

# Development of New Materials for AUSC Power Plant

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### Agenda

- Background
- UK Material Development
- Valve Casting
- Rotor Forging
- Steam Pipework
- Modelling
- Summary and Future Work



## Background



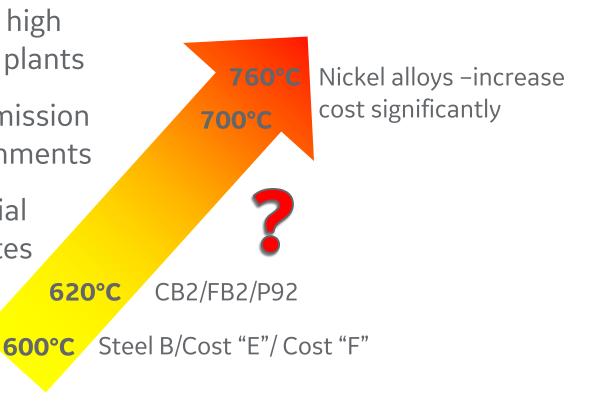
### Past steel developments in European Programs

• COST 501/522/536 – focus on high temperature steels for power plants

 Facilitated by European Commission and funded by national governments

Cooperation between industrial partners and research institutes

• 1983-2009







### **Technology Advancements**

Leading efficiency, lower emissions and better economics.

#### SteamH

With higher steam parameters and higher efficiency rates, GE is the first to market with advanced ultra-supercritical technology. We call this SteamH. This technology can deliver an additional 1.6 percentage points of efficiency beyond the best technology in operation today, driving towards 50% efficiency (compared to 34% average efficiency of global installed base). For a 1000MW base plant in Asia, this is an economic benefit of \$80M in additional value for our customers.

**USC Baseline** 

**OECD** Guidelines **GE SteamH** 

Available Today

330 bar/650°C/670°C

**GE USC** 

Most efficient in operation (RDK8)

+1.6% efficiency (47.5%)

275 bar/600°C/620°C

in NPV for a 1000MW plant

+3.2% efficiency(49.1%)

Point increase in efficiency



<221 bar

>221 bar/550°C/550°C >240 bar/593°C/593°C

>320 bar/610°C/630°C

Subcritical

Supercritical

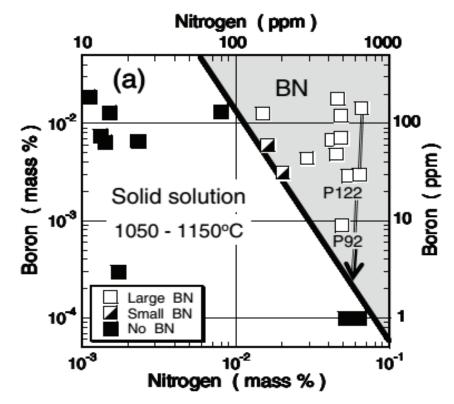
Ultra-supercritical (USC)

Advanced USC (SteamH)



#### MarBN steel

- First developed by Dr Abe at NIMS
- 9Cr-3W-3Co-V-Nb
- MarBN Martensitic + Boron + Nitrogen
- Improve phase stability better creep properties



Boron and Nitrogen solubility in 9Cr steels (Abe, 2008)



### **UK Material Development**



#### MarBN Development

- IMPACT: 2010-2013 funded by InnovateUK
- Consortium including power plant operator, boiler and steam turbines manufacturers, foundry and few research organisations
- Objectives:
  - Development of chemistry
  - Development of optimised heat treatment for creep properties
  - Investigate manufacturability of different product forms

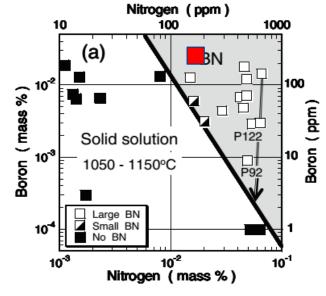




### Chemistry and Heat treatment optimisation

	С	Si	Mn	Cr	Co	W	V	Nb	N	В
Nominal	0.09	0.4	0.55	9.0	3.2	2.7	0.22	0.08	170	120
Composition									ppm	ppm

- Higher normalising temperature to ensure BN dissolution
- Low tempering temperature for better creep strength properties



Boron and Nitrogen solubility in 9Cr steels (Abe, 2008)

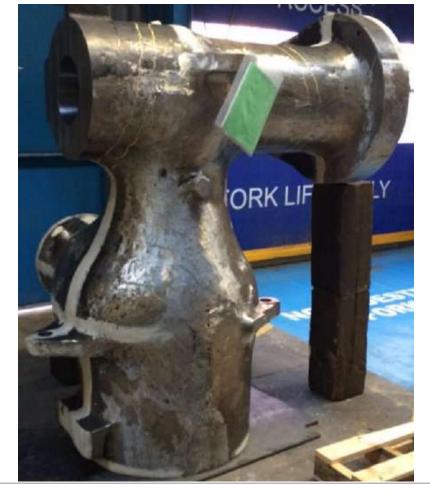


# Valve Casting



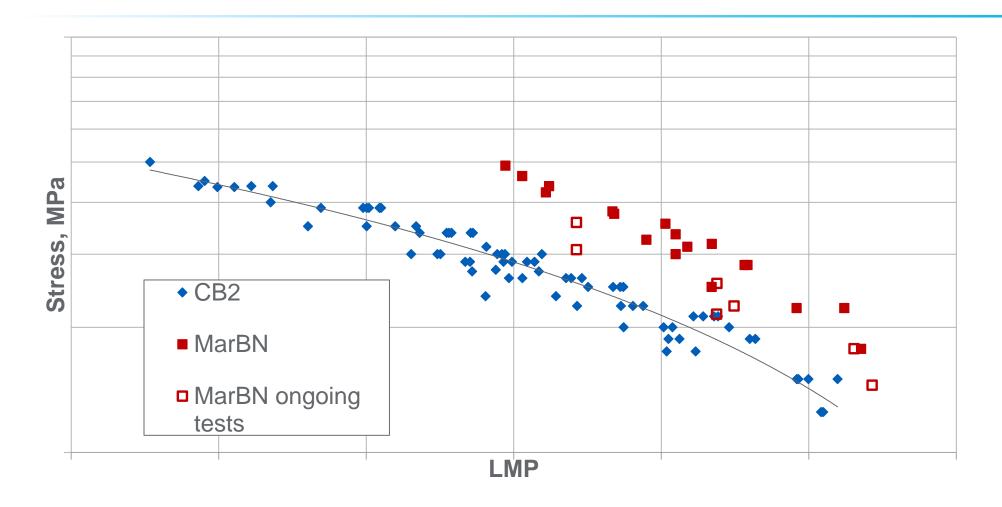
### Valve Casting

- INMAP: 2014-2016 funded by InnovateUK
- 3 industrial partners
- Next step from material development in previous project
- Objectives:
  - Manufacture of power generation cast component
  - Determine the inspectability of MarBN components
  - Characterisation of structural integrity through mechanical testing





### Creep strength – comparison with CB2





# Rotor Forging



#### Rotor Forging Development

- Early results from forging trials show promising results
- German government funded project
- 3 industrial partners (forgemaster and 2 turbine OEMs) and 2 research institutes
- Objectives:
  - Production of turbine forged disk
  - Testing and development of lifing models
  - Weldability investigations



### Steam Pipework



### MarBN pipes

- Tubes installed at UK coal power plant
- Installed in 2014 and 2015
- Operate at approximately 600°C and 40 MPa
- To be removed to assess damage and oxidation



MarBN tubes (Degnan, 2015)

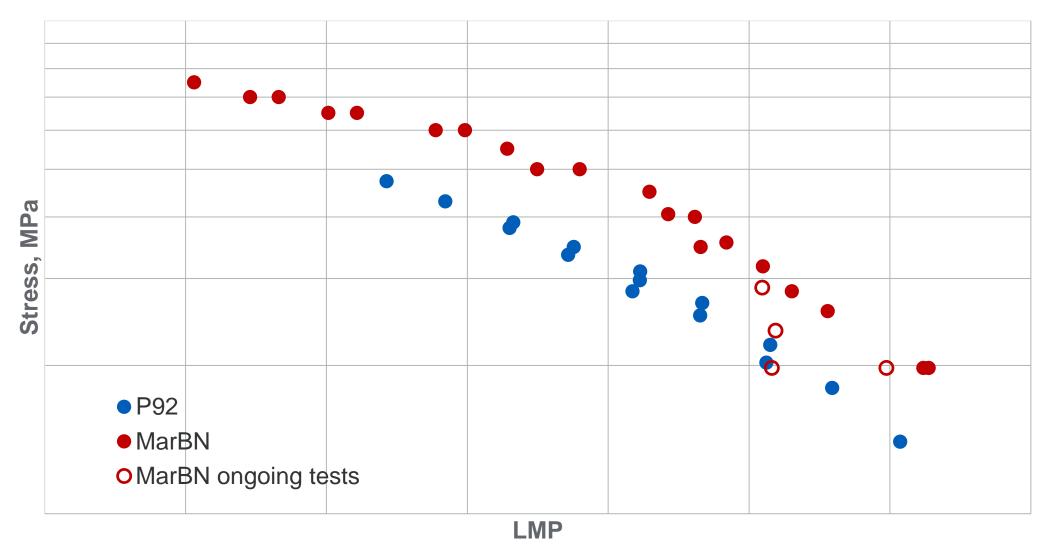


### Pipework and welding development

- IMPULSE: 2016-2019 funded by InnovateUK
- 5 industrial partners including boiler OEMs, ingot and pipe manufacturer, weld consumables manufacturer
- 3 universities
- Objectives:
  - Production of a typical size main steam pipe
  - Development matching weld consumable
  - Characterisation and modelling of material behaviour



### Pipework and welding development



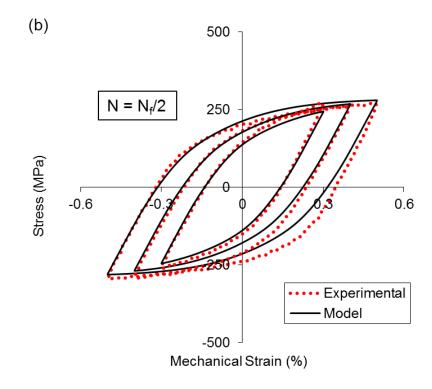


### Modelling



#### HT cyclic behaviour

- Work at NUI Galway funded by IRC and GE
- LCF MarBN behaviour at 600 and 650°C
- Cyclic viscoplasticity model
- Good correlation between model and test data



HTLCF comparison (O'Hara, 2016)



#### Welded Connections

- Can we predict actual component life based on microstructure?
- MECHANNICS: Multi-scale through-process characterisation for innovative manufacture of next-generation welded connections
- NUI Galway, University of Limerick
  - Work funded by Science Foundation Ireland
  - Cooperation with Industrial and Universities in Ireland and UK
- Focus on power generation and offshore industry
  - Materials: P91, MarBN, X100



### Summary and Future Work



#### Summary

- New materials required for higher efficiency, however nickel alloys too expensive
- MarBN type steel a viable option
- European collaboration with significant participation from UK
- Efforts focus on development of various product forms
- Initial results shows possible 20-25°C improvement on current state-of-the-art steels
- Work on microstructure and steam oxidation
- Continuing current projects, extending long term testing



