Distributed Intra-catalyst Temperature Sensor Development

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Motivation

Catalyst-based after-treatment systems are effective:
- Reduces NOx (LNT, SCR)
- Oxidizes CO, HC, SDF (DOC)
- Removes particulates (DPF)

Intra-catalyst measurement offers:
- Insights into detailed chemical reactions and allow more efficient catalyst designs.
- Detailed understanding of high temperature effects and minimize damage from thermal degradation.

Thermal Degradation

Due to prolonged exposure to excess heat (>500ºC) as a result of necessary periodic catalyst operation

Primary causes (Lean NOx Trap): Desulfation: Reverses sulfur poisoning Regeneration: Reduces NOx into N2
Irreversible damage to PGM, storage sites, and substrate --- Reduces catalyst performance & life span.

Optimal mitigation strategies still under development. Detailed mechanisms yet to be clearly identified.

Optical Frequency Domain Reflectometry

Interference-based detection scheme suitable for resolving relative changes in temperature & strain as a function of distance along an optical fiber

Properties:
- Compact optical fiber sensor for minimal flow disturbance
- Flexible sensing element for maximum adaptability
- Low thermal conductivity for precise temperature resolution

Specifications
- High spatial resolution (<1 mm)
- Long measurement range (>100 m)
- Sensitive T & ε detection (<1 K & <1 με)

Principle
- Input light source linearly swept in optical frequency domain
- Interference between two backwards propagating signals
  1. Fresnel reflection from local oscillator (LO)
  2. Rayleigh backscatter from device under test (DUT)
- Detected beating signal analyzed

Specifications
- Long measurement range (>100 m)
- Narrow linewidth (140 kHz)
- OFDR laser light source
- Shown with an auxiliary interferometer for λ correction
- Collection time: 0.2 s/spectra
- ~10 spectra per measurement

Conclusion

- Built a working OFDR sensor with very high spatial resolution using widely available optical telecommunication equipment
- Successfully observed OFDR signal for various fibers
- Refine spatial resolution (<1 mm) and measurement speed