



Doosan Babcock Energy

Advanced Supercritical Boiler Technologies

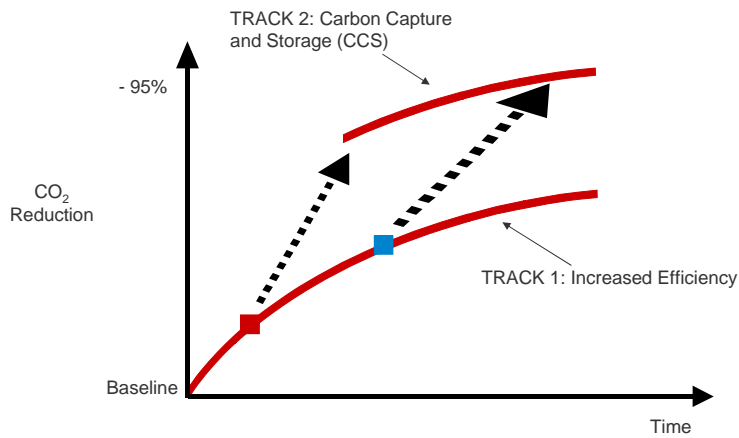
Official Opening of the OxyCoal™ Clean Combustion
Test Facility
Technical Seminar

Dr David Smith
Date: 24 July 2009

AGENDA

- Why Advanced Supercritical?
- Advanced Supercritical : State of the Art
- Next step: Ultra Supercritical

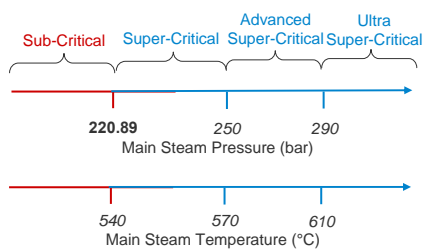
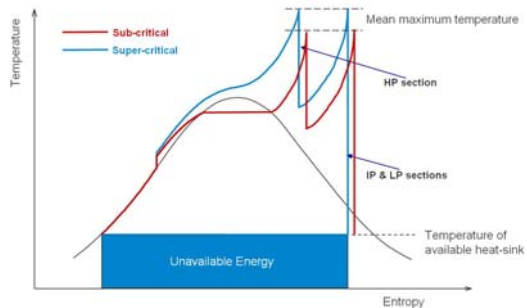
WHY ADVANCED SUPERCRITICAL?



- Both tracks are required to mitigate CO₂ emissions from coal fired generation
- Primary means to increase efficiency is to increase the steam conditions we use in our power plant cycle

WHY ADVANCED SUPERCRITICAL?

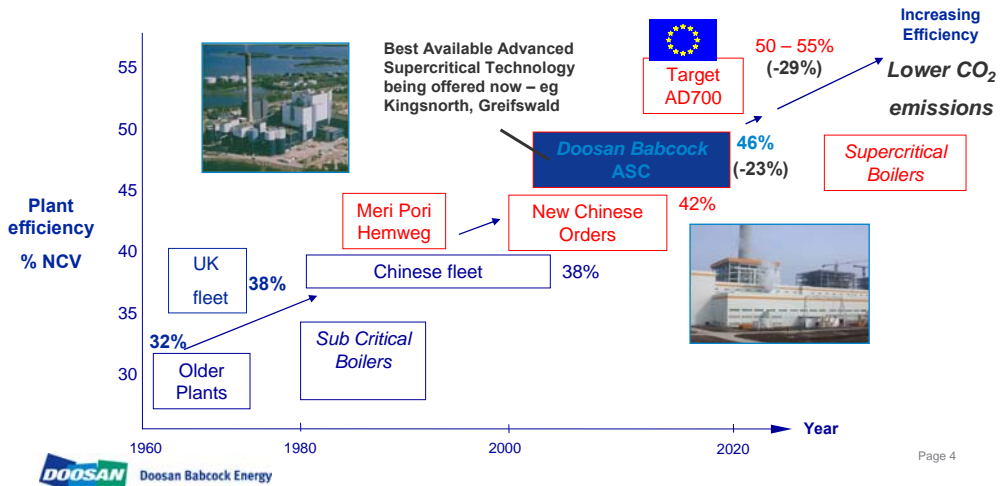
- Efficiency of the Rankine Cycle increases with increasing Turbine inlet Temperature and Pressure
- Cycle efficiency of typical sub-critical plant is 38% whereas today's supercritical technology increases this to around 45-47%



- Supercritical means above the "critical" point for water / steam (220.89 bar) after which there is no phase change between water and steam
- Other terms "Advanced Supercritical" and "Ultra Supercritical" are loose definitions to indicate steps in technology as opposed to any distinction in thermodynamic properties

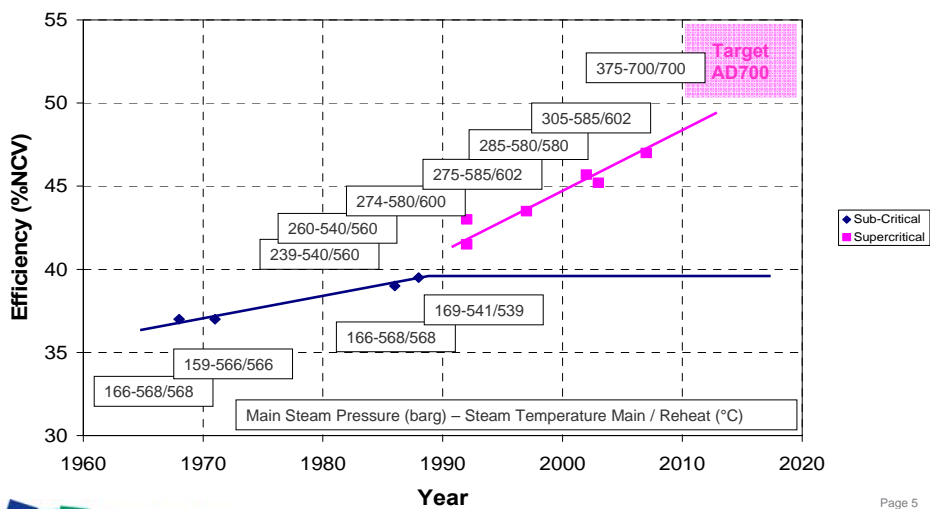
DEVELOPMENT IN THERMAL EFFICIENCY

Meaningful CO₂ reductions can be achieved by replacing old units with modern advanced supercritical plant



STEAM CYCLE AND PLANT EFFICIENCY GAINS

Efficiency gains have mostly been achieved by pushing the steam cycle, lower excess air and lower gas exit temperature have also contributed



AGENDA

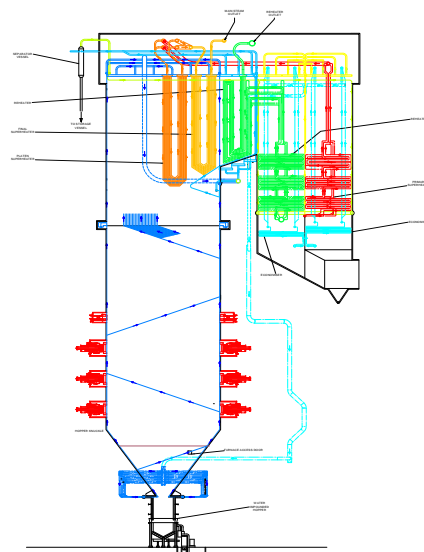
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WANGQU, SHANXI PROVINCE, CHINA



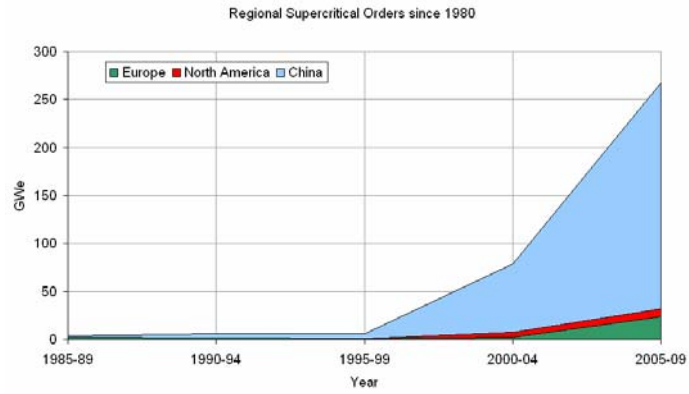
2 x 600MWe Units

Evaporation	540 kg/s
S/htr Outlet Press	248 bar
S/htr Outlet Temperature	571°C
R/htr Outlet Temperature	569°C
Contract Effective	09/03
Operational	36 months later



DEPLOYMENT OF SUPERCRITICAL TECHNOLOGY

China's deployment of supercritical technology far outstrips other countries and regions – UK deployment is zero



GREIFSWALD, GERMANY



2 x 800MWe Units

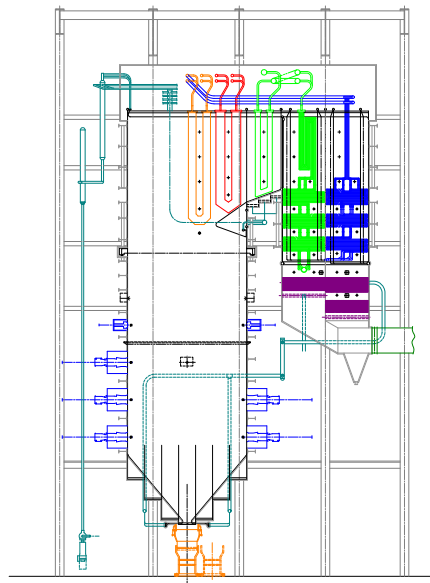
Evaporation 588 kg/s

S/htr Outlet Press 277 bar

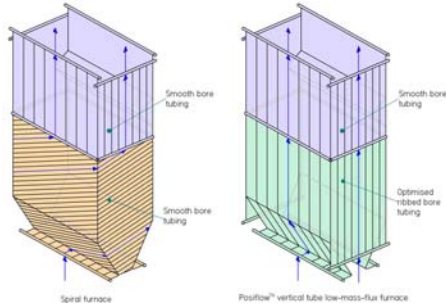
S/htr Outlet Temperature 600°C

R/htr Outlet Temperature 605°C

Posiflow™ vertical tube furnace

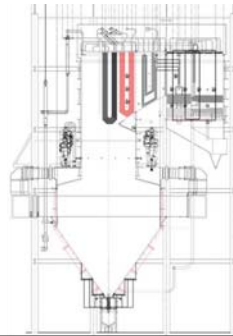


DEVELOPMENTS IN SUPERCRITICAL BOILERS



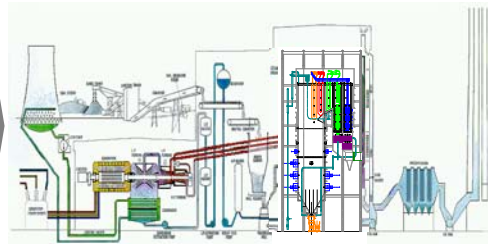
- Posiflow™ Best Available Technology for Once-Through boiler furnace
- Lower pressure drop means lower feed-pump power and lower through-life energy consumption
- Other advantages include better turn-down, simpler construction and improved availability

- With a Posiflow™ furnace the supercritical down-shot boiler can be realised: combines the economic and environmental benefits of supercritical steam conditions with anthracite combustion for the first time
- Doosan Babcock 2 x 600MW supercritical down-shot units for Zhenxiang, Yunnan Province, China.



DEVELOPMENTS IN SUPERCRITICAL BOILERS: PLANT UPGRADE

- Supercritical Retrofit - existing plant can be upgraded to supercritical steam conditions with lower capital cost and more rapid timescale than new plant
- New boiler within existing structure
- POSIFLOW™ vertical tube low mass flux furnace
- Re-use of other equipment (eg fans, airheaters, coal mills)
- New HP and IP turbine

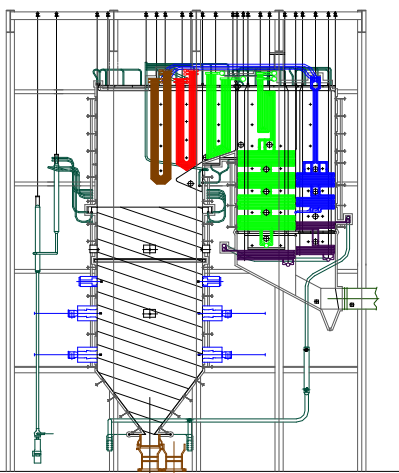


- Doosan Babcock Upgrade of Yaomeng Power Plant in China 2002
- Owner chose not to upgrade to supercritical steam conditions.....
- However, application of Posiflow™ furnace and combustion system modifications gave 10% lower coal consumption and availability of 96%

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ULTRA SUPERCRITICAL



Boiler concept for > 700°C

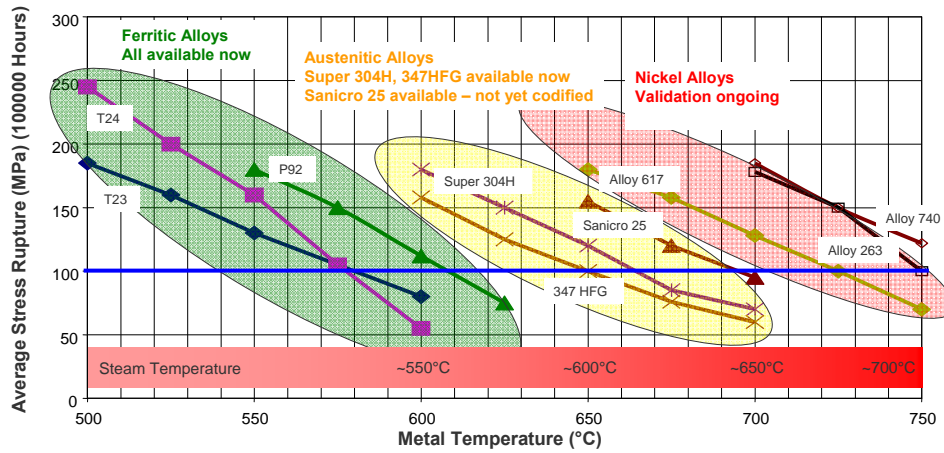
Generation 550MW
Overall cycle efficiency >50%

Main Steam Pressure 365 bar-a
Main Steam Temperature 705°C
Reheat Steam Temperature 720°C

Reduction in CO2 emission relative to sub-critical ~30%

MATERIALS FOR ADVANCED STEAM CYCLES - TUBING

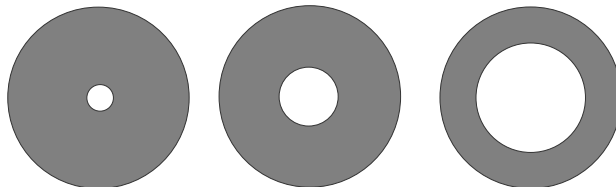
Steam cycle based efficiency gains are constrained by the availability of suitable alloys



MATERIALS FOR ADVANCED STEAM CYCLES - TUBING

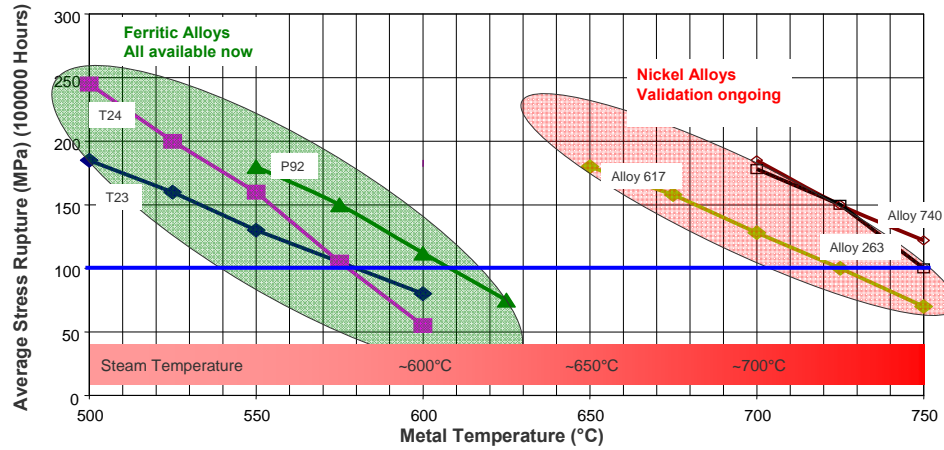
To put that in context consider a 48mm tube operating at 700°C with a design pressure of 380 bar:

	HR3C Austenitic	Alloy 617mod Nickel Alloy	Alloy 740 Nickel Alloy
Allowable Stress @ 750°C (MPa)	44.5	56.0	96.0
Calculated thickness $t = P \cdot D / 2 \cdot \sigma$ (mm)	20.5	16.2	9.5



MATERIALS FOR ADVANCED STEAM CYCLES – HEADERS AND PIPEWORK

Austenitic alloys suffer from thermal fatigue, making them less suitable for thicker wall section components



MATERIALS FOR ADVANCED STEAM CYCLES – MANUFACTURING

Manufacturing processes for components from new materials require extensive validation



Test bending furnace wall panels in T23 material



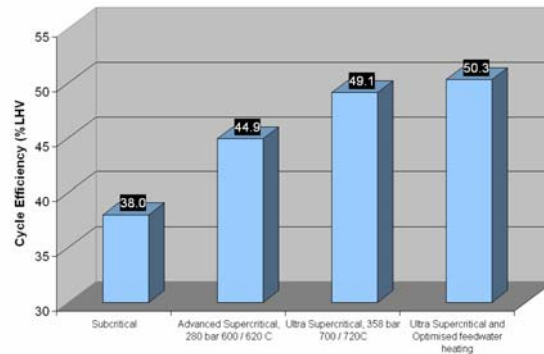
Bend tests in Sanicro 25



Alloy 263 pipe production Alloy 263 weld qualification

ULTRA SUPERCRITICAL – CYCLE OPTIMISATION

- In addition to improvements in Rankine Cycle efficiency from increasing steam temperatures we can make better use of low grade heat in our power plant cycle
- Feedwater heating can be optimised to reduce the quantity of high grade bled steam taken from the turbine and better utilise the low grade heat in the flue gas leaving the boiler



SUMMARY

- Increasing plant efficiency is fundamental to reducing all emissions including CO₂
- Primary means to increase efficiency is to increase the steam pressure and temperature at the turbine inlet
- This means using steam at supercritical pressures – we use terms such as “Advanced Supercritical” and “Ultra Supercritical” to indicate higher ranges of temperatures and pressures
- We can make improvements to the basic once-through boiler concept like the Posiflow™ furnace to further increase efficiency and operating flexibility
- Supercritical technology can be readily retrofitted to life-expired existing plant
- Today’s Advanced Supercritical plant will achieve around 46-47% cycle efficiency (LHV basis) and about 20% reduction in CO₂ for the same MWe output as existing sub-critical plant
- Ultra Supercritical plant operating at steam temperatures above 700°C is the next step. Together with improved cycles this will achieve a plant efficiency over 50% and about a 30% reduction in CO₂ compared to existing sub-critical plant
- Attainment of 700°C is constrained by the availability of suitable materials for the highest temperature components and development programmes are underway

Commercial Contact Details

Doosan Babcock is committed to delivering unique and advanced supercritical boiler technologies.

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