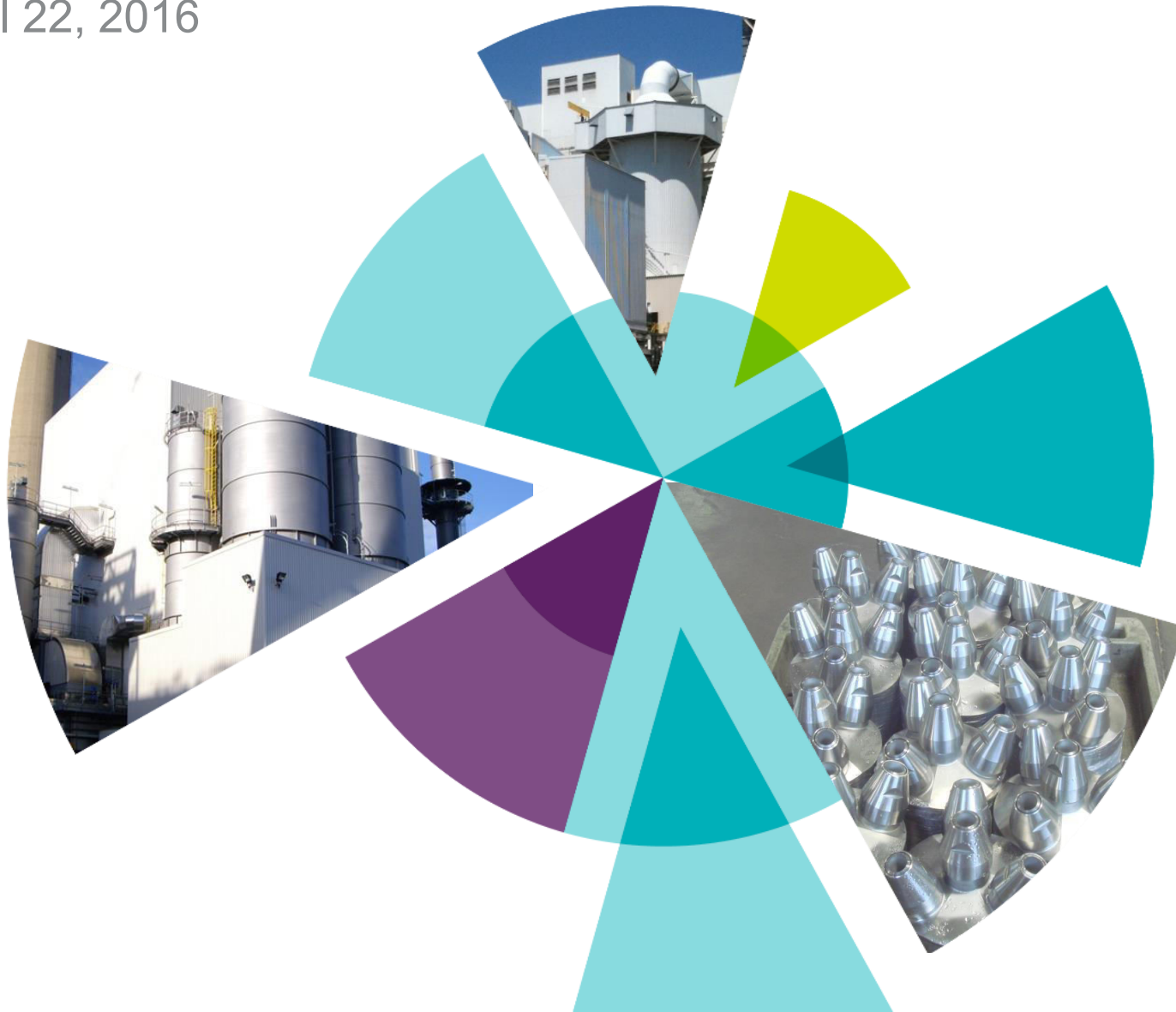


Dual Flow Tray Technology for Wet FGD New Builds, Retrofits, and Performance Upgrades

April 22, 2016



Agenda

1. Regulatory Drivers
2. Dual Flow Tray (DFT) Technology
3. DFT Absorbers for New Build Wet FGD's
4. DFT Applications for Upgrades of existing Wet FGD's
5. Conclusions
6. ? Questions ?

Regulatory Drivers (India)

Emission regulations for Thermal Power Plants released by Ministry of Environment and Forests, Govt. of India in December' 2015. limiting the Particulate Matter, NOx and SOx emissions as per the following table

Pollutant	Unit*	TPPs installed before December 31, 2003 (Refer Note 1)	TPPs installed after 2003 to December 31, 2016 (Refer Note 2)	TPPs to be installed from January 1, 2017	World Bank Norms
Particulate Matter	mg/Nm ³	100	50	30	50
SOx	mg/Nm ³	600 (<500 MW) 200 (>=500 MW)	600 (<500 MW) 200 (>=500 MW)	100	1.NDA: 900 – 1500 (<210 MW) & 200 – 850 (>210 MW) 2. DA: 400(<210 MW) & 200 (>210 MW)
NOx	mg/Nm ³	600	300	100	1.NDA: 510 2.DA: 200

Note 1: TPP's (Units) shall meet the limits within two years from date of the notification.

Note 2: Includes all the TPP's (Units) which have been accorded environmental clearance and are under construction.

*Corresponding to 6% O₂ Dry Volume.

NDA: Non-degraded Airshed, DA: Degraded Airshed (Poor Air Quality)

Dual Flow Tray (DFT) Technology History

- ▶ Amec Foster Wheeler
 - ▶ 1st Tested in 1979
 - ▶ 1st Permanent New Build in 1988
 - ▶ 1st Multiple Tray Installation upgrade in 1991
 - ▶ 1st High Velocity (4.3 m/s) installation in 1999
 - ▶ 1st Multiple Tray New Build in 2006
 - ▶ 80+ DFT absorber modules currently operating on Utility Boilers
- ▶ High SO₂ efficiency (97%+) generally favors DFT absorbers
 - ▶ 90% of New Builds include DFTs
 - ▶ 100% of Upgrades include DFTs



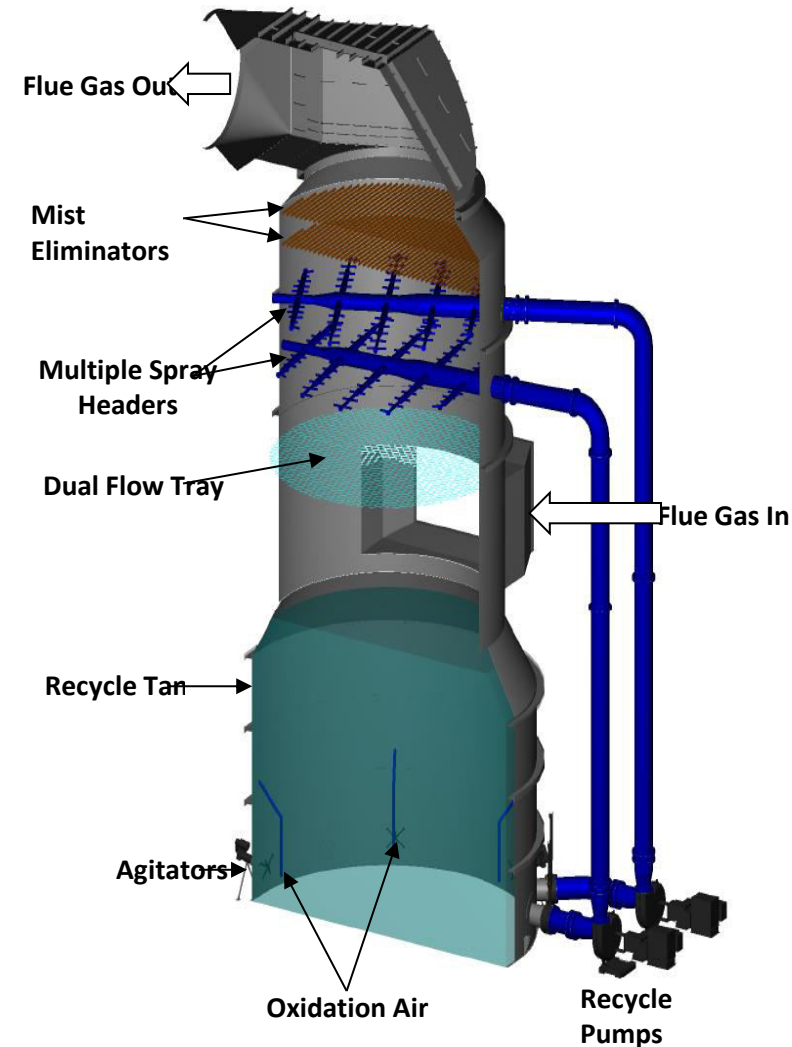
Dual Flow Tray Technology

Theory

- ▶ SO₂ Removal governed by two processes
 - ▶ SO₂ Absorption from flue gas to absorber liquor ($K_G A$, A , $P_{SO_2 \text{ gas}}$, $P_{SO_2 \text{ liq}}$)
 - ▶ Adequate liquid phase alkalinity to quickly neutralize SO₂
- ▶ Mass Transfer Coefficient ($K_G A$) & $P_{SO_2 \text{ gas}}$ are fixed
- ▶ Dissolved Alkalinity is a function of operating pH, Limestone reactivity, Limestone grind, Recycle tank retention time
 - ▶ Chemistry Limitations of operating pH
 - ▶ Limestone reactivity & size
 - ▶ Recycle tank retention time
- ▶ Surface Area for Mass Transfer
 - ▶ Liquid to Gas (L/G) ratio
 - ▶ Number of Spray Levels
 - ▶ Spray Nozzle style
 - ▶ Spray Nozzle droplet size distribution
 - ▶ Dual Flow Tray(s)

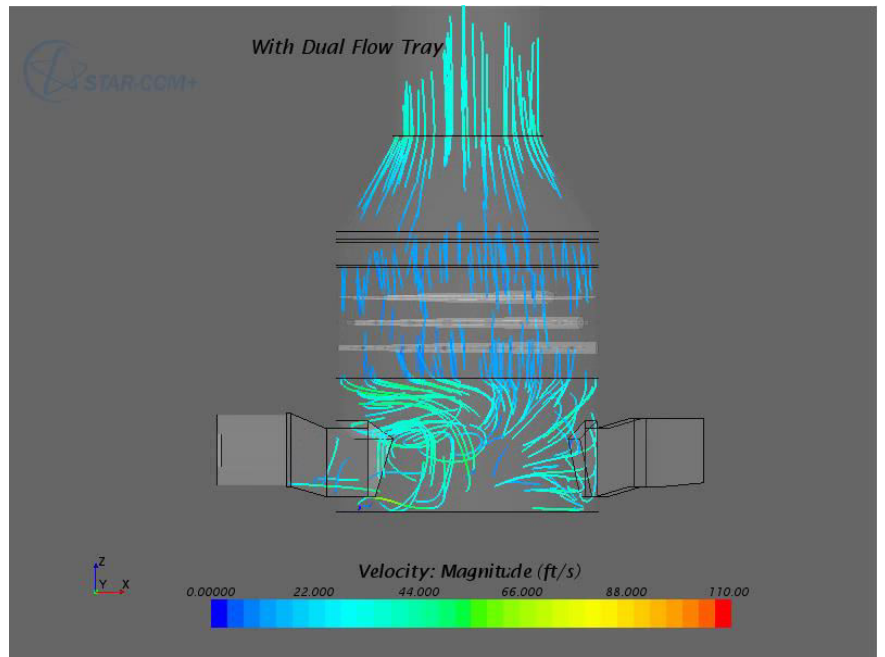
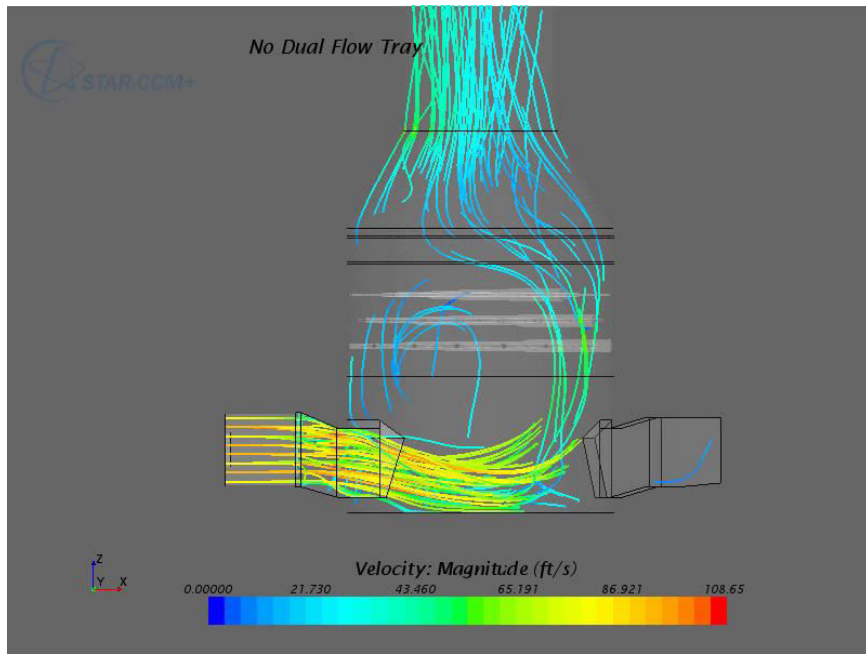
Dual Flow Tray Technology Advantages

- ▶ Improves Flue Gas distribution through Absorption Zone
 - ▶ Resistance at **beginning** of Spray Zone
 - ▶ **Optimal** use of available L/G
- ▶ Maximizes Flue Gas / Liquid Contact
 - ▶ 150mm – 300mm froth forms on Tray
 - ▶ Additional contact time
 - ▶ Equal performance at lower L/G
- ▶ Chemistry Effect
 - ▶ Low L/G on Tray speeds limestone dissolution
 - ▶ Equivalent to more Recycle Tank retention time





Open Spray Chamber vs Dual Flow Tray CFD Model Results @ Low L/G



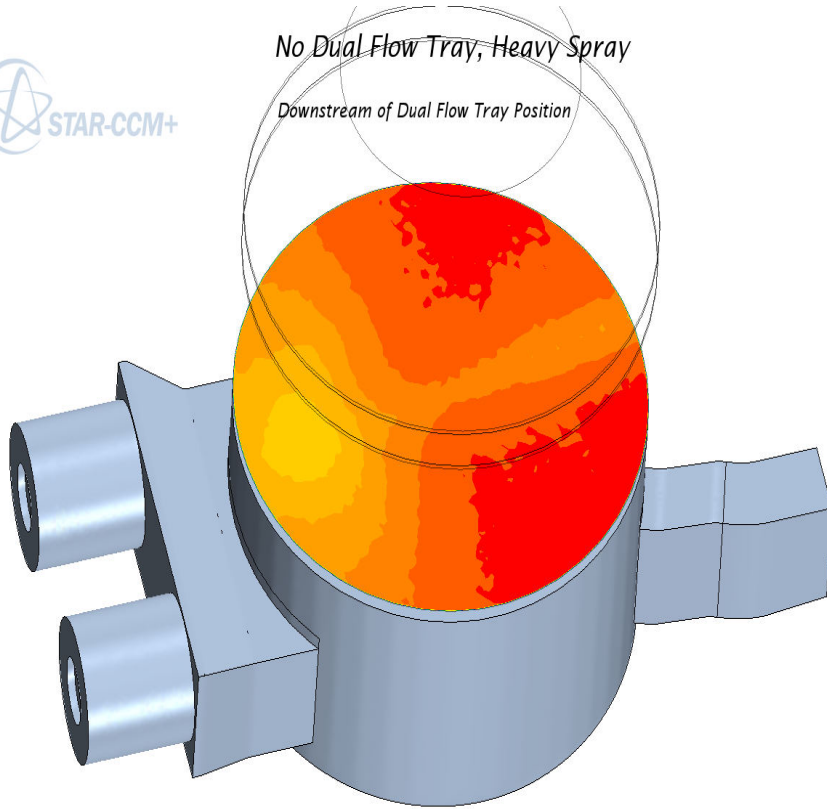


Open Spray Chamber vs Dual Flow Tray CFD Model Results @ High L/G

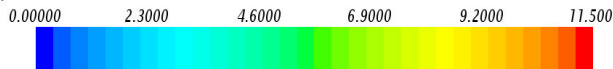


No Dual Flow Tray, Heavy Spray

Downstream of Dual Flow Tray Position

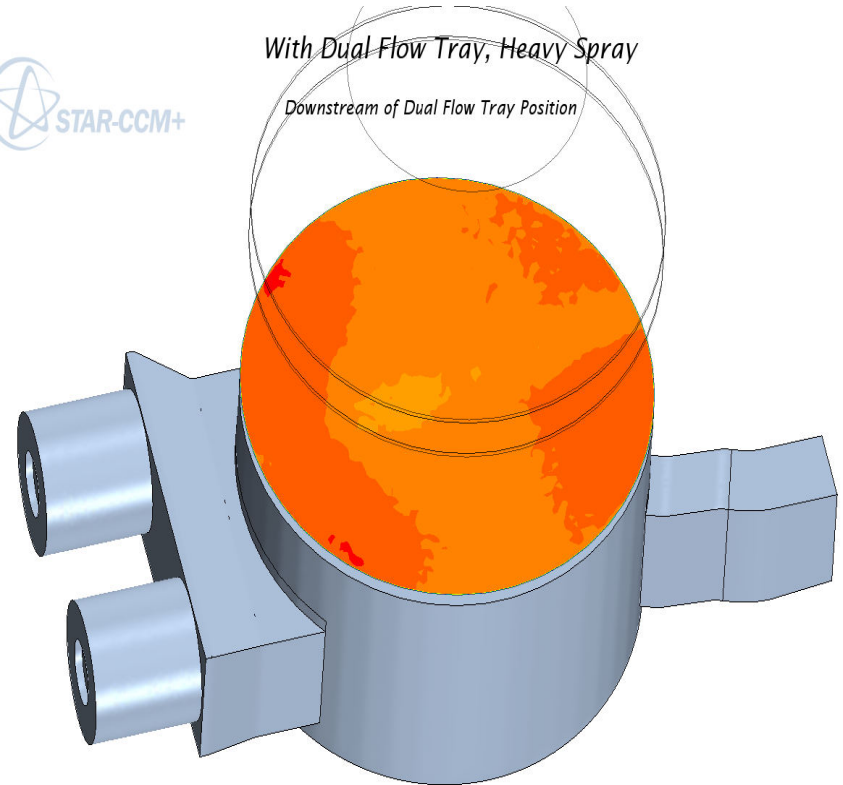


Velocity: Magnitude (ft/s)



With Dual Flow Tray, Heavy Spray

Downstream of Dual Flow Tray Position



Velocity: Magnitude (ft/s)

