Capture, Utilization, and Storage (CCUS)**
Reducing the cost and risk of CCUS to enable wider commercial deployment
-  **Advance Big Data**
Optimizing recovery of oil and gas resources with real-time analysis and machine learning
-  **Energy-Water Nexus**
Improving our efficient use of scarce water resources
-  **Strategic Petroleum Reserve**
Maintaining drawdown readiness while completing Life Extension 2, carrying out mandated crude oil sales, and investigating new ways to monetize the asset

U.S. DEPARTMENT OF ENERGY

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NETL Mission:

Discover, integrate and mature technology solutions to enhance the Nation's energy foundation and protect the environment for future generations:

- Effective resource management
- Efficient energy conversion
- Environmental sustainability

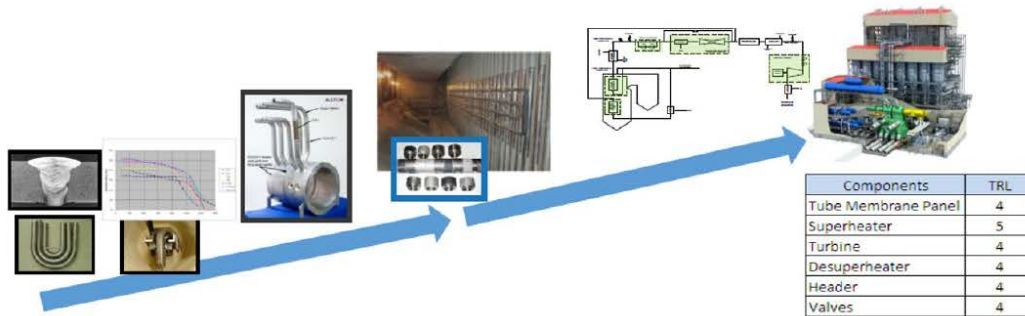
The commercialization of AUSC power generation technology will benefit the environment and reduce energy costs compared to existing coal-fired power generation plants

DOE Investing in AUSC Supply Chain

ComTest Program Working Towards AUSC Demo

AUSC Commercialization Roadmap

Technology Readiness Levels			Roadmap to AUSC Demo		
2000	2005	2010	2015	2020	2025
Materials Evaluation (Nickel Superalloy Focus)	Component Mockup	Steam Loop at Plant Barry. Large forgings & castings	AUSC Component Test (ComTest)	AUSC Demonstration	
Laboratory TRL 2-3	Proof of concept TRL 4	Component Test TRL 4-5	System TRL 4-7	Overall TRL 8-9	



Components	TRL
Tube Membrane Panel	4
Superheater	5
Turbine	4
Desuperheater	4
Header	4
Valves	4

Recently completed DOE-sponsored projects achieved TRL = 4/5

AUSC ComTest will achieve TRL = 7 (ready for full scale demo)

ComTest Program

- Led by Energy Industries of Ohio (EIO)
- Actively focused on establishing a capable domestic supply chain of nickel superalloy AUSC components:
 - Boiler headers, tubing assemblies
 - Turbine rotors, nozzle carrier
- Alloys:
 - Inconel 740H
 - Haynes 282

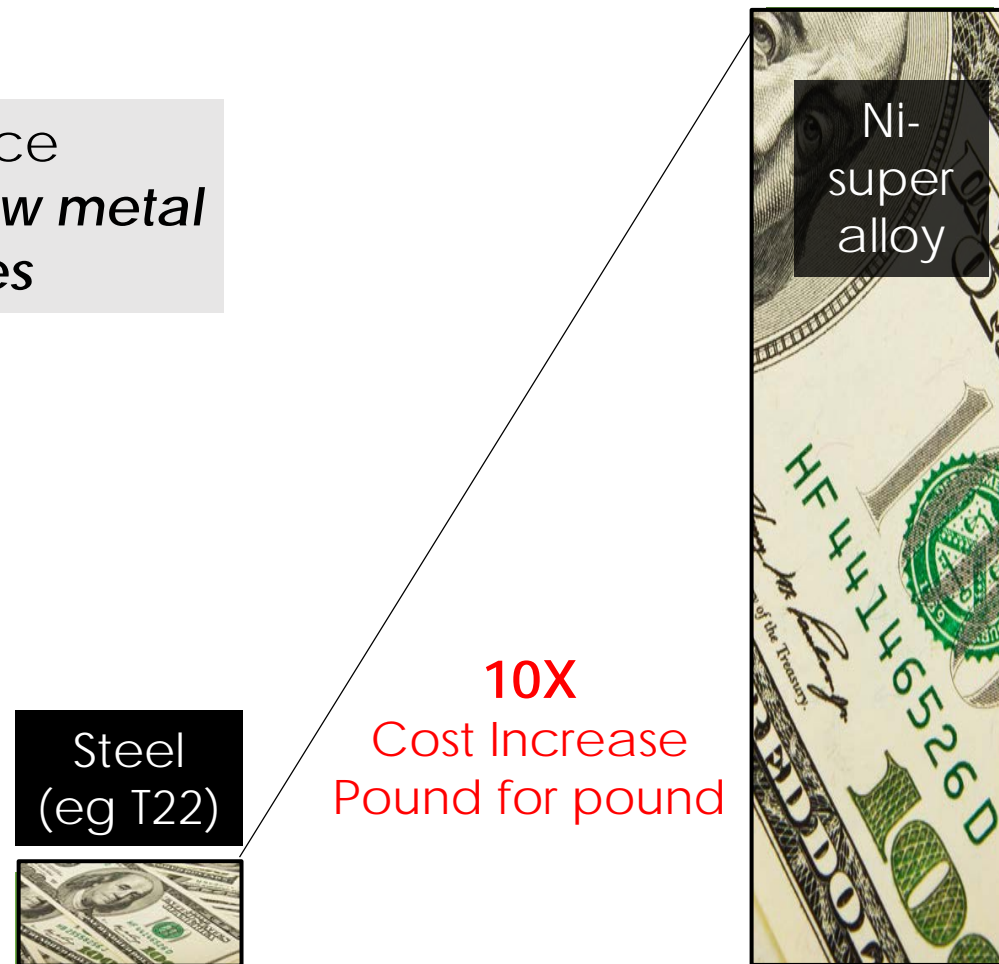
Commercialization Challenges

Enabling technology is required to bring AUSC to market

Advanced Ultrasupercritical steam conditions force large plant *components to be fabricated from new metal alloys to withstand the temperatures and pressures*

Challenges:

- TECHNICAL: Establishing a capable manufacturing processes needed to manufacture these large superalloy components
- ECONOMIC: Making technology available at a cost that ensures market adoption

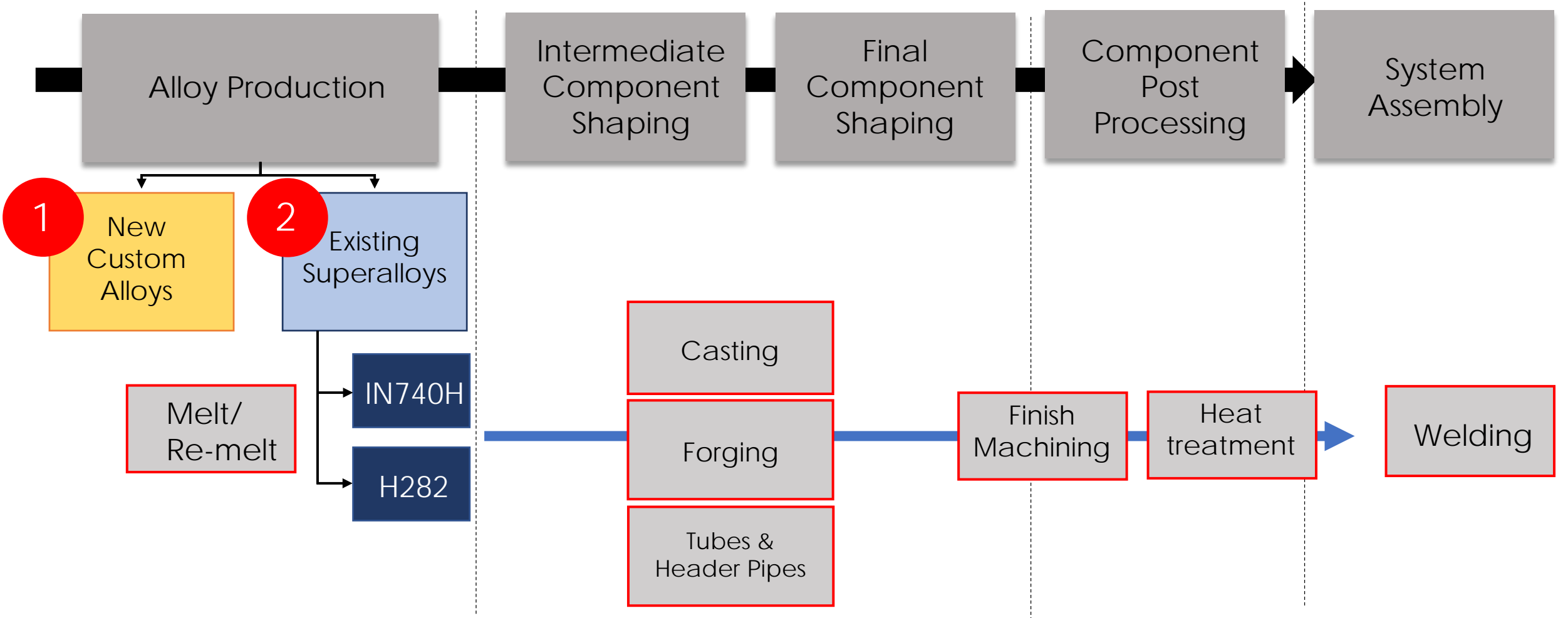


Existing Components

New AUSC Components

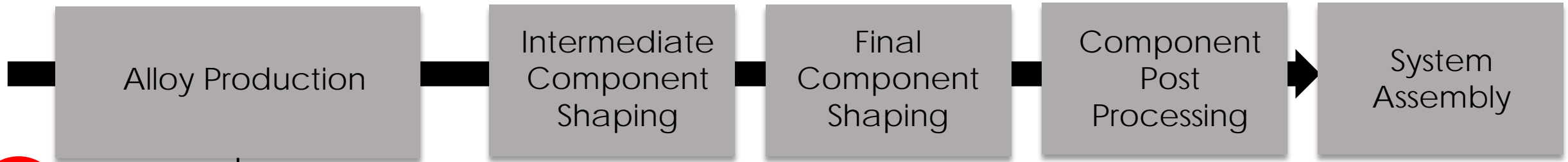
AUSC Component Fabrication

Goal: Identify opportunities to reduce cost in the supply chain



Path 1: Alloy Design Cost Estimation

Understanding tradeoffs between cost and performance



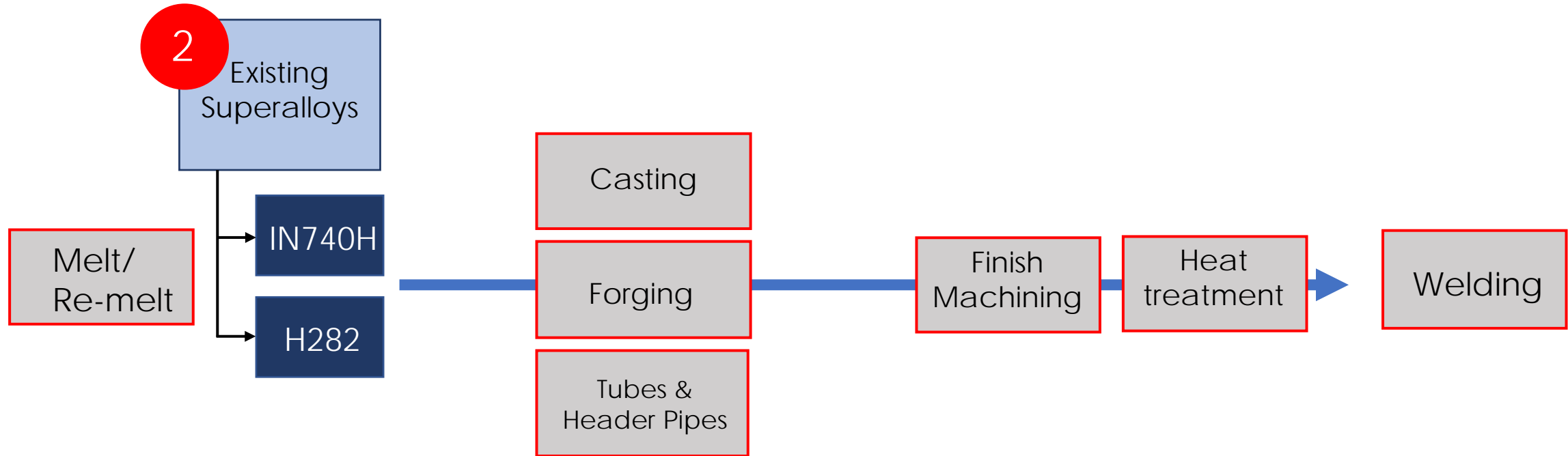
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New Custom Alloys

OBJECTIVE: Develop a more robust cost model to help guide alloy development by making cost trade-offs in alloy composition more apparent

Path 2: Existing Alloy Fabrication

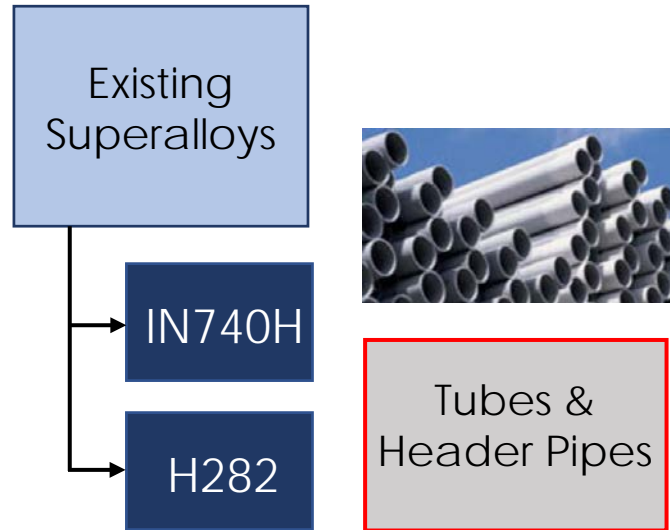
Identify cost and technical challenges related to IN740 & H282



OBJECTIVE: Identify the major sources of cost in the production process of existing AUSC superalloy component designs

Cost Reduction Opportunities

Large-sized tubular components represent biggest opportunity

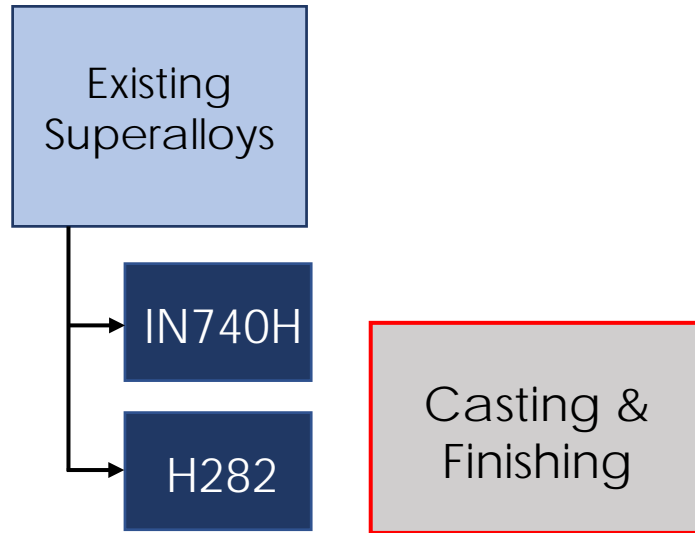


- Tubular components represent the largest share of superalloy parts in AUSC plant designs – *roughly 60-70%*
- The large size and diameter/wall thickness ratio present challenges for conventional extrusion methods
- Only one domestic fabricator with large enough extrusion press
- Cost reduction and sourcing flexibility could be achieved with seam-welded tube and pipe

Seam-welded pipes and tubes will reduce cost, but must overcome industry reluctance to adopt due to product failure concerns

Cost Reduction Opportunities

Near-net shaped fabrication methods may reduce cost



Valve body sand casting performed by Haynes International as part of the ComTest program:

- $\frac{1}{2}$ of the valve body:
 - Pour size: 17,500 lbs
 - Component size: 6,000 lbs

Nearly 3x pour weight to final weight
- Potential to use alternative fabrication methods like powder metallurgy for greater efficiency?

Additive manufacturing or other near-net shape powder metallurgy production methods may yield cost savings compared to casting

Cost Reduction Opportunities

Field sites uncover technology challenges

- Known AUSC Ni-superalloy components technology development challenges:
 - Larger size components
 - Welding dissimilar materials
- Uncovering new challenges: Going from test to field trials
- ComTest project plans AUSC demonstration by 2025
- Opportunities to test and learn sooner?

New challenges will not be known until components are fabricated and tested in field sites at system-integration stage

Summary

Facilitating AUSC technology adoption

- The goal of our work is to uncover opportunities for focused R&D activity to lower the cost of nickel superalloy components
- Initial research conducted with industry interview uncovered three potential areas for DOE investment for IN740H & H282 alloys:
 1. **Seam-welded tubing**: Demonstrate fabrication and risk assessment & testing
 2. **Near-net shape production** methods leveraging PM and/or AM
 3. **System-level testing**: Identify and fund the fabrication and testing of components in comparable environments
- **New alloy development**: Longer term. Continue development of tools to help researchers understand trade-offs between alloy design and cost