Ansys

CASE STUDY /

# Ansys + Ecocat India

"Ansys Fluent helps us to optimize catalyst structures (pipe, cone and mixer), and significantly shorten the product development life cycle. SCR simulations using DPM modeling can correctly simulate AdBlue dosing and wall deposition phenomena."

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CASE STUDY

The catalytic converter converts the toxic gases and pollutants in exhaust gases into harmless compounds like $CO_2$ and $H_2O$. In India, due to increasing air pollution, the introduction of BS-VI emission norms has led to the development of selective catalytic reduction (SCR) technology as well as diesel particulate filters (DPF) and gasoline particulate filters (GPF) for the trapping of particulate matter. The BS-VI emission limits are shown in Figure 2 and 3.

The catalytic converter consists mainly of a diesel oxidation catalyst (DOC), DPF and SCR for a diesel vehicle as well as a three way catalytic converter (TWC) for gasoline and compressed natural gas (CNG) applications. The main purpose of the DOC is to oxidize the CO and HC into $CO_2$ and $H_2O$ as well convert NOx into $NO_2$ (this helps in passive regeneration). SCR tends to reduce NOx with AdBlue dosing, an aqueous solution of Urea $(NH_2)_2CO$ (aq.) that undergoes thermolysis and hydrolysis reactions for ammonia $NH_3$ formation, which reduces the NOx into $N_2$. DPFs are filters that physically captures particulates (carbonaceous soot) and prevents their release in the atmosphere.

## Multiphase Fluids and Structures Simulations for Bharat Stage VI Emission After-Treatment Systems with Ansys

### / Company Description

Ecocat India is a joint venture of the Vikas Group and Ecocat Finland. It produces substrates, coatings, canings and supplies products to OEMS, canners and system integrators. Our mission is to develop technologies for a clean environment, with values that include responsibility, networking, market intimacy and success.

### / Business Challenges

We simulated SCR to optimize the injector configuration, ascertain the AdBlue dosing required per the exhaust gas flow rate and temperature, determine the injection angle, optimize the mixer design with respect to the back pressure limitation, calculate the mixing length required and optimize the heat shield to maintain the desire temperature to prevent wall film thickness formation, and achieve a higher ammonia uniformity index at the substrate wall. We were also challenged to optimize the pipe/cone/diffuser for minimum back pressure and maximum flow distribution.

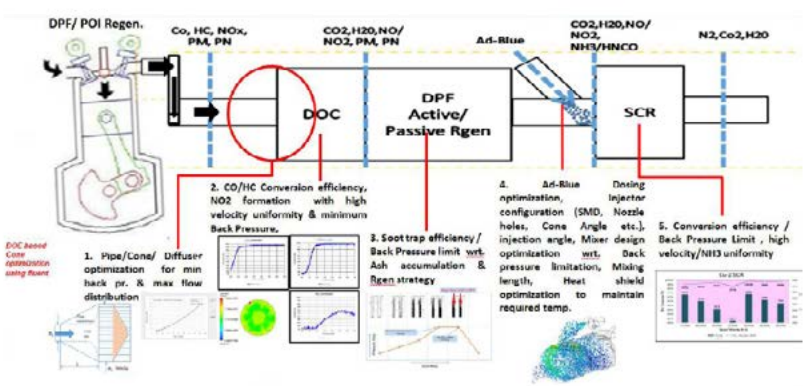



Figure 1. Overview of the after-treatment simulations performed at Ecocat.

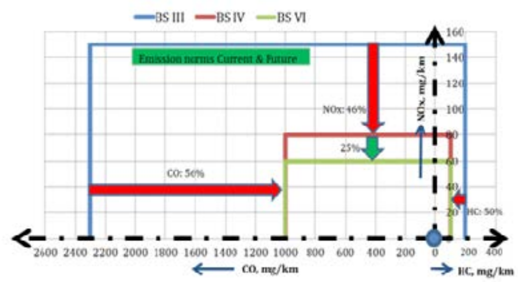



Figure 2. Emission limit for gasoline (current and future).

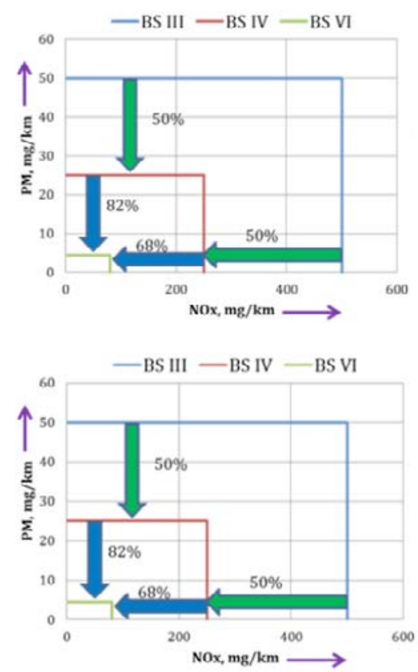



Figure 3. Emission limit for diesel (current and future).

## / Technology Used

- Ansys® Fluent®

## / Methodology Adopted

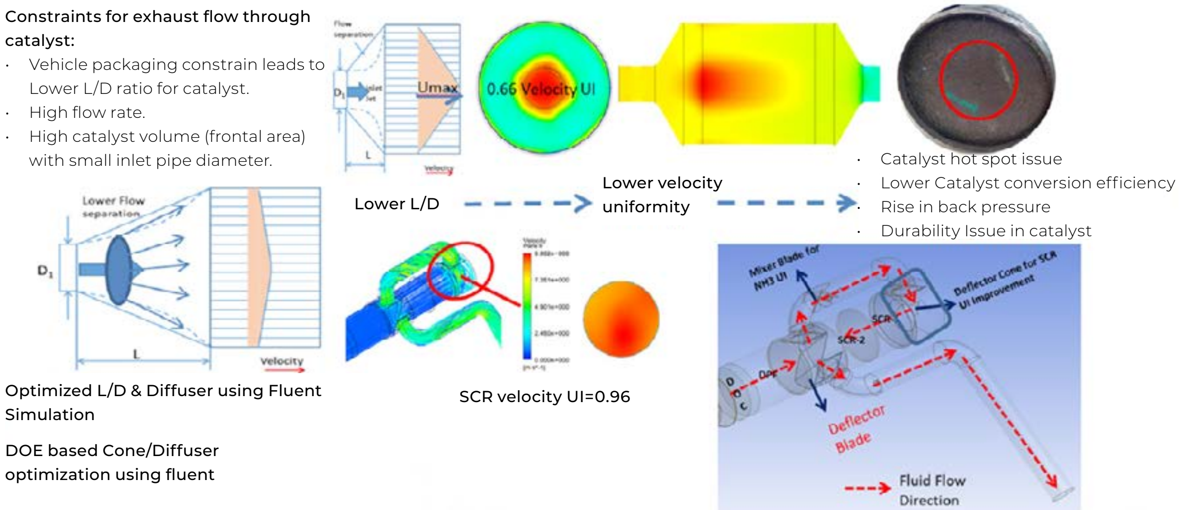



Figure 4. Pipe/cone/diffuser optimization for minimum back pressure and maximum flow distribution.

## / Conclusion

- Ansys Fluent helped us to optimize catalyst structures (pipe, cone and diffuser) and significantly reduce our product development life cycle.
- SCR simulations using DPM modeling can correctly simulate AdBlue dosing and wall deposition phenomena.

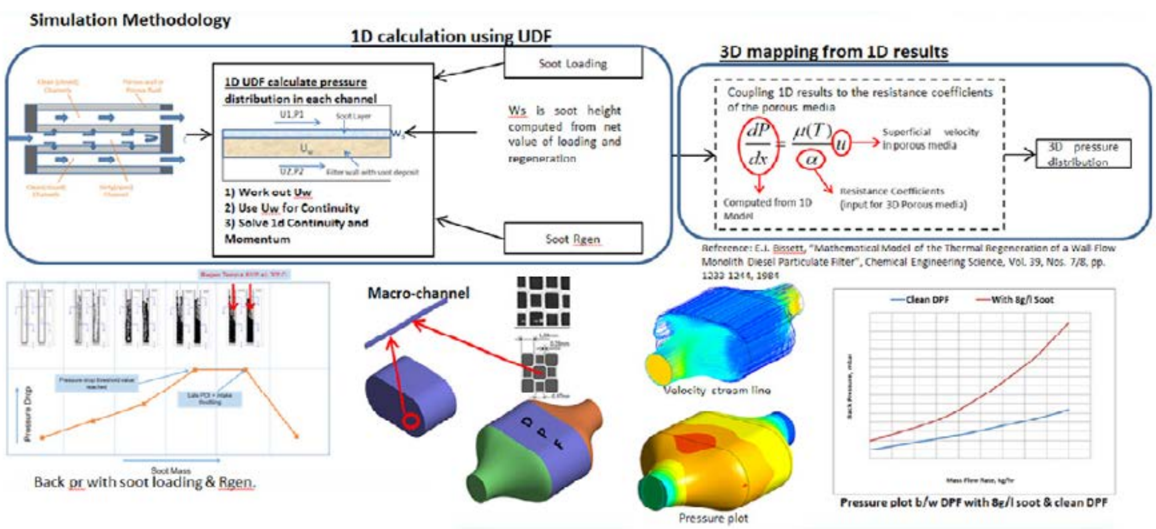
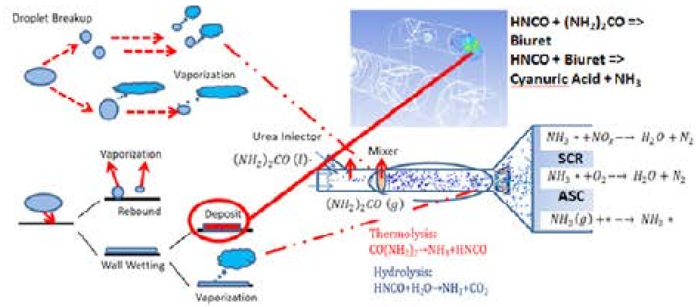



Figure 5. DPF simulation in Ansys Fluent.




### Factors Impacting SCR efficiency

- SCR catalyst (formulation, deactivation ...).
- Temperature (exhaust temperature, heat loss).
- Space velocity.
- NH3 storage level (urea dosing control algorithm).
- Local NH3/$NO_x$ ratio (urea mixing).

### Factors Impacting urea mixing

- Temperature.
- Flow uniformity.
- Injector type (spray angle, droplet size and momentum).
- Injection location.
- Mixing length (time).
- Mixing structure (flow turbulence).

**CFD Simulation using Fluent**

Mainly aims at establishing ammonia uniformity at the SCR catalyst inlet.

**Spray Modeling**

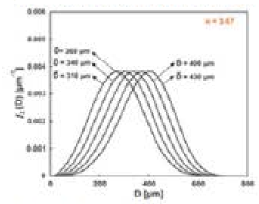
The Rosin-Rammler model is used to describe the size distribution of the droplets. Model assumes an exponential relationship between the droplet diameter, D, and the mass fraction of droplets with diameters greater than D, which can be expressed as:

as: $Y_D = e^{-\left(\frac{D}{\bar{D}}\right)^n}$

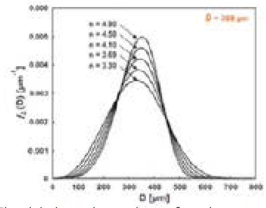
Where,

$Y_D$- Mass fraction of Droplet, D- Droplet diameter
$\bar{D}$- Mean Droplet Diameter, n- Spread parameter

**Effect of mean diameter & spread parameter**




A reduction in D increases the effective surface area of the droplets, resulting in a higher rate of heat and mass transfer from the droplets.




The higher the value of n, the more uniform the droplet size distribution is in the spray. That widening the distribution leads to an increase in the number of small and large droplets simultaneously.

Figure 6. SCR simulations.

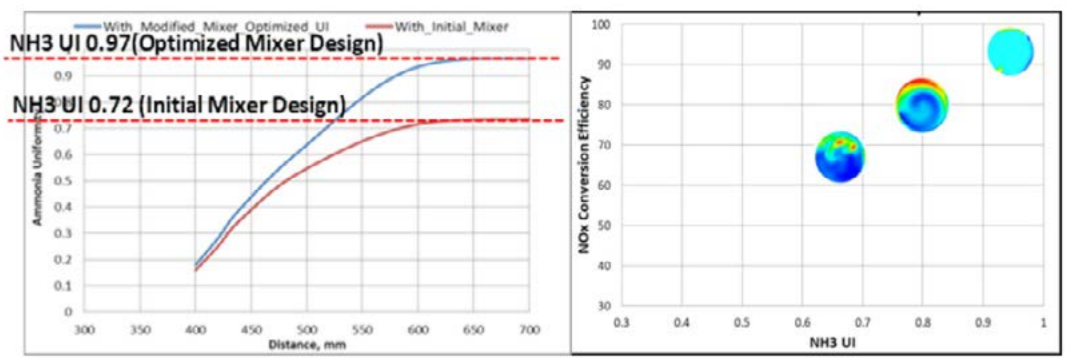



Figure 7. NH3 Uniformity Index (UI) comparison for initial and optimized design and NOx conversion efficiency with respect to NH3 UI.

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