A Holistic View on Urea Injection for NO_x Emission Control: Impingement, Re-atomization and Deposit Formation

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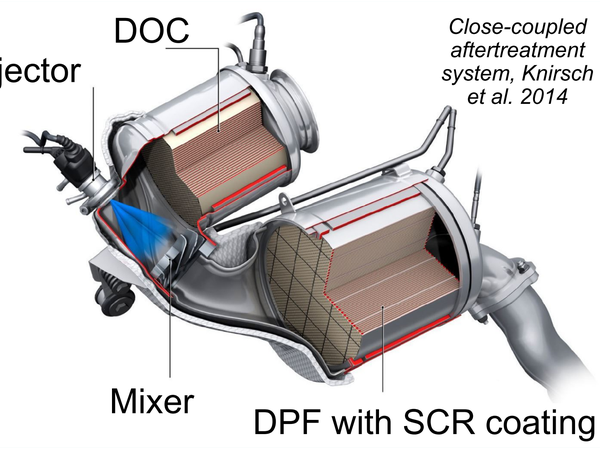
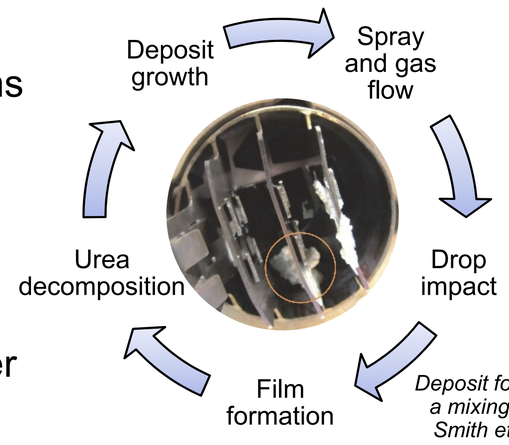
Motivation

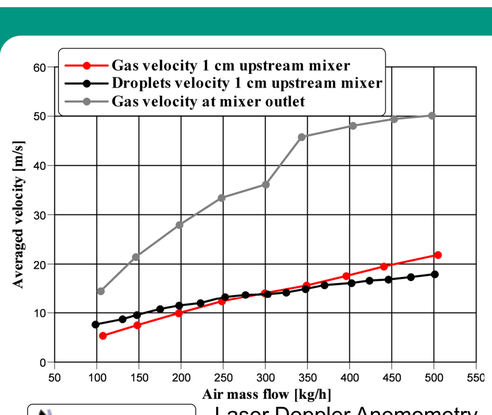


Close-coupled aftertreatment system, Knirsch et al. 2014

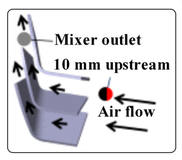
- Advantageous close-to engine positioning of SCR systems
- Significant role of mixing elements
  - Generation of turbulence
  - Impingement target
- Effect on film and deposit formation downstream the mixer



Deposit formation on a mixing element, Smith et al. 2014

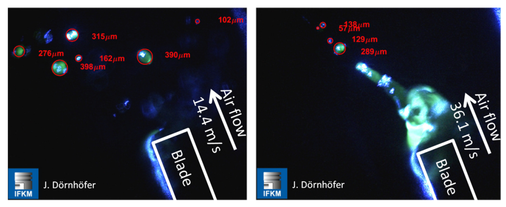


Laser Doppler Anemometry



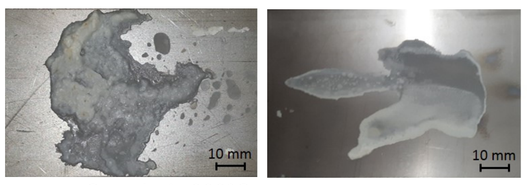
Increased velocity between mixer blades

Influence of kinetic energy of injection



Long Distance Microscopy

Detached droplets size decreases with increased shear flow

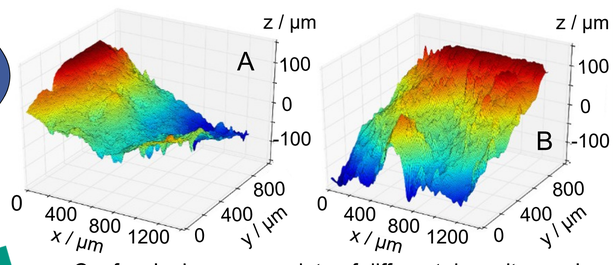


Sample A, 300°C

Sample B, 370°C

- *Generation of deposits at hot gas test rig*
- *Variation of boundary conditions*
- *Topological characterization by confocal microscopy*

- *Rough nature of deposits on micro-scale*
- *2D profiles for reproduction of surface in SPH simulations*



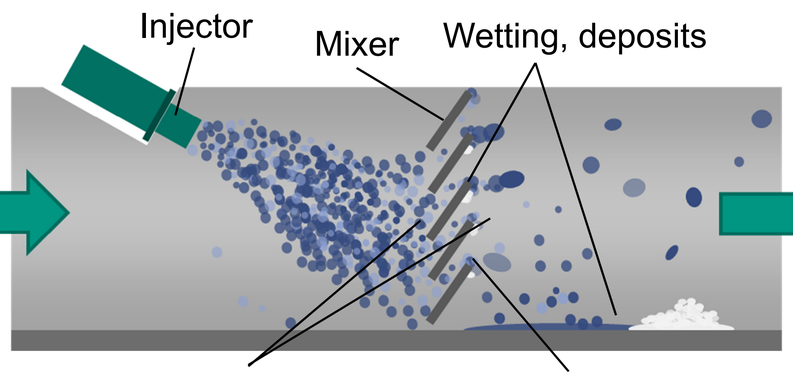
Confocal micropscopy data of different deposit samples

Flow and drop characteristics

Measurement of gas and droplet velocity and size of detached droplets

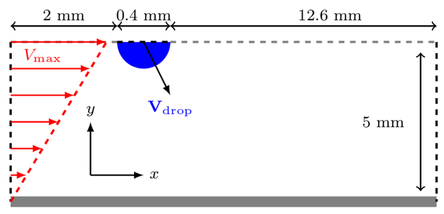
Deposit formation

Deposit generation and topological characterization



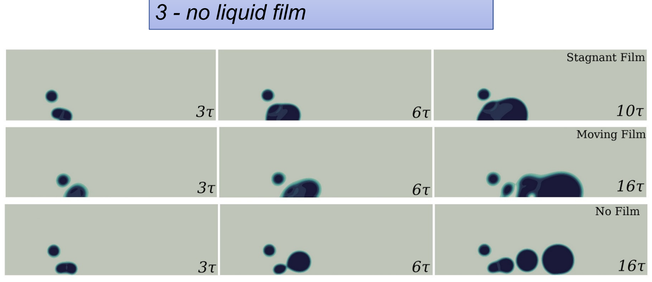
Impingement

Study on impinging droplets inducing film formation



2D numerical simulation of serial drop impact with phase-field method

Droplet-wall interaction regimes:
1 - stagnant liquid film
2 - moving liquid film
3 - no liquid film

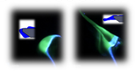


Effective parameters for film formation
- *Drop velocity and trajectory*
- *Exhaust gas flow rate*
- *Wettability of solid surface*

Re-Atomization

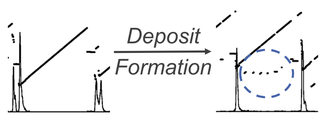
Investigation of primary breakup of UWS and its relationship to deposit formation

Simulations are validated with LDM measurements.

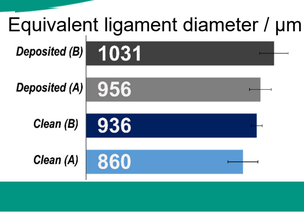


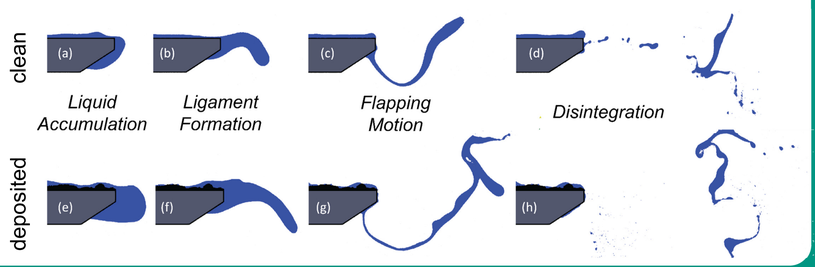
Liquid film becomes less continuous over the deposit layer.

Decreasing liquid load increases the ligament sizes.



Deposit formation increases detached ligament size





Conclusion

- Strong interactions of micro and macro scale phenomena influence film and deposit formation
- Shear flow depends on gas mass flow and geometry and affects the diameter of detached droplets
- Rough deposit structures influence the droplet detachment leading to larger secondary drops
- Stagnant film formation potentially reduced by low wettability, high flow rates and oblique impact

Acknowledgements
This study is partially financially supported by the Friedrich and Elisabeth Boysen Foundation. We would like to thank Mr. Daniel Kümmel from the IAM, KIT for his assistance with confocal microscopy measurements. Simulations were performed on the bwUniCluster funded by the Ministry of Science, research and Arts Baden-Württemberg.

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6th International Symposium on Modeling of Exhaust-Gas After-Treatment, MODEGAT VI, September 8-10, 2019, Bad Herrenalb, Germany